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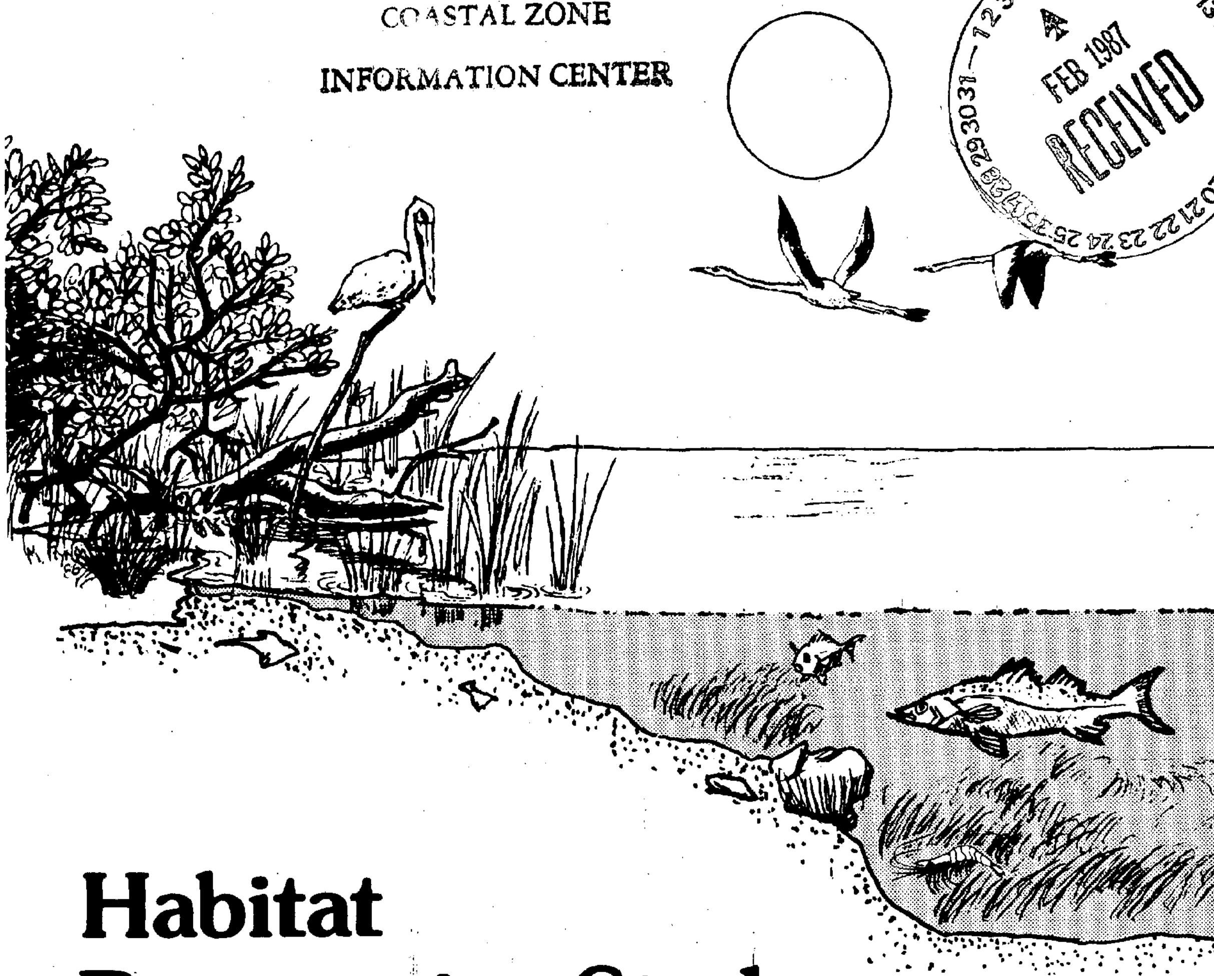

Habitat Restoration Study for the Tampa Bay Region

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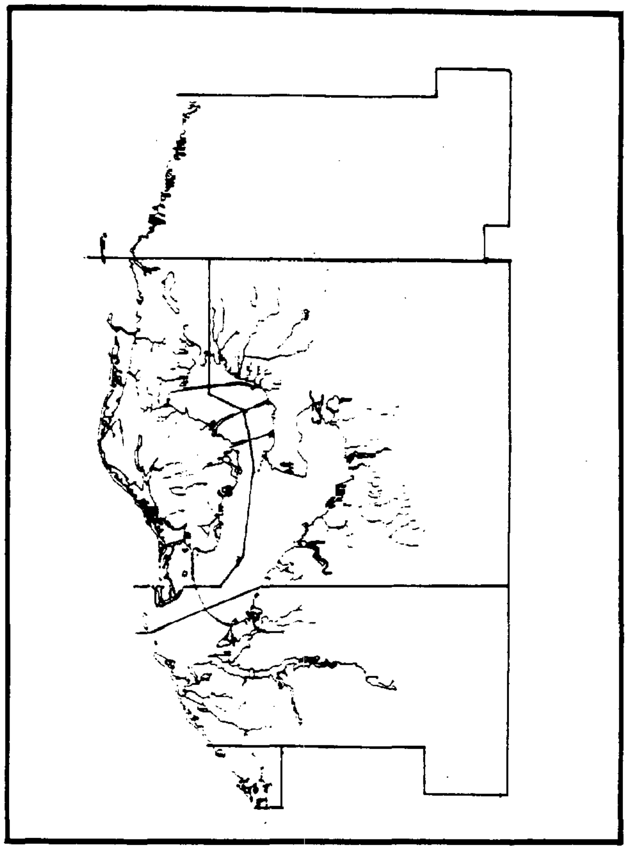
Habitat Restoration Study for the Tampa Bay Region



December 2, 1986

Tampa Bay Regional Planning Council
9455 Koger Boulevard
St. Petersburg, Florida 33702

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EXECUTIVE SUMMARY

Tampa Bay is the largest open water estuary in the State of Florida with over 1.6 million people living in the three counties bordering its shores. Once the state's most diverse and productive estuarine system, rapid urban and industrial development have changed its character and ecology. Habitat loss has resulted in declining populations of economically important fish and shellfish.

The bay constitutes the central geographic feature most responsible for, both historically and presently, the shipping, industrial development, aesthetic and recreational values that encompass the overall attractiveness of the region to population influx. The alarming rate of destruction and modification of coastal and estuarine wetland vegetation has been identified by the Tampa Bay Study Committee as the most serious problem affecting the ecological stability of the bay. Historically, however, local governments have acted independently in regulating the development of their natural resources, and as a result, the effects of habitat destruction generally have been evaluated on a parcel by parcel basis with little concern for the cumulative effects on the entire Tampa Bay system.

The Council, with funds from the Florida Department of Environmental Regulation (FDER), Coastal Zone Management Program, sought to develop a habitat restoration plan for the region. The Council initiated this study with the goal of assessing, from a regional perspective, the needs and opportunities for habitat restoration and management in the Tampa Bay Region.

This report is the culmination of a two-year study that involved staff, consultants, the Council's Agency on Bay Management and other state and regional agencies.

Among its most significant findings are the following:

- The economic and ecological significance of coastal and estuarine habitat in Tampa Bay lays the foundation for this study effort and is found in Chapter I of this report.

- The Council has assisted the U.S. Fish and Wildlife Service (USFWS) and the Florida Department of Natural Resources (FDNR) by providing additional mapping and digitization of LANDSAT aerial imagery. The final product includes a wetland trend analysis of coastal and estuarine systems in the four-county area.

- Statistical analysis has determined that a 47.4 percent loss of seagrass and 56.0 percent loss of salt marsh vegetation has occurred between 1957 and 1982 in the Tampa Bay area. The wetland inventories and trend analysis can be found in Figures 21 through 26, with the statistics reported in Tables 1 through 20.

- The restoration of habitat is normally accomplished by planting vegetation (seagrass, mangroves, saltmarsh) or improving existing conditions for use by the fish and wildlife populations. Chapter III identifies the results of past major habitat restoration attempts in the Tampa Bay Region. Recommendations from this chapter are then used to provide procedures and techniques for proposed restoration sites.

- Chapter IV identifies 50 coastal and estuarine habitat restoration sites in the four-county region. The recommended restoration sites are listed in Figure 104 and Table 32. It should be emphasized that the recommended plan is a habitat restoration plan rather than a mitigation plan. Restoration of historic habitat in the region is necessary to provide additional habitat for fish and wildlife populations.

- Many benefits can be cited for the strengthening of the Council's Agency on Bay Management and the streamlining of certain environmental permitting programs for proposed activities in and around the bay. Examples of the types of resource management responsibilities that such an Agency within the Regional Planning Council could assume include: sewage disposal and other point source discharges to the bay; stormwater management systems involving tidal waters; dredge and fill activities in the bay; shoreline development; aquatic preserve management; mosquito control projects; classification of sanitary shellfishing areas; and habitat restoration projects. Local assumption and consolidation of these programs in a one-stop operation would streamline the permitting process for all potential users of the bay and, more importantly, would result in a more unified management overview of the Tampa Bay estuarine system as a holistic natural resource. A detailed description of recommended management techniques is provided in Chapter V.

- A sound mitigation policy for the Tampa Bay Region should be to maintain as much of the existing estuarine wetland habitats as is feasible, while avoiding or minimizing costly man-assisted restoration efforts through preliminary planning. Where impacts on estuarine habitats are unavoidable, habitat creation or restoration should be required in a systematic manner that will ultimately lead to an incremental net increase in those habitats affected. To accomplish the task, an estuarine habitat mitigation policy is identified within Chapter VI.

Development of this document required contract services with the following organizations:

- Wade-Trim Group (formally Stewart Corporation)
- NUS Corporation
- Mangrove Systems, Inc.

Additional services and documents were provided by:

- The U.S. Fish and Wildlife Service (USFWS)
- The Florida Department of Natural Resources (FDNR)
- The Florida Department of Environmental Regulation (FDER)

The final product is a detailed habitat restoration and management plan for the Tampa Bay Region. It is the intent of the Council to implement all elements of the document wherever feasible during Developments of Regional Impacts (DRIs) and Intergovernmental Coordination and Reviews (IC&R) and through coordination with the FDNR gill-net license fee habitat restoration program, as well as local government initiatives. The efforts of the Council's Agency on Bay Management also will be important in implementing the findings and recommendations of this project.

CHAPTER I

ECONOMIC AND ECOLOGICAL SIGNIFICANCE OF COASTAL AND ESTUARINE HABITAT IN TAMPA BAY

Tampa Bay is the largest open water estuary in the State of Florida, with over 1.6 million people living in the three counties bordering its shores. This population represents a 45 percent increase since 1970. Once the state's most diverse and productive estuarine system, rapid urban and industrial development have significantly changed the character and ecology of Tampa Bay. Recent studies indicate that 44 percent of the original 25,000 acres of mangrove forests and salt marshes have been destroyed, and 81 percent of the original 76,500 acres of seagrasses have disappeared. This habitat loss has resulted in declining populations of economically important fish and shellfish, including a complete collapse of scallop and oyster fisheries, and major declines for bait shrimp, spotted sea trout and redfish.

The Tampa Bay estuarine system is, both directly and indirectly, a vitally important economic asset to the numerous municipalities surrounding the bay. This rapid urbanization has transformed the Tampa Bay area, now the second largest population center in Florida, into a major economic asset to both the state, and the nation as a whole. Tampa Bay is the central geographic feature most responsible for both historic and present shipping, industrial development, aesthetic, and recreational values which encompass the overall attractiveness of the region to population influx. The rapid growth rate of the region's population and business sector over the past 30 years confirms that the mere presence of Tampa Bay has contributed significantly to the economic growth and diversity of the region.

Examples of economic entities which are dependent upon the direct utilization of Tampa Bay include the port facilities of Tampa, St. Petersburg and Manatee County; ship building, repair firms and other marina facilities located around the bay; and the commercial and recreational fishing industries. Indirectly, the mere presence of the bay attracts industries and businesses such as water-oriented residential developments, restaurants, and a myriad of related support industries and commercial and recreational activities that would exist without consideration of the water quality.

ECONOMIC IMPORTANCE OF TAMPA BAY

The environmental quality of Tampa Bay is, intuitively, an important component in the decision making processes of the local governments, businesses and industries bordering its shores. The value of the estuary as a regional economic resource is, however, viewed by various industries and individuals from many different, and often conflicting, perspectives. For example, industries relying upon the availability of a source of water-borne transport may perceive Tampa Bay's value in the same sense that land-based industries would value railroad frontage in determining location decisions. For other firms, industries and even local governments, Tampa Bay is considered to be a convenient receptacle for the inexpensive disposal of treated industrial and urban wastes, or available waterfront space for further development. But for those industries dependent upon the harvest of living resources, or the availability of bay-oriented recreational opportunities, the value of Tampa Bay is perceived to be intimately tied to its ecological health.

The federal Water Pollution Control Act (Clean Water Act) amendments of 1972 mandated that, wherever possible, water quality is to be suitable for the protection and propagation of fish and wildlife, and to provide for recreation in and on all waters by July, 1983. Further, the Act required that all point source pollutant discharges are to be controlled or eliminated by 1985. Local implementation of this Act over the past decade has generally resulted in an overall improvement in the water quality of Tampa Bay. However, no analyses have ever been attempted to document the impacts of this improvement from an economic perspective on the overall economic framework of the area, or to describe available alternatives in achieving an economic/environmental balance in light of the continuing requirements of the Clean Water Act, as well as other relevant federal and state environmental legislation.

In March 1986, the Tampa Bay Regional Planning Council (TBRPC) published a study documenting the importance of Tampa Bay to the economic base of the region (TBRPC, 1986a). Using various methods of economic analysis, including opportunity cost calculations and surveys, the net economic benefits derived from various attributes and uses of Tampa Bay were quantified. The attributes and uses of the bay which were examined included: shipping and water-borne commerce and transportation; sanitary and electric services; commercial fishing; residential waterfront property; water-oriented recreational activities; and ecological services of Tampa Bay. The first two uses may be described as water quality independent, while the latter three uses and attributes may be described as water quality dependent.

<u>Shipping and Water-Borne Commerce</u>

Tampa Bay is one of the country's key commercial waterways, utilizing Florida's largest open water estuary. Including all contiguous wetlands, the total area of the bay is about 398 square miles, representing an average volume within the bay of 116 billion cubic feet (Morgan et al. 1984). The numerous ports and supporting facilities located within Tampa Bay directly benefit from the bay system. Goods and services can be economically transported across great distances and in large volumes, by the water transport system. The natural shape of Tampa Bay provides shelter and easy access for deep draft ocean-going vessels. The Port of Tampa has become the nation's seventh largest port in terms of tonnage transported, and is the third largest U.S. port in volume of foreign exports.

The direct and indirect economic impacts associated with the port activities on and along Tampa Bay are considerable. The primary direct impact of the Port of Tampa is estimated at $298 million per year (TBRPC, 1986a). This figure represents a measure of the revenues that flow from the principal port users. The primary indirect impact associated with the port is the transportation savings that the users realize by routing their shipments via the Port of Tampa in lieu of some other port or mode of transportation. The total transportation savings, and thus benefits, associated with the Port of Tampa alone estimated at $281 million in 1984 (TBRPC, 1986a).

This savings, however, is not without cost. During the past 100 years, channel dimensions in Tampa Bay have repeatedly been enlarged, allowing larger ships to call on the ports, resulting in a dramatic increase in the annual tonnage transiting the port (Figure 1). The deepening of Tampa's shipping channels has resulted in a tremendous economic impact. Dredging is a critical component of the port operations that provide a necessary transportation link upon which major portions of the region's economy depend. To date, the shallow natural depth of Tampa Bay has required dredging in excess of 100 million cubic yards of material to create and maintain the large port infrastructure in place. Disposal practices have historically resulted in large-scale changes in shoreline and benthic topography, and are commonly viewed as major contributors to the loss of natural habitats and changes in water quality which the bay has experienced.

There is a need for maintenance dredging to keep the ports operating. It is imperative that the dredged spoil is placed in an area where it will result in minimal damage to the fragile ecological systems. Dredging can result in physical alteration, turbidity problems, and re-suspension of sediments which can affect seagrasses and other types of highly productive emergent and submergent vegetation. The loss of this vegetation results in a loss of habitat available for nursery utilization and subsequently affecting the adult populations of finfish and shellfish, not only in the bay, but in Gulf populations as well.

Electric and Sanitary Services

Currently, the vast quantity of water existing in Tampa Bay is utilized as a receiving body for treated waste water and industrial effluent discharges, as well as a source of cooling water for electric power generating facilities located on the bay (Figure 2).

The least costly method of waste water disposal involves the ultimate disposal of treated waste water to surface waters of the Tampa Bay watershed. The next best available alternatives include waste water reuse via spray irrigation, deep-well injection and a gulf outfall, or a combination of each of these. Waste water treatment with discharge into Tampa Bay may be the least costly and economically preferable method, however, it is perhaps the most costly regarding the ecological health of the bay. Waste water discharged into the bay contributes to excessive nutrients and fecal coliforms, resulting in closure of public beaches, shellfishing areas and eutrophication conditions within the bay. Figure 3 identifies domestic and industrial discharge points in the Tampa Bay area.

In addition, the use of bay water as a cooling source for electric power generating plants located along Tampa Bay results in both economic and environmental impacts. Cooling system alternatives available to both the Florida Power Corporation and the Tampa Electric Company include the

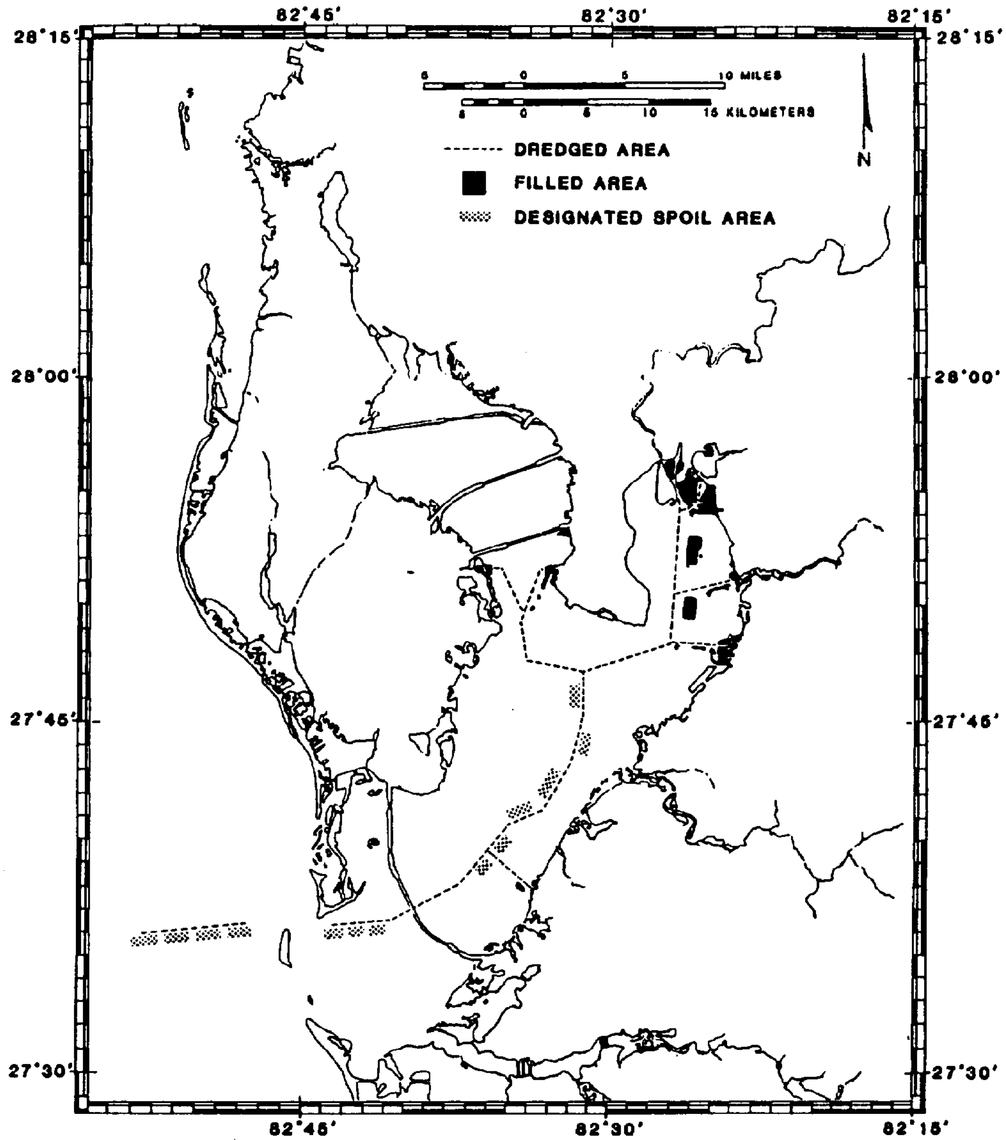
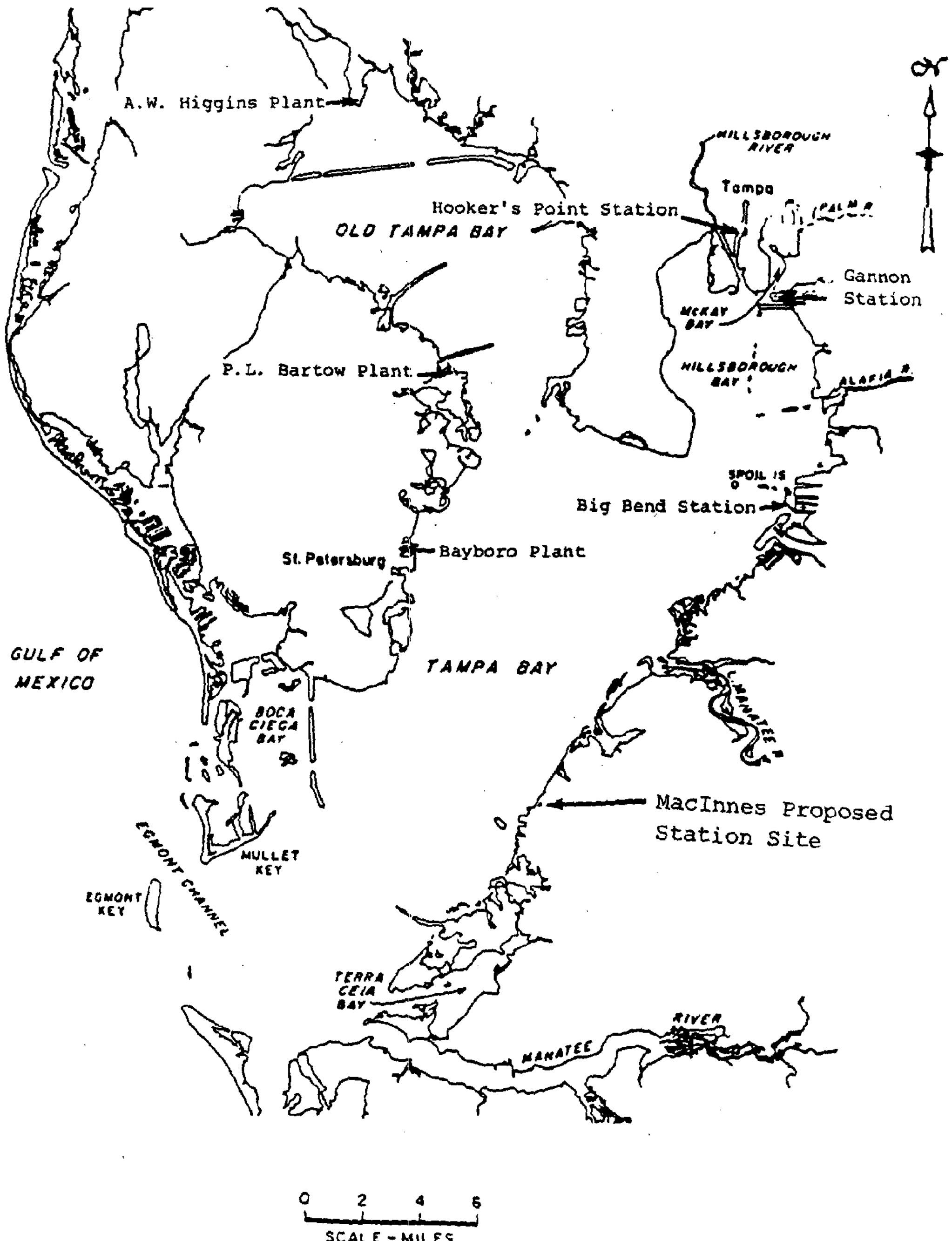


Figure 1

Areas of Tampa Bay dredged or filled for port development, past 100 years (Fehring, 1985)



Source: Florida Power
Florida Power and Light
Tampa Electric Company

Figure 2 Location of Power Plants in Tampa Bay (TBRPC, 1986a)

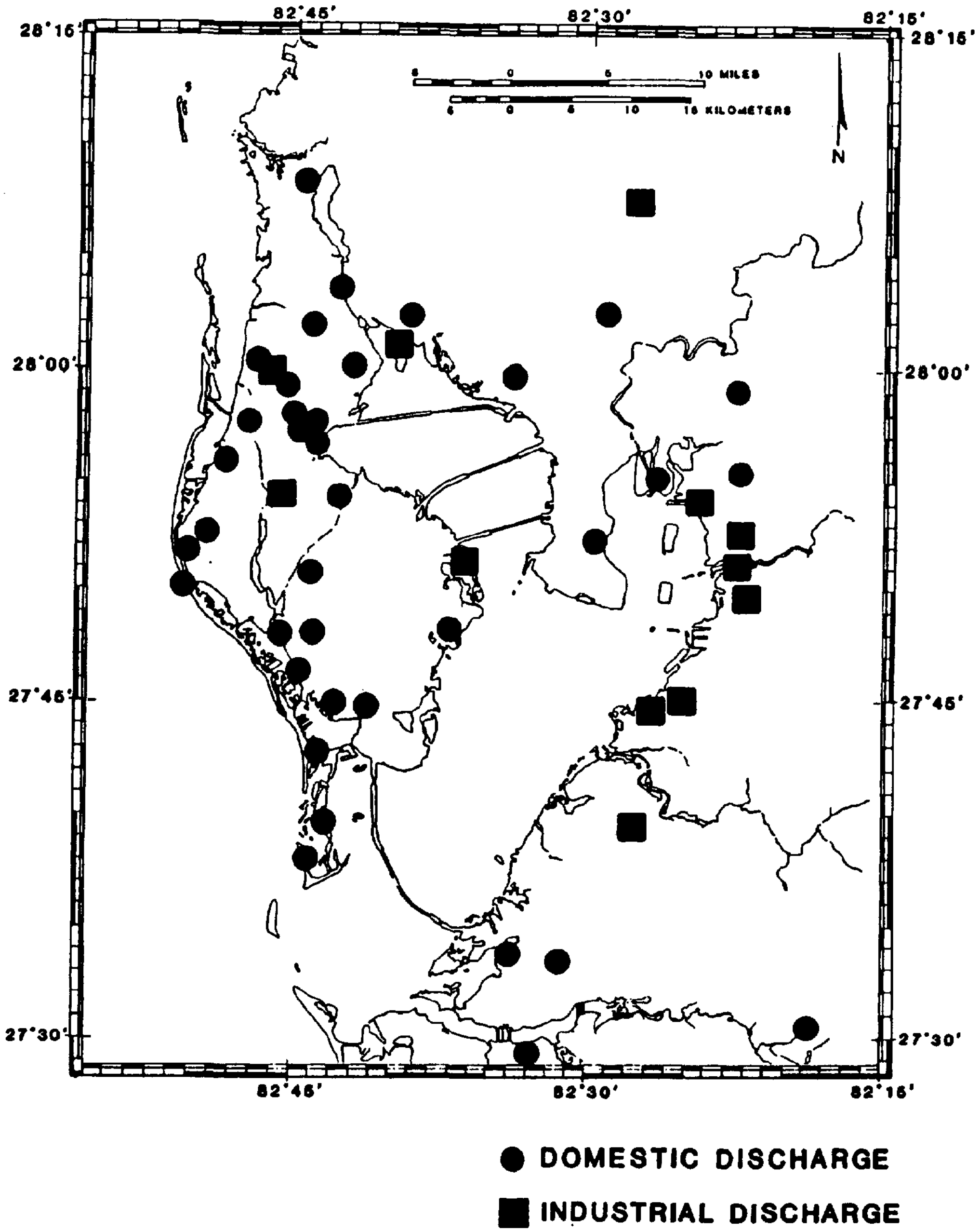


Figure 3 Reported discharge sources, Tampa Bay Area, 1980 (Moon, 1985)

conventional once-through cooling system, cooling towers and cooling ponds. However, there are environmental impacts associated with both the intake of water from Tampa Bay and the ultimate discharge into the bay.

The vast quantity of water contained within Tampa Bay provides an easily accessible cooling water source (and reservoir). The most economical way of condensing steam to be returned to the boilers, in the electrical power production process, is achieved using an open-cycle cooling system which passes water from the environment through the condenser element and discharges it back into the environment at an elevated temperature. Although the discharges of "waste" heat into the subtropical Tampa Bay estuary results in demonstrable impacts, perhaps a greater problem results from the capture and inclusion of planktonic eggs and larvae of fish and shellfish in the cooling water of power plants. This process termed "entrainment," usually leads to high rates of mortality for those organisms involved. Mortality results from thermal stresses, chemical stresses (associated with biocides used to prevent fouling of the cooling system), physical stresses (associated with pressure changes) and other impacts and abrasions during passage through the cooling system. Assuming a 100 percent mortality rate for all entrained organisms, and adjusting for estimated natural mortality rates of estuarine fish eggs and larvae, it can be estimated that power plant entrainment is responsible for annually removing approximately three billion harvestable adults from the commercial and recreational fisheries of Tampa Bay (TBRPC, 1978).

Historically, the diluting potential of bay waters has been taken for granted in the design of stormwater systems. In the past, stormwater drainage systems were designed to remove the potential floodwaters as quickly as possible. In effect, this was accomplished by channeling runoff directly into Tampa Bay and tributaries without the benefit of pretreatment. Urban and agricultural stormwater runoff have been identified as the major source of water pollution to Tampa Bay, with the former apparently predominating (TBRPC, 1978). Due to the highly urbanized character of the study area, and the slow natural flushing rates in portions of the estuary, stormwater run-off pollution resents a particularly intractable problem for Tampa Bay.

Stormwater runoff and municipal discharge are major contributors of nutrients into the water column. This addition of nutrient rich material can result in a eutrophication problem in the bay. This nutrient rich condition can trigger algal blooms which will cause fish kills, shade out submergent plants, and create unpleasant odors in the bay.

Residential Waterfront Property

In general terms, the presence of Tampa Bay enhances the value and desirability of the homes and neighborhoods located on the bay. It appears that owners of single-family, residential waterfront property are willing to pay more for their home, primarily for the water view, and secondarily for the ease of access to the bay and ability to navigate a boat close to their home.

The intrinsic value of Tampa Bay is closely associated with water quality. A waterfront home on Tampa Bay would not be as valuable if the bay water were to deteriorate or be degraded. The value of property fluctuates in relation to its geographic proximity to Tampa Bay and tributaries. The value of land adjacent to water will vary according to proposed land use and zoning densities. However, it is generally accepted that property values increase with water frontage or direct access to the bay.

In addition to residential property values, commercial and office space located on or near the waters of Tampa Bay generally demand a higher price per square foot. Again, the environmental amenity offered is largely one of a water view. Some examples of waterfront development that preclude higher prices in terms of owning, leasing or utilizing include: high rise, waterfront office space; hotel, motel, and tourist court establishments; and restaurants, and other eating and drinking establishments.

Water-Oriented Recreational Activities

The recreation-related uses of Tampa Bay include boating, fishing, saltwater beach activities and boat ramp use. An inventory of marinas located around Tampa Bay is included on Figure 4. These activities have a tremendous impact on the region's economy. The retail sales reported for motorboats, yachts and marine accessories in Pinellas, Hillsborough and Manatee Counties was approximately $184 million in 1983, while the total economic value of recreational fishing in the Tampa Bay Region was estimated at $197 million (TBRPC, 1986a).

The recreational benefits of Tampa Bay are directly linked to water quality. The alteration of the system beyond its ability to recover can cause significant degradation, resulting in a decline in tourism, boating, and recreational activities in general. The bay could become a major liability rather than an asset.

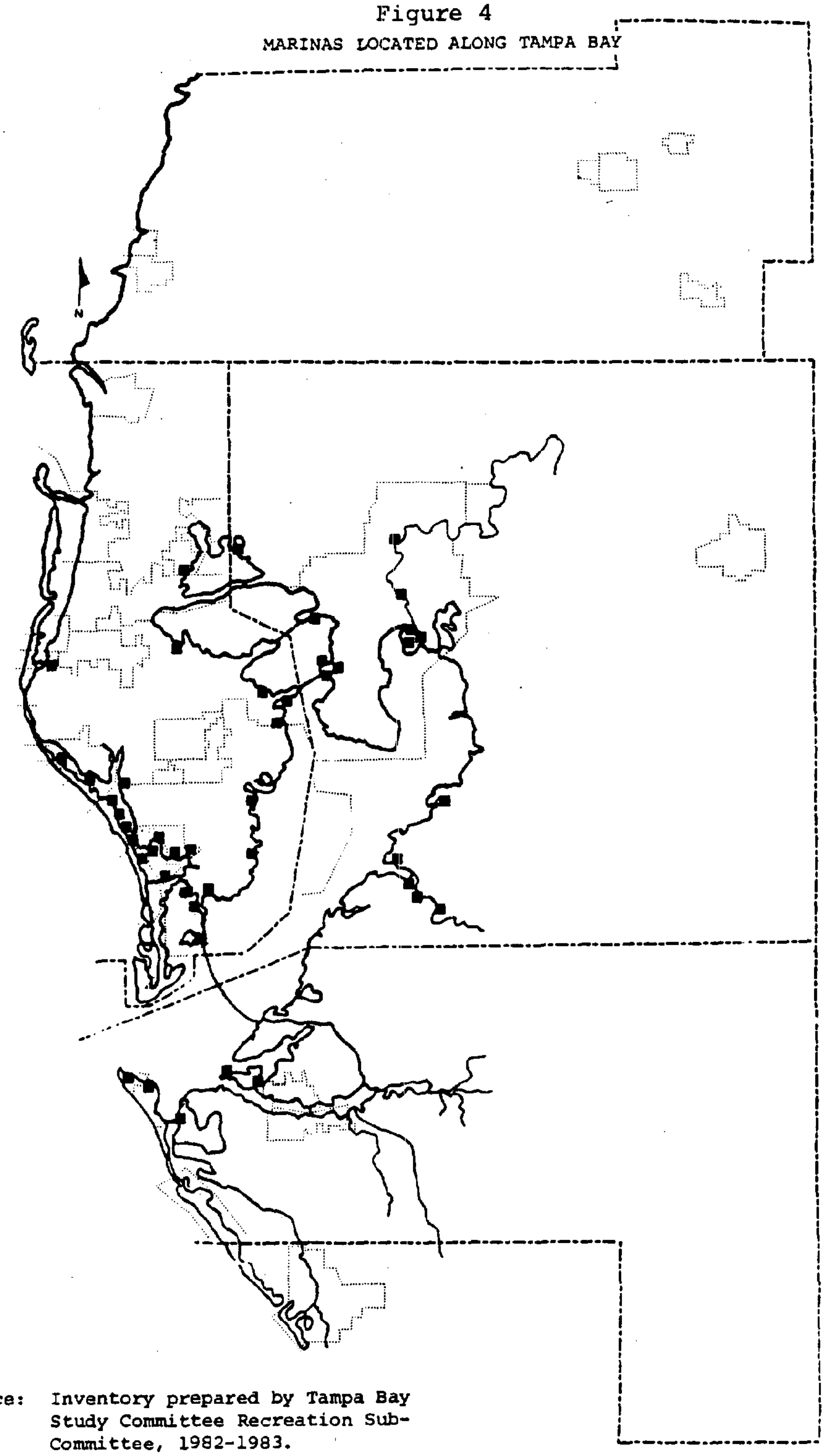
Commercial and Recreational Fishing

Historically, Tampa Bay has been one of the state's most productive fishery habitats. Prior to the turn of the century, sturgeon were still fished commercially. The bay supported thriving scallop and oyster fisheries up until the early 1950s. Those fisheries have since collapsed completely primarily due to overfishing, water quality degradation and habitat loss. Tampa Bay still supports reasonably productive fisheries for spotted sea trout, red and black drum and mullet. Of special concern are spotted sea trout and red drum which constitute the bulk of the recreational finfish landings in Tampa Bay.

Commercially and recreationally valuable macroinvertebrates within the Tampa Bay estuary include the following: pink shrimp, stone crab, blue crab, oyster, bay scallop, southern quahog, sunray venus clam, and squid (T.I. Inc., 1978). Currently, the most valuable fishery is the pink shrimp.

Figure 4

MARINAS LOCATED ALONG TAMPA BAY



Source: Inventory prepared by Tampa Bay Study Committee Recreation Sub-Committee, 1982-1983.

The commercial fishing industry remains an important source of income and employment in the Tampa Bay Region. A total of 1,952 commercial fishermen plied their trade during 1984 in Hillsborough, Manatee and Pinellas Counties, which represents ten percent of all commercial fishermen in Florida. A total of 22.1 million pounds of fish, valued at $19.5 million, were landed in Hillsborough, Manatee and Pinellas Counties in 1984 (TBRPC, 1986a).

Both commercial and recreational fisheries are affected by a loss of habitat. With 90 percent of the commercially and recreationally valuable species being estuarine-dependent, any loss of saltmarsh shoreline (development activities) or seagrass beds (dredging, water quality) will contribute to the decline of fishery stocks. This trend can be slowed through the acceptance of the value of these habitats and efforts to restore this valuable area where possible.

The loss of available habitat for fish and wildlife is reflected by a decrease in the harvestable adult population. Figure 5 identifies the decreasing trend in Florida landings of shrimp over 30 years. Figure 6 portrays the Florida landings of commercial marine products over the same time period. The direct result of the trend is reflected by an increase in the monetary value of commercial marine landings (Figure 7), for the same time frame as dictated by supply and demand. Figure 8 identifies the value of harvested species in 1977. Future demand on harvestable species will continue to pressure remaining stocks and may lead to the increase in foreign imports of saltwater fishery products.

ECOLOGICAL SIGNIFICANCE OF TAMPA BAY

The intertidal and submerged wetlands of Tampa Bay perform many natural functions having intrinsic value. Of all bodies of water, estuarine systems offer the greatest diversity in water composition. An estuary is defined as a semi-enclosed coastal body of water with an open access to the ocean, that is measurably diluted by the influx of freshwater (Pritchard, 1967). Freshwater mixing with salt water creates unique chemical and physical environments each of which supports different communities of organisms particularly suited to that type of water.

According to Taylor (1973), the recorded diversity and abundance of macro-invertebrate marine life in the Tampa Bay estuary is not exceeded by any other estuary between Chesapeake Bay and the Laguna Madre of Texas. The richness of Tampa Bay marine life has been attributed to the geographic position of the estuary between temperate and subtropical waters (Simon, 1974). Another contributing factor to the diversity and abundance of Tampa Bay marine life is that salinity is typically in the range of 25-35 parts per thousand (ppt) over most of the estuary, without the wide fluctuations and significant vertical stratification that characterize many other estuaries. As a result of the stability of the salinity regime, many ocean species can co-exist with typical estuarine species.

Figure 5 Florida landings of shrimp, 1952-1982 (Lewis et al. 1985)

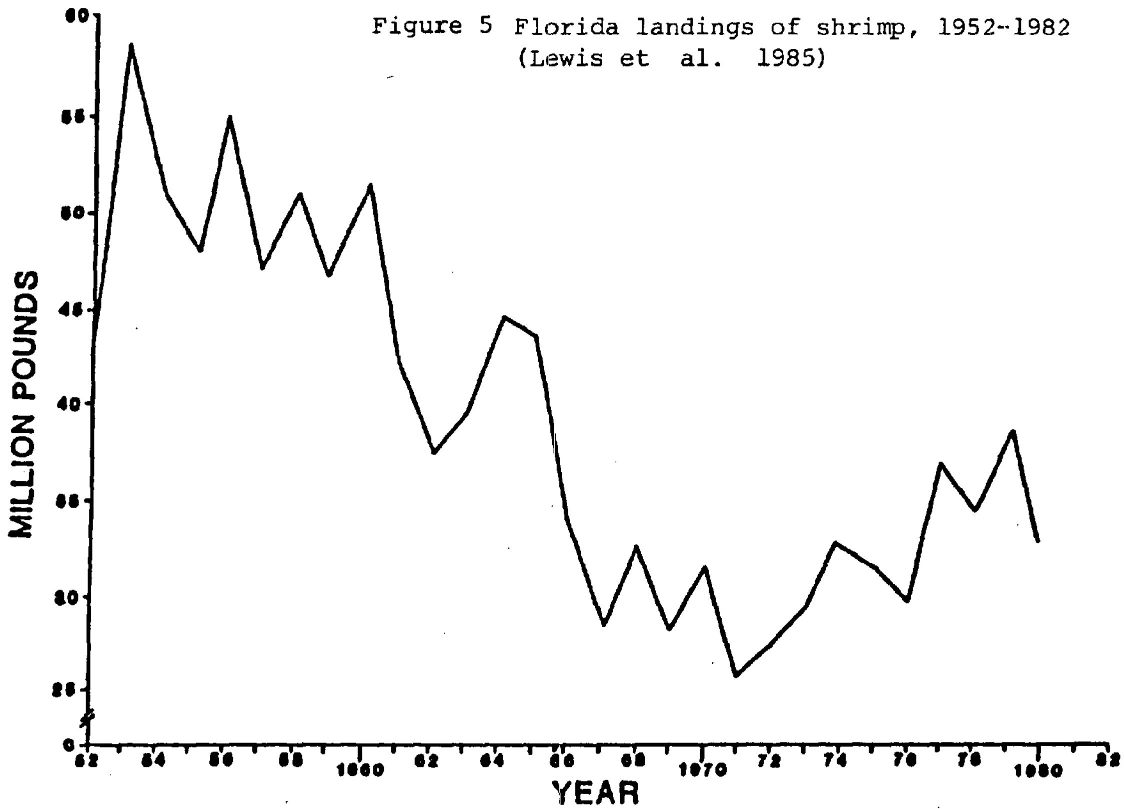
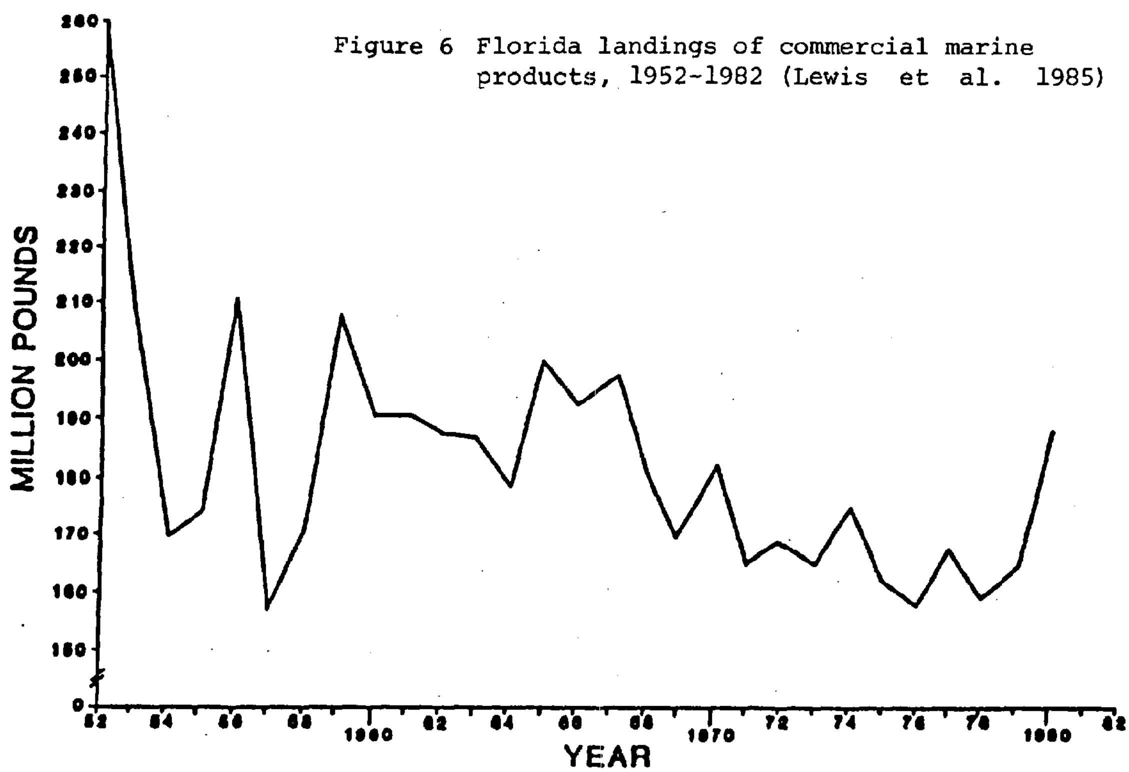


Figure 6 Florida landings of commercial marine products, 1952-1982 (Lewis et al. 1985)



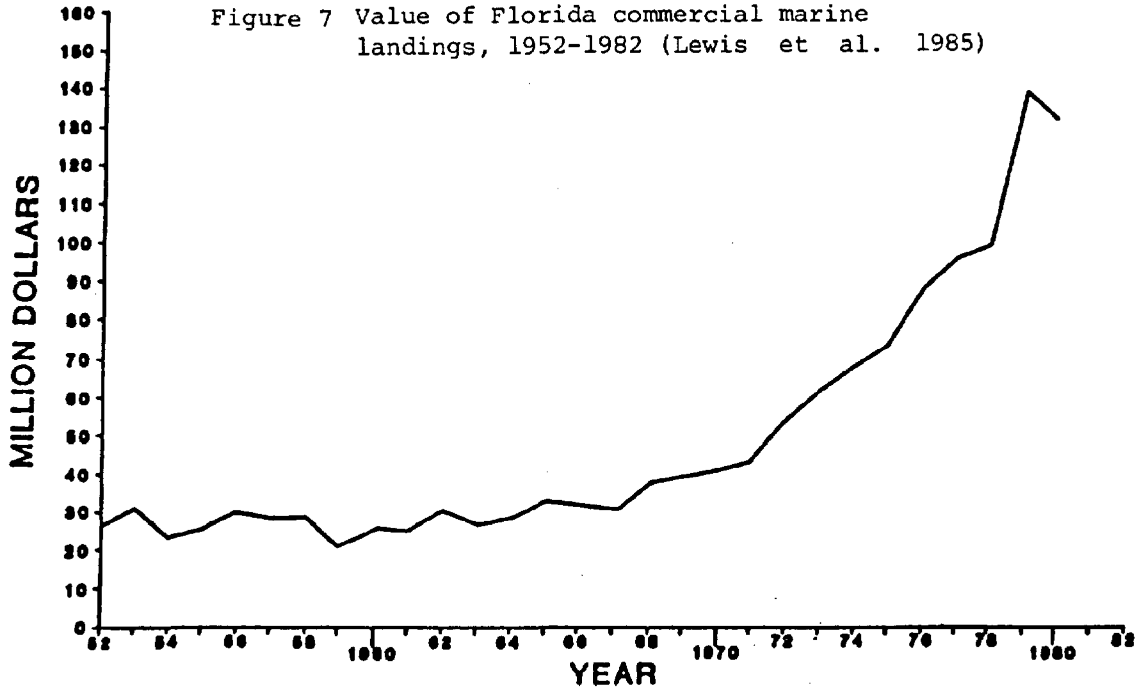


Figure 7 Value of Florida commercial marine landings, 1952-1982 (Lewis et al. 1985)

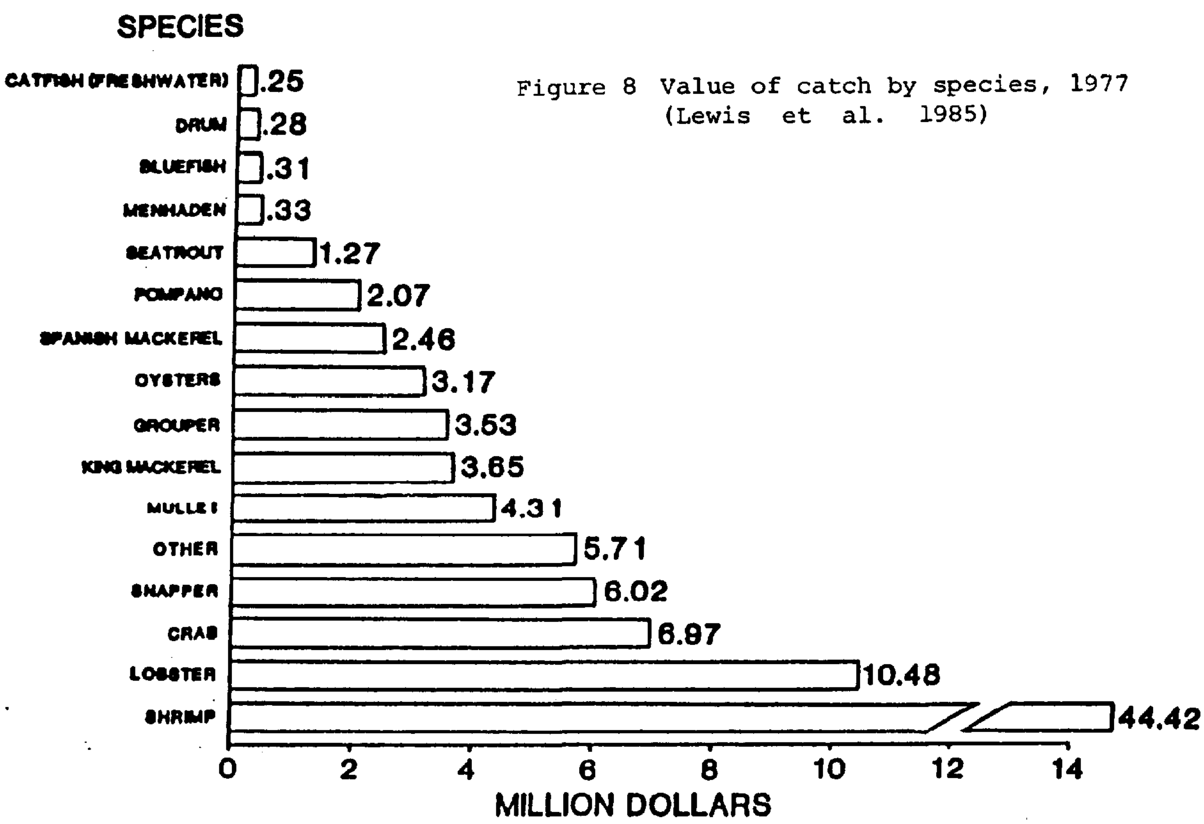


Figure 8 Value of catch by species, 1977 (Lewis et al. 1985)

The importance of rivers and creeks to estuaries has been documented by studies throughout the world. Rivers and lesser streams import freshwater, foodstuffs, sediments, minerals and nutrients to estuaries and provide critical habitat, refuge, feeding and breeding grounds for the early life history stages of marine and estuarine life forms (Figure 9 and 10). Rivers and lesser tributaries flowing to Tampa Bay vary greatly in condition. Historical and anecdotal evidence exist to show that these streams were immensely productive estuarine zones. Modern data on relatively pristine rivers and creeks support this view.

The Tampa Bay estuary and contiguous coastal waters serve as home, feeding ground and/or nursery for more than 270 species of resident, migrant and commercial fishes of the Gulf of Mexico that utilize estuaries at some time in their life cycle. The most critical use of Tampa Bay, for numerous species, is as a protected nursery area for larval and juvenile life history stages. The protective function arises from the generally greater osmoregulatory capabilities of younger marine fishes, shallow depths and protective cover. Reduced salinities in estuarine waters tend to exclude larger marine restricted fishes that otherwise prey on young juveniles and larvae. The nursery function is developed from the high primary productivity of estuaries which provide a ready source of food.

Dredging and filling for commercial and residential development have contributed significantly to the loss of live bay bottom. Boca Ciega Bay for example, has lost 22 percent of bay bottom through dredging and filling activities to create finger canals and increase the number of structures having water frontage. These "dead-end" finger canals severely restrict the mixing of the water, degrading the water quality in the canal. The loss of benthic and intertidal area also eliminates the nursery function of the area affecting the recruitment of juvenile fish and other equally important marine organisms.

Tampa Bay is a naturally shallow body of water, having an average depth of about 12 feet (Goodwin, 1984), and a maximum natural depth of about 90 feet in Egmont Channel, at the mouth of the bay. Approximately 90 percent of the bay bottom is less than 22 feet in depth (Olson and Morrill, 1955).

Despite the relative shallow nature of Tampa Bay, the estuarine ecosystem provides excellent resiliency to man-made and natural destructive forces. The resiliency potential of estuaries is aided by the vigor of the rhythmic and turbulent circulation pattern which continuously and endogenously renews the supply of water, food larvae, nutrients and other essential elements of any small damaged area. This assists in recovery and protects long-term net stability patterns of the estuarine system.

The substantial buffering capacity of estuaries, usually operating through the carbonate system, is another element which resists changes imposed on estuaries. The capacity of seawater to assimilate and/or dilute toxic pollutants has been well documented. The potential is not so great as the buffering capacity of the open ocean, but it is greater than most rivers, and is enormously important in the estuaries where pollution is received, as in Tampa Bay.

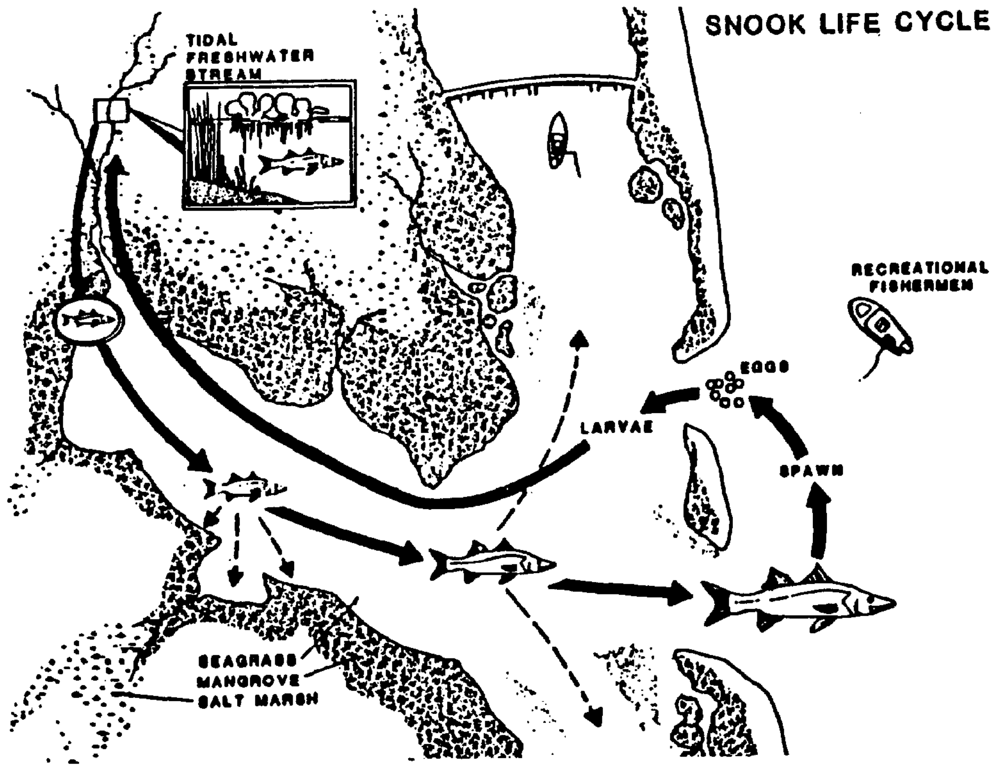


Figure 9 Life cycle of the snook (<u>Centropomus undecimalis</u>) (Lewis et al. 1985)

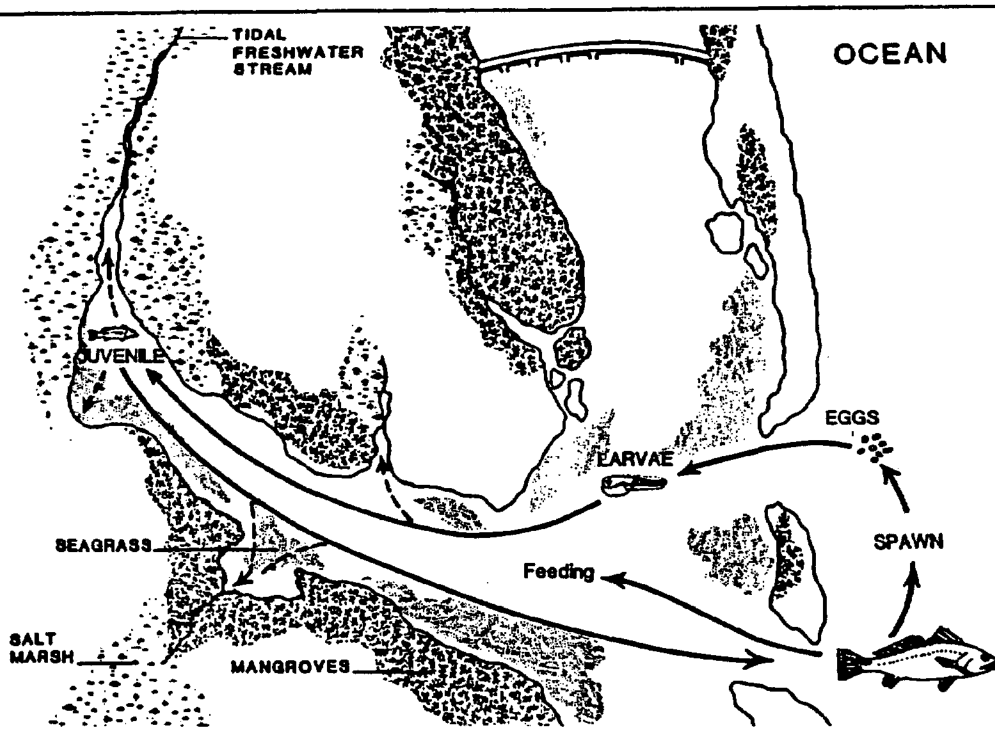


Figure 10 Life cycle of the redfish (<u>Sciaenops ocellatus</u>) (Lewis et al. 1985)

Many species have biological characteristics or adaptations which provide special advantages in estuarine survival. These characteristics usually protect the species against natural violence in estuaries, and they are often helpful in resisting terrigenous forces. Simon (1974) believes that such resilience exists because of natural stress factors, such as red tide, which favor organisms that recover quickly. Such long-term periodic stresses as hurricanes, droughts, and red tide may, in effect, pre-adapt the benthic community to other stresses that originate from man's activities (e.g. slime spills, shell dredging, thermal and industrial effluent).

ESTUARINE HABITAT

The importance of mangrove forests, salt marshes, and seagrass beds to coastal and estuarine ecosystems has been well documented over the past two decades. As primary producers, these species of wetland vegetation provide the foundation of coastal and estuarine food webs; both as direct sources of nutrition and as generators of detrital particles (Figure 11 and 12). Secondary to their role as primary producers, coastal and estuarine wetlands provide protection and habitat for such organisms as shrimp, crabs, scallops and juvenile fishes (Figure 13). Also, wetland vegetation provides necessary substrate for the attachment of organisms that are major food sources for many economically important species of finfish.

In addition to their contributions to the biology of the marine ecosystems, coastal and estuarine wetlands play an important role in modifying the geologic and hydrographic characteristics of the area. Acting as baffles, roots and leaves reduce the velocity of water over the bottom causing suspended particles to settle out and become trapped at the base of the plants. In this way mangroves, marshes, and seagrasses reduce turbidity, increase sedimentation rates, stabilize sediments, and attenuate wave action on adjacent shorelines and reduce flood crests and flow rates after storm events (Figure 14). The binding and stabilization characteristics of these habitats are documented by reports of some coastal marshes and seagrass meadows surviving the destructive scouring forces of coastal storms and hurricanes in the Gulf states.

The mangrove forest community exists near the beginning of the estuarine wetland zone. Mangroves share commensal communities of associated flora and fauna commonly attached to the root system. The general consensus is that mangroves, particularly red mangroves, through their ability to trap sediments, act as land stabilizers rather than land builders (Odum et al. 1982). Localized environmental factors such as soil salinity and tidal flushing determine zonation patterns among mangrove species.

Salt prairies and marshes provide habitat for a variety of fish and wildlife, in addition to the specialized vegetation that occurs in this extremely sensitive zone. Salt barrens, because of the hypersaline soil water, are generally devoid of vegetation. As this soil water slowly leaches from the surface and is diluted by rainwater, salt flats (prairies) and meadows (marshes) may form. These rapidly changing physiochemical conditions caused by tides, evaporation, and freshwater runoff result in unique and sporadic assortment of vegetation. In general, the moderate to high salinity marshes support more marine invertebrates (snails, mussels, polychaetes) than do the low salinity marshes (Carter et al. 1973). Other

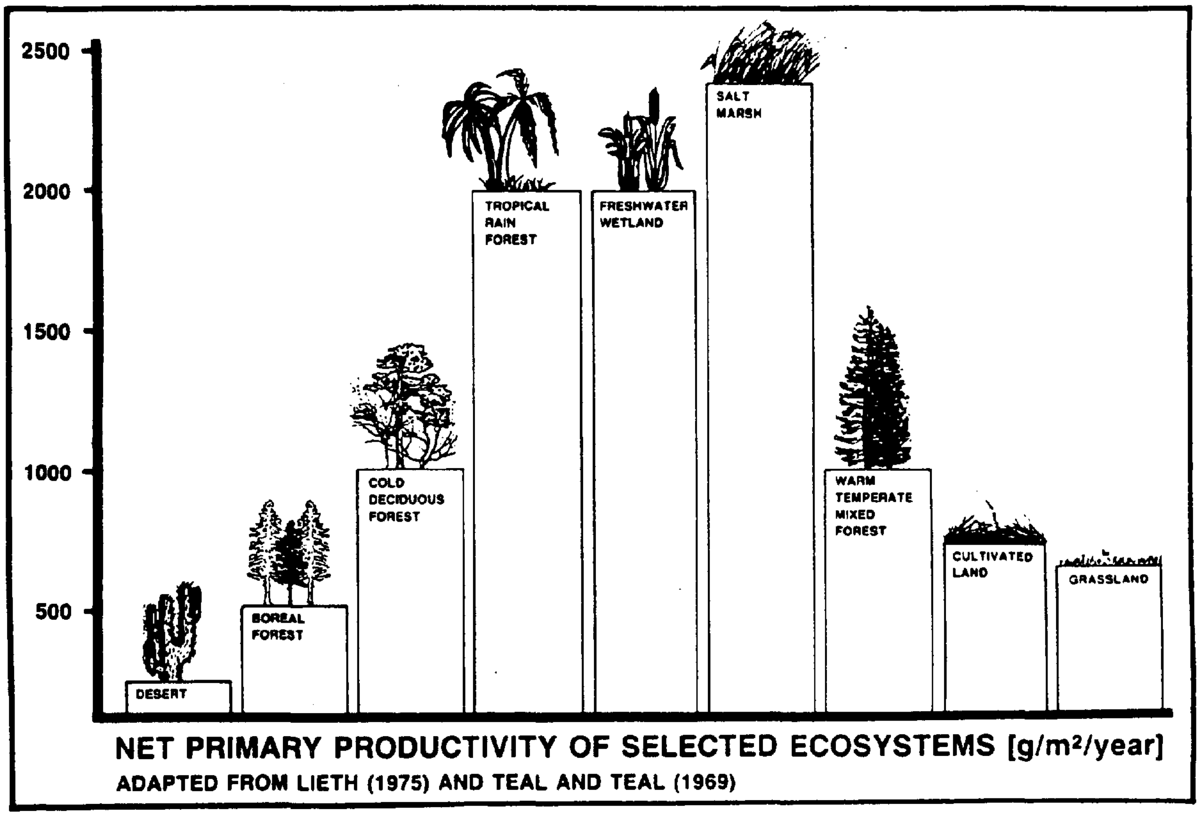


Figure 11 Relative productivity of wetland ecosystems in relation to others (Newton, 1981; in Tiner, 1984)

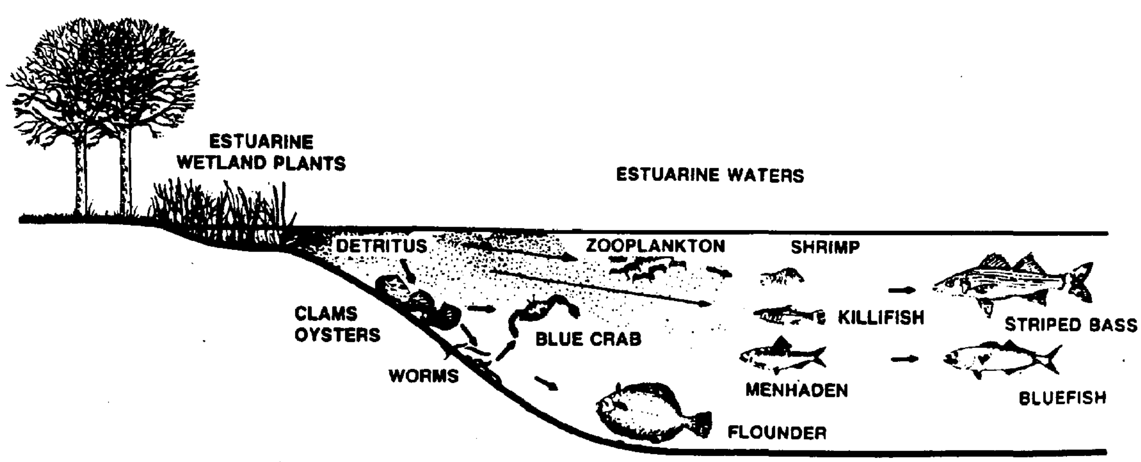


Figure 12 Simplified food pathways from estuarine wetland vegetation to commercial and recreational fishes (Tiner, 1984)

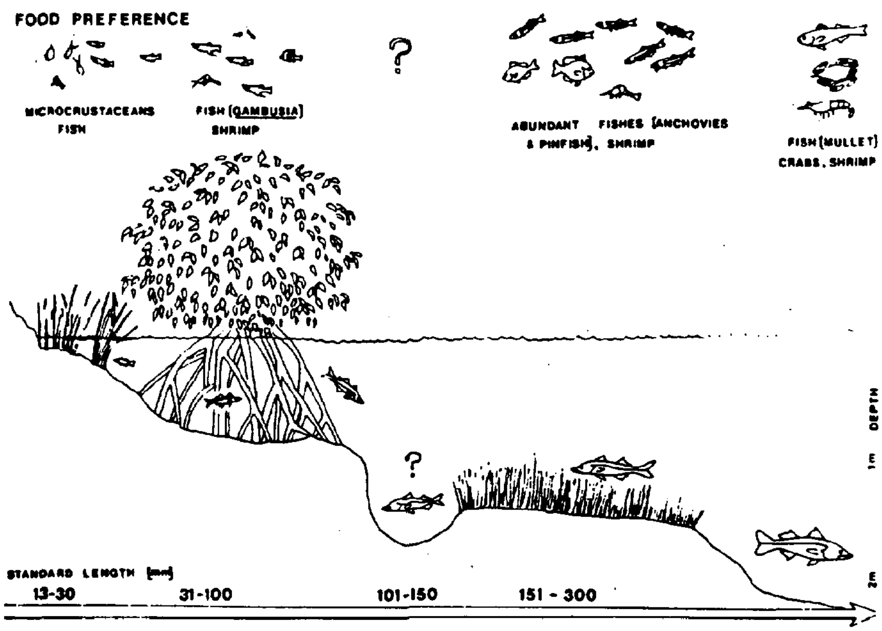


Figure 13 Schematic representation of juvenile snook migration and association with various habitats and subsequent changes in food items consumed. (Gilmore, et. al., 1983)

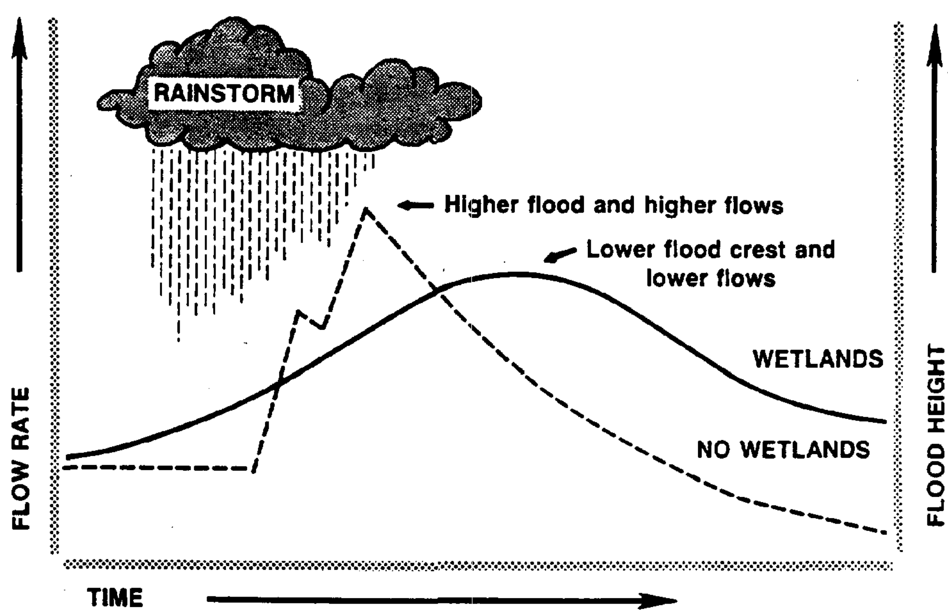


Figure 14 Wetland value in reducing flood crests and flow rates after rainstorms (adapted from Kusler, 1983)

important invertebrate groups include amphipods, benthic foraminiferans, insects and their larvae. Additionally, marshes attract numerous wading birds (herons and egrets), other more transient birds (red winged blackbird, marsh hawk), mammals (rabbits, raccoons), and some reptiles (alligators, salt marsh snake).

Seagrass beds are widely recognized as one of the most productive benthic habitats encountered in estuarine and nearshore waters. Seagrasses play at least four roles in the ecology of an estuary: (1) habitat; (2) food source; (3) nutrient buffer; and (4) sediment trap. Seagrasses serve as a fisheries habitat including: nurseries for juvenile stages of some fish species; refuge for mating blue crabs, other invertebrates, and finfish; a substrate for epiphytic plants and animals; and food source for all fauna subsisting directly on seagrasses and its epiphytes or detritus derived from them.

SUMMARY

When environmental problems are approached from an ecosystem perspective, proposed solutions to specific problems are evaluated in light of their effect on all other elements within the system. A truly effective solution not only corrects the problem, but avoids damaging other elements or relationships within the ecosystem. This approach makes problem-solving a great deal more challenging, but leads to more effective environmental management.

In order to adequately define the Tampa Bay system, we must go far behind the actual shores of the bay itself. The composition and problems of the entire drainage basin significantly impact the functions and inter-relationships of the bay proper. The weather, air, land, water, plants and animals all form a complex web of interdependencies which together make up the Tampa Bay ecosystem. Let us not forget that humans are also an important and very dependent part of this overall system.

Presently, Tampa Bay continues to perform the various natural functions indicative of all estuaries, however, the ability of the bay to "function naturally" has been stressed by 100 years of competing uses. Although the Tampa Bay estuary has great resiliency and recovery potential through the natural systems, it takes many years for the system to recover. Tampa Bay is being stressed through stormwater runoff, waste water discharge, dredging activities, development and habitat loss, faster than the system can recover naturally. In order for Tampa Bay to remain an economic resource, it must be allowed to function as a natural resource.

CHAPTER II

WETLAND TREND ANALYSIS

PURPOSE OF ANALYSIS

A comprehensive, regional analysis of coastal and estuarine habitat was performed to assess wetland losses and gains from the post World War II era to the present, a time of unprecedented urbanization in the Tampa Bay region. The purpose of this effort was to quantify wetland gains and losses and to analyze what factors, both natural and anthropogenic, were most responsible for wetland acreage changes over this time period. The quantitative aspect of this effort was critical. Over the last three decades there has been a growing intuitive concern on the part of the regulatory and scientific communities that estuarine habitat acreage in the Tampa Bay region has seriously declined as a result of dredge and fill activities, and general water quality degradation. However, until the recent advent of computerized geographic information systems, quantitative analysis of land cover on a regional scale has been extremely time consuming and costly. As a result, such analyses have generally eluded environmental planners and regulators seeking to address this perceived problem.

The wetland trend analysis which follows was developed using state-of-the-art methods, and represents the only regional data base of its kind in the State of Florida. It is intended that the information generated from this analysis serve as the basis for the development of both environmental policy and law with regard to state and local estuarine management in the Tampa Bay region. Furthermore, it is hoped that these analyses serve as a model approach for planners and regulators striving for the resource management of other estuarine systems in the State of Florida and nationwide.

RELATIONSHIP TO EARLIER WORK

Lewis et al. (1985) were probably the first investigators to attempt a quantitative trend analysis of estuarine wetland habitat in the Tampa Bay region. They examined maps dating back to 1848, as well as aerial photography of Tampa Bay taken by the Soil Conservation Service between 1938 and 1942 (both obtained from the National Archives, Washington, D.C.) to prepare maps of historical seagrass coverage in Tampa Bay. Using planimetric methods, it was estimated that seagrass meadows covered 30,970 ha (76,496 acres) prior to man's major impact on the bay (ca. 1876). Comparing this acreage to the 5,750 ha (14,203 acres) calculated from photointerpreting 1981 color aerial photographs, they estimated that 81% of the original seagrass meadows in Tampa Bay has been eliminated. Figures 15 and 16 show their interpretation of historic and existing seagrass coverage in Tampa Bay. Using similar methods, Lewis (1978) reported that total emergent marine wetlands (tidal marshes and mangrove forests) in Tampa Bay have declined from a historical coverage (ca. 1876) of 10,053 ha (24,831 acres) to a current coverage (ca. 1976) of 5,630 ha (13,906 acres), an approximate loss of 44% of the original areal cover.

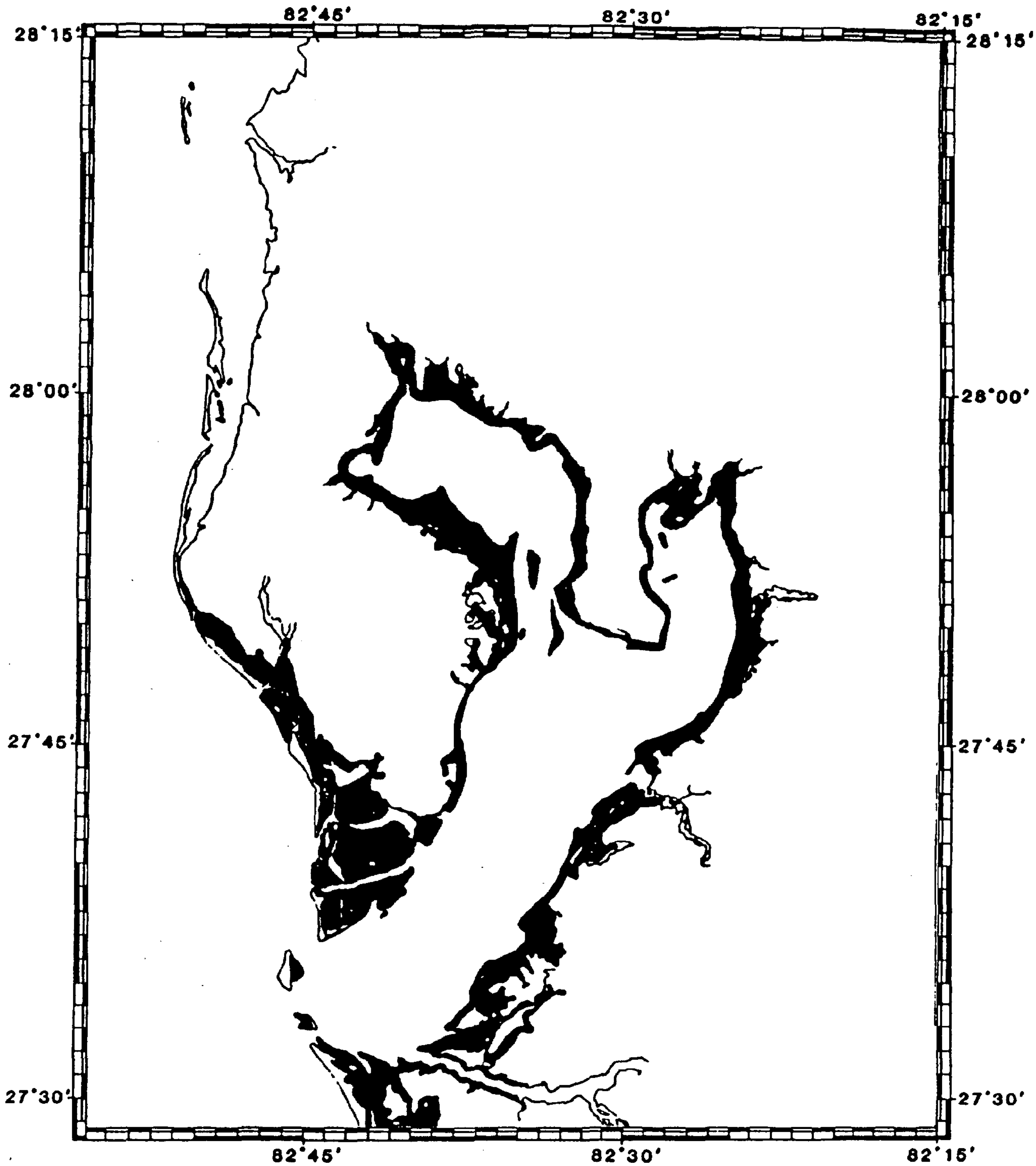


Figure 15 Estimated extent of seagrass meadows in Tampa Bay - 1879 (Lewis et al. 1985)

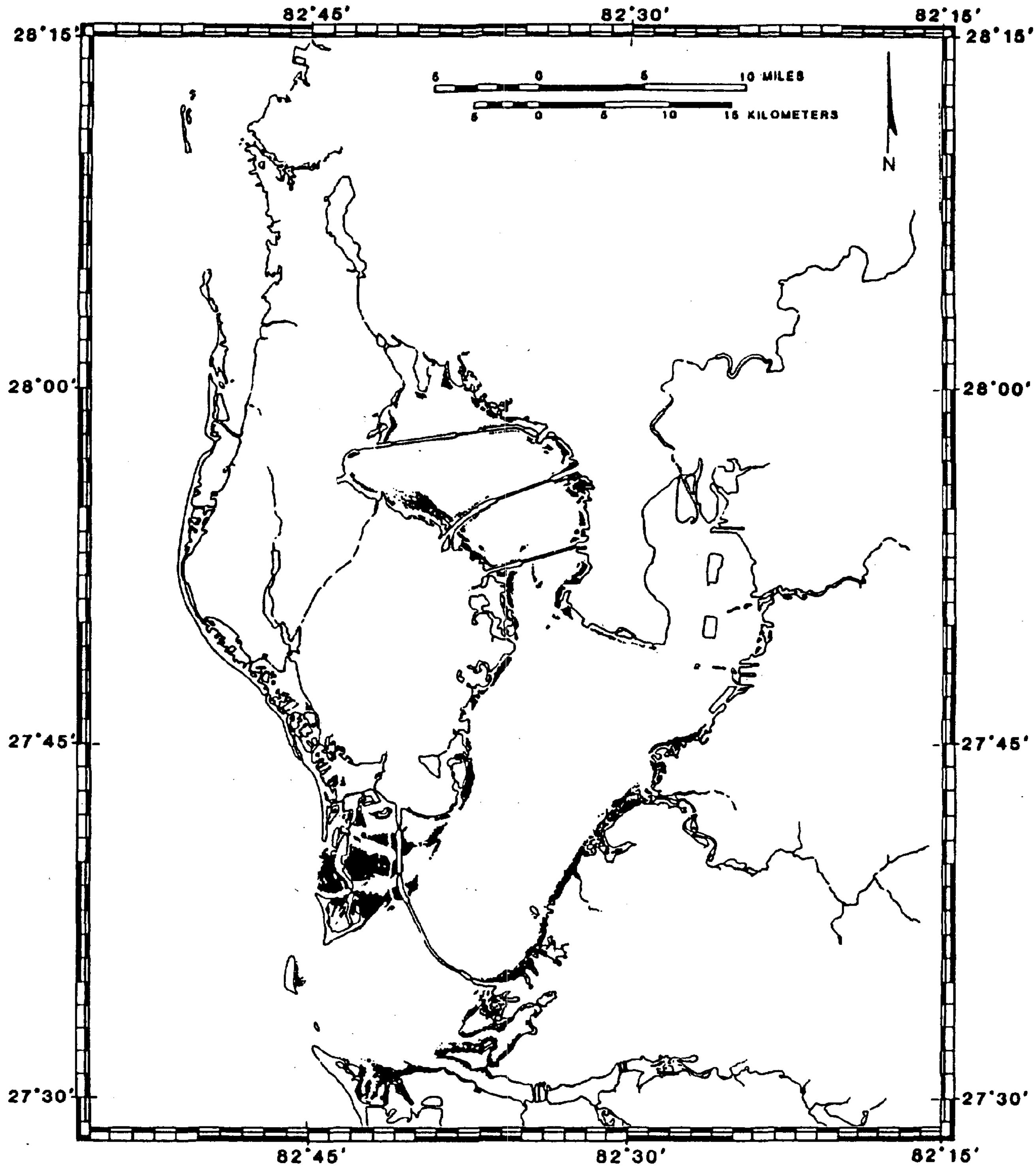


Figure 16 Estimated extent of seagrass meadows in Tampa Bay - 1982 (Lewis et al. 1985)

Lewis (1984) also performed an estuarine wetland trend analysis in Clearwater Harbor using standard photointerpretive and planimetric methods. Results of this analysis indicated that for Clearwater Harbor (Dunedin Causeway to the Narrows), mangrove and tidal marsh coverage has decreased by 50.8% (829.9 acres to 408.5 acres), and seagrass meadows have decreased by 69.7% (3,840.4 acres to 1,163.3 acres) between 1942 and 1984. Figures 17 and 18 show his interpretation of the wetland habitat in 1942, and existing in 1984, respectively in the area covered by the United States Geological Survey (USGS) Clearwater quadrangle. The remaining portion is included in Figure 19 and 20 which compare the same vegetative communities over the same time period for the area covered by the USGS Dunedin quadrangle.

In association with the 1984 Tampa Bay 205(j) Water Quality Impact Study (McClelland, 1984), the Florida Department of Environmental Regulation contracted with Continental Shelf Associates, Inc. (CSA) to perform a trend analysis of Tampa Bay seagrasses over the past two decades. They reported a 14% increase in seagrass cover for middle and lower Tampa Bay in contrast to the earlier works of Lewis et al. (1985). The cause for these discrepancies has been attributed to the use by CSA of aerial photography at too small a scale (1"=80,000') to accurately detect seagrass meadow density during the photointerpretive process. A review of the literature indicates that seagrass and other submerged vascular plants are typically mapped at a scale of 1:24,000 (1"=2000') or larger (Orth and Moore, 1983).

In 1983, the Florida Department of Natural Resources - Marine Research Laboratory (FDNR) in St. Petersburg received a Coastal Management grant to perform a comparative mapping study and trend analysis of estuarine wetland habitat in Charlotte Harbor and Tampa Bay. The FDNR entered into an agreement with the U.S. Fish and Wildlife Services (USFWS) - Coastal Ecosystems Team - in Slidell, Louisiana to map, digitize and analyze estuarine habitat, over three time periods, (1954, 1972 and 1983) for the 21 USGS quadrangles covering the Tampa Bay estuarine system, utilizing the USFWS Map Overlay Statistical System (MOSS). In the fall of 1984, The Tampa Bay Regional Planning Council (TBRPC) received a Coastal Management grant to perform a regional estuarine habitat management study to include trend analyses of the coastal portions of Pasco, Pinellas, Hillsborough and Manatee Counties. Because these efforts were initiated simultaneously, and involved considerable overlap, an agreement was made between FDNR and TBRPC to have an additional five USGS quadrangles digitized and analyzed which covered the remaining areas in the four county region not included in the USFWS work. The methods used, and the products generated, were to be consistent and compatible with those of USFWS so that the net result was a larger, contiguous data base to be made available for use by all involved agencies.

The analyses that follow, therefore, represent the compilation of two separately generated data bases - the original 21 USGS quads digitized by USFWS and the additional 5 quads digitized by NUS Corporation for the TBRPC. These two data bases have been standardized and combined using the most advanced digital methods. The data presented in this document represent the first publication of this extensive work.

Figure 17 Clearwater Quadrangle Estuarine Habitat Map- 1942
(Mangrove Systems, Inc., 1984)

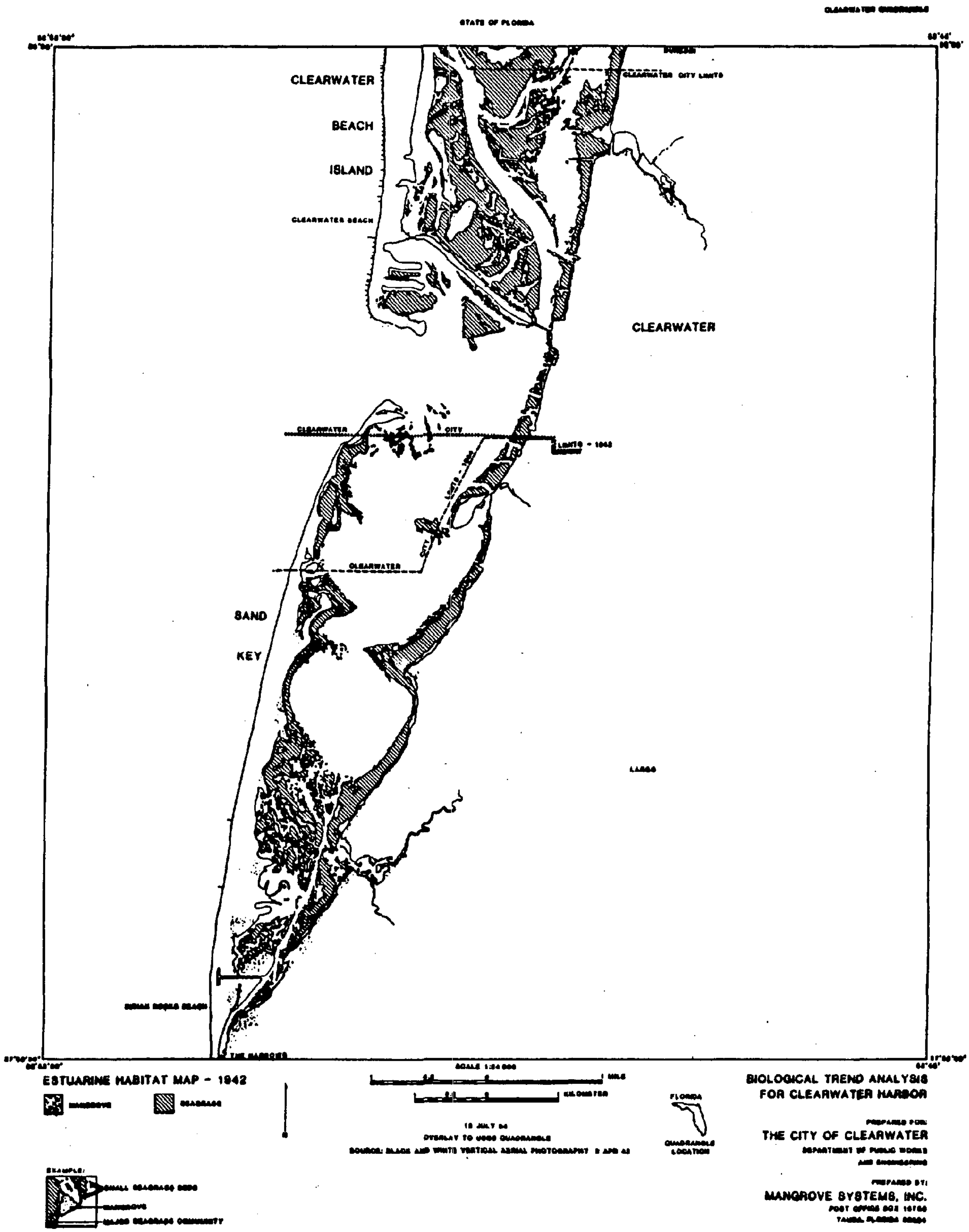


Figure 18 Clearwater Quadrangle Estuarine Habitat Map- 1984
(Mangrove Systems, Inc., 1984)

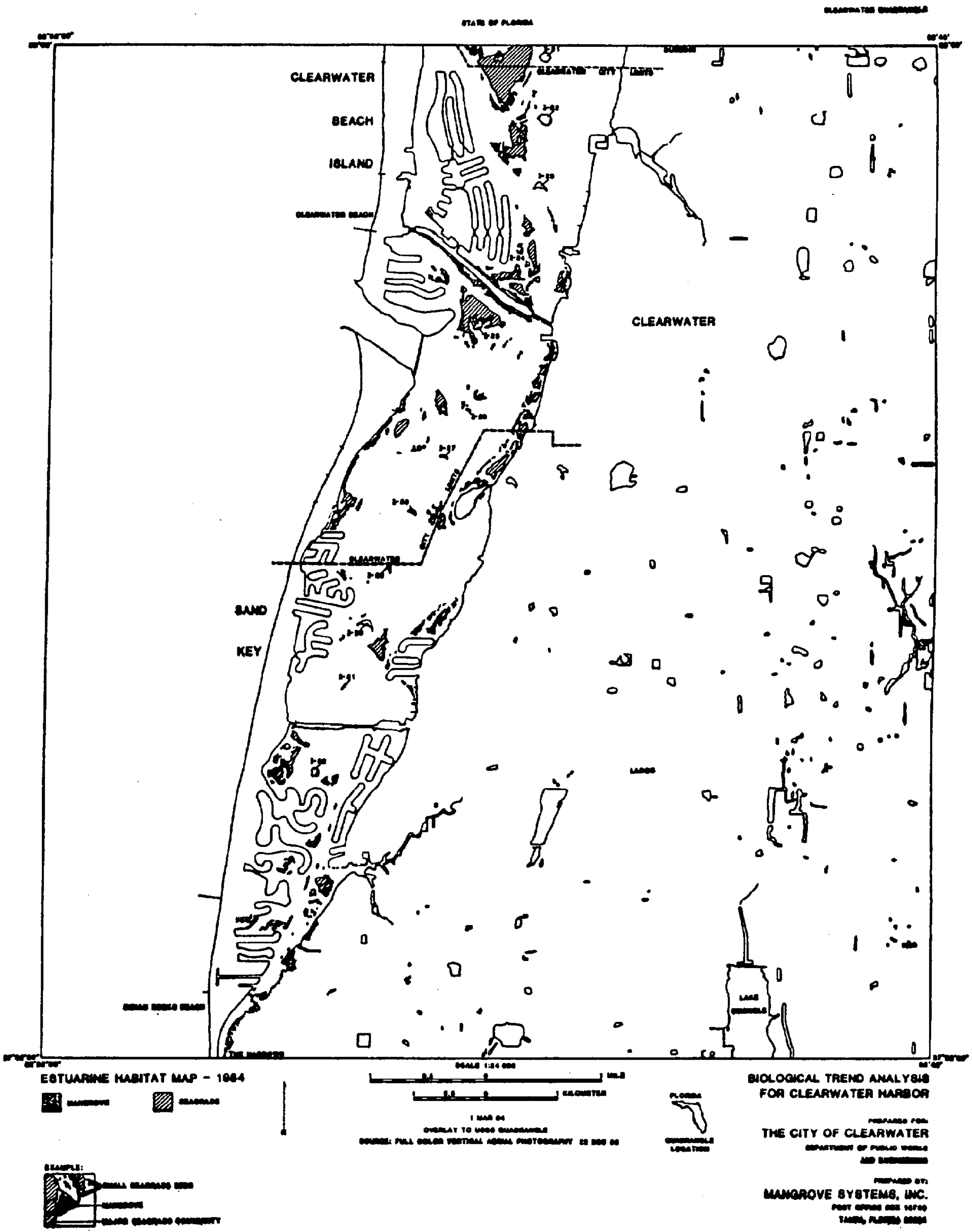


Figure 19 Dunedine Quadrangle Estuarine Habitat Map- 1942
(Mangrove Systems, Inc., 1984)

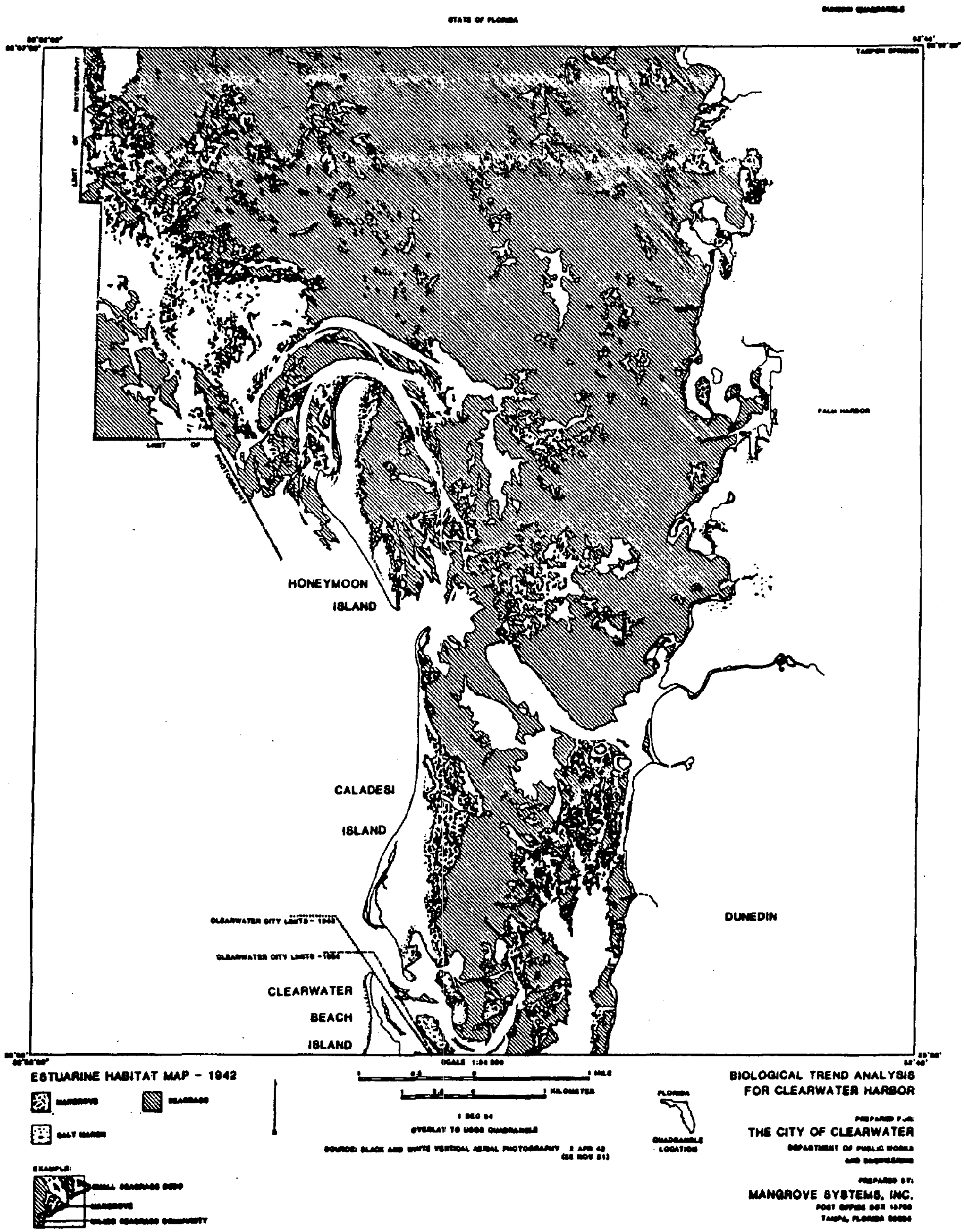
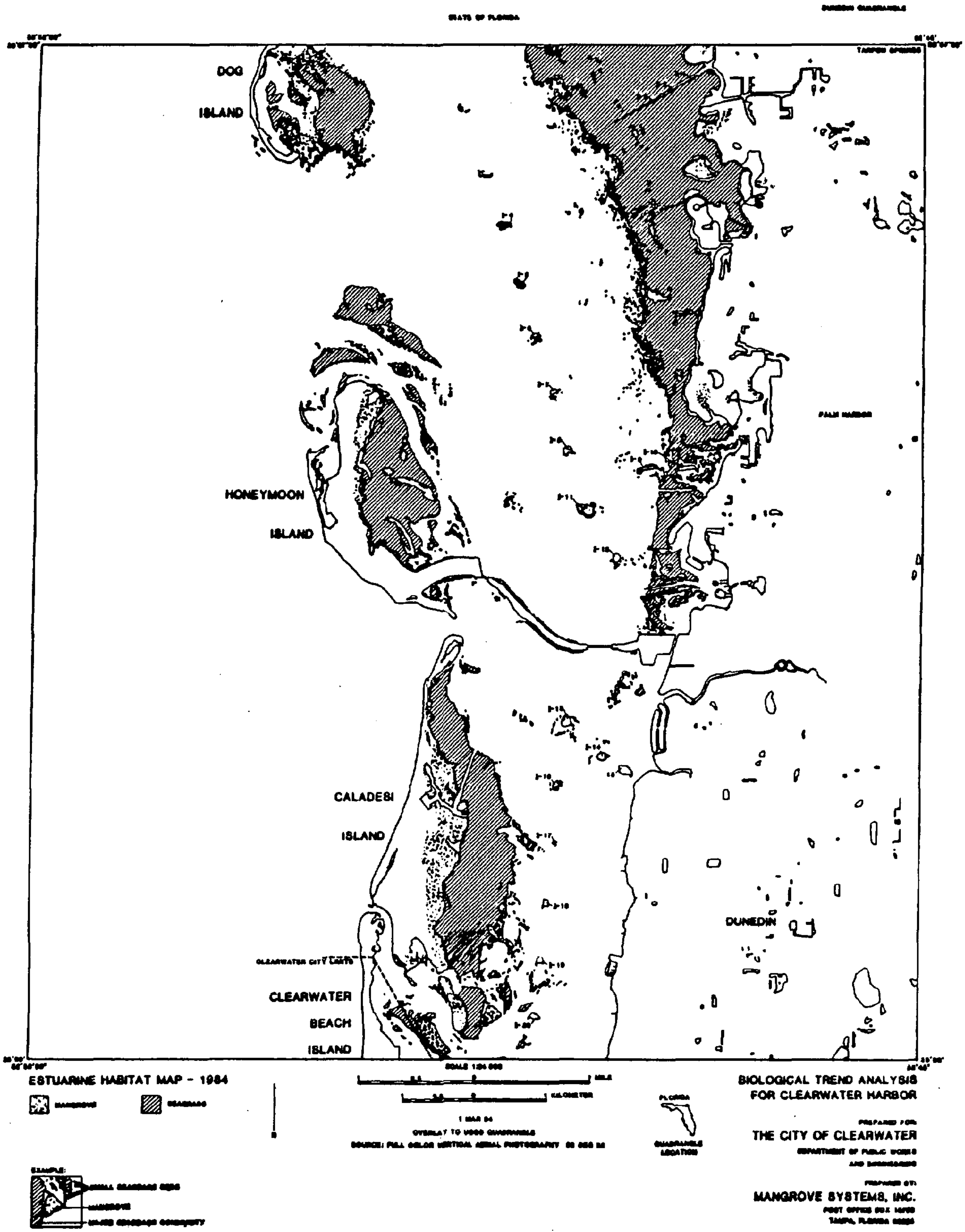


Figure 20 Dunedine Quadrangle Estuarine Habitat Map- 1984
(Mangrove Systems, Inc., 1984)



Methods

Mangrove Systems, Inc. (MSI) was subcontracted to photointerpret, groundtruth and map estuarine wetland habitat (including seagrasses, mangrove forests and tidal marshes) and other general land use cover classifications for the areas covered in five USGS quadrangles including: Aripeka, Port Richey, Tarpon Springs, Dunedin and Bradenton Beach. For each of the five quads 1=24,000 scale black and white aerial photography, taken at two reference time periods (1957-58 and 1982), was used for photointerpretation. Upon completion, a total of ten maps were sent to the NUS Corporation for digital analysis.

NUS Corporation, Inc. began by digitizing the five quadrangles of coastal and estuarine wetlands not included in the USFWS data base but which were required for the study. Mylar overlays of two time frames (1957-58 and 1982) for each quad were digitized, initially into approximately 150 land use classes developed by the USFWS, representing the total number of different classes identified on the maps. These classes were aggregated and digitized into 13 classes. These classes were suggested by USFWS personnel and approved by the Tampa Bay Regional Planning Council staff. They included the following:

1. Marine Open Water - The marine open water class consists of marine subtidal unconsolidated bottom and open water subclasses. The primary USFWS designations for this class are MIOW and MIUB.

2. Estuarine Open Water - This class consists of estuarine subtidal, unconsolidated bottom and open water subclasses, including estuarine water in dredge areas. USFWS designations included in this class are EIOW and EIUB.

3. Beaches, Flats and Bars - This class consists of all USFWS marine and estuarine unconsolidated shore, beach/bar, and flat, classes. River, lake and palustrine deposits are classified under fresh open water.

4. Dredged Spoil Area - Dredged spoil areas represent disposal areas for spoil from channel dredging. These areas were designated by the USFWS by the special modified "s". Only marine and estuarine systems with this modifier are included in this class.

5. Marine Aquatic Vegetation - The marine aquatic vegetation class is comprised of subtidal and intertidal algal and vascular aquatic beds. The USFWS designations are MIAB and M2AB, with appropriate subclass designations.

6. Estuarine Vascular Aquatic Vegetation (Seagrass) - This class represents areas of estuarine vascular (seagrass vegetation. Primary USFWS designations include EIAB and E2AB.

7. Mangrove - The mangrove class includes all estuarine scrub/shrub and forest designations (E2FO and E2SS). Species other than mangroves are included in this class.

8. Estuarine Emergent (salt marsh) - This class represents estuarine salt marsh vegetation including all USFWS subclasses. E2EM is the USFWS designation.

9. Fresh Open Water - All palustrine, lacustrine and riverine fresh water is included in this class. Unconsolidated shore deposits and aquatic bed vegetation in the areas above are also included.

10. Palustrine Emergent Vegetation - This class represents all types of upland emergent vegetation. The primary USFWS designation is PEM.

11. Palustrine Forested Wetland - Upland deciduous, evergreen forest and scrub-shrub vegetation is included in this class. PFO and PSS are the primary USFWS designations.

12. Upland Developed - This class represents upland areas with substantial urban characteristics. No information concerning population density should be inferred.

13. Other Upland Classes - Other upland classes include agriculture, range, forest, barren, and spoil land cover classes. This class is the most generic of the 13 classes.

The mylar overlays prepared by Mangrove Systems Inc. presented two related problems in the analysis: most overlays were not completely classified, and there were boundary inconsistencies in delineating the unclassified areas between 1957 and 1982. In order to provide some consistency and accuracy, arbitrary boundaries were chosen and digitized, defining areas of unknown data. No identified estuarine classes were eliminated in this process. The data was georeferenced to the Universal Transverse Mercator (UTM) grid to provide spatial control. A 20 meter square grid cell format was used.

Data received from the USFWS was in two halves. The northern half consisted of the following quads: Oldsmar, Citrus Park, Clearwater, Safety Harbor, Gandy Bridge, Tampa, Brandon, Seminole, St. Petersburg, Port Tampa, Gibsonton and Riverview. The southern half consisted of Pass-A-Grille Beach, Cockroach Bay, Ruskin, Egmont Key, Anna Maria, Palmetto, Parrish, Bradenton and Lorraine quads. Both of these data sets were georeferenced to the UTM grid and used a 30 x 30 meter grid cell size. Classification of these quads for the initial time frame was based on aerial photography dated between 1948 and 1956. The classification of the later time frame was based on 1982 aerial photography for all quads. Land cover classification of this data set identified between 208 and 313 classes, depending on the file.

Aggregation of this large number of classes into the previously developed 13 was made more difficult by the lack of tabular information defining the actual classes present in the northern half. The recode of the northern half data was accomplished using information from the southern half recode, USFWS 1:250,000 National Wetlands Reconnaissance Survey maps, 1982 Wetlands Inventory for the Oldsmar quadrangle, the 1957 classification of the Citrus Park quadrangle and professional judgment. The majority of the recode values are correct; however, small errors in acreage amounts may occur in determining the limits of the beaches, flats, and bars, palustrine open water, and palustrine forest categories.

The next step in the process was to merge the data prepared by NUS Corporation with the USFWS data. This was accomplished on the computer using UTM coordinates to ensure a precise and accurate fit. NUS Corporation generated data was rectified into a 30 meter square grid cell format to match the USFWS format. In order to improve spatial understanding and graphics quality, two data bases were created: an area within two quadrangles of Tampa Bay, and an adjacent area north of the bay. The North Tampa area included the Aripeka, Port Richey, and Tarpon Springs quadrangles. Statistical programs were then run on the computer to determine acreage totals for each class in the two data bases. This provides an inventory of land cover/vegetation types for the area in both 1957 and 1982. Four matrix analyses were performed using these inventories to identify general wetland/land cover changes over time and to focus on the three wetland types of particular concern: seagrass, mangrove and salt marsh. This process was taken a step further to determine what land cover type critical wetlands were lost to and to determine what land cover type new wetlands were created from. Identical statistical analyses were performed individually on the five quads prepared by NUS Corporation.

The analyses performed by NUS Corporation produced highly precise estimates of wetland trends. However, their accuracy is limited somewhat by the potential misclassification of data received as input to the process and by the previously mentioned difficulty in aggregating and recoding the north USFWS data. The aggregation process may also affect the accuracy of urban and mangrove classifications. The urban class does not indicate any density level and may be overstated due to the inclusion of all estuarine woody vegetation in the class. "Possible new wetland" classes created by this analysis resulted from the inconsistent boundaries for unclassified areas previously mentioned. Little reliability should be placed in the acreages reported for the "possible new" classes.

Results

The results of the 1957 and 1982 wetland inventories, as well as the net areal gains and losses over that time period, are summarized for the Tampa Bay and North Tampa study areas in Tables 1 and 2, respectively. Because the focus of this study is on areal trends in estuarine vegetative communities, results presented for the estuarine vascular aquatic (seagrass), mangrove, and estuarine emergent (salt marsh) classes are shown in bold print. The respective inventories and trend analyses for the Tampa Bay and North Tampa study areas are graphically depicted in Figure 21 through 26.

In the Tampa Bay study area (Table 1), the results of these analyses indicate that, over the 25 year study period, seagrasses have declined by 47.37 percent (a loss of 28,116.63 acres), mangrove forests have declined by 4.24 percent (a loss of 8.82.25 acres), and salt marshes have declined by 56.02 percent (a loss of 4,427.94 acres). Although the declines of estuarine wetland habitat in the North Tampa study area have not been as severe, they have, nevertheless, been quite extensive. As shown in Table 2, seagrasses have declined by 32.54 percent (7,321 acres), mangrove forests have declined by 15.90 percent (214.61 acres) and salt marshes have declined by 10.30 percent (606.48 acres).

Table 1. Tampa Bay area habitat gains and losses.

	1957 Inventory		1982 Inventory		Gains/Losses	
Habitat Type	Acres	% Total	Acres	% Total	Acres	% Change
Marine Open Water	199757.81	18.94	201289.02	19.08	+1531.21	0.77
Estuarine Open Water	212067.52	20.11	226722.86	21.49	+14655.34	6.91
Beaches, Flats and Bars	17712.41	1.68	23002.81	2.18	+5290.40	29.87
Dredged Spoil Area	120.54	0.01	253.09	0.02	+132.55	109.96
Marine Aquatic	1305.03	0.12	75.62	0.01	-1229.41	94.20
Estuarine Vascular Aquatic	**59356.83**	**5.63**	**31240.20**	**2.96**	**-28116.63**	**47.37**
Mangrove	**20826.65**	**1.97**	**19944.40**	**1.89**	**-882.25**	**4.24**
Estuarine Emergent	**7903.57**	**0.75**	**3475.63**	**0.33**	**-4427.94**	**56.02**
Fresh Open Water	6166.64	0.58	14596.18	1.38	+8429.54	136.70
Palustrine Emergent	18945.17	1.80	8288.98	0.79	-10656.19	56.25
Palustrine Forested Wetland	30115.76	2.86	29008.22	2.75	-1107.54	3.68
Upland Developed	79992.66	7.58	251498.62	23.84	+171505.96	214.40
Other Upland Classes	388220.72	36.81	228063.47	21.63	-160157.25	41.25
Unknown Data	12263.01	1.16	17370.15	1.65	+5107.14	41.65
Totals	1054754.30	100.00	1054829.30	100.00	-	-

Table 2. North Tampa area habitat gains and losses.

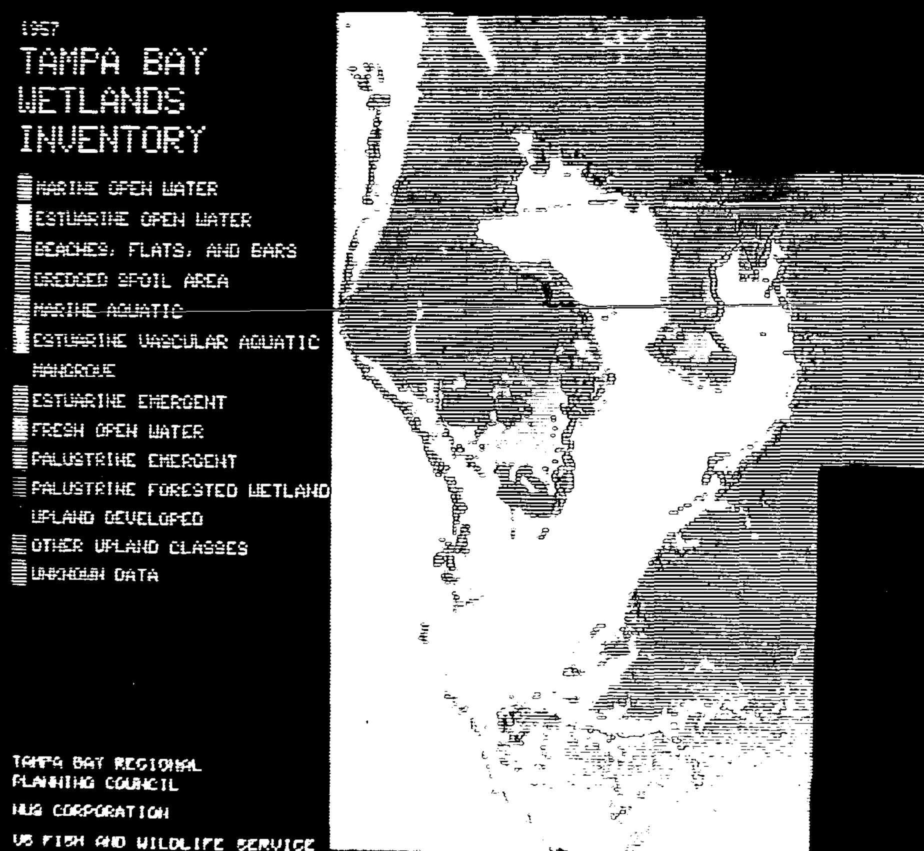
	1957 Inventory		1982 Inventory		Gains/Losses	
Habitat Type	Acres	% Total	Acres	% Total	Acres	% Change
Marine Open Water	28170.23	22.37	26962.61	21.41	-1207.62	4.29
Estuarine Open Water	2656.32	2.11	10982.67	8.72	+8326.35	313.45
Beaches, Flats and Bars	5617.77	4.46	4740.19	3.76	-877.58	15.62
Dredged Spoil Area	175.25	0.14	77.39	0.06	-97.86	55.84
Marine Aquatic	5791.24	4.60	6964.83	5.53	+1173.59*	20.26
Estuarine Vascular Aquatic	**22500.42**	**17.86**	**15178.87**	**12.05**	**-7321.55**	**32.54**
Mangrove	**1349.95**	**1.07**	**1135.34**	**0.90**	**-214.61**	**15.90**
Estuarine Emergent	**5887.31**	**4.67**	**5280.83**	**4.19**	**-606.48**	**10.30**
Fresh Open Water	32.92	0.03	147.23	0.12	+114.31	347.24
Palustrine Emergent	151.68	0.12	48.93	0.04	-102.75	67.74
Palustrine Forested Wetland	521.97	0.41	471.93	0.37	-50.04	9.59
Upland Developed	232.85	0.18	4276.49	3.40	+4043.64	1736.59
Other Upland Classes	7061.57	5.61	4301.62	3.42	-2759.95	39.08
Unknown Data	45798.58	36.37	45378.25	36.03	-420.33	0.91
Totals	125948.06	100.00	125947.18	100.00	-	-

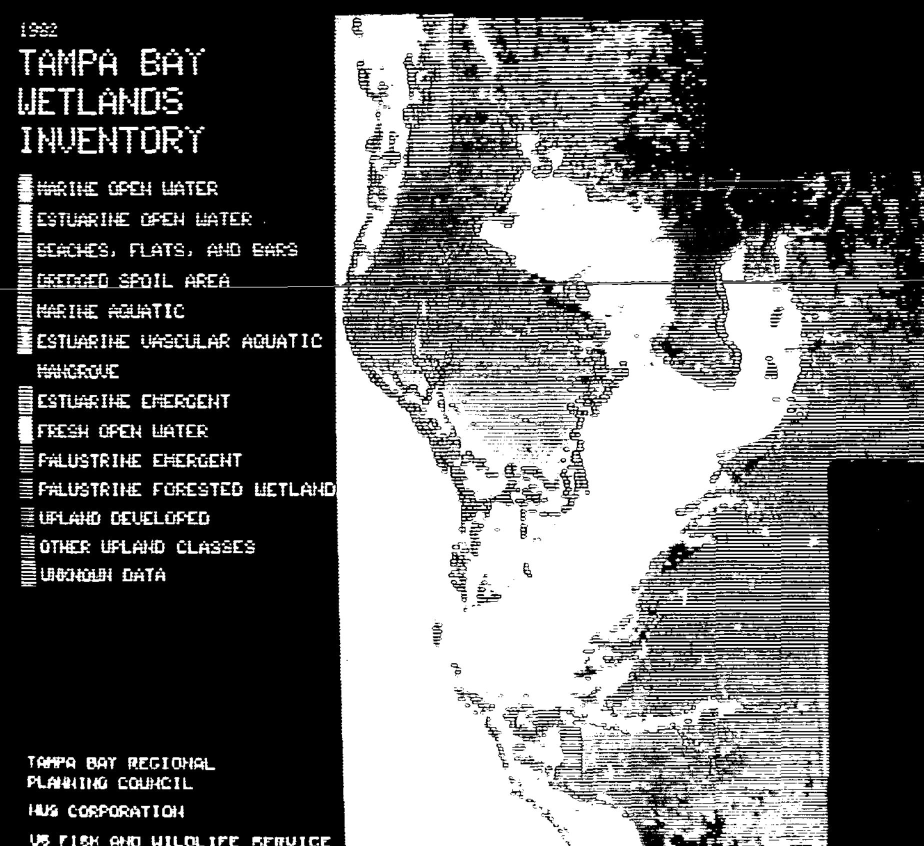
* Possible erred data

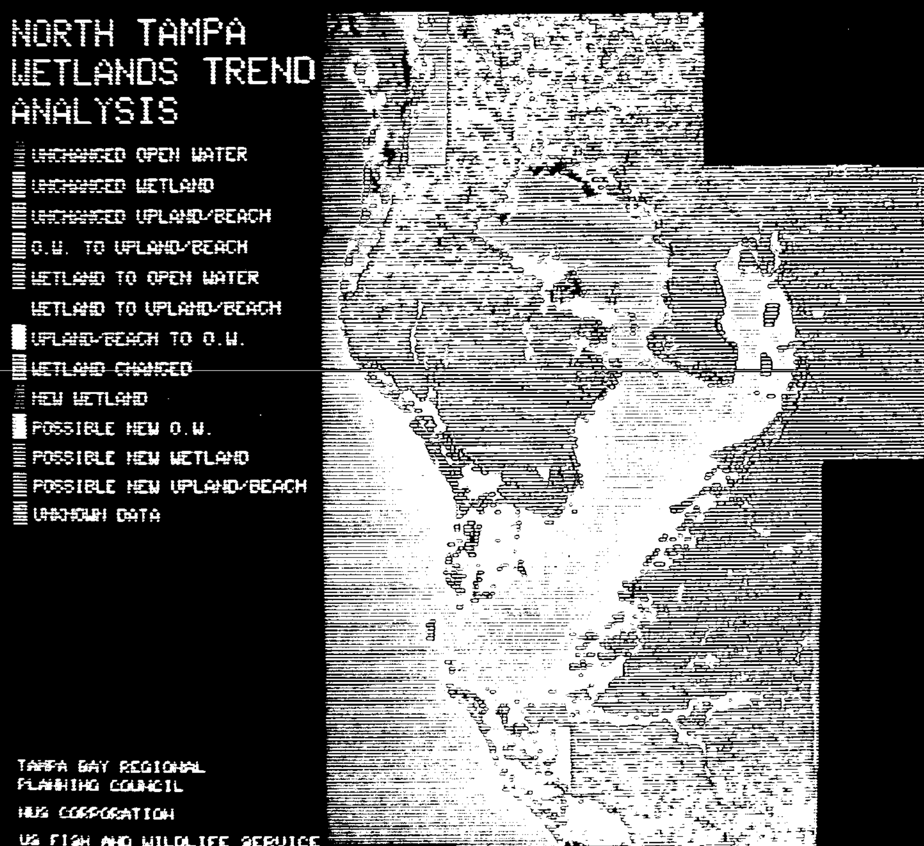
The results of more detailed trend analyses, however, demonstrate that the calculated losses in the three major habitat types represent the net result of a dynamic interaction between both natural and anthropogenic factors, rather than a simple areal decline in habitat over time. For example, Table 3 indicates that, in the Tampa Bay study area, 59.39 percent of the 59,386.83 acres of seagrasses occurring in 1957 were lost, while 40.61 percent remained unchanged. The results also indicate that 7,132.96 acres (12.02 percent) of new seagrass have developed over the time period under study, yielding the net calculated seagrass loss of 47.37 percent.

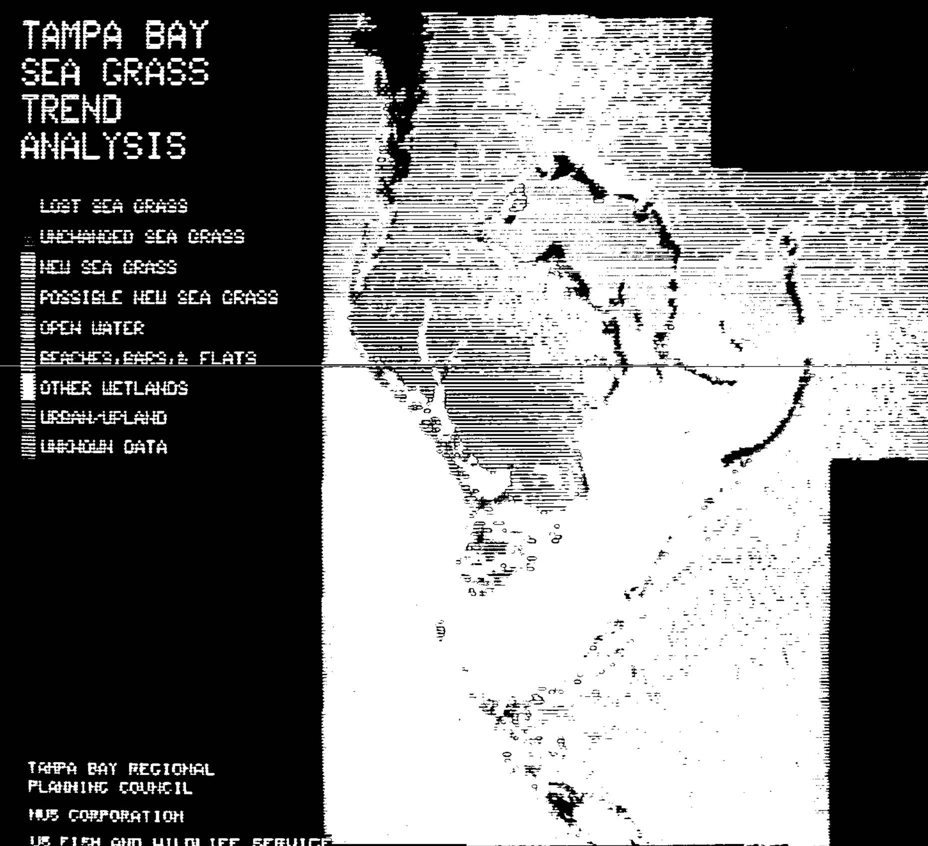
The results of further analyses presented in Tables 4 and 5 enumerate those classes that seagrass was lost to, and developed from, respectively. As shown in Table 4, the overwhelming majority of the seagrass existing in 1957 was converted to estuarine open water (52.93 percent), or to denuded beaches, flats, and bars (29.38 percent). Approximately 12.14 percent of the pre-existing seagrass was converted to upland classes. A small percentage (2.94 percent) has succeeded into mangrove forest. Table 5 indicates that of the 7,132.96 acres of new seagrass growth, 34.52 and 50.53 percent has developed from estuarine open water, and beaches, flats and bars, respectively. Another 6.51 percent has developed from areas previously vegetated by mangroves, while 5.51 percent has developed from areas previously vegetated by salt marsh grasses. As shown in Figure 23, the majority of seagrasses lost over the study time period occurred in St. Joseph's Sound, Boca Ciega Bay, and the Apollo Beach area. Concentrations of new seagrass growth occurred primarily in Palma Sola Bay, the gateway tract in Pinellas County, and near Coopers Point. The majority of unchanged seagrass occurred in the Mullet Key area.

The results of the mangrove trend analyses for the Tampa Bay study area are summarized in Tables 6, 7 and 8. As shown in Table 6, 39.78 percent of the 20,826.65 acres of mangrove forest present in 1957 were lost or replaced by 1982. However, over the same time period 7,363.59 acres (35.36 percent) of new mangrove growth occurred resulting in a net loss of only 4.24 percent. Approximately 12,542.34 acres (60.22 percent) remained unchanged over the study period. Of the 8,284.09 acres of mangroves that were lost (Table 7) the overwhelming majority (62.71 percent) was converted to upland classes, while 15.66 percent was converted to estuarine open water. Another 6.85 and 6.26 percent were converted to beaches, flats and bars, and salt marsh, respectively. As shown in Table 8, new mangrove growth has developed from a number of pre-existing habitat types. Approximately 31.30 percent of the 7,363.59 acres of new mangrove has developed from previously undeveloped uplands. Significant natural succession of mangrove forests from other intertidal habitats is also indicated. Approximately 21.69 percent of the new mangrove growth has succeeded from salt marsh, while 19.99 and 14.07 percent has succeeded from beaches, flats and bars, and seagrass, respectively. Another 7.93 percent has developed from estuarine open water. As shown in Figure 23, the majority of the mangrove loss occurred in Boca Ciega Bay and the Apollo Beach area, while most of the new mangrove growth occurred along the gateway tract, the southern shore of MacDill Air Force Base and in Cockroach Bay. The highest concentrations of unchanged mangroves occurred near the Bower tract in Hillsborough County and the Gateway tract in Pinellas County.


1957
TAMPA BAY
WETLANDS
INVENTORY
MARINE OPEN WATER
ESTUARINE OPEN WATER
BEACHES, FLATS, AND BARS
DREDGED SPOIL AREA
MARINE AQUATIC
ESTUARINE VASCULAR AQUATIC
MANGROVE
ESTUARINE EMERGENT
FRESH OPEN WATER
PALUSTRINE EMERGENT
PALUSTRINE FORESTED WETLAND
UPLAND DEVELOPED
OTHER UPLAND CLASSES
UNKNOWN DATA
TAMPA BAY REGIONAL
PLANNING COUNCIL
HUS CORPORATION
US FISH AND WILDLIFE SERVICE


1982
TAMPA BAY
WETLANDS
INVENTORY
MARINE OPEN WATER
ESTUARINE OPEN WATER
BEACHES, FLATS, AND BARS
DREDGED SPOIL AREA
MARINE AQUATIC
ESTUARINE VASCULAR AQUATIC
MANGROVE
ESTUARINE EMERGENT
FRESH OPEN WATER
PALUSTRINE EMERGENT
PALUSTRINE FORESTED WETLAND
UPLAND DEVELOPED
OTHER UPLAND CLASSES
UNKNOWN DATA
TAMPA BAY REGIONAL
PLANNING COUNCIL
HUS CORPORATION
US FISH AND WILDLIFE SERVICE


NORTH TAMPA
WETLANDS TREND
ANALYSIS
UNCHANGED OPEN WATER
UNCHANGED WETLAND
UNCHANGED UPLAND/BEACH
O.W. TO UPLAND/BEACH
WETLAND TO OPEN WATER
WETLAND TO UPLAND/BEACH
UPLAND/BEACH TO O.W.
WETLAND CHANGED
NEW WETLAND
POSSIBLE NEW O.W.
POSSIBLE NEW WETLAND
POSSIBLE NEW UPLAND/BEACH
UNKNOWN DATA
TAMPA BAY REGIONAL
PLANNING COUNCIL
NUS CORPORATION
US FISH AND WILDLIFE SERVICE


TAMPA BAY
SEA GRASS
TREND
ANALYSIS
LOST SEA GRASS
UNCHANGED SEA GRASS
NEW SEA GRASS
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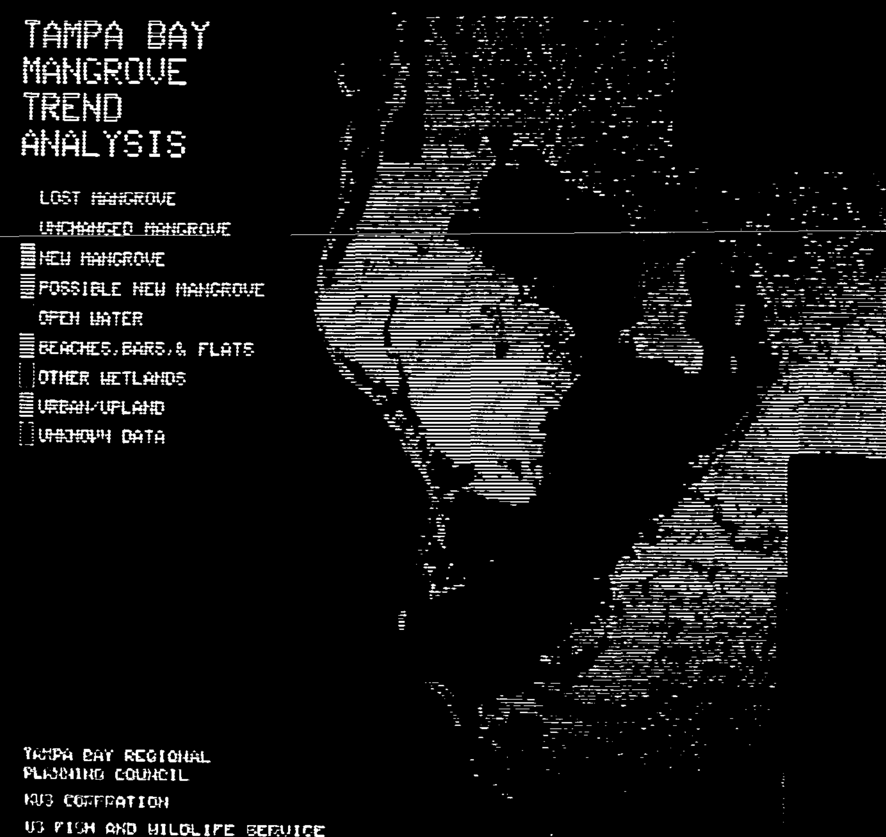
OPEN WATER
BEACHES,BARS,& FLATS
OTHER WETLANDS
URBAN-UPLAND
UNKNOWN DATA
TAMPA BAY REGIONAL
PLANNING COUNCIL
NUS CORPORATION
US FISH AND WILDLIFE SERVICE


TAMPA BAY
SALT MARSH
TREND
ANALYSIS
LOST SALT MARSH
UNCHANGED SALT MARSH
NEW SALT MARSH
POSSIBLE NEW SALT MARSH
OPEN WATER
BEACHES, BARS, & FLATS
OTHER WETLANDS
URBAN/UPLAND
UNKNOWN DATA
TAMPA BAY REGIONAL
PLANNING COUNCIL
NUS CORPORATION
US FISH AND WILDLIFE SERVICE


TAMPA BAY
MANGROVE
TREND
ANALYSIS
LOST MANGROVE
UNCHANGED MANGROVE
NEW MANGROVE
POSSIBLE NEW MANGROVE
OPEN WATER
BEACHES, BARS, & FLATS
OTHER WETLANDS
URBAN/UPLAND
UNKNOWN DATA
TAMPA BAY REGIONAL
PLANNING COUNCIL
NUS CORPORATION
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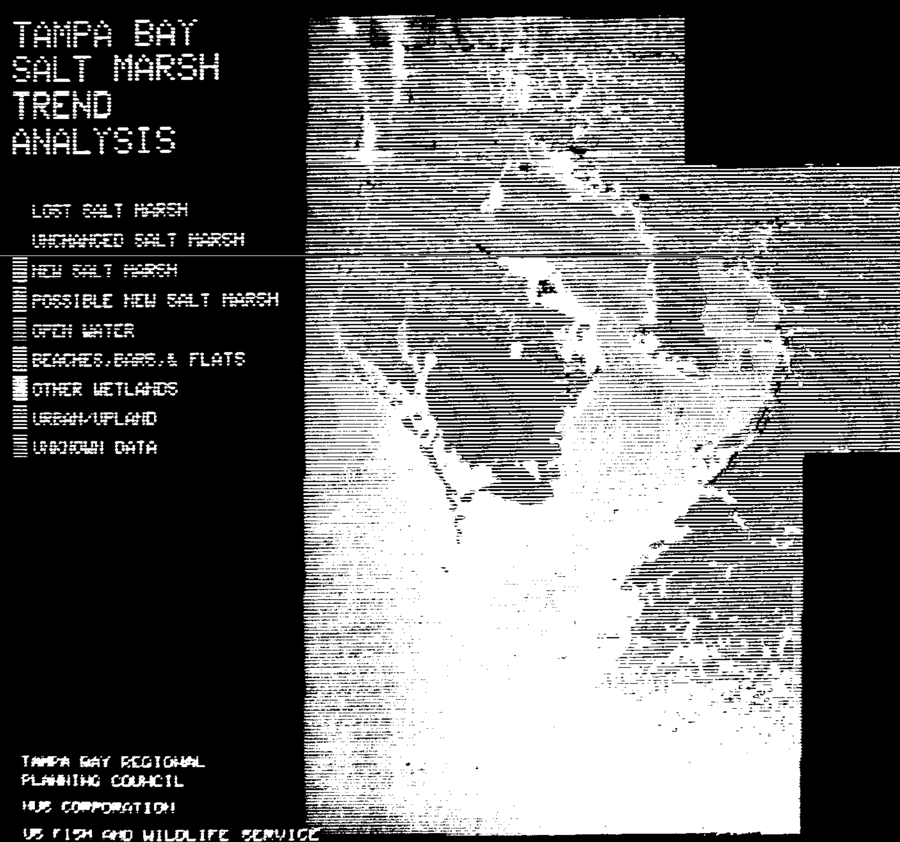
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SALT MARSH
TREND
ANALYSIS
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OPEN WATER
BEACHES, BARS, & FLATS
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URBAN/UPLAND
UNKNOWN DATA
TAMPA BAY REGIONAL
PLANNING COUNCIL
HUS CORPORATION
US FISH AND WILDLIFE SERVICE

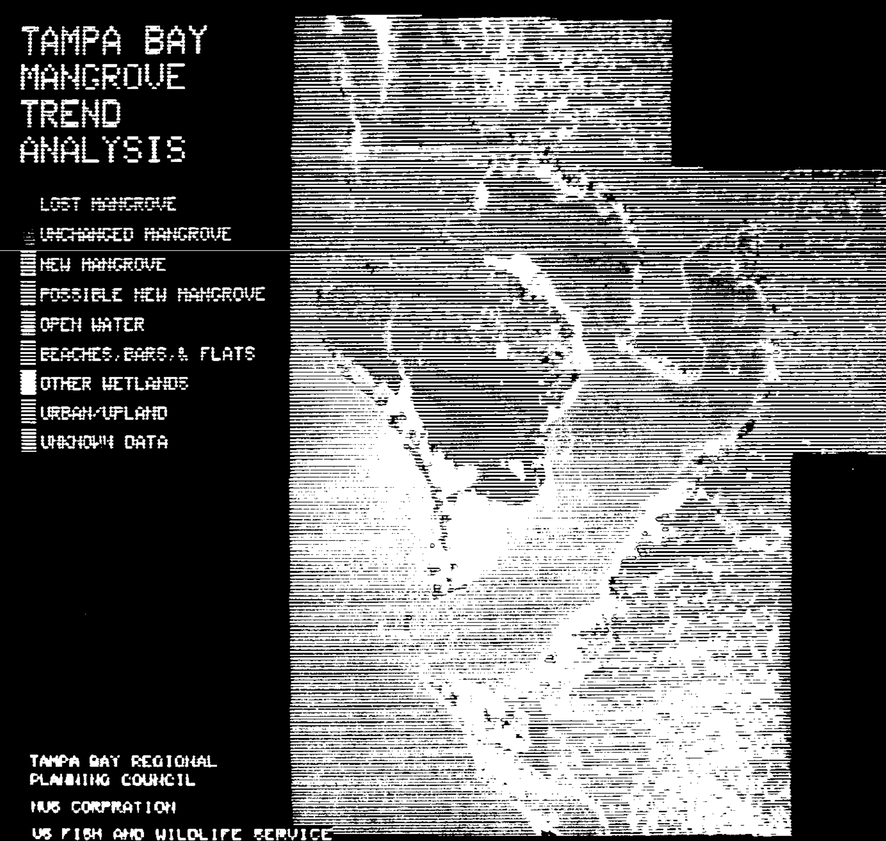

TAMPA BAY
MANGROVE
TREND
ANALYSIS
LOST MANGROVE
UNCHANGED MANGROVE
NEW MANGROVE
POSSIBLE NEW MANGROVE
OPEN WATER
BEACHES, BARS, & FLATS
OTHER WETLANDS
URBAN/UPLAND
UNKNOWN DATA
TAMPA BAY REGIONAL
PLANNING COUNCIL
HUS CORPRATION
US FISH AND WILDLIFE SERVICE

Figure 21 Tampa Bay Wetlands Inventory - 1957

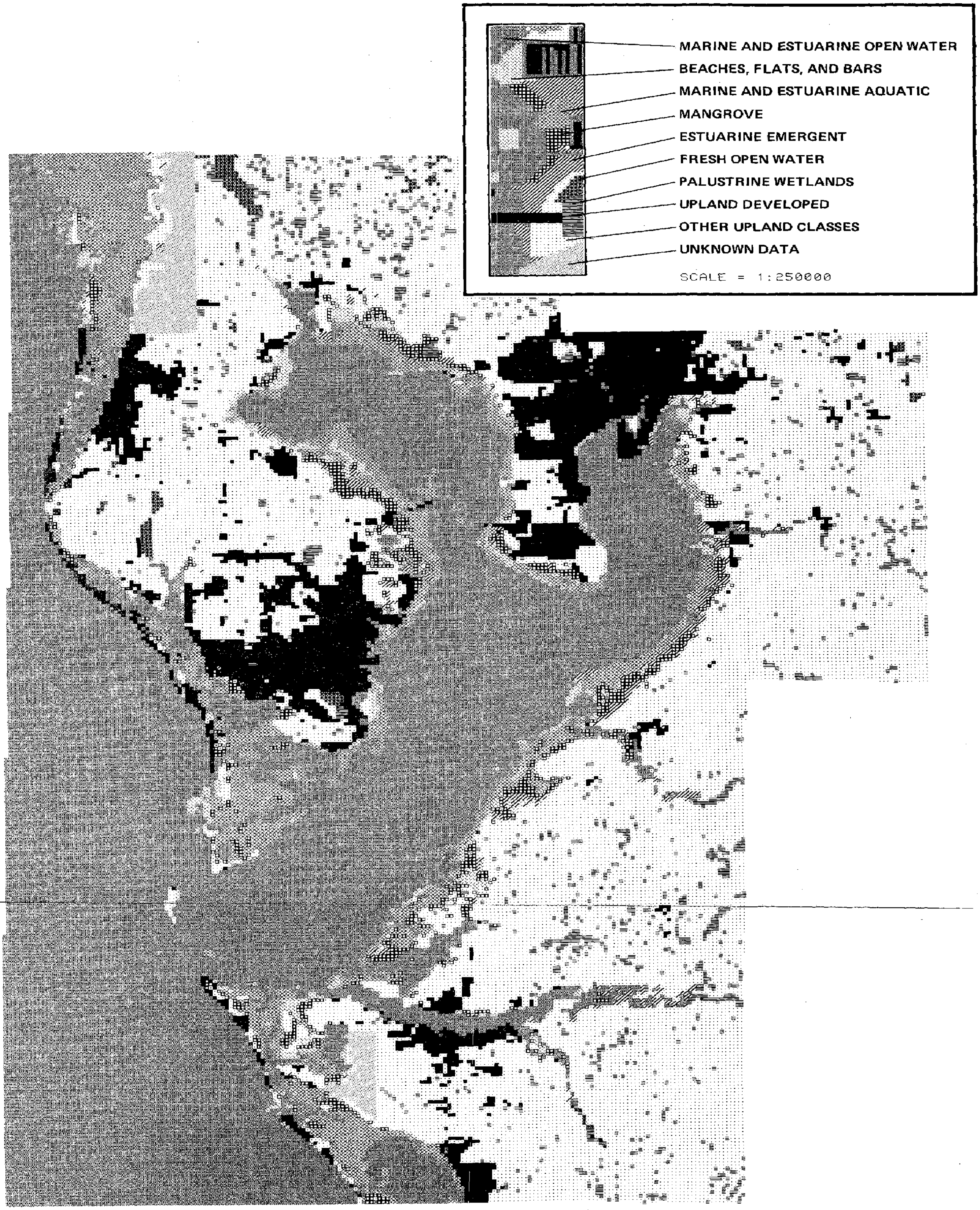


Figure 22 Tampa Bay Wetlands Inventory - 1982

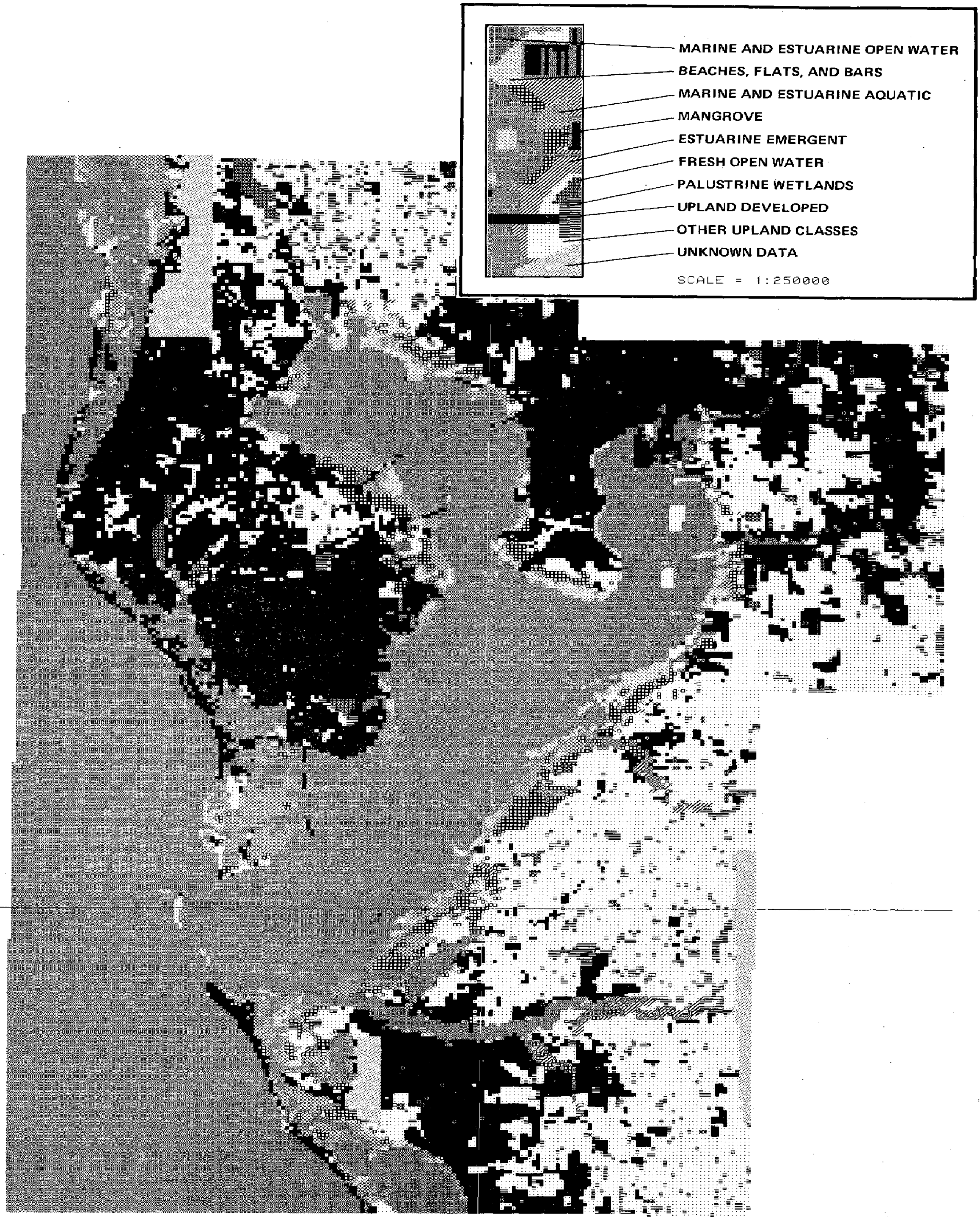


Figure 23 Tampa Bay Wetlands Trend Analysis

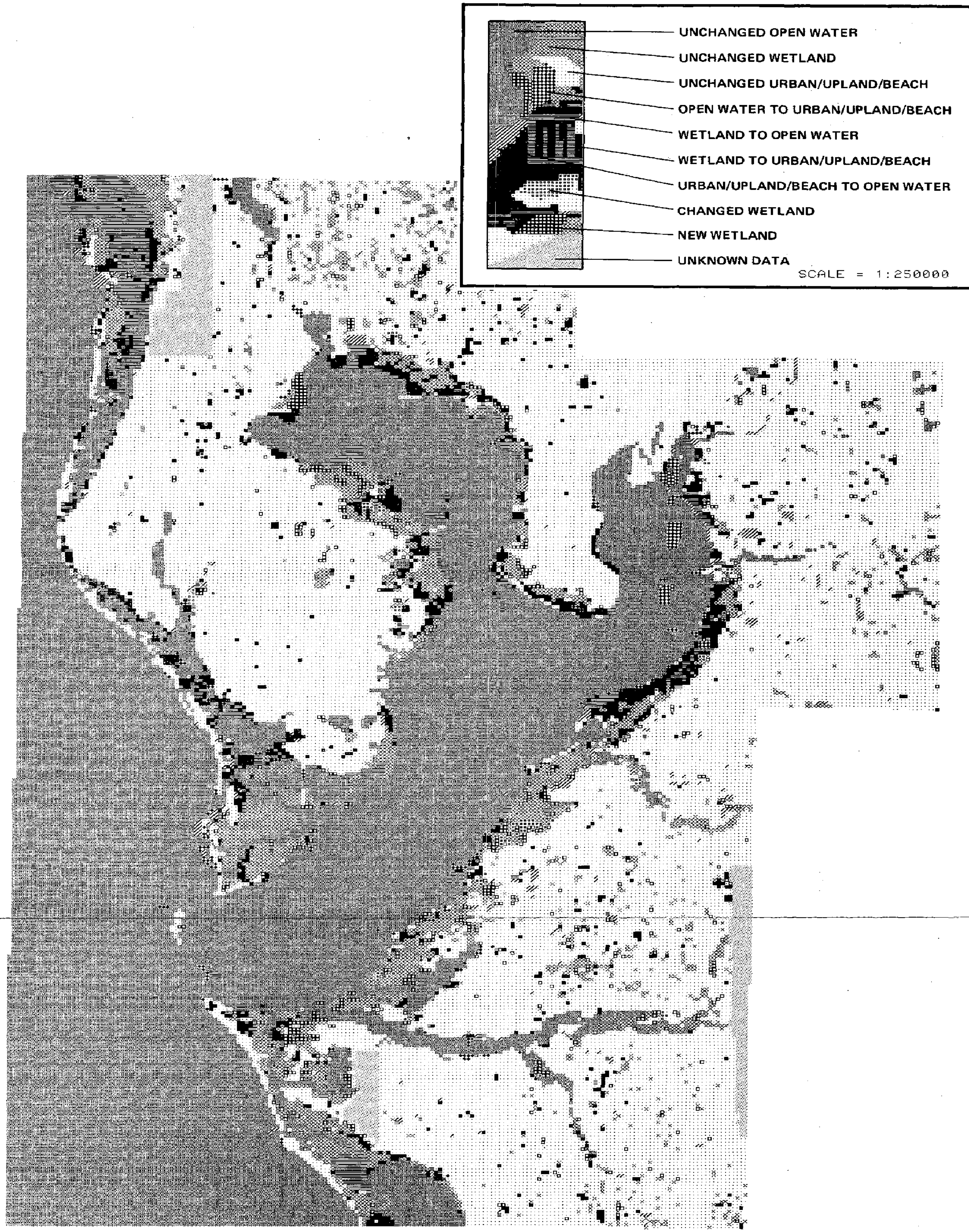


Figure 24 North Tampa Wetlands Inventory - 1957

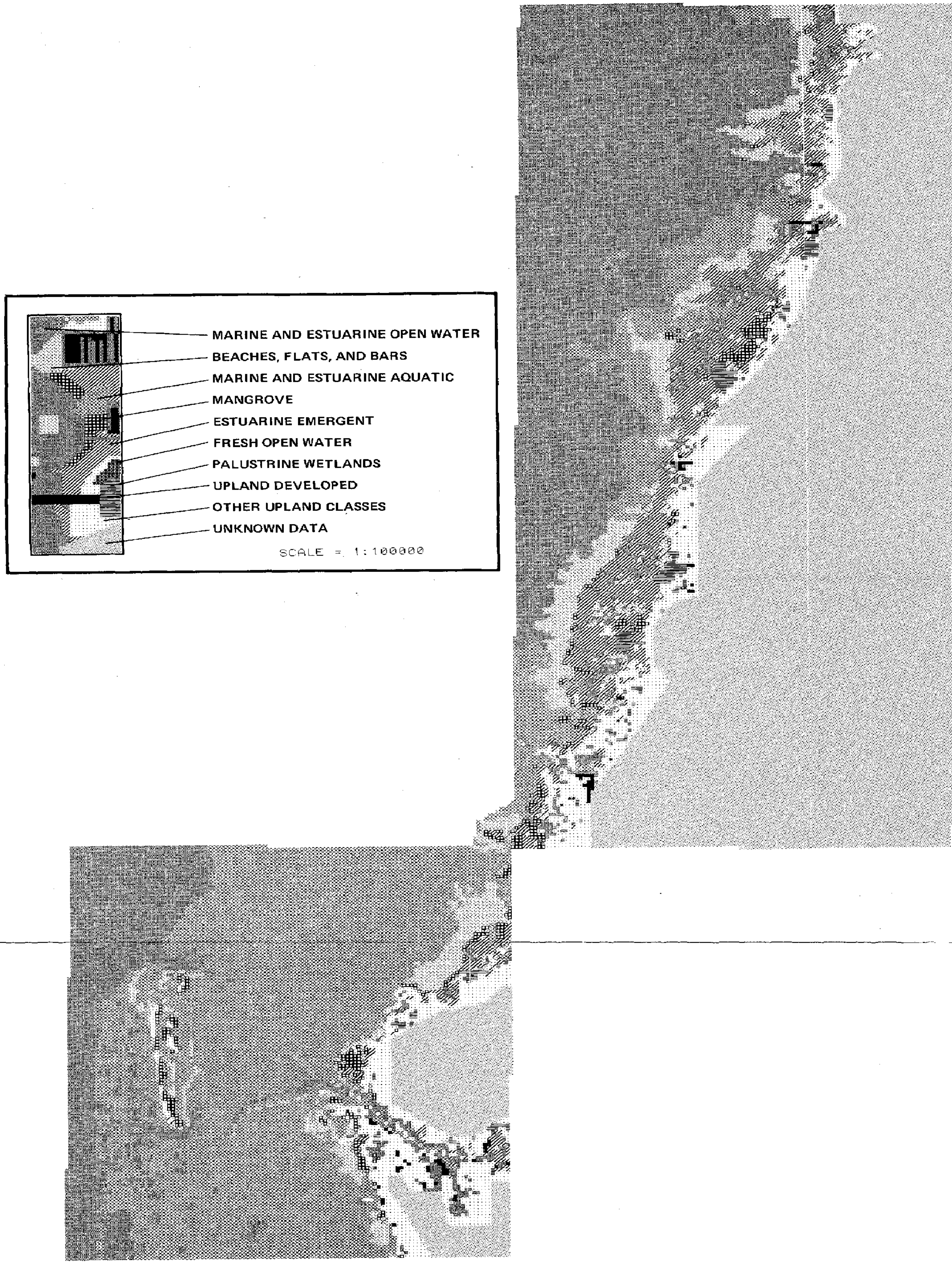


Figure 25 North Tampa Wetlands Inventory - 1982

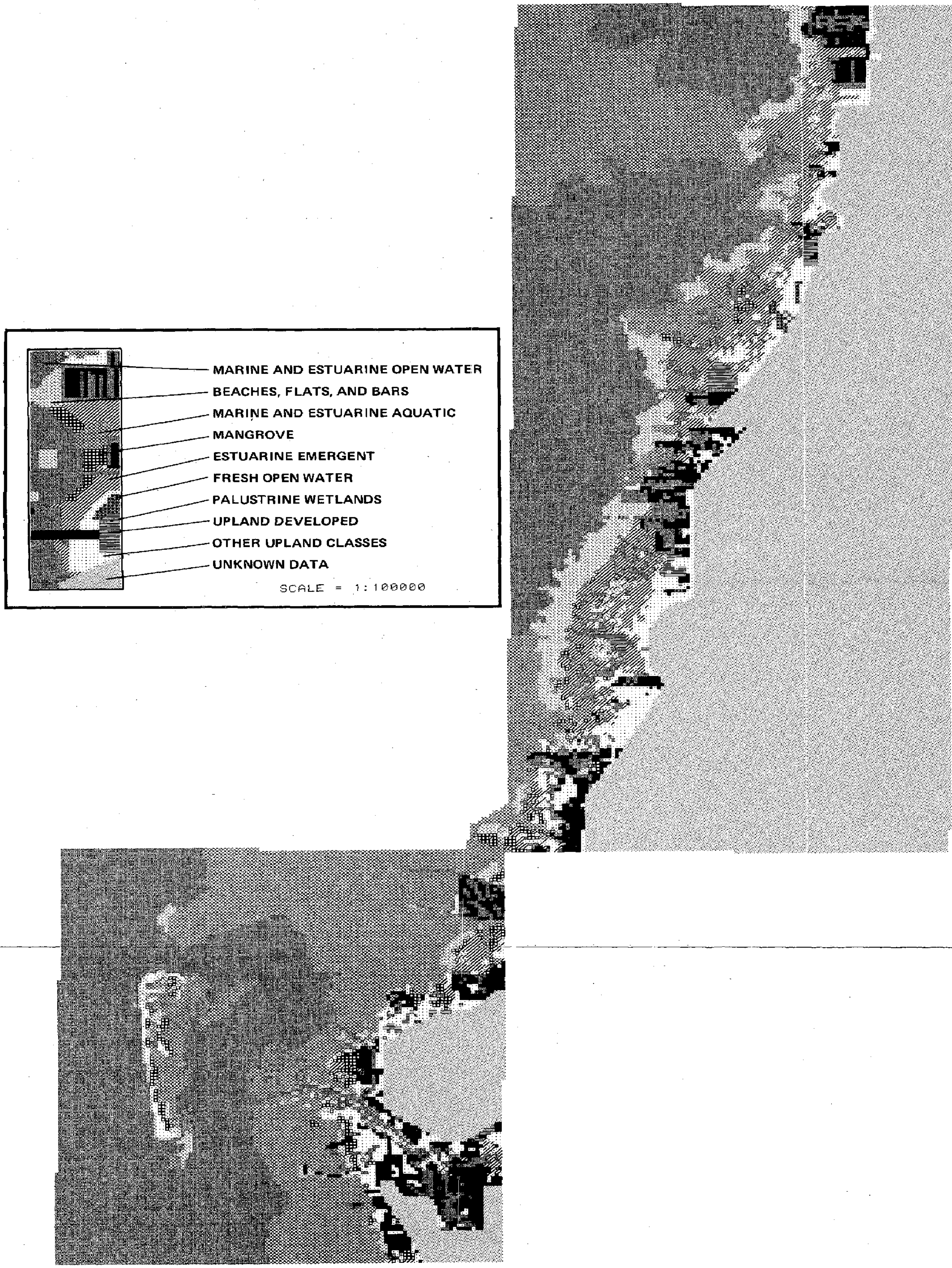


Figure 26 North Tampa Wetlands Trend Analysis

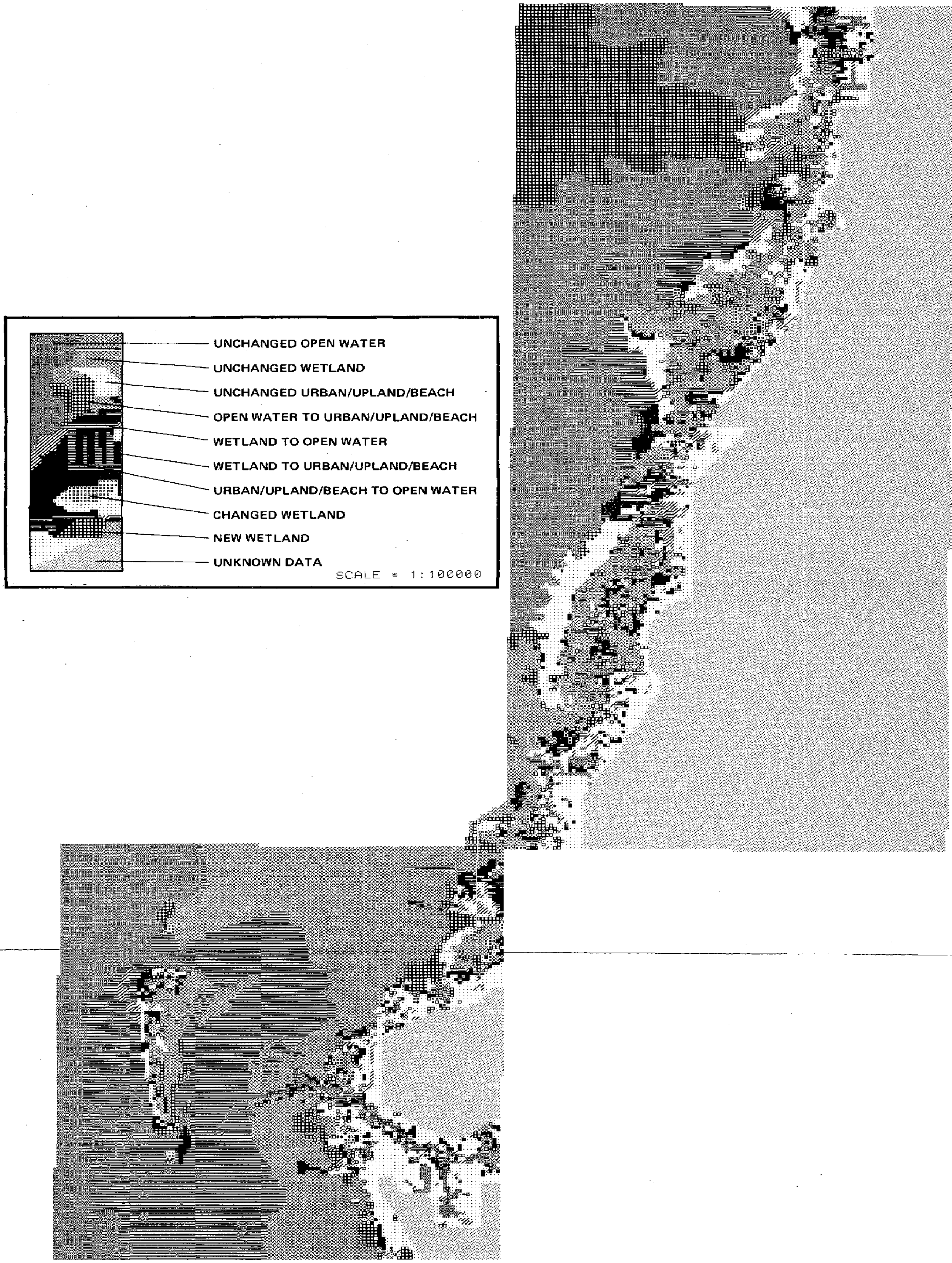


Table 3. Tampa Bay area seagrass trend analysis

Class	Acres	% 1957 Total
Lost Seagrass	35,249.81	59.39
Unchanged Seagrass	24,107.02	40.61
New Seagrass	7,132.96	12.02

Table 4. Tampa Bay area breakdown of lost seagrass.

Class	Acres	% Total
Marine Open Water	646.07	1.83
Estuarine Open Water	18,658.05	52.93
Beaches, Flats and Bars	10,357.06	29.38
Dredged Spoil Areas	186.37	0.53
Mangrove	1,035.93	2.94
Estuarine Emergent	24.46	0.07
Fresh Open Water	41.14	0.12
Palustrine Emergent	19.35	0.05
Palustrine Forested Wetland	1.33	0.00
Upland Developed	2,918.30	8.28
Other Upland Classes	1,361.74	3.86
	35,249.81	

Table 5. Tampa Bay area breakdown of new seagrass.

Class	Acres	% Total
Marine Open Water	26.02	0.36
Estuarine Open Water	2,462.61	34.52
Beaches, Flats and Bars	3,604.62	50.53
Dredged Spoil Areas	18.68	0.26
Marine Aquatic	86.51	1.21
Mangrove	464.37	6.51
Estuarine Emergent	393.20	5.51
Upland Developed	14.68	0.21
Other Upland Classes	62.27	0.87
	7,132.96	

Table 6. Tampa Bay area mangrove trend analysis.

Class	Acres	% 1957 Total
Lost Mangrove	8,284.09	39.78
Unchanged Mangrove	12,542.34	60.22
New Mangrove	7,363.59	35.36

Table 7. Tampa Bay area breakdown of lost mangrove.

Class	Acres	% Total
Estuarine Open Water	1,297.69	15.66
Beaches, Flats and Bars	567.56	6.85
Estuarine Vascular Aquatic	464.37	5.61
Estuarine Emergent	518.19	6.26
Fresh Open Water	130.10	1.57
Palustrine Emergent	37.36	0.45
Palustrine Forested Wetland	74.06	0.89
Upland Developed	3,010.15	36.34
Other Upland Classes	2,184.61	26.37
	8,284.09	

Table 8. Tampa Bay area breakdown of new mangrove.

Class	Acres	% Total
Estuarine Open Water	583.57	7.93
Beaches, Flats and Bars	1,472.05	19.99
Dredged Spoil Areas	5.78	0.08
Estuarine Vascular Aquatic	1,035.93	14.07
Estuarine Emergent	1,597.04	21.69
Fresh Open Water	4.45	0.06
Palustrine Emergent	74.95	1.02
Palustrine Forested Wetland	182.14	2.47
Upland Developed	103.19	1.40
Other Upland Classes	2,304.49	31.30
	7,363.59	

The results of the salt marsh trend analysis for the Tampa Bay study area are summarized in Tables 9, 10 and 11. As shown in Table 9, 80.03 percent of the 7903.57 acres of salt marsh present in 1957 was lost or replaced by 1982. Over the same time period approximately 1874.37 acres (23.72 percent) of new salt marsh growth occurred resulting in a net loss of 56.02 percent. Of the 6325.21 acres of salt marsh that was lost (Table 10), 29.34 percent has been converted to upland classes, 20.05 percent was replaced by beaches, bars and flats, and 14.91 percent was converted to estuarine open water. Approximately 25.25 percent has succeeded to mangrove forest. As shown in Table 11, the majority of new salt marsh growth (27.65 percent) has developed from areas previously vegetated with mangroves, while another 18.41 percent has developed from unvegetated beaches, flats and bars. Approximately 22.64 and 21.30 percent of new salt marsh was converted from upland and estuarine open water, respectively. As shown in Figure 23, salt marsh losses occurred primarily in the Apollo Beach and gateway tract areas while new salt marsh growth was concentrated near the Bower tract and elsewhere in northern Old Tampa Bay.

The results of the North Tampa area seagrass trend analyses were summarized in Tables 12, 13 and 14. As shown in Table 12, 41.38 percent of the 22,500.42 acres of seagrass occurring in 1957 was lost by 1982. Over the same time period about 1988.46 acres of new seagrass growth occurred resulting in a net loss of 32.54. Approximately 58.64 percent of the 1957 seagrass acreage remained unchanged. Of the 9310.01 acres of lost seagrass (Table 13), 83.45 was converted to estuarine open water, while 8.51 was replaced by beaches, flats and bars. As shown in Table 14, the majority of new seagrass growth developed from previously denuded beaches, bars and flats (57.16 percent) and estuarine open water (18.75 percent). Another 7.51 percent developed from dredge spoil areas. As shown in Figure 26, the vast majority of the lost seagrass occurred within the Anclote River anchorage, behind Anclote Key. New seagrass growth was distributed sparsely along the entire North Tampa study area shoreline. Large areas of unchanged seagrass occurred both north and south of the Anclote anchorage.

The results of the North Tampa area mangrove trend analyses are summarized in Tables 15, 16 and 17. As shown in Table 15, 55.24 percent of the 1349.95 acres of mangrove forest present in 1957 was lost or replaced by 1982. Over the 25-year study period 531.09 acres (39.34 percent) of new mangrove growth occurred resulting in a net loss of 15.90 percent. Approximately 604.26 acres (44.76) of the 1957 mangrove acreage remained unchanged. Of the 745.70 acres of lost mangrove (Table 16), the majority (34.80 percent) was replaced by salt marsh vegetation while 28.21 percent was lost to upland. Another 10.77 and 10.62 percent was replaced by estuarine open water, and beaches, flats and bars, respectively. As shown in Table 17, the majority of new mangrove growth has succeeded from salt marsh (49.79 percent), while another 12.90 and 11.77 percent converted from seagrass and estuarine open water, respectively. As shown in Figure 26, the majority of lost mangrove occurred along the Pasco County shoreline in association with the Gulf Harbors and Bayonet Point residential developments. New and unchanged mangrove was distributed relatively evenly along the North Tampa study area shoreline.

The results of the salt marsh trend analysis for the North Tampa area are summarized in Tables 18, 19 and 20. As shown in Table 18, 35.22 percent of the 5887.31 acres of salt marsh occurring in 1957 was lost or replaced by

Table 9. Tampa Bay area salt marsh trend analysis.

Class	Acres	% 1957 Total
Lost Salt Marsh	6,325.21	80.03
Unchanged Salt Marsh	1,578.36	19.97
New Salt Marsh	1,874.37	23.72

Table 10. Tampa Bay area breakdown of lost salt marsh.

Class	Acres	% Total
Marine Open Water	0.45	0.01
Estuarine Open Water	943.19	14.91
Beaches, Flats and Bars	1,268.33	20.05
Dredged Spoil Areas	0.45	0.01
Estuarine Vascular Aquatic	393.20	6.22
Mangrove	1,597.04	25.25
Fresh Open Water	43.15	0.68
Palustrine Emergent	46.48	0.73
Palustrine Forested Wetland	176.58	2.79
Upland Developed	1,044.60	16.51
Other Upland Classes	811.75	12.83
	6,325.21	

Table 11. Tampa Bay area breakdown of new salt marsh.

Class	Acres	% Total
Marine Open Water	0.89	0.05
Estuarine Open Water	399.20	21.30
Beaches, Flats and Bars	345.16	18.41
Dredged Spoil Area	1.78	0.09
Marine Aquatic	3.78	0.20
Estuarine Vascular Aquatic	24.46	1.31
Mangrove	518.19	27.65
Fresh Open Water	30.25	1.61
Palustrine Emergent	27.13	1.45
Palustrine Forested Wetland	95.85	5.11
Upland Developed	3.34	0.18
Other Upland Classes	424.34	22.64
	1,874.37	

Table 12. North Tampa Area seagrass trend analysis.

Class	Acres	% 1957 Total
Lost Seagrass	9,310.01	41.38
Unchanged Seagrass	13,190.41	58.62
New Seagrass	1,988.46	8.84

Table 13. North Tampa area breakdown of lost seagrass.

Class	Acres	% Total
Marine Open Water	240.41	2.58
Estuarine Open Water	7,768.80	83.45
Beaches, Flats and Bars	792.18	8.51
Dredged Spoil Area	47.82	0.51
Marine Aquatic	74.28	0.80
Mangrove	68.50	0.74
Estuarine Emergent	80.95	0.87
Fresh Open Water	1.56	0.02
Upland Developed	163.91	1.76
Other Upland Classes	71.61	0.77
	9,310.01	

Table 14. North Tampa area breakdown of new seagrass.

Class	Acres	% Total
Marine Open Water	111.64	5.61
Estuarine Open Water	372.74	18.75
Beaches, Flats and Bars	1,136.68	57.16
Dredged Spoil Area	141.68	7.12
Marine Aquatic	71.17	3.58
Mangrove	58.27	2.93
Estuarine Emergent	65.16	3.28
Upland Developed	1.56	0.08
Other Upland Classes	29.58	1.49
	1,988.46	

Table 15. North Tampa area mangrove trend analysis.

Class	Acres	% 1957 Total
Lost Mangrove	745.70	55.24
Unchanged Mangrove	604.26	44.76
New Mangrove	531.09	39.34

Table 16. North Tampa area breakdown of lost mangroves.

Class	Acres	% Total
Estuarine Open Water	79.17	10.62
Beaches, Flats and Bars	80.29	10.77
Marine Aquatic	1.56	0.21
Estuarine Vascular Aquatic	58.27	7.81
Estuarine Emergent	259.54	34.80
Fresh Open Water	1.33	0.18
Palustrine Forested Wetland	2.45	0.33
Upland Developed	52.71	7.07
Other Upland Classes	210.39	28.21
	745.70	

Table 17. North Tampa area breakdown of new mangove.

Class	Acres	% Total
Estuarine Open Water	62.94	11.77
Beaches, Flats and Bars	45.59	8.58
Dredged Spoil Area	0.67	0.13
Estuarine Vascular Aquatic	68.50	12.90
Estuarine Emergent	264.43	49.79
Palustrine Forested Wetland	0.22	0.04
Upland developed	0.22	0.04
Other Upland Classes	88.96	16.75
	531.09	

1982. About 64.77 percent of the 1957 salt marsh acreage remained unchanged. Over the same time period, 1449.81 acres (24.63 percent) of new salt marsh growth occurred resulting in a net loss of 10.30 percent. Of the 2073.86 acres of lost salt marsh (Table 19), the majority was lost to upland classes (38.68 percent) and to estuarine open water (32.77 percent). About 12.75 percent succeeded to mangrove forest. As shown in Table 20, the majority of new salt marsh growth has developed from estuarine open water (28.30 percent) and from previously upland areas (23.09 percent). Another 20.51 and 17.90 percent has succeeded from beaches, flats and bars, and mangrove forest, respectively. As shown in Figure 26, areas of lost salt marsh are primarily associated with coastal residential developments in Pasco County. Areas of unchanged and new salt marsh were distributed relatively evenly along the central and northern Pasco County shoreline.

COMPARISON WITH OTHER STUDIES

It is difficult to compare the above results with those generated from previous wetland trend analyses for various reasons, including:

- The study time intervals are often randomly chosen and are inconsistent between studies
- The study boundary areas are often discontinuous, overlapping, or poorly defined
- The scale and quality of the aerial photography used for photointerpretation are often variable
- Photointerpretative skills differ considerably between various investigations, and
- The methods used for quantifying acreages represented by mapped polygons differ between studies.

Perhaps the most suitable study available for comparative purposes is that of Mangrove Systems, Inc. (1984). In both studies, the USGS Dunedin quadrangle was analyzed for estuarine wetland trends. In addition, the same individuals were responsible for photointerpreting the respective aerial photography in both studies. In the Lewis study, however, the study interval was 1942-1984, and standard planimetric methods were used to quantify wetland acreages.

As shown in Table 21, the results of the two studies are generally comparable, however, they differ considerably with respect to mangrove/salt marsh acreage. The most notable difference lies in the reference year acreage figures. In the Lewis study, the 1942 mangrove/marsh acreage was 662.0, whereas in the present study the 1957 acreage was 964.6 - a difference of about 45.7 percent. Because it is difficult to attribute this apparent increase in mangrove/marsh acreage between 1942 and 1957 to natural causes, it is concluded that the observed differences between the two studies represent a rough estimate of the error involved in macro-scale trend analyses of land cover forms.

Table 18. North Tampa area salt marsh trend analysis.

Class	Acres	% 1957 Total
Lost Salt Marsh	2,073.86	35.22
Unchanged Salt Marsh	3,813.45	64.77
New Salt Marsh	1,449.81	24.63

Table 19. North Tampa area breakdown of lost salt marsh.

Class	Acres	% Total
Marine Open Water	1.11	0.05
Estuarine Open Water	679.65	32.77
Beaches, Flats and Bars	225.73	10.88
Estuarine Vascular Aquatic	65.16	3.14
Mangrove	264.43	12.75
Fresh Open Water	3.56	0.17
Palustrine Emergent	0.89	0.04
Palustrine Forested Wetland	31.14	1.50
Upland Developed	492.61	23.75
Other Upland Classes	309.58	14.93
	2,073.86	

Table 20. North Tampa area breakdown of new salt marsh.

Class	Acres	% Total
Marine Open Water	2.89	0.20
Estuarine Open Water	410.32	28.30
Beaches, Flats and Bars	297.35	20.51
Estuarine Vascular Aquatic	80.93	5.58
Mangrove	259.54	17.90
Fresh Open Water	2.00	0.14
Palustrine Emergent	7.12	0.49
Palustrine Forested Wetland	51.37	3.54
Upland Developed	3.56	0.25
Other Uland Classes	334.71	23.09
	1,449.81	

Table 21. Comparison of estuarine wetland trend analyses for the USGS Dunedin quadrangle between Lewis (1984) and the present study.

	Lewis (1984)			Present Study		
Habitat Class	1942	1984	% Change	1957	1982	% Change
Mangrove/Marsh	662.0	533.6	-19.4	964.6	655.9	-32.0
Seagrass	13,184.9	3,437.7	-73.9	12,567.3	3,816.6	-69.0

DISCUSSION

Of the three major estuarine habitat types (seagrass, mangrove and salt marsh), the net loss of seagrass in the Tampa Bay region has been the most extensive and catastrophic. Although it is difficult to discern cause and effect relationships from the wetland trend analyses presented above, a number of relationships can be inferred regarding seagrass declines. In the Tampa Bay study area the most notable seagrass declines occurred in St. Joseph's Sound. In the North Tampa study areas vast declines in seagrass coverage occurred within the Anclote anchorage. During the period under study (1957-1982), two large-scale dredge and fill projects were implemented in these impacted areas including 1) the dredging of the intracoastal waterway along the Florida Gulf coast during the mid-1960s; and, 2) the construction of the Florida Power Corporation Anclote Power Plant in the early 1970s. These two projects represent the first major dredge/fill perturbations effected in these areas, and their direct impacts on pre-existing seagrass beds cannot be underestimated. Similar large scale declines in Tampa Bay proper were probably not observed over the study period because the majority of the pre-existing seagrass beds had already been destroyed prior to 1957 by previous anthropogenic impacts (Taylor and Saloman, 1968).

The fact that dredge and fill activities have been directly responsible for massive seagrass declines in the Tampa Bay region cannot be disputed. Goodwin (1984) calculated that the total surface area of the bay has been reduced by 3.6% (33.67 km2) due to the dredging of navigation channels and the filling of shallow intertidal or subtidal areas for power generation sites, or for residential, port and transportation development. It should, however, be noted that seagrasses have disappeared from large areas that were never directly excavated or filled. Although some of these losses can be attributed to the secondary impacts of dredging with localized increases in suspended solids followed by siltation of adjacent seagrass beds, this cannot account for widespread seagrass declines in areas far from any dredging activity. This conclusion is further supported by the findings of Goodwin and Michaelis (1984) that seasonal minimal turbidity levels in Hillsborough Bay were only increased over baseline levels by two nepholometric turbidity units during the extensive dredging of the Tampa Harbor Deepening Project in 1977 and 1978.

Because seagrasses are submerged flowering plants, they require large amounts of light to survive and reproduce. It has been calculated that between 10 and 50 percent of the sunlight striking the waters' surface must penetrate to the leaves of seagrasses to ensure sufficient photosynthesis for survival (Williams and McRoy, 1982). For this reason the survival of seagrasses is tied intimately to the transparency of the overlying water column. There is growing evidence that the seagrasses in Tampa Bay, as well as those in other urbanized estuaries (EPA, 1982), are living in a marginal light environment by virtue of anthropogenic nutrient enrichment, and that progressive changes in water quality will further stress the plant communities. The issue as far as light is concerned is not simply restricted to suspended material, both organic and inorganic, in the water column. Recent observations and studies indicate that increasing nutrient enrichment of estuarine waters is responsible for the stimulation of excessive epiphytic growth of microalgae on the leaves of seagrasses (EPA, 1982; Lewis et al. 1985). By reducing the amount of light available to seagrasses, the combined effects of eutrophication - increased epiphytic growth and organic suspended material (phytoplankton) - may be the most significant cause of the observed seagrass declines in the Tampa Bay region (Lewis et al. 1985).

During the study period, the St. Joseph Sound and Anclote River watersheds underwent substantial urbanization, probably contributing to a significant increase in coastal nutrient enrichment. This can also be said for those areas in Tampa Bay proper where declines were observed (i.e., at the mouth of urbanized tidal creeks). Unfortunately, water-quality data bases over this time period are not available for these areas to substantiate this theory. Although general eutrophication and dredging are proposed as the major causes of seagrass declines in these areas, other factors cannot be ignored. These include propeller damage from increased boating traffic, the use of herbicides to control aquatic weed growth, and, in the case of the Anclote anchorage, thermal and chemical (anti-fouling detergents) discharges from the power plant. In conclusion, the decline of seagrasses in the region is probably the result of a complex interaction of numerous anthropogenic impacts. Natural stresses, including climatic and salinity regimes as well as stingray and manatee feeding damage, do not appear to be responsible for the presently reduced seagrass populations. Seagrasses have always been subject to these pressures and the historic record, as best as it can be reconstructed, does not reveal previous declines of such magnitudes.

Unlike seagrasses, the trends observed for estuarine emergent vegetation can, in many cases, be related to natural climatic extremes, recruitment and successional patterns. In addition, because they are intertidal, anthropogenic impact on mangroves and salt marshes are almost exclusively attributable to the direct effects of dredging and filling.

The natural relationship between mangroves and salt marshes in the Tampa Bay region is not precisely defined. On the Florida Gulf coast, Tampa Bay generally represents the latitudinal limit of the dominant mangrove community. In upper Old Tampa Bay and in rivers flowing to the bay, or north of the Anclote River along the coast, the mangrove community is replaced by a Juncus dominated salt marsh community. Spartina salt marshes generally occur as fringes seaward of both mangroves and Juncus marshes. It has been demonstrated, however, that Spartina is almost always the first natural recruit on new intertidal substrate (Lewis and Dunstan, 1975).

Under prolonged conditions of mild weather (i.e., several consecutive winters without a freeze), the primary natural successional pattern proceeds from pioneer salt marsh (usually Spartina) to a mixed zonation of three mangrove species (Estevez and Mosura, 1985). However, because of their presence near the northern latitudinal limit, mangroves in the Tampa Bay region are subject to periodic large scale reductions due to freeze damage. Secondary succession following freezes often depends upon their severity and frequency as well as the presence of suitable seed stock. Uniform fringing stands of mangroves killed by a freeze may remain unvegetated for many years, or re-develop as a Spartina marsh; whereas, severe freeze damage to a Spartina marsh may lead to the development of a Juncus marsh (Estevez and Mosura, 1985).

As a result of these complex meteorological and ecological factors, intertidal habitat in the Tampa Bay region is always in somewhat of a natural flux between unvegetated substrate, salt marsh, and mangrove vegetation. This natural flux is apparent in the wetland trend analyses presented above where new salt marsh and mangrove growth has replaced areas previously characterized by the other.

Losses of emergent vegetation due to anthropogenic impacts occurring over the study period are probably accurately quantified in the net losses shown in Tables 1 and 2. Net losses have almost been exclusively associated with coastal dredging and filling for coastal development, where suitable intertidal substrate (i.e., shallow littoral shelves) were simply eliminated, thus preventing natural successional patterns from occurring. During essentially the same study period (1952-1982), Harris et al. (1983) reported an areal increase in mangrove coverage of 10 percent (from 20,860 to 22,928 ha) in Charlotte Harbor. Over this time period Charlotte Harbor has experienced far less development pressure than has the Tampa Bay and North Tampa study areas. The reported increases in mangroves in Charlotte Harbor probably represents natural succession from salt marsh vegetation.

Although the effects are much more difficult to quantify, intertidal habitat in the Tampa Bay region has probably been somewhat adversely impacted by numerous minor oil spills, and by extensive mosquito ditching. Lewis (1980) reviewed the generalized consequences of severe oil spills in Tampa Bay mangrove forests and concluded that complete recovery from chronic sub-lethal effects may take 10 to 50 years. Although virtually unstudied, it has also been proposed that mosquito ditching has created suitable habitat for noxious and exotic vegetation such as Brazilian Pepper (Schinus terebinthifolia) which has in recent years begun to compete critically with native mangrove species in the upper intertidal zone (Estevez and Mosura, 1985).

Although recent regulations have essentially eliminated the massive dredge and fill projects of the post-war era, the long-term future of estuarine wetland habitat in the Tampa Bay region remains threatened. Recent studies have predicted that increasing concentrations of greenhouse gases in the earths' atmosphere could cause sea level to rise one or two meters through the year 2100 (EPA, 1986). Under undeveloped conditions, the impact of a rise in sea level would involve natural compensatory and eustatic changes in coastal wetlands allowing such ecosystems to remain intact. However, human impacts, such as coastal development, bulkheading and riverflow management (impoundment), could disable many of the natural mechanisms that allow coastal wetlands to adapt to rising sea level, thereby substantially increasing the loss of wetlands over what would occur naturally. In the case of intertidal wetlands where contiguous upland development has extended to the mean high water line, rising sea level over time will eliminate whole ecosystems by the restriction and permanently flooding of the intertidal zone. In the case of subtidal wetlands, a rise in sea level of one to two meters will remove virtually all of the existing seagrass beds from the productive euphotic zone. Compounded with increasing urbanization and eutrophication, the ability of existing seagrass beds to productively expand shoreward remains doubtful. Unless wetland managers in the Tampa Bay region acknowledge and begin to address this potentially catastrophic problem now, all other restorative measures are of questionable validity.

CHAPTER III

TAMPA BAY HABITAT RESTORATION TECHNIQUES

Restoration of the fish and wildlife habitat in Tampa Bay is orientated toward the creation of additional habitat available for use by fish and wildlife populations. The losses of vegetational systems and associated decline in wildlife has been illustrated in previous chapters. Review of the vegetational losses aid in the establishment of priority needs for habitat creation.

Restoration types can be separated into two representative categories. Subtidal habitat restoration types to be discussed include:

- seagrass
- oyster bar
- borrow pits
- benthic algae
- artificial reefs

Intertidal habitat restoration projects include:

- salt marsh
- mangrove

In addition, restoration for Tampa Bay can further be expanded to include general ecosystems. This includes, but is not limited to restoration of tidal tributaries, impoundments and littoral shelf creation within the estuary. TBRPC (1986b) identified 20 stressed, 11 restorable and nine natural tidal tributaries in the three counties surrounding Tampa Bay. (Figure 27, Table 22). The variety of tributary conditions provide the opportunity for major restoration of these important feeding and nursery areas.

The restoration or creation of habitat utilizes numerous techniques that can be applied to specific sites. The techniques will vary depending upon site conditions. Basically the approach should be taken to review adjacent areas of similar habitat to be created, and then duplicating the conditions for success.

SUBTIDAL SYSTEMS

Seagrass Restoration Review

The decline in seagrass beds in Tampa Bay has been enormous. Seagrass plantings have occurred within Tampa Bay by a number of researchers on a small scale experimental basis. The seagrasses used are the dominant Tampa Bay species including *Thalassia testudinum*, *Halodule wrightii*, and *Syringodium filiforme*. Figure 28 identifies the four species of seagrass that commonly occur in Tampa Bay.

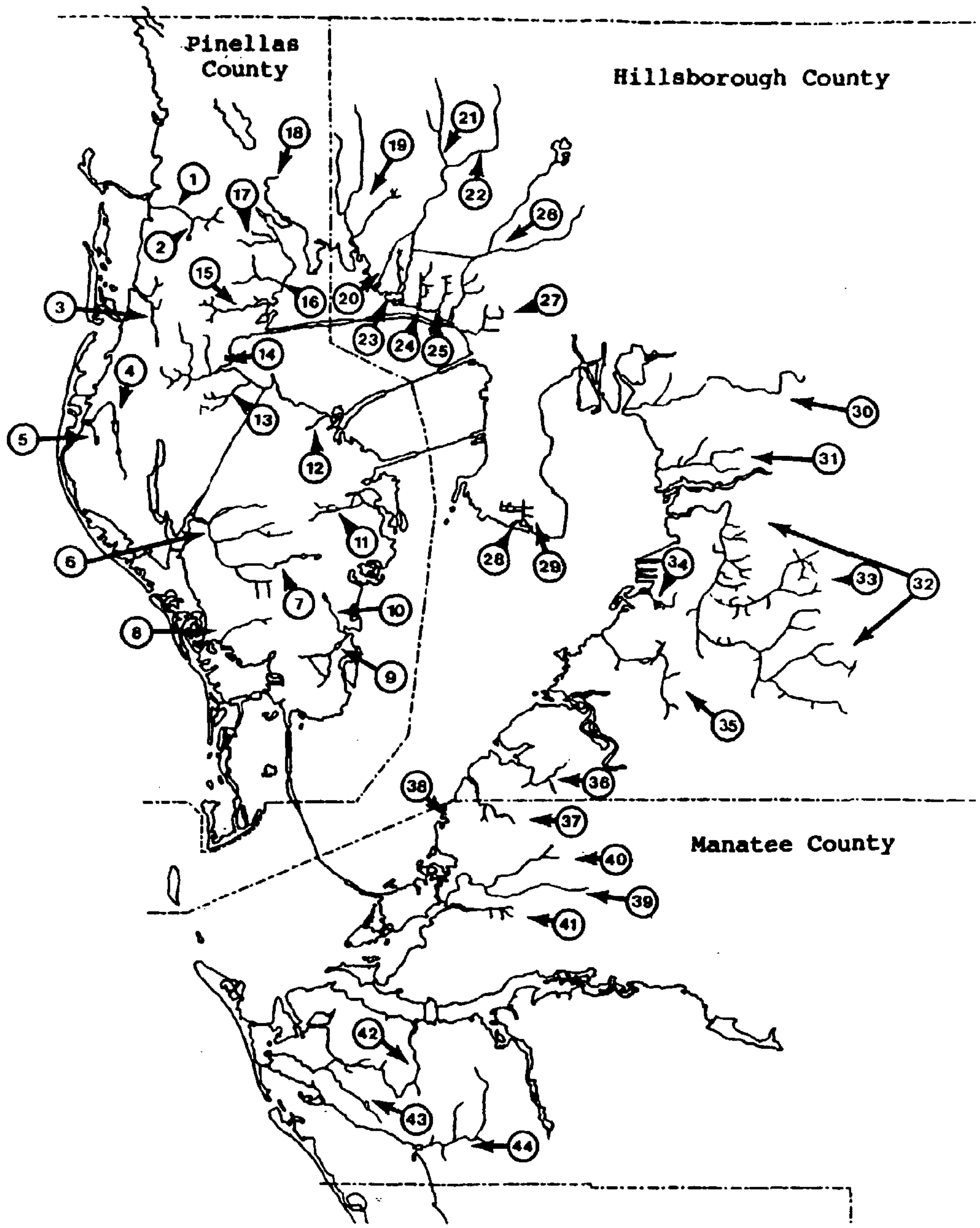
Hoffman et al. (1985) reviewed ten seagrass experimental plantings in Tampa Bay (Figure 29, Table 23). The review included species planted, percent survival and appropriate techniques used. Hoffman et al. (1985) evaluated the success (defined as survival of planted units over a specific period of

Figure 27
Location of classified minor tidal tributaries in the Tampa Bay region (TBRPC, 1986b)

Pinellas County
1. Curlew Creek
2. Jerry Branch
3. Stevenson Creek
4. McKay Creek
5. Church Creek
6. Joe's Creek
7. St. Joe's Creek
8. Bears Creek
9. Salt Creek
10. Booker Creek
11. Tinney Creek
12. Grassy Creek
13. Long Branch Creek
14. Allen's Creek
15. Alligator Creek
16. Mullet Creek
17. Bishop Creek
18. Moccasin Creek

Hillsborough County
19. Double Branch Creek
20. Channel A
21. Rocky Creek
22. Brushy Creek
23. Dick Creek
24. Woods Creek
25. Peppermound Creek
26. Sweetwater Creek
27. Fish Creek
28. Coon Hammock Creek
29. Broad Creek
30. Delaney Creek
31. Archie Creek
32. Bullfrog Creek
33. Little Bullfrog Creek
34. Newman Branch
35. Wolf Branch
36. Cockroach Creek
37. Piney Point Creek

Manatee County
38. Redfish and Little Redfish Creek
39. Frog Creek
40. Cabbage Slough
41. McMullen Creek
42. Wares Creek
43. Palma Sola Creek
44. Bowles Creek



TIDAL CREEK SUMMARY

Table 22

Creek/County	Approx. Length (Miles)	Land Use	Condition
Pinellas County			
1. Curlew Creek	4	Res.	Stressed
2. Jerry Branch	2.4	Res.	Stressed
3. Stevenson Creek	4	Res./Ind.	Stressed
4. McKay Creek	4.7	Res.	Stressed
5. Church Creek	1.6	Low Res.	Stressed
6. Joe's Creek	2.0	Res./Ind.	Stressed
7. St. Joe's Creek	6.6	Res./Ind.	Stressed
8. Bear Creek	2.7	Res.	Stressed
9. Salt Creek	1.5	Res.	Stressed
10. Booker Creek	1.9	Comm./Ind./Res.	Stressed
11. Tinney Creek	2.7	Res./Comm.	Stressed
12. Grassy Creek	0.8	Open Space/Comm.	Natural
13. Long Branch Creek	3.4	Res./Comm.	Restorable
14. Allen Creek	6.0	Res./Comm.	Stressed
15. Alligator Creek	4.4	Res./Agr.	Stressed
16. Mullet Creek	2.3	Res./Comm.	Restorable
17. Bishop Creek	1.8	Res.	Natural
18. Moccasin Creek	1.5	Res./Agr.	Natural
Hillsborough County			
19. Double Branch Creek	6.8	Agr.	Natural
20. Channel A	4.1	Res./Agr.	Man-made
21. Rocky Creek	10.9	Res./Agr.	Stressed
22. Brushy Creek	6.4	Res./Agr.	Non-tidal
23. Dick Creek	1.6	Res./Open	Restorable
24. Woods Creek	1.6	Res./Ind.	Stressed
25. Peppermound Creek	1.6	Res.	Restorable
26. Sweetwater Creek	10.4	Res./Agr.	Stressed
27. Fish Creek	2.3	Comm.	Restorable
28. Coon Hammock Creek	0.5	Open Space	Restorable
29. Broad Creek	2.5	Comm.	Restorable
30. Delany Creek	10.8	Ind./Agr.	Stressed
31. Archie Creek	4.9	Ind./Res.	Restorable
32. Bullfrog Creek	17.5	Agr.	Restorable
33. Little Bullfrog Creek	6.0	Agr.	Non-Tidal
34. Newman Branch	2.5	Ind./Res.	Stressed
35. Wolf Branch	6.5	Agr.	Restorable
36. Cockroach Creek	2.5	Agr./Res.	Natural
37. Piney Point Creek	2.7	Agr./Ind.	Natural
Manatee County			
38. Little Redfish Creek	0.5	Open/Ind.	Restorable
39. Frog Creek	11.5	Open/Agr.	Natural
40. Cabbage Slough	3.9	Agr.	Non-tidal
41. McMullen Creek	3.8	Res./Agr.	Natural
42. Wares Creek	9.4	Res./Comm./Ind.	Stressed
43. Palma Sola Creek	4.1	Res./Agr.	Natural
44. Bowles Creek	4.1	Res./Ind./Agr.	Stressed

NOTE: Res.=Residential, Comm.=Commercial, Ind.=Industrial, Agr.=Agricultural
(TBRPC, 1986b)

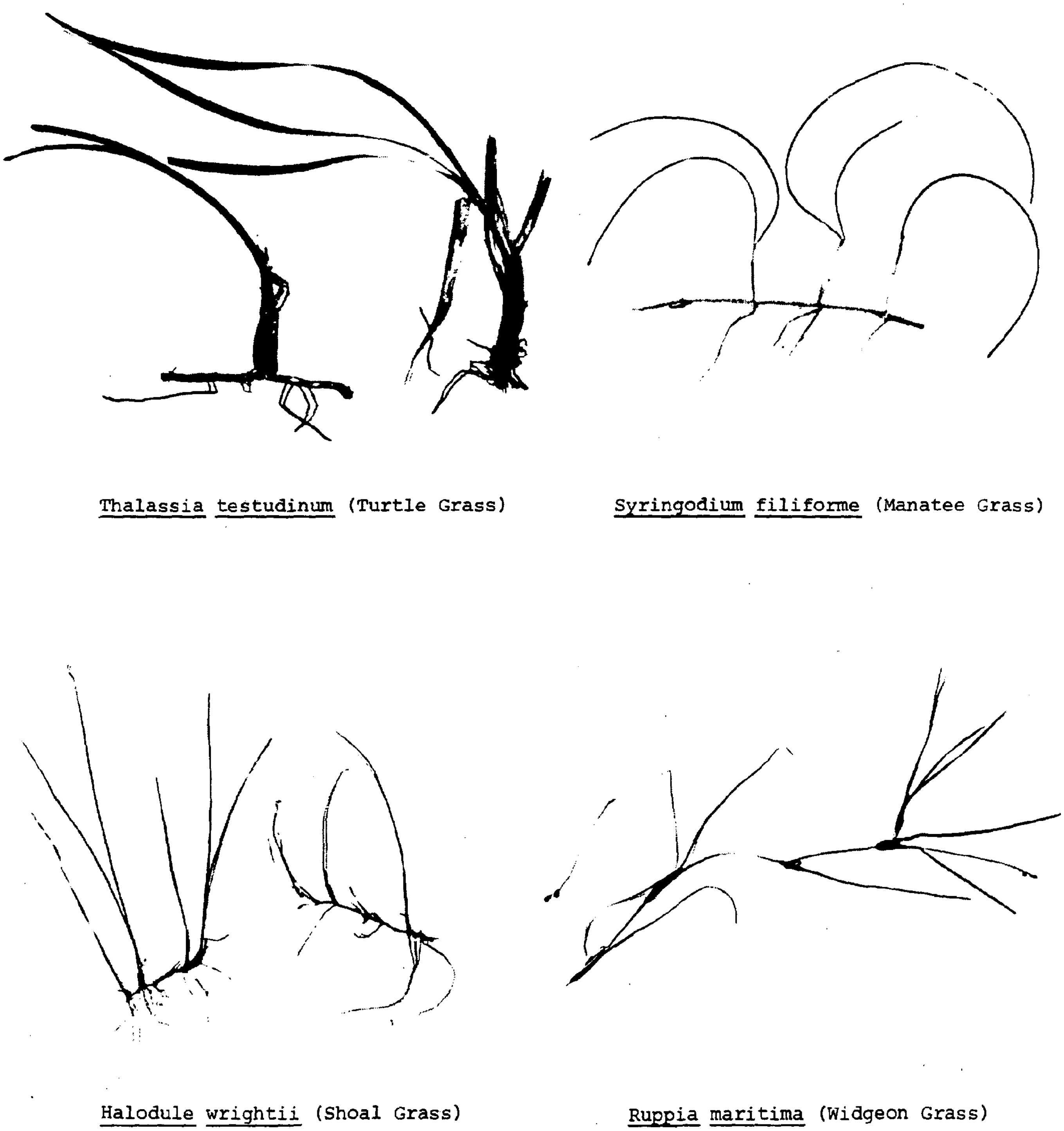


Figure 28 Commen seagrasses in Tampa Bay (Adapted from Darovec et al. 1975)

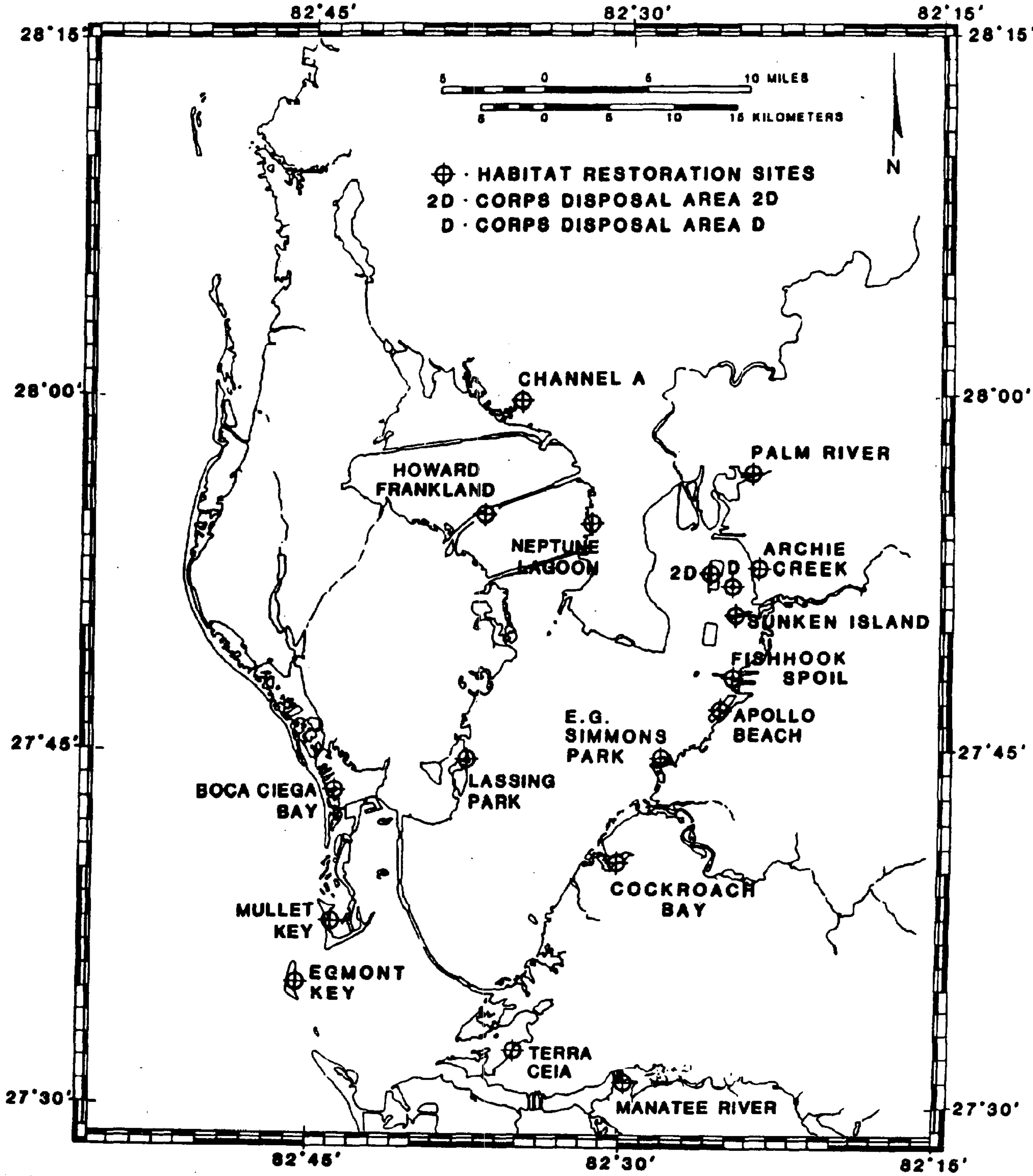


Figure 29 Habitat Restoration Project Sites Reviewed by Hoffman et al. (1985)

Table 23 Seagrass experimental plantings in Tampa Bay to 1982 (Hoffman et al. 1985)

Project site (Reference)	Date	Species	Number Planted	Technique	% Survival	Comments
Tampa Bay (Phillips 1974)	Aug 1960	T. testudinum H. wrightii	52	sods (0.1 m^2)	0 moderate	erosion problems prompted use of wood or sheet metal barricades.
Boca Ciega Bay (Kelly et al. 1971)	Jul 1966	T. testudinum	120	plugs (400 cm^2)	0-70	plugs anchored in cans more successful when protected by concrete enclosures.
	Apr 1967	T. testudinum	60	sprigs	0-100	construction rod best anchor; NAPH induced heavy rooting.
Lassing Park (Van Breedveld 1975)	Feb 1972	T. testudinum	10	plugs (single row)	100	unanchored.
			60	shoots (6 rows)	0-100	construction rod better than polyethylene bags as anchors.
Cats Point (Van Breedveld 1975)	Mar 1972	T. testudinum	60	plugs (2 rows - 10; 8 rows - 5)	30-100	various anchors tested, high energy site.
Lassing Park (Van Breedveld 1975)	Mar 1972	T. testudinum	40	plugs (single row)	15-37	site exposed at spring low tides.
Point Brittany (Van Breedveld 1975)	Jul 1972	T. testudinum	20	plugs (4 rows)	20	unanchored; deep, high turbidity site.
North of Bayway (Van Breedveld 1975)	Aug 1972	T. testudinum	40	plugs (8 rows)	50-60	unanchored; aerobic sediments.
Lassing Park (Van Breedveld 1975)	Aug 1972	T. testudinum	60	plugs (6 rows)	100	unanchored; spread and formed massive bed.
	Sep 1972	T. testudinum	11	plugs (circular)	27	unanchored; 2.5 m spacing too large; aerobic sediments.
	Oct 1972	T. testudinum	10	plugs (single row)	100	unanchored, 60 cm spacing, lower water temperatures.
	Nov 1972	S. filiforme	10	plugs	100	unanchored, rapid spread.
	Dec 1972	T. testudinum, S. filiforme	10	plugs (single row alternating)	100	unanchored.
Boca Ciega Bay (Durako and Moffler 1981)	Nov 1980	T. testudinum	42	seedlings	0	site was physically disrupted, water turbid.
Egmont Key (Moffler and Durako unpub.)	Jul 1981	T. testudinum	24	seedlings	4	Tampa Bay seedling only survivor, site disturbed.

time) of seagrass revegetation projects as follows:

"The first attempt to transplant seagrasses in the bay found that sods of H. wrightii were moderately successful, but sods of T. testudinum completely failed due to substrate erosion (Phillips, 1974). The use of barricades for erosion control improved survival success in higher energy areas. Erosion of transplants has proved to be a major problem locally. The number of techniques that have been tested to overcome this problem reflects its complexity. Kelly et al. (1971) attained complete or partial success in seven of 14 techniques they tested. All plugs that were balled in burlap failed, presumably due to toxic decomposition products of the decaying burlap. Plugs anchored in tin cans were 50% successful at their control site, but only 15% successful at a finger fill canal site, where concrete block barriers were required as erosion control. Plugs transported to the site in polyethylene bags and then directly transplanted were less successful (3:5) than the use of tin cans. Construction rods were found to be the most effective device for anchoring sprigs, and rods used in conjunction with the hormone treatment resulted in 100% success. Pipe and brick proved to be poor anchors as well as being more difficult to handle in the field. All new short shoots produced by the transplants arose from rhizome apices, which also occurred in earlier tank cultures (Fuss and Kelly, 1969).

While early work concentrated on anchoring devices, Van Breedveld (1975) studied the importance of substrate in the success of T. testudinum transplants. He found that transplanting clumps of four to seven short shoots including sediments was the most successful method. In unfavorable sediments, the clumps should be closely spaced; in favorable areas they can be planted up to 30 centimeters (cm) apart. He recommended transplanting when water temperatures are below 21°C and found no increase in survival or growth when plant hormones were used. Also, the S. filiforme transplants he performed survived and exhibited relatively rapid growth.

The lack of success in initial transplanting of laboratory cultured T. testudinum seedlings from the Florida Keys, Biscayne Bay and Tampa Bay to a site in Boca Ciega Bay was mainly due to physical disturbance of the site as well as to high water turbidity (Durako and Moffler, 1981). Many of the peat pellets were knocked out of the sediments, which prevented an accurate assessment of the technique. One-year old seedlings that were transplanted to Egmont Key exhibited rapid initial growth and appeared healthy (Moffler and Durako, unpublished data). After approximately 50 days, leaf areas were drastically reduced due to grazing on the blades. The plot was then buried by what appeared to be propwash. Only one seedling from Tampa Bay survived the burial and this plant continued to grow, producing a second short shoot eight months after being transplanted. However, seedlings from the Florida Keys had produced additional short shoots after only 21 days from transplanting, indicating variability between populations."

Thorhang (1986) additionally reviewed 165 world-wide seagrass restoration efforts. Table 24 identifies seagrass restoration attempts in the Biscayne Bay area of Florida. Included in the analysis is a comparison between seagrass techniques (Table 25) and planting requirements of seagrasses (Table 26).

In addition, CSA (1986) reviewed 32 seagrass revegetation projects in tropical subtropical North America, including seven sites in Tampa Bay (Table 27). The review included species, location, substrate, percent success of planted units and appropriate techniques. The evaluation by CSA (1985) for seagrass restoration attempts is as follows.

"The case studies reviewed illustrate the difficulty of seagrass revegetation. The recommendation is that seagrass habitat not be destroyed with expectation of mitigation by planting seagrasses. At the present time, the revegetation of seagrasses is experimental. The planting methods are not proven and the problems affecting planting success are not known. Successful re-establishment has occurred in some damaged seagrass habitats, but planting on dredged material or in previously unvegetated areas has not been very successful.

When successful, re-establishment of T. testudinum at Turkey Point in Biscayne Bay resulted in significantly more abundance and species of organisms in restored areas than unvegetated barren areas, and that restored sites were not statistically different from control T. testudinum sites.

The most successful revegetation attempts have utilized the pioneering aspects of H. wrightii. H. wrightii planted as shoots has been proven to have inconsistent, but at times, good survivorship with comparatively rapid spread from the planting unit, providing stabilization of sediment. The cost of planting shoots is less than with the labor intensive plug method. The use of shoots of H. wrightii does not cause major disruption of the donor grass beds, especially if the "runners" described by Derrenbacker and Lewis (1982) are used.

The use of T. testudinum shoots or seeds has been successful, but spread from the planting units is slow. Shoots, seedlings, or seeds of T. testudinum planted within sparse or recently revegetated beds of H. wrightii may aid in the acceleration of the vegetative community to climax state. This method was used with good success at Turkey Point with T. testudinum seeds. The success of the restoration at Turkey Point can also be attributed to the quality of the sediment, which had not changed after being denuded by heated effluent and low wave energy.

Table 24 Review of Seagrass Planting Projects by Thorhaug (1986)

Date	Sponsor	Location	Species	Methods	Acreage	Success rate	Certified by government agency as complying
1986	United Nations FAO	Philippines	*Enhalus* *Halodule* *Cymodocea*	plugs seeds shoots		still pending, monitoring	
1985	United Nations FAO	Philippines (Luzon and Marinduque)	6 species	plugs seeds shoots	test plots	still being monitored	yes
1985	Dade County Port of Miami	Central Biscayne Bay	*Thalassia* *Syringodium*	plugs	75.3 areas (61 m × 61 m)	high, still being monitored	yes
1984	Dade County Department of Transportation (Rickenbacker)	North Biscayne Bay	*Halodule* *Thalassia*	plugs shoots	3,764 m^2	high	yes
1984	Dade County Port of Miami	North Biscayne Bay	*Thalassia* *Halodule*	shoots	2 ha 6 ha	av. 88% av. 54%	yes
1984	Dade County Homestead Marina	North Biscayne Bay	*Halodule*	shoots	2,833 m^2		yes
1983	Florida International University and National Resources Conservation Department	Jamaica	*Thalassia* *Halodule* *Syringodium*	Seeds Plugs Shoots Steel rod Clips Inert block	20 test sites approx.	*Halodule* 63%	yes
1982	Port of Miami	Biscayne Bay	*Thalassia* *Halodule* *Syringodium*	Seeds Plugs Shoots Steel rod Clips	15 ha	varying from 100% to 0% dependent on test plot and season	yes
1981	Latex Construction Co. and Florida Keys Aquaduct Authority	Lake Surprise	*Halodule*	Shoots Steel rod	6,475 m^2	100%	yes
1978	Port of Miami Miami-Dade Water and Sewer Authority	Biscayne Bay	*Thalassia* *Halodule*	Seeds	2 ha	80%	yes
1976	Port of Miami Miami-Dade Water and Sewer Authority	Biscayne Bay	*Thalassia* *Halodule*	Seeds	2 ha	80%	yes
1974	University of Miami Sea Grant	Biscayne Bay	*Thalassia*	Seeds	10 test sites	varying 0–80%	yes
1973	U.S. Department of Energy and Florida Power and Light, Co.	Turkey Point	*Thalassia*	Seeds	1,619 m^2	80%	yes

Table 25 Comparison between seagrass techniques (Thorhaug, 1986)

	Plugs	Seeds	Sprigs	Turfs
Cost	high	low	medium	medium
Flexibility of situation	high	medium	medium	medium
Mechanization	extraction	planting	planting	planting
Transport	costly difficult	easy	medium	medium
Damage to donor bed	high	none	medium	high
Use in high exposure areas	high	anchored only	medium anchored only	medium anchored only
Potential for survival	high	high	medium	high
Season for planting	can occur all year in tropics and subtropics	season differs for species	arctic, temperate, subtropics seasonal	can occur all year in tropics and subtropics
Total attempts	71	25	53	16
Successes	37	14	12 (some pending)	8

Table 26 Planting requirements of seagrass (Thorhaug, 1986)

Sediment:	Needs minimum sediment depth. Required sediment varies per species. Sand through mud appropriate for most species. Gravel to rock not appropriate.
Light penetration:	Needs minimum compensation level. Varies per species. Tropical much deeper compensation depth than temperate. Turbidity from land run-off strongly affects light penetration.
Tidal currents:	If high currents, heavy anchors with deep-rooted species. May be impossible in strong currents.
Wave energy:	High energy of open sandy beaches extremely difficult to restore. Only deep-rooted species with heavy anchors. Medium energy: with anchors only, deep-rooted species. Low energy: any species.
Salinity:	Varies greatly with species (*Ruppia* sp. the largest range). Intertidal species tolerate wider ranges. Limits not known for all species. Generally 15 to 45 parts per thousand.
Temperature:	Varies with species and ecological zone. Some species much more tolerant than others. Vicinity close to power plant effluents can be planted with tolerant species. Temperature may determine planting season. Winter poor in temperate and subtropics for many species.

Table 27 Seagrass transplanting projects in tropical-subtropical North America (Adapted from Phillips, 1982; in CSA, 1986)

Species	Propagules	Anchoring method	Location	Chemical additive	Substrate: Dredged material	Substrate: Native sediment	Success (%)	Reference
Thalassia testudinum	Vegetative shoots	Iron rods	Port Aransas, TX	10% NAPH		X	0	Phillips 1980
				None			0	
"	Vegetative shoots	Nails	Port Aransas, TX	None		X	0	Phillips 1980
"	Vegetative shoots	Wire mesh	Port Aransas, TX	None	X		0	Carangelo et al. 1979
						X	Limited (6 mo)	
"	Vegetative shoots	Iron rods, concrete blocks, wire mesh	Mississippi Sound, MS	None	X		0	Eleuteris 1974
						X	4	
"	Vegetative shoots	None	Mississippi Sound, MS	None	X	X	0	Eleuteris 1974
"	Vegetative shoots	Iron rods	Tampa Bay, FL	10% NAPH		X	0 - 100 (total of 30 short shoots tested)	Kelly et al. 1971
"				None		X	0 - 16.7 (total of 30 shoots tested)	
"	Vegetative shoots	Iron rods, plastic bags	Tampa, FL[a]	5% NAPH		X X	0 - 20 20 - 40	Van Breedveld 1975
"	Vegetative shoots	Concrete rings	Florida keys, FL[a]	None		X	0	Continental Shelf Associates, Inc. 1982
"	Plugs, turfs	None	Port Aransas, TX	None		X	73 (until sediment loading and cold killed)	Carangelo et al. 1979
Thalassia testudinum	Plugs, turfs	None	Port Aransas, TX	None	X		0	Carangelo et al. 1979
						X	Limited	
"	Plugs, turfs	None	Tampa Bay, FL	None		X	0	Phillips 1974
"	Plugs, turfs	None	Tampa Bay, FL	None	X		15	Kelly et al. 1971
						X	40	
"	Plugs, turfs	None	Tampa Bay, FL	None 5% NAPH		X	0 - 100 (hormones had no effect) (highest when done in winter, i.e., water less than 21°C)	Van Breedveld 1975
"	Plugs, turfs	None	Tampa Bay, FL	None		X	0 (test for effect of thermal effluents from power plant	Blake et al. 1974
"	Plugs	None	Florida keys, FL[a]	None	X X	X X	90 (2-m centers) 98 (1-m centers)	Continental Shelf Associates, Inc. 1982
"	Seedlings	Plastic	South Biscayne[a] Bay, FL Turkey Point, FL	10% NAPH		X	80	Thorhaug and Austin 1976
"	Seedlings	Plastic peat pots	North Biscayne Bay, FL	10% NAPH		X	5 - 33	Thorhaug and Hixon 1975
"	Seedlings	None	Florida keys, FL[a]	None		X X X	0 (2-m centers) 6 (1-m centers) 18 (1/3-m centers)	Continental Shelf Associates, Inc. 1982

Table 27 (Continued).

Species	Propagules	Anchoring method	Location	Chemical additive	Substrate: Dredged material	Substrate: Native sediment	Success (%)	Reference
Thalassia testudinum	Seedlings	Plastic tags[a]	Florida keys, FL	None			29 (raised in lab for 6 mo)	Continental Shelf Associates, Inc. 1982
Halodule wrightii	Vegetative shoots	Iron rods	Port Aransas, TX	10% NAPH		X	0	Phillips 1980
"	Vegetative shoots	Wire mesh	Port Aransas, TX	None	X 	 X	0 Limited	Carangelo et al. 1979
"	Vegetative shoots	Iron rods, concrete blocks, wire mesh	Mississippi Sound, MS	None	X 	 X	0 13	Eleuterius 1974
"	Vegetative shoots	No anchors, but placed in sediment in aquarium	Indian River, FL	0.05% NAPH 0.1% NAPH 0.5% NAPH 1.0% NAPH			28 45 73 75	Zimmerman et al. 1981
"	Vegetative shoots	Concrete rings	Florida keys, FL[a]	None		X	0 (2-m centers) 4 (1-m centers)	Continental Shelf Associates, Inc. 1982
"	Plugs, turfs	None	Port Aransas, TX	None		X	58 (until sediment loading and cold set in)	Phillips 1980
"	Plugs, turfs	None	Port Aransas, TX	None	X 	 X	0 Limited	Carangelo et al. 1979
Halodule wrightii	Plugs, turfs	None	St. Joe Bay,[a] FL	None	X		13 overall (after 1 yr) (ultimately eroded away by surge from hurricanes)	Phillips et al., 1978
"	Plugs, turfs	None	Florida keys, FL[a]	None		X X X	0 (2-m centers) (first planting) 0 (1-m centers) (first planting) 61 (1-m centers) (second planting using stocks from deeper water)	Continental Shelf Associates, Inc. 1982
Syringodium filiforme	Vegetative shoots	Iron rods, concrete blocks, wire mesh	Mississippi Sound, MS	None	X	X	0	Eleuterius 1974
"		Concrete rings	Florida keys, FL	None		X X	0 (2-m centers) 0 (1-m centers)	Continental Shelf Associates, Inc. 1982
"	Plugs	None	Tampa, FL[a]	None		X	100	Van Breedveld 1975
"	Plugs	None	Florida keys, FL[a]	None		X X	0 (2 m centers) 61 (1-m centers; those remaining expanded over 75 of a 49 m^2 plots)	Continental Shelf Associates, Inc. 1982
Ruppia maritima	Vegetative shoots	Wire mesh	Port Aransas, TX	None		X	0	Carangelo et al. 1979
"	Plugs	None	Port Aransas, TX	None		X	0	Carangelo et al. 1979 .

S. filiforme has not been used extensively in planting projects. The results, therefore, are insufficient to make conclusions on use or planting means.

Test plantings should be done before undertaking any large-scale seagrass restoration projects in Tampa Bay. The basic concept and design of the multiple-phase Port of Miami Seagrass Restoration Project is the best approach. If the inconsistencies that existed in Phase I of that project were avoided in future projects, this approach would allow one to identify the species, planting methods, and locations best suited for a large-scale planting project.

The loss of seagrass cover in Tampa Bay has been attributed to a reduction of light penetration to the bottom caused by an increase in substances in the water column in recent years. These substances can include suspended sediment, detritus, tannins, and phytoplankton and have been caused by dredge-and-fill activities and point and nonpoint discharges of surface water and sewage."

Table 28 reports the feasibility of restoration techniques (including seagrasses) and recommendations by CSA (1985).

Recommended Seagrass Restoration Techniques

Review of the Tampa Bay seagrass planting projects indicate that H. wrightii is the optimum species for additional restoration attempts. H. wrightii is the desired species due to the ability to tolerate environmental stress and pioneering capability. T. testudinum plantings have had limited success in Tampa Bay, moreover, T. testudinum does not grow as rapidly as H. wrightii.

Seagrass plantings commonly use seeds, shoots (sprigs), or plugs. Seeds are the easiest to plant in large areas, but are more susceptible to erosion. In addition, there is a lack of a seed source in Tampa Bay for Thalassia, Halodule and Syringodium. Shoot or sprig plantings require collection from donor beds or beach wrack. Seagrass sprigs can then be stapled to the bottom sediments to aid establishment (Figure 30). Seagrass plugs are acquired from donor beds or cultivated in peat pots. The plug is then inserted into the sediments and stapled to maintain in place.

The recommended technique for seagrass planting is to initially use H. wrightii sprigs or plugs. The spacing is dependant upon local erosion energies and project cost. Normally seagrass plantings occur on two to three foot centers. The planting units will require stapling to the sediments to prevent erosion. A minimum of five planted rows is recommended. T. testudinum plugs can be intermittently placed to aid in natural succession by this species.

Table 28 Feasibility and Recommendations For Habitat Restoration (CSA, 1986)

Habitat type	Feasibility of mitigation/ restoration	Recommended planting species	Recommended planting technique	Recommended approach(es)	Potential problems	Potential use of dredged material
Mangrove	Good	*Rhizophora mangle* *Avicennia germinans* *Laguncularia racemosa* (depending on site elevation)	Seeds or seedlings	Improve existing mangrove habitats; plant within existing mangrove habitats; precondition areas by planting with *S. alterniflora*	Slow growing; Highly susceptible to waves, erosion, etc.; sensitive to soil conditions (nutrient contents elevation)	Not recommended unless protected from waves and human interference
Salt marsh	Good	*Spartina alterniflora* *Juncus roemerianus* (depending on site elevation)	Sprigs or plugs	Plant in newly created habitats, e.g., dredged material islands	Requires proper soil elevation; May require fertilizers; May require protection by breakwaters in high energy environments	Recommended
Seagrass	Poor	*Halodule wrightii* *Thalassia testudinum*	Plugs, shoots, or seedlings	Test planting designs with experimental plantings to identify species, location, and method of planting	Need to improve water quality	Possibly
Mud flats	Good	N/A[a]	N/A	Include in design of large mitigation/ restoration projects	Requires proper elevation and low-wave energy	Recommended
Artificial Reefs	Good	N/A	N/A	Reef should be constructed to enhance specific targeted species (e.g., lobsters, finfishes)	Inadequate monitoring of past projects to predict problems	N/A
Oyster Reefs	Good	*Crassostrea virginica*	Cultch or seed oysters	N/A	Need to improve water quality	Possibly

[a]N/A = not applicable.

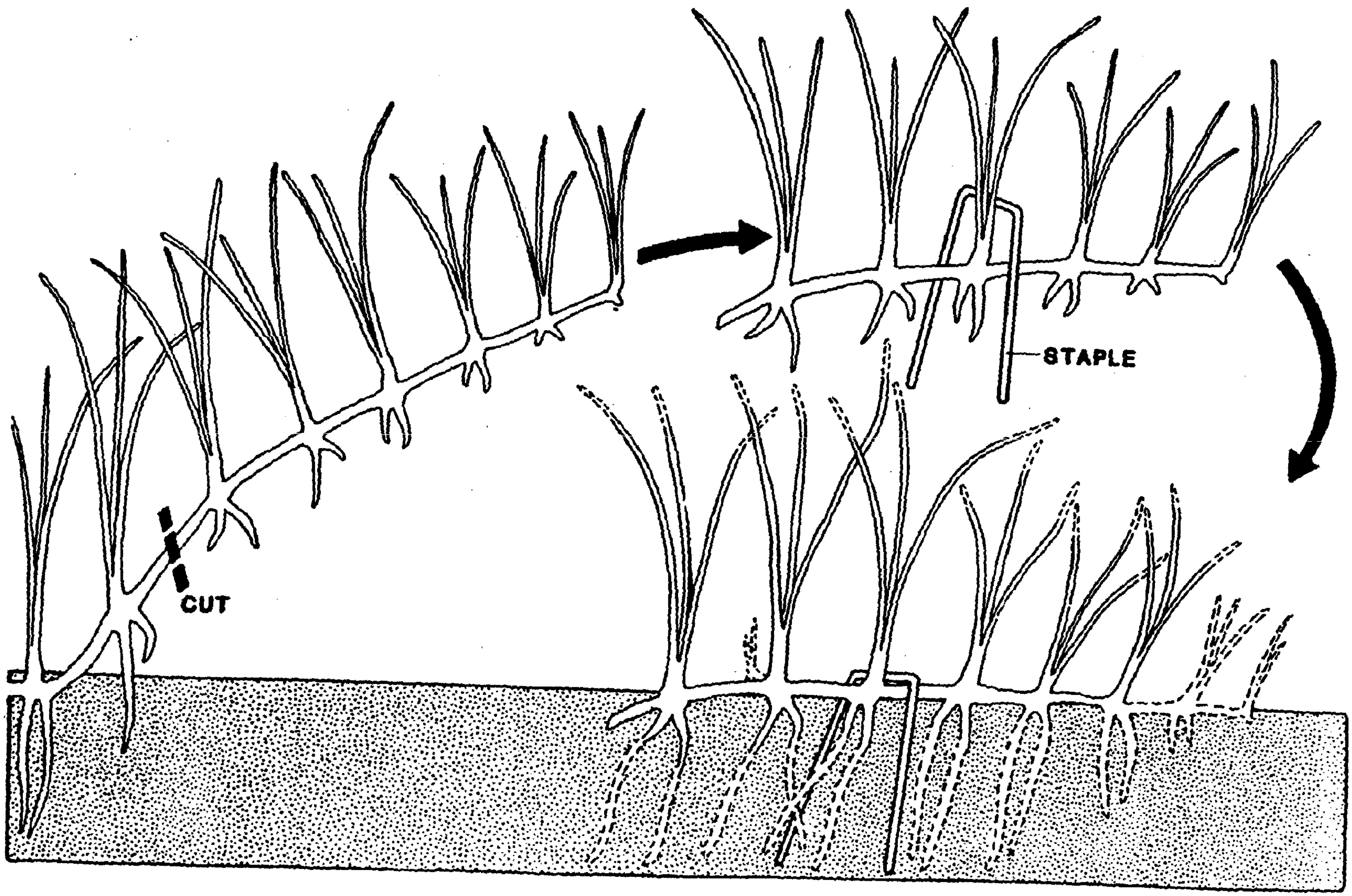


Figure 30 Transplantation of _Halodule_ Sprig for Habitat Restoration (Adapted from Derrenbacker and Lewis, 1981)

Additional considerations include:

- local water quality conditions
- erosional force attenuation
- sediment composition and consolidation
- planting depth and tidal range
- public degradations

All of these factors will need to be controlled or monitored to ensure a successful functioning habitat through revegetation efforts.

Benthic Algae: Review and Recommendations

The use of benthic algae for restoration of habitat, to date, has not been evaluated for Tampa Bay. Dawes (1982) has identified 221 taxa of macroalgal flora in Tampa Bay including 23 blue-green, 68 green, one xanthophyte, 30 brown and 99 red algae.

One experimental transplanting project has been accomplished by Mangrove Systems, Inc. for MacDill Air Force Base in October 1986. Initial observations of transplanted *Caulerpa prolifera* at the two-week post-planting inspection indicated that 85 to 90% of the 2,000 units initially installed were surviving and appeared to be rooted (Mattson, personal communication).

Additional studies are necessary to better understand the contributions of macroalgal to support habitat for fish and wildlife. However, due to the wide distribution and ability to tolerate environmental stress, macroalgae is available to potentially stabilize sediments and allow colonization of vascular aquatic vegetation. *C. prolifera* is an attached benthic algae that occurs in dense beds in Tampa Bay. Collection of the material can be acquired from donor beds by means of a post hole digger or other hand tool. The algae can then be stapled to the bottom to facilitate establishment. The planted area should be monitored for:

- plant establishment
- spreading
- seagrass colonization
- sediment stabilization
- wildlife utilization

The results of benthic algae transplants should be carefully evaluated to determine future applications in habitat restoration.

Oyster Bars: Review and Recommendations

Oysters have been an important food item for the coastal dwelling man for thousands of years. Locally, this is evidenced by the many large Indian shell mounds surrounding Tampa Bay. Due to man's development within the Tampa Bay watershed, many shellfish areas are no longer safe for human harvesting and consumption. Figure 31 identifies approved or conditionally

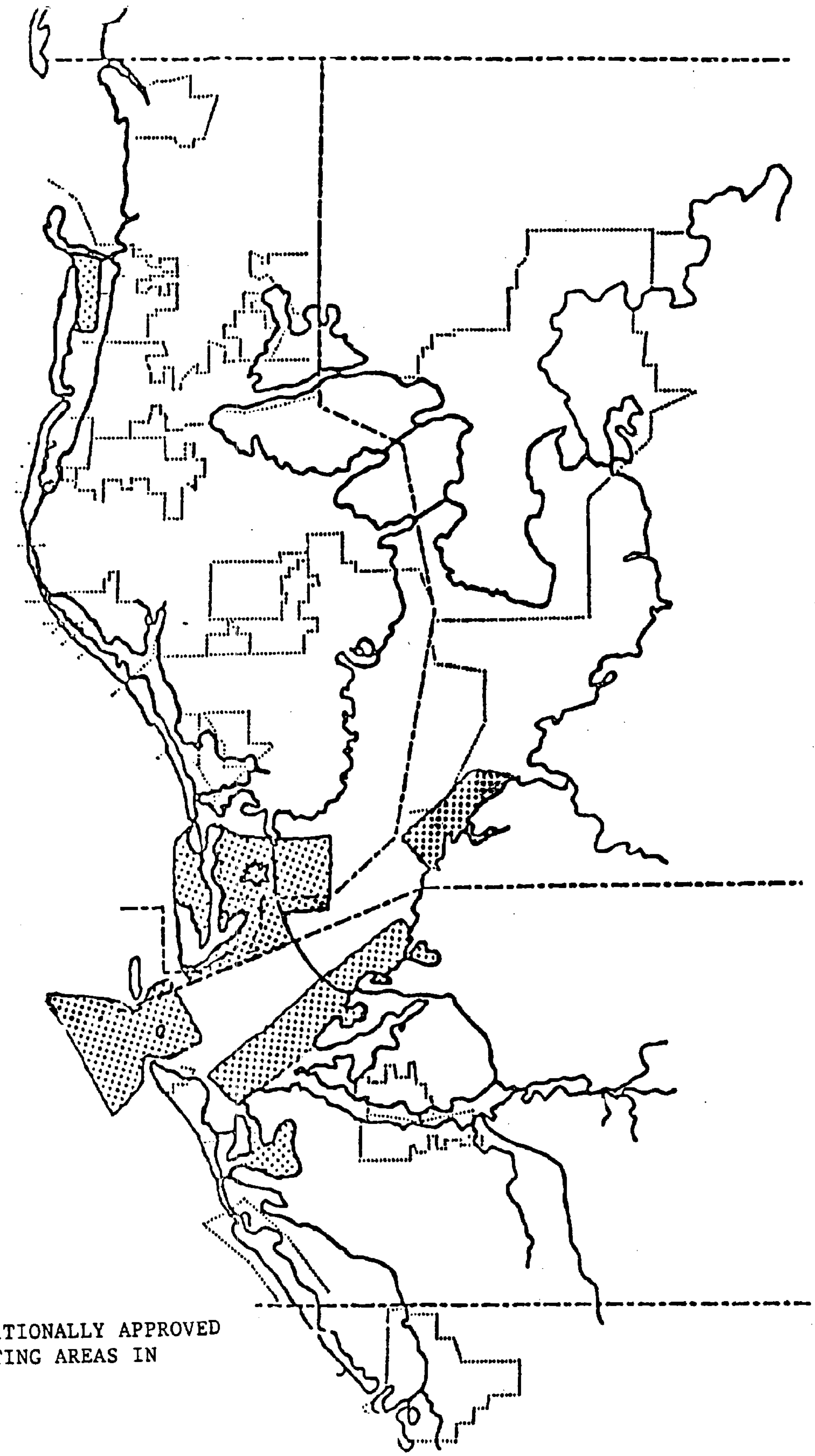


Figure 31

APPROVED OR CONDITIONALLY APPROVED SHELLFISH HARVESTING AREAS IN TAMPA BAY approved shellfish harvesting areas in the three counties surrounding Tampa Bay.

Mote Marine Laboratories (MCUD, 1984 in FDNR Draft, 1985a) studied two natural and one artificially created oyster reef to qualitatively evaluate environmental stress. Results indicated no statistical differences between the oyster reefs and associated fauna utilizing the systems. This signifies that created oyster bars can be used for successful restoration of an important ecological community.

Creation of oyster beds can best be accomplished by the deposition of substrate (cultch) for the attachment of larval oysters (spat). Cultch material can be a variety of material including limestone rubble, concrete, or tires, but the most successful material is old oyster shells (mined or shucked). Cultch deposition can be used to enlarge existing oyster beds or create new oyster communities in shallow barren estuarine areas.

The creation/restoration/enhancement of oyster beds in Tampa Bay can provide harvestable shellfish in approved harvesting areas. In prohibited areas the oyster beds can assist in the continued growth of the beds, and provide efficient biological filtering agents and valuable fisheries habitat.

Borrow Pits: Review and Recommendations

Upland and subtidal borrow pits are located in numerous areas within the Tampa Bay Region. The subtidal pits are relics of historic unregulated dredge and fill development. In the post World War II era, a common practice was to dredge bay bottom sediments and then cast the material on adjacent areas to create developable uplands. Subtidal borrow pits occur next to many of the causeways, estuarine beaches and finger fill developments in the region.

Borrow pits have numerous inherent problems. The bottom of the pits are usually one to three meters below the adjacent undisturbed bay bottom. The increase in bottom depth allows fine particles (silt or clay) to settle out instead of being transported with normal "uniform" bottom currents. Therefore, the pits become "sinks" for the finer materials in a lower circulation environment. The problem is perpetuated by low dissolved oxygen (DO) concentrations reported in the pit bottom then in surrounding bay bottom areas. The accumulation of fine material and lowered DO concentrations identify the borrow pits as sources for poor water quality.

In addition, the lowering of bottom depth in borrow pits commonly removes the benthic area from the photosynthetic zone. Without available light, the borrow areas are normally too deep for reestablishment of seagrass. Benthic infauna and wildlife usage of the borrow pits is speculated to be minimal, but is not adequately documented to date.

A submerged 3.9 ha borrow pit at Lassing Park was filled in August 1984 to remove a public hazard. Filling of the pit provided additional acreage for potential seagrass establishment. CSA (1986) reviewed the site and reported colonization by benthic algae and benthic onuphid polychaete tubes. Filling of the borrow area demonstrated that suitable material can be successfully used to attain the elevation of adjacent bay bottom.

Restoration of borrow pits is normally accomplished by filling the pit with clean, suitable fill material to raise the bottom within the photic zone. Overfilling of the pit may be necessary to allow sediment consolidation. Fill material placement requires care to prevent the fine materials from being displaced into the water column, creating a water quality problem. One potential solution can be to use larger rubble to infill and then capping the rubble with coarser sandy fill material. After sediment consolidation, the benthic area can then be revegetated with vascular aquatic submerged vegetation.

As an alternative, the pits can be filled with large rubble or suitable construction material to create an artificial reef. The hard material will allow organism attachment (oysters, sponges) and bottom relief for pelagic species (fish).

Artificial Reefs: Review and Recommendations

Artificial reefs have received growing attention in Florida. Artificial reefs are man-made formations created from scrap material (construction debris, ship hulls, automobile bodies and tires) placed on the bottom sediments to enhance fish habitats in coastal and estuarine waters. When properly constructed, these reefs can provide hard-bottom habitat for attached organisms and increase total fish biomass without detracting from the biomass potential of the area (Stone et al. 1979).

Artificial reefs should be constructed to enhance the production of selected fisheries that have experienced or are expected to experience declines. For many years the Japanese have been designing and constructing reefs to enhance specific mollusk, crustacean, or finfish fisheries (Stone, 1982). In 1965, the City of Clearwater (Pinellas County) built and emplaced 200 Japanese-style "pill box" reef units to enhance lobster habitat. Each box measured 2.4 m x 1.2 m x 0.9 m and had 46-cm diameter holes in the sides and top. Due to inadequate planning and improper placement, however, only 20 units can be found in the intended area of placement, while the rest are scattered over an unknown area of bottom (Sheehy, 1982). Panama City and Jacksonville were selected as sites to test Japanese fiberglass reinforced plastic reefs in Florida (Sheehy, 1982). The reefs have been installed and are currently being monitored (CSA, 1986).

There are 173 permitted artificial reefs in Florida (Aska and Pybas, 1983). Most have been constructed in offshore coastal waters, but a few have been constructed within estuarine embayments. Mathews (1985) compared two artificial reef projects, Pinellas Point and St. Petersburg Reef, in Tampa Bay. The results of the study indicated that:

"These artificial reefs do increase habitat for benthic invertebrates and fish, and when built in the photic zone they also provide substrate for benthic algae growth that increases the food available up the food chains leading to the higher trophic levels. The limited observations of these inshore reefs also indicate that they have a very heavy juvenile population of many important food and game fish species, so there can be no doubt that they are serving as more than just a concentrator of existing species as was originally thought."

Design and construction of artificial reefs must consider local conditions and material composition for success. Factors affecting successful construction include:

- Bottom sediment composition
- Benthic biotic usage
- Water quality
- Current velocity
- Accessibility
- Decomposition of material
- Proximity to navigational channels
- Sedimentation

Ideal areas for artificial reef construction include:

- Unvegetated or barren locations in the Gulf of Mexico
- Well-mixed estuarine waters on barren benthic surfaces with sediment characteristics that will support artificial reef material.

In addition to the ability of artificial reefs to concentrate benthic fish species into areas easily accessible to fishermen, Mathews (1966, 1986) identified that when the reefs are built in the photic zone, the primary production within the water column increases. Proper artificial reef construction and placement within the Tampa Bay Region will aid in providing additional habitat for aquatic organisms.

INTERTIDAL SYSTEMS

Review of Intertidal Restoration

Salt marshes are herbaceous plant communities in the intertidal zone of estuaries (Kruczynski, 1982). In Florida, salt marshes are found north of Daytona Beach along the east coast, and north of Tarpon Springs along the west coast and panhandle. Farther south, mangrove communities predominate and marsh plants are typically pioneers in marginal or newly formed habitats. Common intertidal species in Florida are Spartina alterniflora (smooth cordgrass), Rhizophora mangle (red mangrove), Avicennia germinans (white mangroves), and Laguncularia racemosa (black mangroves) which are found between mean sea level and mean high tide level (low marsh); and Juncus roemerianus (black needlerush), which is found above the mean high tide level (high marsh) and in areas of lower salinity. Other grasses, such as Distichlis spicata and Paspalum vaginatum and succulents, such as

Batis maritima, Salicornia virginica, and Sesuvium portulacastrum, are also found in the high marsh.

Intertidal habitat restoration projects in Tampa Bay, to 1982, have been reviewed by Hoffman et al. (1985) and illustrated in Table 29. The most common reason for habitat creation, to date, has been mitigation for habitat destruction. The most common practice utilized for smooth cordgrass establishment was culm or plug transplants while mangroves were predominantly transplanted from mature field stock. Hoffman et al. (1985) further described intertidal vegetation projects accomplished in Tampa Bay as follows:

> "The greatest growth rates are seen for plantings of Spartina alterniflora (up to 1100% for 14 months at Sunken Island). Growth rates over 100% reflect an increase in culm number from the original planting due to the rhizomatous growth typical of cordgrass. Figure 32 shows an example of S. alterniflora planting and 14- and 24- month growth. Within two years, the original rows (2 m apart) are obscured due to coalescence of individual plugs. Note the pioneer mangrove seedlings in Figure 32C, which have been trapped in the cordgrass, a process noted by Lewis and Dunstan (1976).
>
> A number of factors affect success of an intertidal planting, in addition to wave energy and tidal elevation. If local residents did not want the planting and had access to it, they destroyed the planting. This occurred at the Cockroach Bay site where mangrove transplants were uprooted. The survival at Simmons Park ranged from 0 to 250% over the first six months. The low figure reflects areas where fishermen trampled the plugs, while those areas remote to traffic were unaffected and grew normally. At Apollo Beach, the mangrove seedlings were planted while still in plastic containers. The plants died within nine months due to an inability to produce a sufficient root mass. Neptune Lagoon is an example illustrating the importance of proper tidal elevation. Tidal elevations of the planting were lower than those specified (by approximately 5 cm). As a result, S. alterniflora in the upper portions of the planting survived and coalesced within the expected amount of time while that in the lower areas did not survive. Time of year may have been critical to the mangrove transplants on CDA-D. Of the first 100 trees which were planted in December, all experienced leaf drop during the period from December - February. Only 34 of these trees recovered, indicating that the stress of low temperatures had compounded the stress of transplanting.
>
> The poorest survival rates were on CDA-2D for the original plantings of S. alterniflora nursery stock and R. mangle seedlings, probably due to poor substrate quality and improper plant installation. While J. roemerianus showed a 50% survival rate, it also exhibits a rhizomatous growth habit and has the potential for greater than 100% survival (i.e. through spreading). However, spreading is lower than Spartina (Lewis, 1983)."

Table 29 **Intertidal habitat restoration** projects in Tampa Bay to 1982. R = random planting; N/A = not available; + = survival is evident; however, no quantity available. PURPOSE: TP = test planting; M = mitigation; HR = habitat restoration; EC = erosion control. TECHNIQUE: P = propagule; CT = culm transplant; NS = nursery seedling; T = transplant; PT = plug transplant (Hoffman et al. 1985)

Project Site (Reference)	Date Planted	Plants Used	Purpose	Number Planted	Technique	Area Covered	% Survival /Time (mos.)
Howard Frankland (Savage 1972)	Sep 71	R. mangle	TP	61	NS	R	67.2/3
Terra Ceia (Savage 1972)	Apr 71	R. mangle	TP	5	T	R	60.0/6
	Apr 71	A. germinans	TP	5	T	R	80.0/6
	Apr 71	L. racemosa	TP	5	T	R	0/6
Mullet Key (Pulver 1976)	Mar 73	R. mangle	TP	40	T	R	100/12
	Mar 73	A. germinans	TP	40	T	R	95.0/12
	Mar 73	L. racemosa	TP	40	T	R	100/12
Fishhook Spoil (Lewis and Dunstan 1976)	Jul 74	R. mangle	TP	100	P	10 m^2	25/72
(Lewis and Dunstan 1977)	Sep 76	S. alterniflora	TP	36	CT	36.0 m^2	741/10
Archie Creek (Lewis et al. 1979)	May 78	S. alterniflora	M	2,127	CT	2127 m^2	75/12
Apollo Beach (Fehring et al. 1979)	Jun 78	R. mangle	M	275	NS	275 m^2	74.5/5
Cockroach Bay (Durako, unpub. data)	Sep 78	R. mangle	M/TP	45	T	400 m^2	88.9/6
	Sep 78	A. germinans	M/TP	45	T	400 m^2	51.1/6
	Sep 78	L. racemosa	M/TP	63	T	400 m^2	66.7/6
Neptune Lagoon (Fehring et al. 1979)	Dec 78	S. alterniflora	M	700	PT	700 m^2	64.0/5
Sunken Island (Hoffman and Rodgers 1981)	Mar 79	S. alterniflora	HR	7,261	PT	1.64 ha	1100/14
(Hoffman, unpub. data)	Oct 79	S. patens	HR	300	CT	300 m^2	230/3
CDA-D (Hoffman and Rodgers 1981)	Jun 79	A. germinans	M	947	T	0.32 ha	63.0/13
	Jun 79	L. racemosa	M	566	T	0.19 ha	37.0/13
Palm River (Courser and Lewis 1981)	Jun 79	S. alterniflora	EC	1,050	PT	326 m^2	20.0/6
	Jun 79	P. vaginatum	EC	400	PT	368 m^2	100/6
CDA-2D	Dec 79	S. alterniflora	M	N/A	NS	N/A	0/2
	Dec 79	S. patens	M	N/A	NS	N/A	+/2
	Dec 79	R. mangle	M	N/A	NS	N/A	0/2
Manatee River (Lewis 1981)	Jun 80	J. roemerianus	M	21,000	PT	3.04 ha	50/22
Channel A (Hoffman, unpub. data)	Sep 80	S. alterniflora	EC	8,091	PT	0.81 ha	235/6
Simmons Park (Hoffman, unpub. data)	Sep 80	S. alterniflora	EC	7,999	PT	0.80 ha	97.0/6
CDA-2D (Philp, unpub. data)	Jun 81	S. alterniflora	M	N/A	PT	2.0 ha	+/12

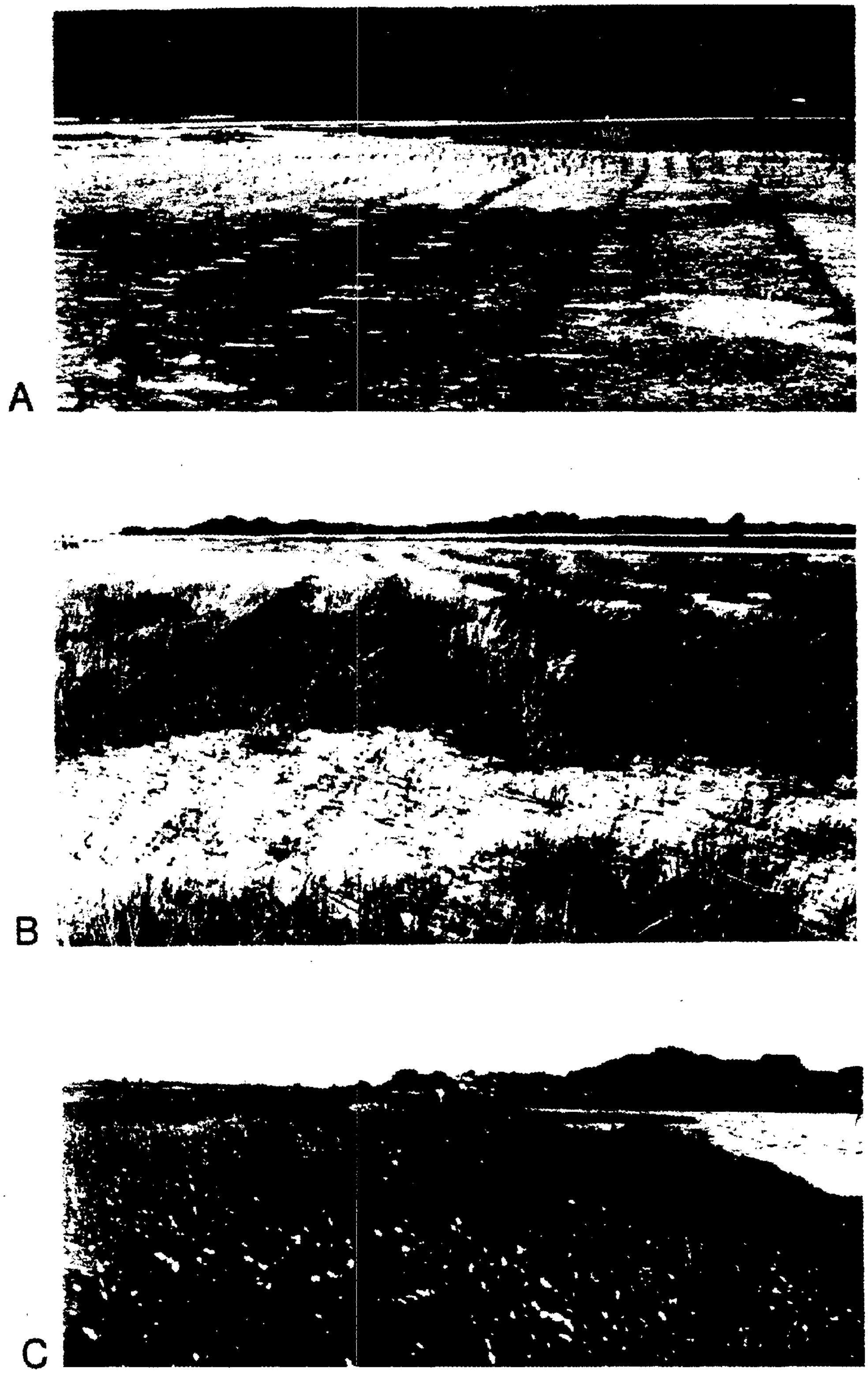


Figure 32 *Spartina alterniflora* at zero (A), 14 (B) and 24 (C) months after planting (Hoffman et al. 1985)

Hoffman et al. (1985) recommended further research into the use of air-layering to provide planting material for establishment of mangroves and other herbaceous salt tolerant vegetation. This is anticipated to reduce cost of planting units and degradation of donor beds.

CSA reviewed four S. alterniflora sites, three mangrove and S. alterniflora sites, two mangrove sites and one J. roemerianus marsh site. Many of the sites (Table 30) have been previously reviewed by Hoffman et al. (1986) (Table 29). CSA (1986) performed follow-up site inspections and results are reported to accumulate available information for the Tampa Bay Region. Major factors affecting establishment of mangroves reported by CSA (1986) included erosion and failure to restore the restoration site to appropriate elevations. The evaluation reported excellent growth for S. alterniflora can be achieved in Tampa Bay given the proper conditions. Additional recommendations and restoration techniques are shown in Table 28 by CSA (1986).

Factors contributing to poor survival include: failure to restore the habitat to appropriate elevations; shoreline erosion; poor maintenance (i.e., removal of exotic vegetation, floating debris, etc.); competition by high marsh or upland plants; and poor planting technique (CSA, 1986).

The J. roemerianus marsh restoration site is reported as containing only 50 percent survival of planted species after 22 months. The poor success of the Branches Hammock Juncus marsh project is attributed to improper planting elevations and slow growth rate (CSA, 1986).

Detweiler et al. (1975) reviewed secondary succession in a disturbed mangrove community. The report detailed zonation patterns of intertidal vegetation reestablished in the disturbed area and within a natural adjacent area. The results identify the average elevation in which 13 plant species occur in disturbed and in natural areas south of Apollo Beach (Table 31). Although tidal amplitude varies throughout the region, Table 31 identifies the zonation and elevations in which these species naturally occur and are capable of recolonization within this particular location.

The Bureau of Marine Research (FDNR) and Mangrove Systems, Inc. are compiling information for a database concerning previous coastal restoration/mitigation projects. The database will include information on mangrove saltmarsh and seagrass species and how they were incorporated into restoration/mitigation efforts. To date, approximately 50 percent of the site visits scheduled for emergent saline - adapted vegetation communities have been accomplished (Crewz, personal communication to Bell, 1986). Identified as the limiting factors of vegetational survival and expansion are elevation, slope, and concomitant drainage patterns. Crewz (Personal communication to Bell, 1986) tabulated available information and recommended:

> "Although I feel we lack adequate scientific perspective concerning restoration/mitigation methodologies and their subsequent impacts, some of the following considerations may enhance interim monitoring capabilities and rule-making:

Table 30 Summary of information on selected mitigation/restoration projects in Tampa Bay (CSA, 1986)

Habitat type called for in restoration	Project name	Reasons for restoration	Time of restoration	Size of planted plot (ha)	Wetland habitat loss (ha)	Permanent loss (ha)	Survival after 1 yr %	Average density (at time of study) per m^2
Spartina	Archie Creek	Mitigation	1978	1.82	1.5	0	75	230
	Sunken Island	Habitat enhancement	1978	1.64	NA.[a]	NA.[a]	93.4	102
	Feather Cove	Enforced mitigation	1983 and 1984	0.6 2.5	4	b	90 <10	163 0
	Placido Bayou	Mitigation	1983	1.0	1.0	b	70	31
Mangrove and *Spartina*	Palm River	Erosion mitigation	1979	0.012	Unknown	c	19	ND
	Fantasy Island and Spoil Island and 2-D	Mitigation	1979 and 1981	2.12	2.1	c	73.3[d]	3[d] 110[f]
Mangrove	Apollo Beach	Enforced mitigation	1974	1.6	110+	b	<10	10-17
	Harbor Island	Enforced mitigation	1974	10	10	b	<10	0
Juncus marsh	Branches Hammock	Mitigation	1980	2.32	2.86	1.9	50[e]	ND
Subtidal fill	Lassing Park	Safety	1983	3.9	NA.[a]	NA.[a]	NA.[a]	NA.[a]

[a] Not applicable.
[b] Cannot be determined with existing data.
[c] Permanent losses occurred, but area cannot be determined with existing data.
[d] % mangroves only.
[e] % survival after 22 months.
[f] *Spartina* only

Table 31 Elevation ranges and mean (x) elevation of 13 plant species found in a control (C.A.) and disturbed (D.A.) areas of a mangrove community (elevation in feet). (Detweiler et al. 1975)

Species	No. of Quadrats	range	$\bar{x}$	No. of Quadrats	range	$\bar{x}$
Laguncularia racemosa	47	+2.5 - +0.7	+1.5	28	+2.3 - +0.4	+1.2
Avicennia germinans	49	+2.5 - +0.4	+1.5	22	+2.3 - +0.4	+1.4
Rhizophora mangle	35	+1.6 - +0.2	+1.0	3	+1.2 - +0.9	+1.1
Salicornia virginica	10	+1.9 - +1.6	+1.7	48	+2.3 - +0.6	+1.5
Spartina alterniflora	4	+1.7 - +1.6	+1.7	26	+1.9 - +0.6	+1.7
Batis maritima	14	+212 - +1.6	+1.8	10	+2.3 - +1.0	+1.7
Limonium carolinianum	6	+1.7 - +1.6	+1.7	4	+1.9 - +0.9	+1.5
Sporobolus virginicus	-	-	-	4	+1.9 - +0.9	+1.6
Sesuvium portulacastrum	2	+1.7	+1.7	2	+2.2 - +1.4	+1.8
Paspalum vaginatum	-	-	-	1	+1.9	+1.9
Monanthocloe littoralis	-	-	-	1	+2.0	+2.0
Philoxerus verminicularis	5	+2.2 - +1.6	+1.9	-	-	-
Borrichia frutescens	2	+1.9	+1.9	-	-	-

1) Although planting densities are usually specified, the rationale for densities and arrangement of units is often vague. Frequently, plants are placed in areas in which elevational criteria, considered over the entire year, is lacking. For example, because of varying site characteristics, seedling red mangroves may not be the appropriate unit at lower elevations, even though adult mangroves may be established at the same level. In addition, variation throughout the year in tidal amplitude requires specific planting times for establishment. Also, what are desirable planting densities? Should not natural rates of colonization be emulated in planting design for some species? In many areas propagules are extremely dense and only vigorous individuals survive. I believe that denser plantings than heretofore required should be considered in order to enhance rate of recovery and quality of survivors.

2) As mentioned above, elevation is likely a critical factor in survival and spread of planting units. Consideration needs to be given to methods for establishing contours and follow-up measures to ensure that elevations are as reported. Included in elevational concerns is the rationale for creating suitable slopes and drainage systems, such as dendritic channels; complete flushing through the year may be critical to plant (and habitat) quality. In addition to adequate flushing, well designed drainage systems provide avenues for continual natural colonization, thereby further enhancing recovery. Inherent in all restoration/mitigation attempts is the requirement for extensive connectivity to the entire marine ecosystem. Connectivity maximizes habitat utilization and contribution to marine productivity.

3) Mitigation sites must have heterogeneity designed into them (e.g., channels, flats, species zones). It is not enough to plop a few plants around and write the area off when some of them take root and spread. Unfortunately, at this time heterogeneity relationships have not been defined to the extent needed. Comparative values of similar acreages of wetlands have not and may never be established. As a consequence, the concept that the mitigation/environmental preservation dilemma is resolvable has not been demonstrated adequately. In the final analysis, the potential for dynamic change within a given area contributed substantially to habitat value; absolute acreage is not a true measure of resource quality.

4) Monitoring of sites is difficult, especially if the reviewer is not familiar with the extent of the area. Key elevations need to be determined in order to detect trends of accretion or subsidence. In order to facilitate comparison, permanent benchmarks should be established in a place convenient to the site. This means that costs entailed for follow-up personnel must be included in original design estimates. In addition to a benchmark, "permanent" and easily visible markers should define the site for future monitoring, "permanent" sample plots and/or

transects for monitoring should be established, and areas of heterogeneous planting should be clearly delineated.

5) Standards for 'success' should be established. Coupled to this is sampling methodology. 'How many samples and when should they be taken?' 'What size are sample units and how will site size and shape affect monitoring results?' These questions address critical concerns that must be worked out beforehand.

6) Criteria for post-mitigation site protection should be formulated. Pedestrian access, dumping, and trash intrusion severely damage growth of planting units. 'Should fencing or signs be used to prevent access?' 'Is rubble appropriate to prevent boat-wake damage?'

7) Development of mitigated areas should be discouraged. Continual pressure to develop shallow wetland areas will ensue from mitigation laws and will result in increased degradation of the environment, both wetland and upland. There must be a clause of vulnerability limitation, at least until the site is 'mature,' if such a condition can be determined. Mitigation directives will result in habitat loss, but where the habitat comes from will be determined by how laws are written.

8) Another area of concern is regulation of businesses which are involved in planting and follow-up activities. Inexperienced individuals seeking to make a fast buck must be prevented from implementing low quality mitigations. Possibly licensing and bonding may be required to demonstrate experience and reliability.

9) Efforts should be made to standardize plant species and selection for forms that do best under certain conditions. For example, studies show that marsh hay (Spartina patens) clones from dunes will not do well in marsh situations, but marsh clones will survive in dunes. Businesses which provide plants should be required to demonstrate sources and type of material used (i.e., nursery grown vs. field stocks, etc.).

10) Monitoring is costly. If excessive costs accrue to the state, the developer should be required to bear the burden of monitoring activities. We do not need more laws that cannot be enforced, so regulatory agencies should receive adequate additional funding.

11) Regulatory and other monitoring personnel should receive schooling and follow-up courses or workshops which ensure standardization of evaluation."

Consideration of the natural extent of tidal influence is the primary factor affecting successful establishment (CSA, 1986). However, wave climate can have a direct impact on plantings by increasing erosion or burial. Knutson et al. (1981) developed a procedure to evaluate the effect of erosion on potential revegetation projects using fetch, shoreline geometry and sediment types (Figures 33).

Spartina alterniflora Recommendations

Spartina alterniflora is accepted as a quick growing, sediment stabilizer for initial planting of intertidal areas. In addition, the S. alterniflora plantings trap mangrove seeds and protect the seedlings through early growth (Lewis and Dunstan, 1976). CSA (1986) recommend S. alterniflora for mitigation planting by stating, "...because of its pioneering role, (S. alterniflora) should be considered as the primary species to use for intertidal wetland revegetation projects in Tampa Bay; however, to compensate for the time lag in recovery of the mangrove habitat, a greater amount of area should be restored than was lost."

Revegetation projects in Tampa Bay predominantly use S. alterniflora and/or red mangrove (R. mangle). Woodhouse and Knutson (1982) compiled knowledge gained from previous studies and summarized planting techniques and guidelines for common salt marsh vegetation. The following techniques have been used to plant the salt marsh vegetation found in Florida (Woodhouse, 1979; Woodhouse and Knutson, 1982 in CSA, 1986):

1) seeds planted 1 to 3 cm deep in the upper 20% to 30% of the tidal range

2) sprigs or culms, intact single stem plants taken from nursery grown plants or plugs, planted 10 to 15 cm deep in holes

3) plugs or plants with sediment intact, taken from natural stand and planted into a hole, and

4) nursery grown plants in peat pots planted in a hole.

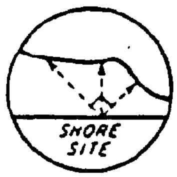
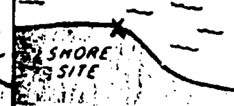
Figure 34 illustrates a plug and sprig used in habitat restoration projects.

Although a seed source from S. alterniflora exists in Florida, neither the planting of seeds nor their use for nursery growing have occurred extensively. Lewis (1982) stated that most seeds of S. alterniflora harvested in Florida, to date, are either sterile or damaged by insects.

Additional factors affecting successful establishment of salt marsh revegetation include tidal evelation, salinity levels, wave climate and soil composition.

Mangrove Recommendations

Mangroves are an important natural resource in coastal south Florida. They protect shorelines, contribute detritus to estuarine food webs, and provide habitat for a variety of animals, including commercially important fishes and wildlife (Teas, 1977; Odum et al. 1982). Three mangrove species are found in south Florida: Rhizophora mangle (red mangrove), Avicennia germinans (black mangrove), and Laguncularia racemosa (white mangrove). R.

1. SHORE CHARACTERISTICS	2. DESCRIPTIVE CATEGORIES (SCORE WEIGHTED BY PERCENT SUCCESSFUL)				3. WEIGHTED SCORE
a. FETCH-AVERAGE AVERAGE DISTANCE IN KILOMETERS (MILES) OF OPEN WATER MEASURED PERPENDICULAR TO THE SHORE AND 45° EITHER SIDE OF PERPENDICULAR  	LESS THAN 1.0 (0.6)	1.1 (0.7) to 3.0 (1.9)	3.1 (1.9) to 9.0 (5.6)	GREATER THAN 9.0 (5.6)	
	(87)	(66)	(44)	(37)	
b. FETCH-LONGEST LONGEST DISTANCE IN KILOMETERS (MILES) OF OPEN WATER MEASURED PERPENDICULAR TO THE SHORE OR 45° EITHER SIDE OF PERPENDICULAR  	LESS THAN 2.0 (1.2)	2.1 (1.3) to 6.0 (3.7)	6.1 (3.8) to 18.0 (11.2)	GREATER THAN 18.0 (11.2)	
	(89)	(67)	(41)	(17)	
c. SHORELINE GEOMETRY GENERAL SHAPE OF THE SHORELINE AT THE POINT OF INTEREST PLUS 200 METERS (660 FT) ON EITHER SIDE	COVE  	MEANDER OR STRAIGHT  	HEADLAND  		
	(85)	(62)	(50)		
d. SEDIMENT[1] GRAIN SIZE OF SEDIMENTS IN SWASH ZONE (mm)	less than 0.4	0.4 – 0.8	greater than 0.8		
	(84)	(41)	(18)		
4. CUMULATIVE SCORE					

5. SCORE INTERPRETATION			
a. CUMULATIVE SCORE	122 – 200	201 – 300	300 – 345
b. POTENTIAL SUCCESS RATE	0 to 30%	30 to 80%	80 to 100%

Figure 33 Form for evaluating the effect of wave climate on a potential salt marsh planting site (from Knutsen and Woodhouse 1983).

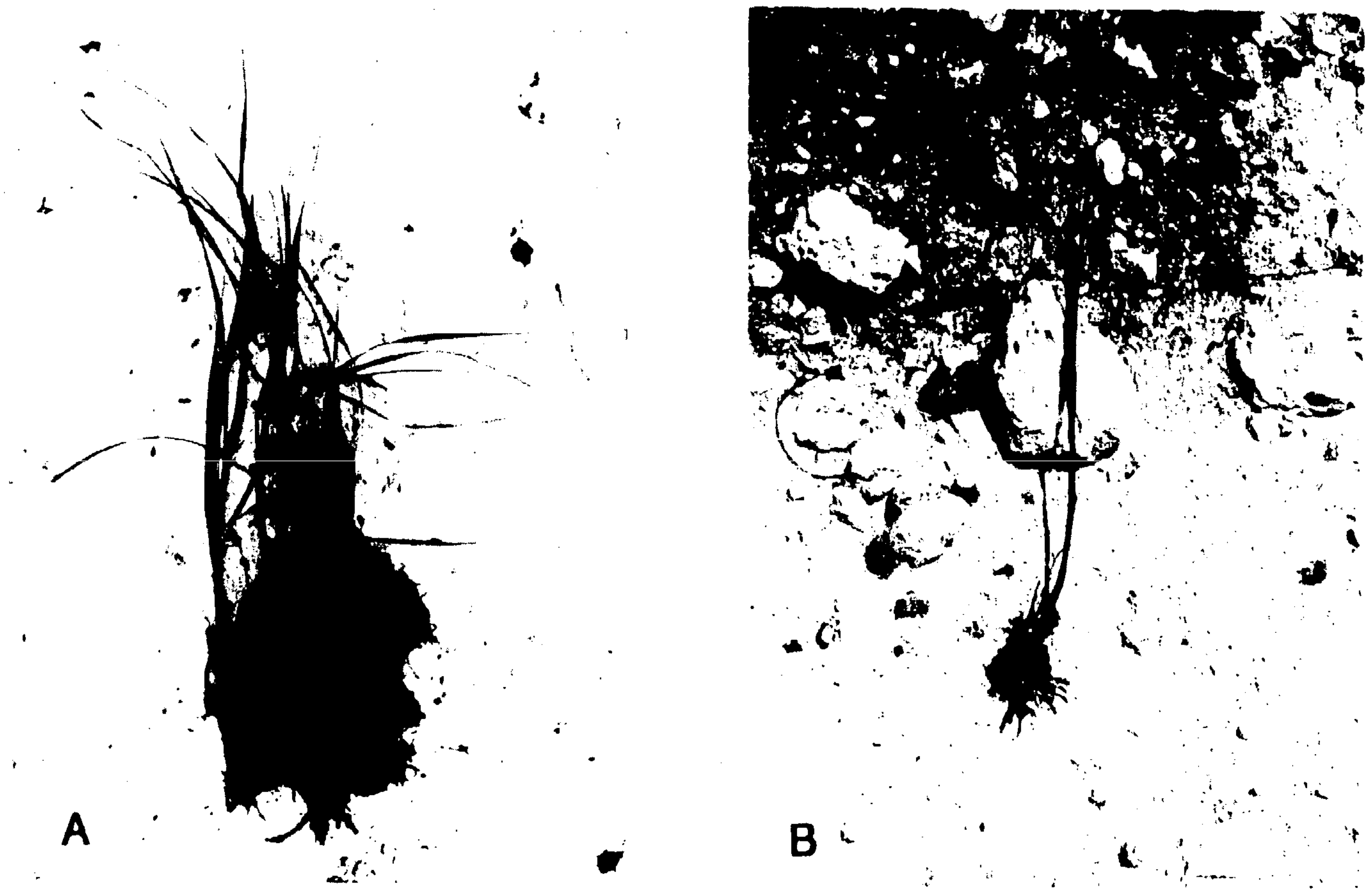


Figure 34

Spartina alterniflora plug (A) and sprig (B) used in habitat restoration projects.
(Hoffman et al. 1985)

mangle and L. racemosa have been reported as far north as Cedar Key on the west coast of Florida (Rehm, 1976), and north of Ponce de Leon Inlet on the east coast; these northern extremes lie at approximately 29°10'N Lat. (Teas, 1977) (Figure 35). A. germinans has been found as far north as 30°N Lat. on the east coast (Savage, 1972) and it also occurs as scattered shrubs along the islands of the Gulf coast states to Mexico (Odum et al. 1982 in CSA, 1986). Figure 36 identifies the three common mangrove species in Tampa Bay.

Mangroves have been planted in various forms from seed to mature plant. The seed, or propagule in the case of R. mangle, can be planted on site or can be nursery grown to seedling or tree (Figure 37). Seedlings or trees can also be transplanted from natural stands. Cost of the revegetation project usually depends upon planting type and spacing. The cost of the project has been shown (Lewis, 1982b) to increase directly with the size of the plant, and inversely with spacing of the plantings. Planting success typically increases with increasing plant size, but results are variable; attempts to plant large trees have been unsuccessful (e.g., Teas, 1977 in CSA, 1986).

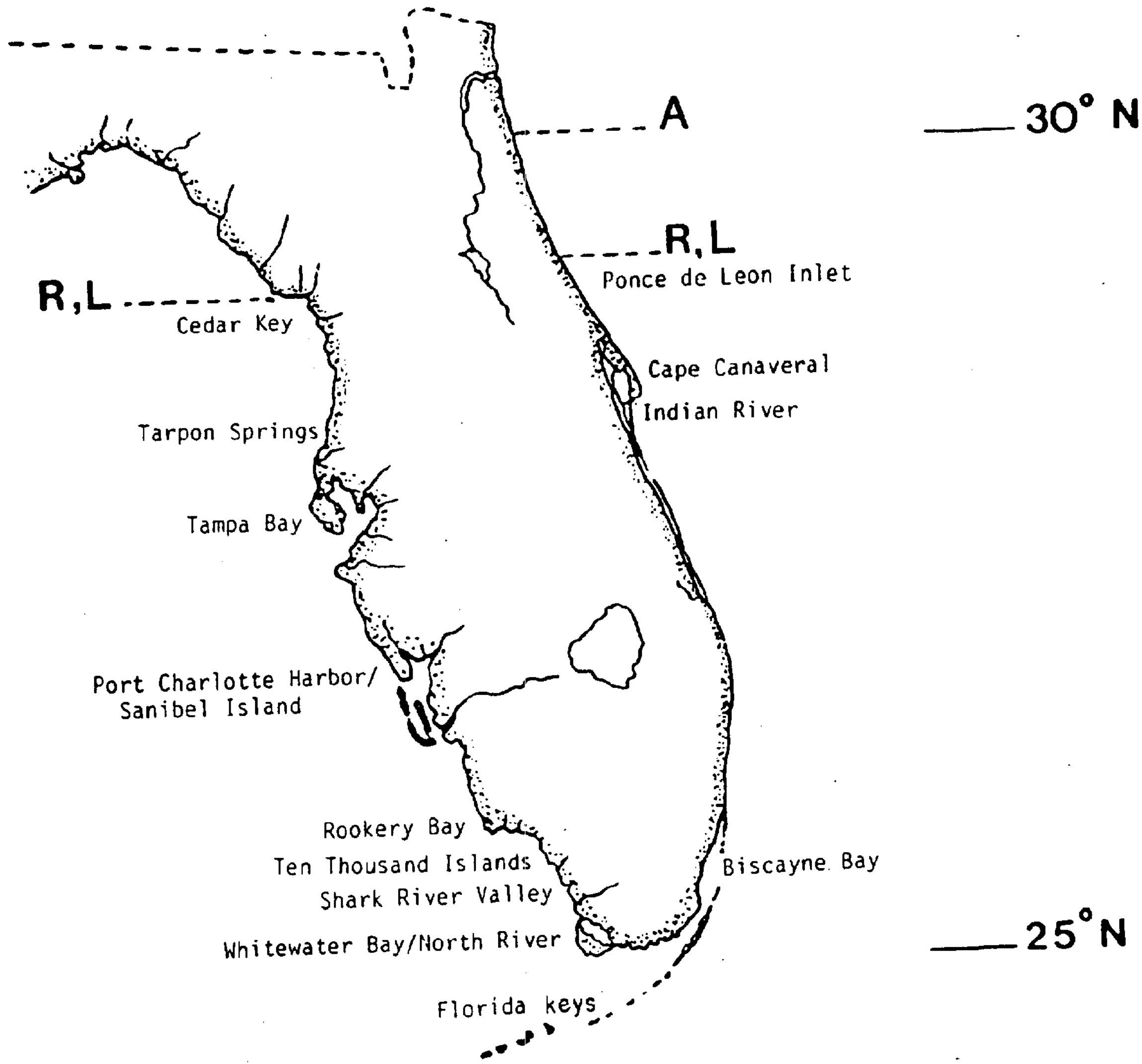
Lewis (1982b) recommended that the easiest way to ensure proper elevation for mangrove planting is to survey the elevation of adjacent mangrove areas and duplicate the zonation elevations for success. Successful mangrove mitigation/restoration projects, in terms of percent survival of plants, occur in estuarine areas when care has been taken to attain proper planting elevations, soils are amenable to planting, and wave energy (from wind and boat wakes) and human interference (e.g., trampling, vandalism) are low. These conditions are usually found within existing large wetland areas or in areas designed to provide appropriate conditions for mangrove establishment.

Mangroves can be planted within S. alterniflora revegetation projects. Mangroves planted on ten-foot centers will aid in natural succession by the species.

Planters Box Littoral Shelf

The vast quantity of seawall and finger fill development occurring within the Tampa Bay Region offers the opportunity to restore an intertidal salt marsh fringe. Width of the intertidal zone in seawalled areas will determine the available area for planting. Fehring et al. (1979) used sand bags to create a berm behind which Spartina and mangroves were planted (Figure 38). Similar projects for wave-stilling and creation of intertidal zone (by backfill, if necessary) could be devised from rip-rap, pvc pipe, sand fence or other materials.

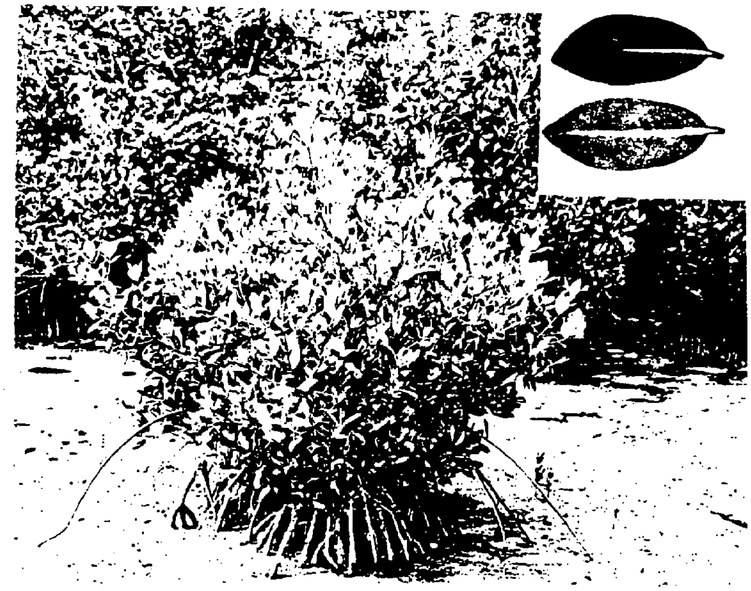
In addition to problems with current and wave energy, intertidal plantings in seawalled areas suffer from reflected boat wakes and waves. One unique design for creating a vegetated intertidal zone which reflects wave energy is entitled "Planter Box Revetment," by Ecoshore, Inc. (Figure 38). This system makes use of modular sections which can be assembled in variable number according to intertidal zone width. Slope is set by underfilling a group of sections to achieve the proper elevation and sediment depth.



NOTE: (BASED ON SAVAGE 1972): ALTHOUGH NOT INDICATED IN THE FIGURE, THE A. GERMINANS EXTENDS ALONG THE NORTHERN GULF OF MEXICO AS SCATTERED SHRUBS.

Figure 35 Approximate northern limits for *Rhizophora mangle* (R), *Avicennia germinans* (A), and *Laguncularia racemosa* (L), in Florida (from Odum et al. 1982).

Rhizophora mangle
(red mangrove)



Avicennia germinans
(black mangrove)

Laguncularia racemosa
(white mangrove)

Figure 36

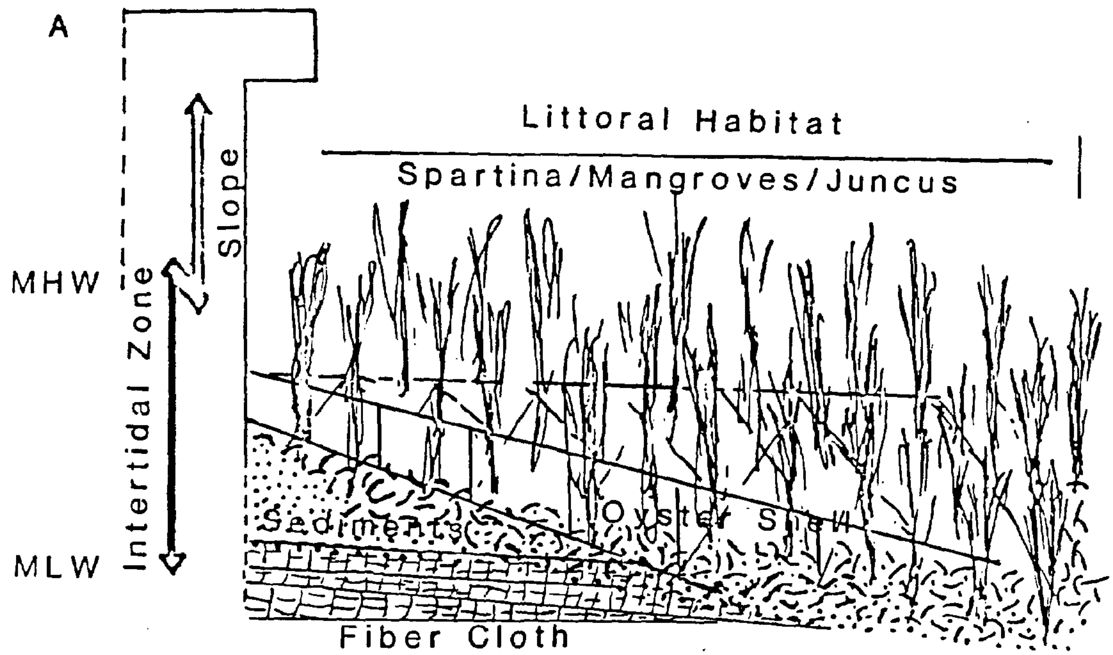
Mangroves of Tampa Bay
(Adapted from Darovec
et al. 1975)

Figure 37

Rhizophora mangle (red mangrove) propagule (A) and seedling (B)

(Hoffman et al. 1985)

A



B

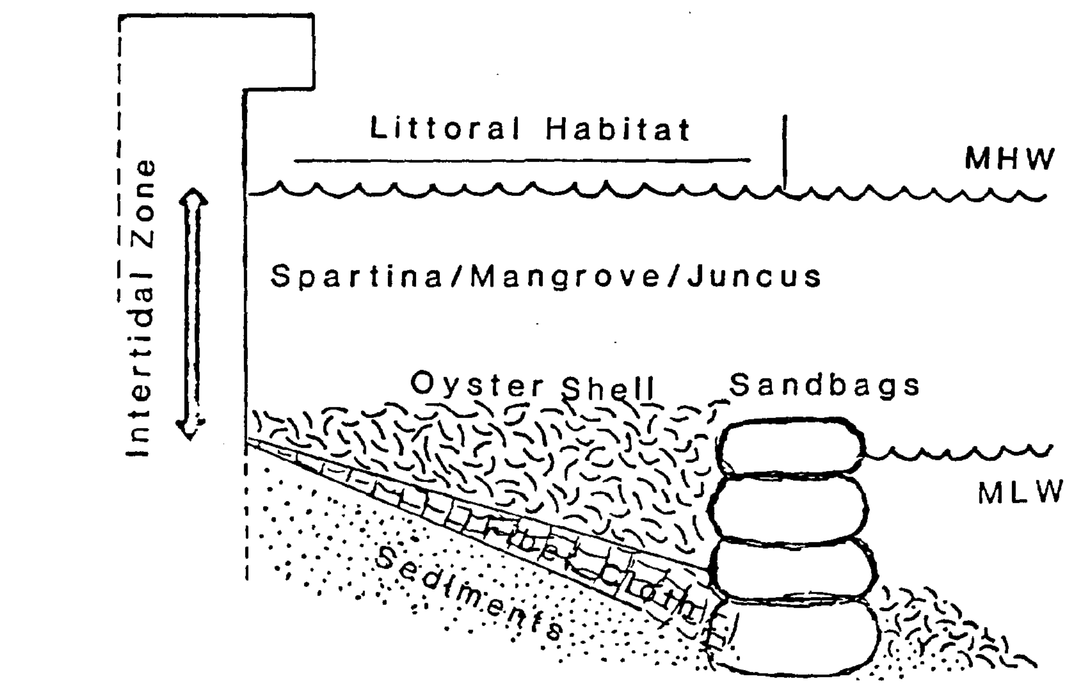


Figure 38 Wave attenuating schemes for littoral shelf creation - saltmarsh restoration in seawalled areas; A) Modular Planterbox Revetment (Ecoshores, Incorp.), B) Sandbag or Rip-Rap Design (DNR Draft, 1985a)

Sections can be linearly connected to cover the desired length of shoreline. Sloping surfaces of the planter box revetment act to reduce wave energy (FDNR Draft, 1985a).

The littoral planters box with salt marsh plantings can be constructed in association with stormwater outfalls. The design should include dissipation of high volume flows into the planters box. Stormwater would then be allowed to filter through planted vegetation promoting water quality improvements.

The construction of littoral shelf areas within planter boxes is particularly important to future habitat restoration efforts, due to the quantity of seawall development. The majority of salt marsh and mangrove losses historically occurred through outright destruction of intertidal zones from urban development. This method of restoration can ultimately aid to reverse the trend by littoral shelf plantings along seawalled areas. This method is an attractive alternative for homeowners, developers, and government entities.

TIDAL CREEK RESTORATION

Tributaries maintain the estuarine character of Tampa Bay. The importance of rivers and lesser streams to estuaries has been documented by studies throughout the world. Tributaries channel and deliver freshwater and food sources to the estuary system. In addition, the rivers and streams provide crucial habitat, protective cover, and feeding grounds for the early life history stages of marine and estuarine life forms.

Management or restoration of the tidal tributaries to Tampa Bay can prevent further degradation to the nursery area critical for adult fish and shellfish populations. Rivers and tidal creeks are vulnerable to numerous impacts which also become evident downstream in terms of decreased estuarine productivity. Examples include hydroperiod alterations through excess drainage or impoundments; loss of corridor by damming; changes to stream loads by increasing runoff or discharging pollutants, and diverting or preventing flows; increased relief and habitat losses through dredging and filling; and contamination through disposal of toxic materials. As rivers and creeks deteriorate, their ability to buffer cultural shocks to the estuary are lost (TBRPC, 1984, 1986b).

Restoration of tidal tributaries to Tampa Bay can be accomplished by efforts to recover the natural functions the tributaries provide. Historic flood control, navigational needs and wetland drainage practices have channelized, to some extent, the majority of the tributaries in the region. In the process of creek channelization, spoil material is often piled along the creek banks. This practice creates steep banks with little littoral area, buries underlying wetlands, and limits circulation to wetlands located behind the spoil piles or berms. Restoration of historic channelization activities can be accomplished by:

- Spoil pile removal. This will create additional intertidal area for planting and provide circulation to adjacent areas.

- Bank reshaping. This is undertaken to reduce the bank slope. A reduction in slope will decrease erosion energies and increase the area for littoral plantings.

- Cuts can be constructed through berms to aid in circulation of wetland areas behind the spoil piles.

- Orientation of the tributary can be designed to meander through the natural or created marsh system. This increases the available habitat along the stream alignment and allows the marsh system additional surface contact with the water body for pollutant assimilation.

Freshwater flowing down tributaries to Tampa Bay can be diverted or prevented from reaching estuarine waters. This is accomplished to provide potable water supply, agricultural irrigation or industrial process water. Alterations of the freshwater flow down the tidal tributary can eliminate the creek's estuarine system or disrupt the natural movement of the saltwater-freshwater interface and associated environmental systems. Maintenance or improvement of freshwater flow can be attained by permitting freshwater to be discharged over the dam or other water control structures during ecologically relevant periods of time. In addition, a reduction in freshwater consumption will allow freshwater to continue downstream. Water recycling and other controls can protect existing quantities of freshwater for the estuarine system.

All development within any specific watershed of a tidal tributary has the potential to affect not only the tributary but the downstream receiving water body. The wide scale development within the Tampa Bay Region has impacted the water quality and natural resources that are dependant upon water quality conditions. Within the tidal tributary watershed improvements can be made to restore water quality conditions, which include:

- Control and treat urban and agricultural stormwater runoff.

- Minimize discharge of point source pollutants.

- Additional marsh creation.

- Reorient channel alignment to allow meanders through marsh systems for pollutant assimilation.

- Control bank erosion.

- Control of sedimentation from upland sources.

Tributaries are dynamic systems which provide crucial habitat, protective cover and feeding grounds for fish and wildlife; maintain the estuarine character of natural systems; and provide drainageways for floodwaters and effluent discharges from man's development. The protection and restoration of these important systems can provide critical habitat and promote improved water quality for fish and wildlife usage.

CHAPTER IV

REGIONAL HABITAT RESTORATION RECOMMENDED SITES

INTRODUCTION

An enormous portion of the historic vegetation habitats have been displaced by increasing urbanization within the Tampa Bay Region. In order to offset this undesirable trend it will be necessary to restore or create additional habitat available for fish and wildlife populations. The purpose of this section is to describe many areas within the region that can potentially be restored to provide critical habitat.

It should be emphasized that the recommended plan that follows is a habitat restoration plan, rather than a mitigation plan. Although the restorative measures recommended in the plan could be used as off-site mitigation for large projects with unavoidable impacts, and for which on-site mitigation is not a viable alternative. Restoration of degraded habitat should not be considered adequate mitigation on a one-for-one replacement basis because, depending on the size and relative functionality of the degraded area to be restored, it generally results in a regional net loss of habitat. In such instances, true habitat creation from uplands should be the mitigative option of choice.

As a habitat restoration plan, the emphasis is on re-creating pre-existing geologic and hydrologic conditions in which the desired floral, and hence faunal, communities will flourish. To accomplish this, it is often necessary to reverse a particular dredge or fill action where such an action was the original cause of the degradation. The re-grading of spoil disposal areas, or the filling of poorly flushed borrow areas, are examples of such actions. Although the earthwork involved in such efforts is considerably more costly than revegetation alone, it often assures the lasting success of large restoration projects. The planting of desired floral species on denuded areas should not be considered an acceptable restorative measure in the absence of topographic and hydrologic analyses. If conditions are suitable for the establishment of a desired floral species then natural floral succession should be an indication of the suitability, providing that an adequate seed source is available. Although plantings in areas where natural re-establishment is occurring may accelerate the floral succession of such areas, it is recommended that all areas to be revegetated be first surveyed and then graded to the exact elevations of the nearest area in which the desired floral species is found to be flourishing. It is further recommended that particular attention be paid to the energy environment of areas to be restored. Erosion due to wave energy has been found to be a major factor in the failure of restoration efforts (CSA, 1986).

METHODS

The material provided in the following section of this report is a collection of habitat restoration plans from:

- Stewart Engineering, Pasco County Habitat Restoration Plan. Acquired through contract agreement to provide the FDNR a plan to be implemented with gill net license fees (Chapter 84-471, Laws of Florida) or other future funding sources.

- The FDNR Pinellas County and Manatee County Marine Habitat and Restoration Plan (Draft 1985 a and b) to be implemented through Chapter 84-471.

- Recommended sites from Mitigation Options Related to Port Development for Fish and Wildlife Resources of Tampa Bay (CSA, 1986). The document was developed through the U.S. Fish and Wildlife Service to provide a mitigation plan for future port expansion in Tampa Bay.

- Sites selected and developed by the Tampa Bay Regional Planning Council (TBRPC).

- Recommended sites by members of the Council's Agency on Bay Management that have been developed by TBRPC.

The recommended restoration sites are not intended to duplicate other programs but to provide a regional listing of sites and techniques to be implemented through local, regional, state and federal programs where available. For this reason, priorities are not established for the recommended sites. It is anticipated that site restoration will be based on funding mechanisms and program requirements.

As previously stated, the Pasco County Plan is provided through a consultant contract agreement. Therefore, the Pasco Plan is provided as a separate and complete section within this chapter. The remaining projects are identified within the specific county in which they occur.

The site selection criteria utilized in the final plan development included the following priority considerations:

- Maximize feasibility of implementation

- Maximize the probability of success

- Maximize the restoration of large, contiguous tracts of functional habitat; and

- Maximize the re-creation of pre-existing natural conditions.

In selected restoration sites a review of historic trends will be accomplished. In locations where wetlands have been altered the creation of replacement vegetation is recommended. The trend analysis will aid in the identification of historical alterations and extent of existing wetland acreage.

The regional list of restoration sites should not be considered complete. Many areas exist that have not been evaluated to the extent necessary for inclusion. In addition, recommended restoration sites have been included regardless of land ownership. It is anticipated that sites listed in private or unknown ownership will be reviewed and identified for public acquisition or protected from future development activities.

PASCO COUNTY HABITAT RESTORATION PLAN

Purpose of Plan

The purpose of this plan is to identify sites along the Pasco County coastline on which estuarine habitat restoration or enhancement could be feasibly implemented using both existing and proposed sources of funding. In the immediate future it is anticipated that funds generated from gill net license fees (Chapter 84-471, Laws of Florida, currently administered by the Florida Department of Natural Resources) will be used to initiate restoration/enhancement activities on these sites. To fully implement the proposed plan, however, additional sources of funding, both public and private, will be necessary. Recurrent sources of funding will be especially important for future monitoring and assessment of the restoration/enhancement projects.

Site Selection Process

Potential sites for habitat restoration/enhancement were identified from 1982, 1:24,000 scale color aerial photographs of the Pasco County coastline. The first priority in photointerpretive process was to identify areas in which some obvious physical disturbance (i.e. dredge and/or fill) of the natural environment had taken place. In such cases, the emphasis would be on restorative measures rather than on habitat creation. In some instances where existing habitat had been degraded by construction activities (i.e. impoundment), but still appeared functional, measures to enhancement were considered.

The second priority in the site selection process was the identification of publicly owned lands. This was considered to be a high priority because, without an adequate mechanism to compensate private land owners for the loss of development potential, restoration/enhancement activities can only feasibly be accomplished on publicly owned lands. Consequently, public parks, bird sanctuaries, conservation easements and other vacant dedicated lands were highly scrutinized during the selection process. On publicly owned lands wetland habitat creation from uplands is a viable strategy.

On August 19, 1986, potential restoration/enhancement sites identified from aerial photographs were groundtruthed and assessed for the following features:

- Topography
- Soils and sediment characteristics
- Floral and faunal composition
- Water quality
- Existing land use
- Feasibility of mitigative options

Following the field assessment process, the ownership of each potential site was researched at the Pasco County Tax Assessor's office in New Port Richey. Once favorable land ownership was determined, the feasible sites were revisited on August 29, 1986, to collect further information for plan formulation.

A total of seven sites were chosen for inclusion in the final habitat restoration plan.

RECOMMENDED RESTORATION PLAN

The general locations of the seven sites chosen for analysis are shown on Figure 39. Because much of the central and northern portions of the Pasco County coastline remain undeveloped the majority of the sites are located in the southern portion of the county. The Pasco County coastline is characterized by a very broad, shallow shelf with the dominant intertidal habitat type being extensive monotypic black rush (*Juncus roemerianus*) marshes often found alongside less prevalent stands of smooth cordgrass (*Spartina alterniflora*). Although mangroves exist as fringe forests in Pasco County, the Anclote River is generally considered to be the northern boundary of their range of intertidal dominance along the west coast of Florida. The black mangrove (*Avicennia germinans*) is the most prevalent mangrove species in Pasco County. Seagrasses generally flourish in the shallow subtidal waters of Pasco County and have been relatively unimpacted by coastal development there in comparison to intertidal habitat. However, because methods for restoring seagrasses are poorly understood, and because intertidal habitat has been impacted by coastal development more than subtidal habitat in Pasco County, the recommended plan which follows focuses exclusively on the restoration of intertidal habitat. If fully implemented, the proposed plan will result in the restoration/enhancement of 69.36 total acres of intertidal wetland habitat.

Site 1: Anclote River Park

Site Description: The Anclote River Park is located in the north bank of the mouth of the Anclote River estuary, directly adjacent to the Florida Power Corporation (F.P.C.) Anclote Power Plant intake canal (Figure 40). The park includes a boat ramp, a small swimming beach and a number of covered picnic areas.

Water quality at the park is strongly influenced by the Gulf of Mexico and is generally good. Strong currents occur along the north end of the park due to the power plant cooling water intake, however, vegetative patterns along the southern end of the park are indicative of a low energy environment. Intertidal vegetation occurs along the southern shoreline of the park and is primarily represented by a fringing marsh of *S. alterniflora*, with *Distichlis spicata* occurring upland of this. A small tidal lagoon exists which is densely vegetated with mangroves including *A. germinans* and *Rhizophora mangle*.

Review of the 1957 and 1982 wetland inventories (Figure 41 and 42, respectively) and the trend analysis (Figure 43) indicates a small mangrove embayment existing on Site 1 in 1957. The small mangrove area has been replaced by beach and upland classes, as indicated by the 1982 inventory and trend analysis.

RESTORATION SITES

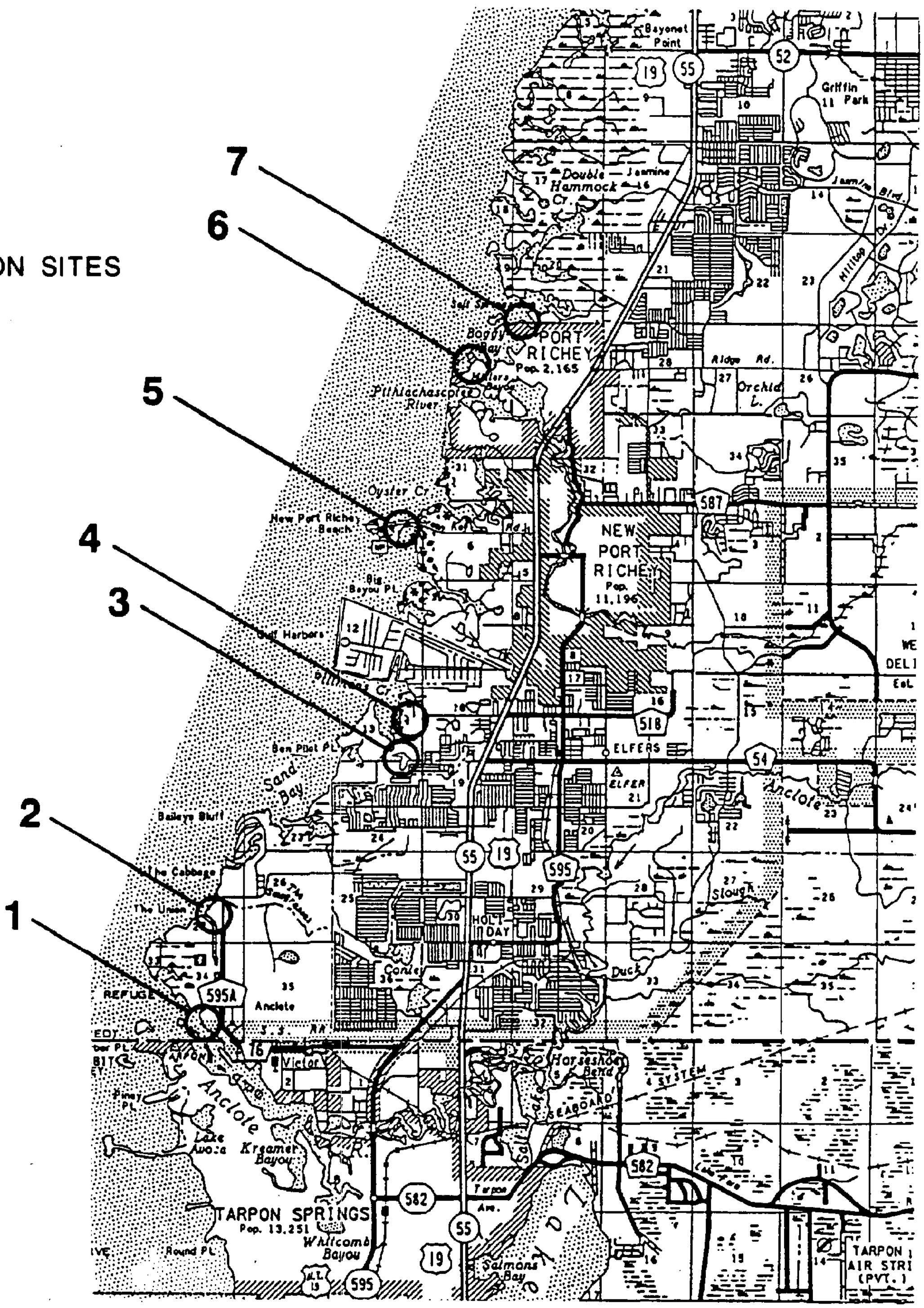


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Figure 39

General Location of Restoration Sites in Pasco County

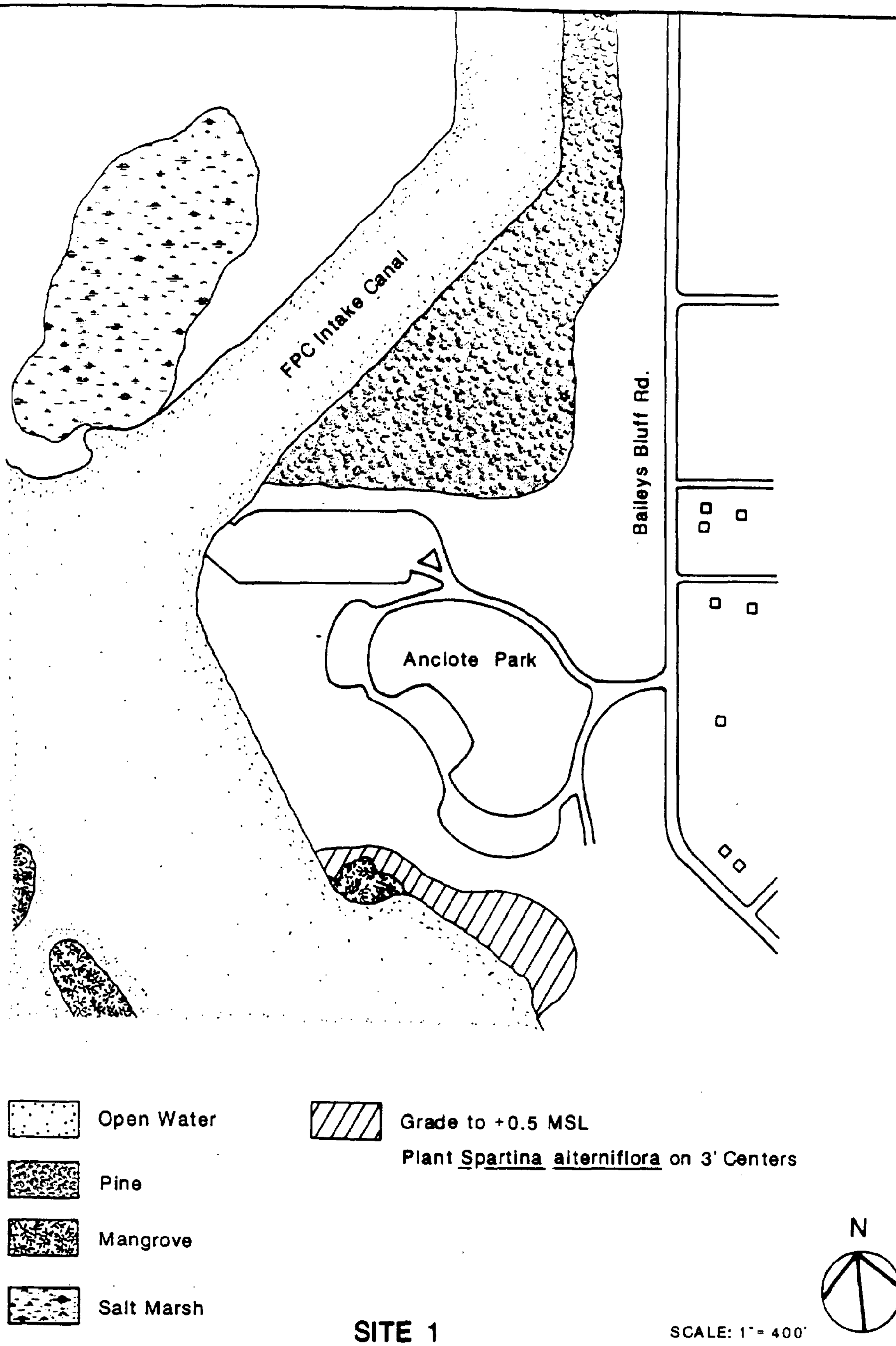

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Figure 40

Anclote River Park
Habitat Creation Plan

Figure 41 Wetland Inventory of the Anclote River Mouth Area - 1957

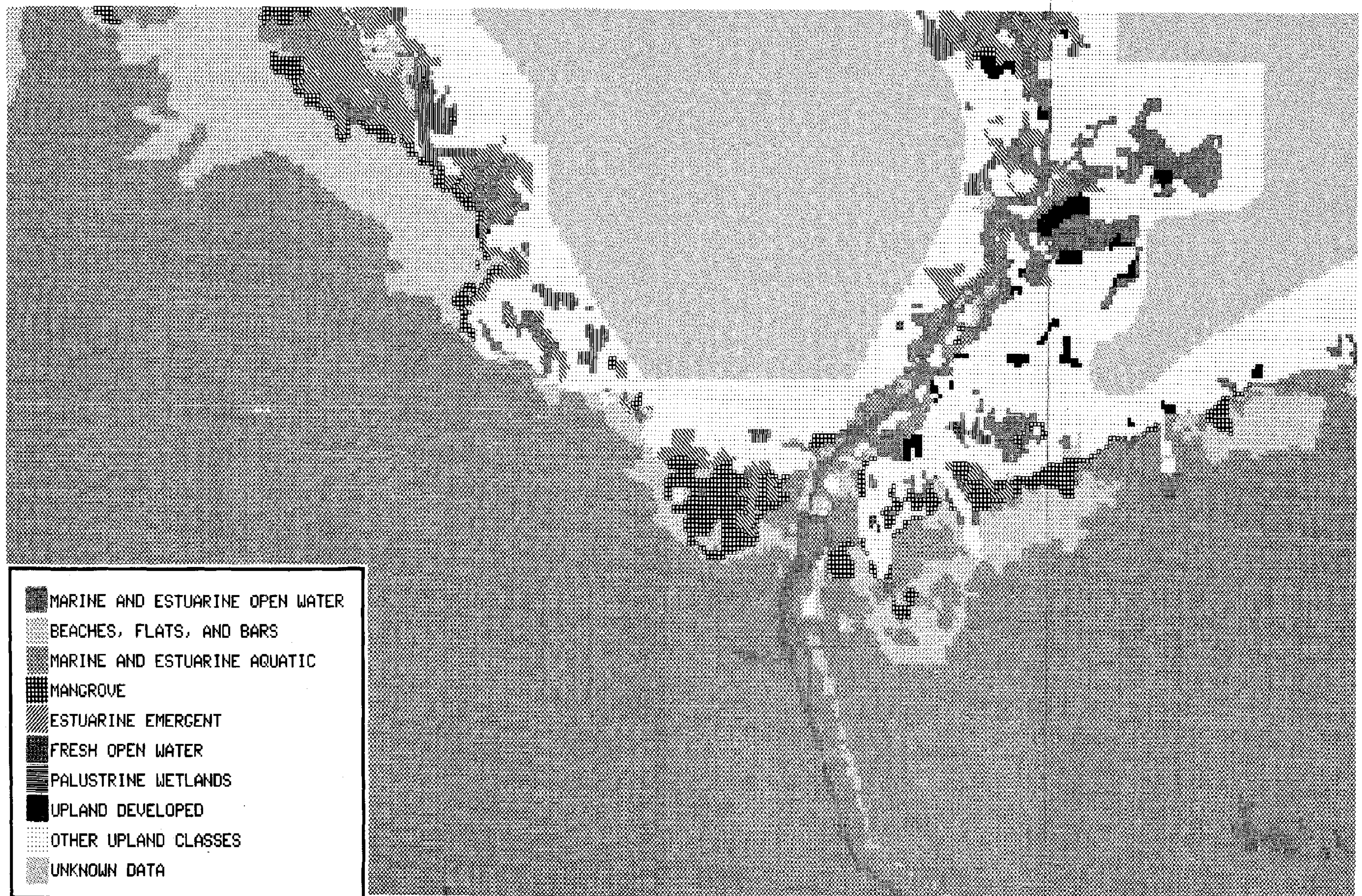


Figure 42 Wetland Inventory of the Anclote River Mouth Area - 1982

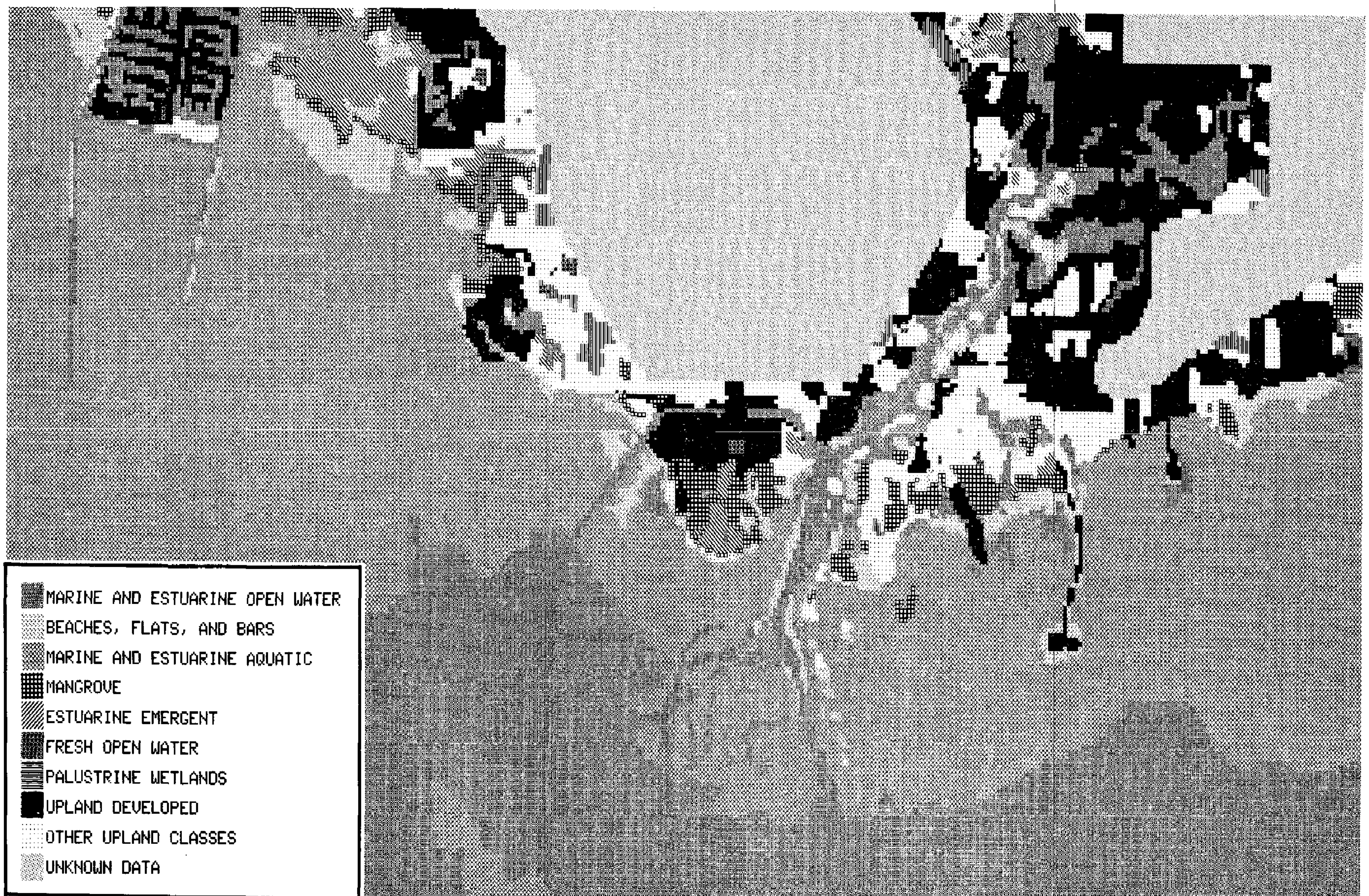
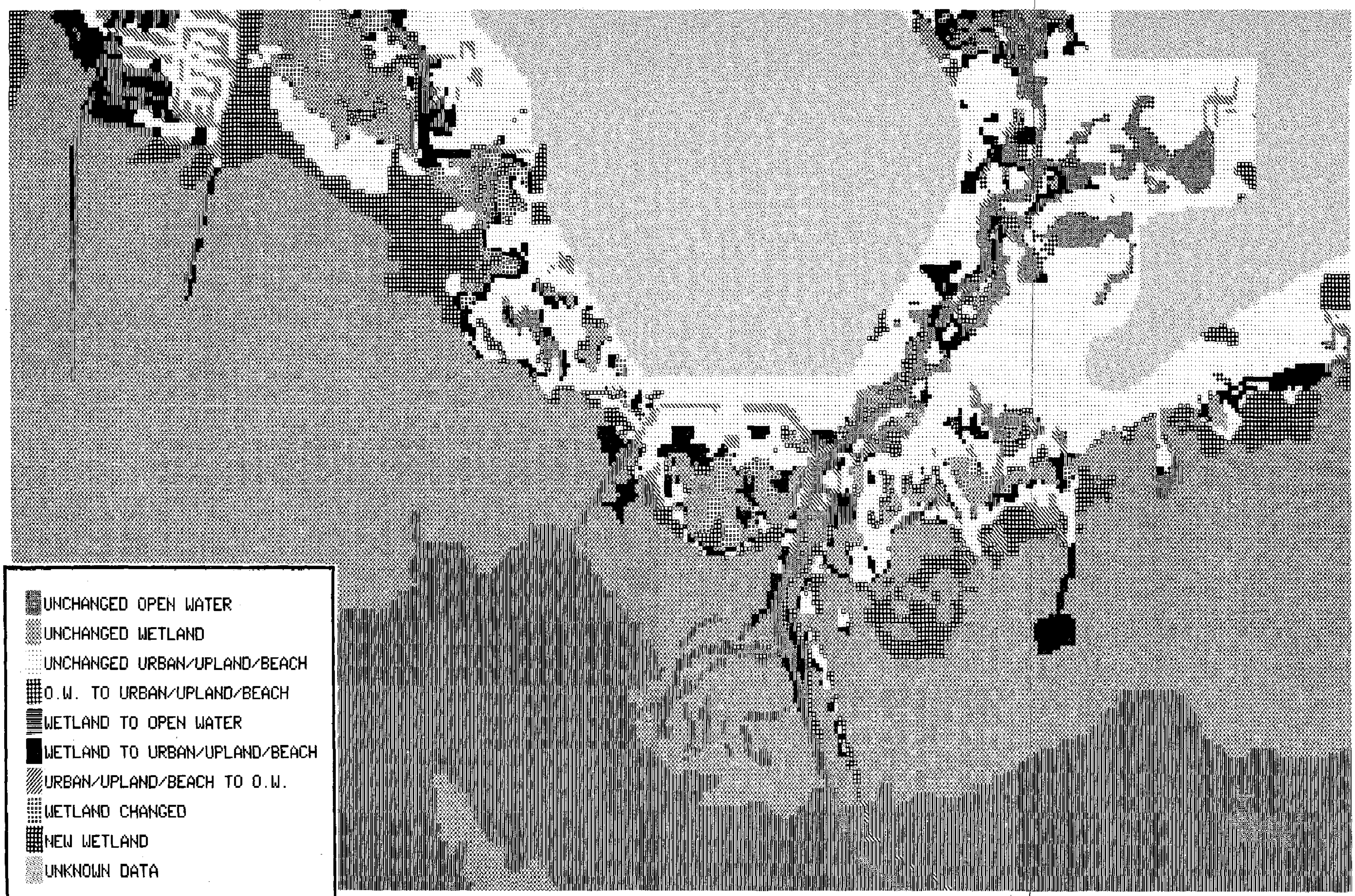


Figure 43 Wetland Trend Analysis of the Anclote River Mouth Area



Land Use: The park site is currently owned by the Florida Power Corporation but is leased in perpetuity to the Pasco County Department of Parks and Recreation for park development. The submerged lands are owned by the State of Florida.

Restoration Plan: The primary goal of the restoration plan is to expand the limits of the intertidal marsh and tidal lagoon area along the southern shoreline of the park. It is proposed that approximately 2.23 acres of course sand uplands be graded down to 0.5 Mean Sea Level (MSL) and planted with S. alterniflora on three-foot centers. Figure 2 shows the extent of the proposed enhancement plan. The natural occurrence of both S. alterniflora and mangrove species indicates that the sediments and energy environment of the site are suitable for further marsh expansion. If implemented, this plan will result in the creation/enhancement of 2.23 acres of intertidal wetlands.

Site 2: Florida Power Corporation (FPC) Spoil Disposal Site

Site Description: The FPC spoil disposal site is located directly adjacent to the mouth of the Anclote Power Plant thermal effluent discharge canal (Figure 44). During the dredging of the power plant cooling water canal in the late 1960s, large volumes of spoil material were deposited in a 13.63 acre area of intertidal wetlands along the Gulf of Mexico. Seaward of the spoil deposit a remnant of the original intertidal wetland exists, including a fringe growth of mangroves (A. germinans and R. mangle). Many of the older black mangroves appeared to have been killed by frosts during recent years. Within the perimeter of mangrove growth a small tidal pond exists which is sparsely vegetated with S. alterniflora. High marsh areas occurring along the low banks of the spoil deposits include D. spicata, Batis maritima and Salicornia virginica. Conspicuous wildlife utilizing this area included the yellow crowned night heron (Nyctanassa violacea), the little blue heron (Florida caerulea) and the common egret (Casmerodius allous). The spoil deposit is elevated approximately at +8.0' to 10.0' MSL, and is primarily vegetated with terrestrial pioneer species.

Wetlands inventory for 1957 (Figure 41) identified Site 2 as a combination of estuarine beach and seagrass beds. By 1982 the area has been replaced by upland classes (Figure 42) which is reflected in the inventory and trend analysis (Figure 43) during this time period.

Land Ownership: The spoil disposal site is owned by the Florida Power Corporation while the submerged lands are owned by the Federal Government.

Restoration Plan: The goal of the restoration plan is to remove the old spoil deposits and re-establish an intertidal wetland in its place. A cursory examination of the spoil deposit sediments indicated that the bulk of the material consists of clean, course-to-fine sands, which are probably suitable for commercial fill. Staff personnel with the FPC Environmental Affairs Department have indicated an interest in selling the spoil deposits as fill material and restoring the disposal site as possible off-site mitigation for thermal effluent impacts generated by FPC Crystal River Plant. The proposed plan, as shown in Figure 44, calls for the removal of the spoil material, grading the area to +0.5' MSL and replanting with S. alterniflora on three-foot centers. The pioneering characteristics of S.

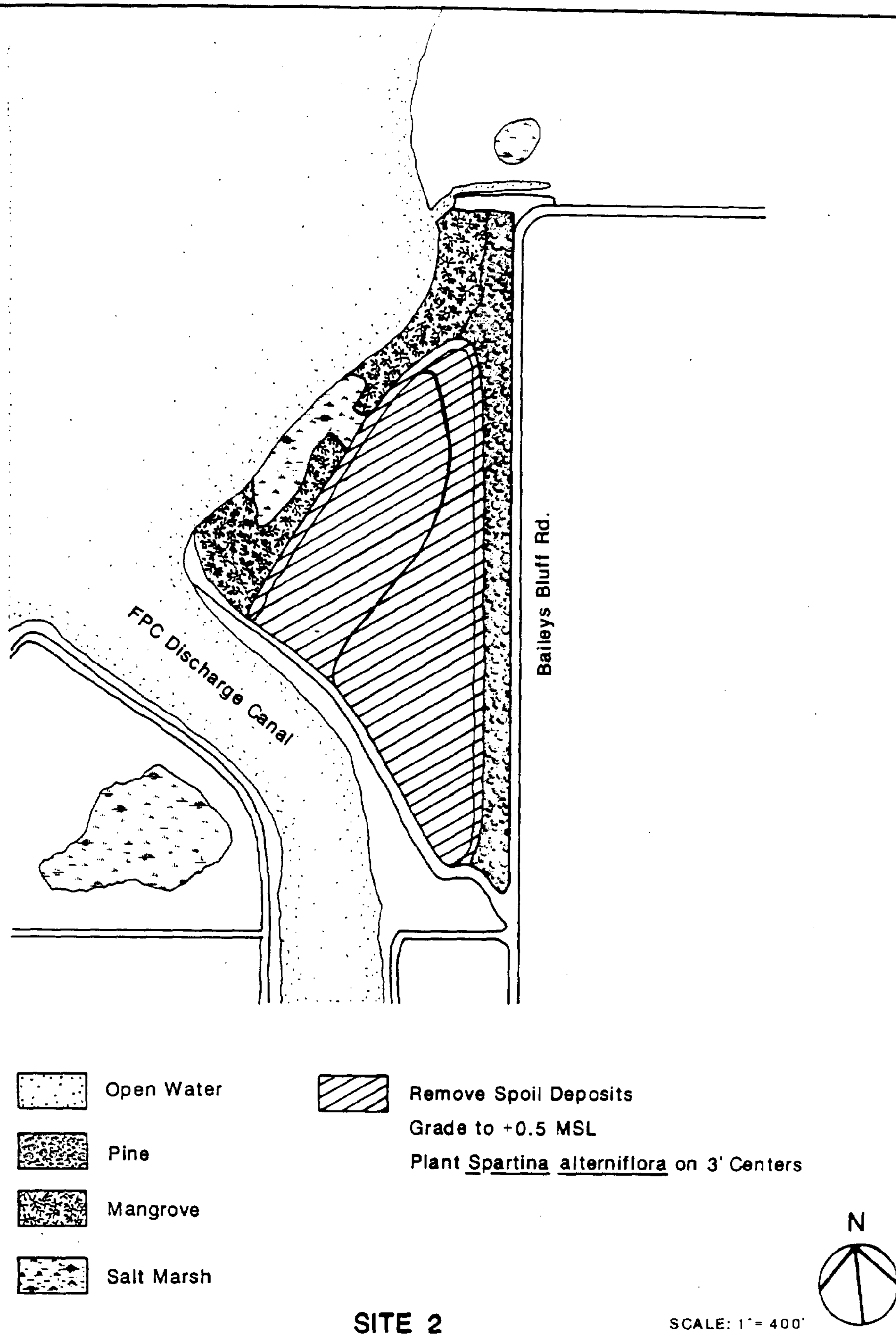


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Figure 44

F.P.C. Spoil Disposal Site Restoration Plan alterniflora is expected lead to the floral succession of mangroves in this area. If implemented, the proposed plan would result in 13.63 acres of restored intertidal wetlands.

Site 3: Mickler Property

Site Description: The Mickler Property is located along Stauber Memorial Highway, directly landward of Fillmans Creek. The site is characterized by a lush monotypic J. roemerianus marsh interspersed with upland "islands" vegetated with cabbage palms and slash pines. Two distinct areas of impact have been created apparently by the deposition of spoil material generated from the dredging of canals in association with adjacent residential development. The spoil deposit areas are primarily denuded, however in areas where flooding does occur, high marsh succulents including B. maritima and S. virginica, grow densely. The entire area has been impounded by the construction of Stauber Memorial Highway, with infrequent flooding only occurring by virtue of a single, inadequate culvert.

Portion of the Mickler Property (Site 3) can be evaluated with the wetlands inventory (1957, Figure 41; and 1982, Figure 42). The 1957 inventory reflects areas of emergent wetlands with pockets of flats and uplands. The 1982 inventory identifies replacement with: mangroves; upland; and flats, beaches and bars designations. The trend analysis (Figure 43) depicts the alteration of wetland vegetation in this area.

Land Ownership: The site is owned by the Mickler estate, but has been dedicated to Pasco County indefinitely as a Bird Sanctuary. Although this designation is subject to change by the owners it is unlikely that this area will ever be developed due to the preponderance of jurisdictional wetlands.

Restoration Plan: The goal of the restoration plan is to remove the spoil material and to re-establish a contiguous J. roemerianus marsh. Figure 45 illustrates the extent of the proposed restoration activities. In addition, tidal flooding of the entire area is to be improved by replacing the existing RCP culvert with a larger box culvert. A cursory examination of the sediments indicated that the spoil deposits are primarily composed of clean, fine sands which may be suitable for commercial use as fill material. Upon removal of the spoil deposits, the impacted area is to be graded to +1.5' MSL and replanted with J. roemerianus on three-foot centers. If implemented, this plan will result in the restoration of approximately 25.30 acres of intertidal wetlands.

As an alternative, the restoration plan can be simplified by the construction of a dendritic tidal creek throughout the impacted area. This can be accomplished using a rotary ditcher commonly used by mosquito control agencies. The creation of tidal ditches can be expected to provide additional circulation in higher elevation areas and provide avenues for fishery usage.

Revegetation of the newly ditched areas can be planted or allowed to establish naturally from adjacent areas. Turbidity control measures must be implemented during construction to prevent degradation of state waters. The upland "islands" are to be preserved to provide a variety of habitats within the site for fish and wildlife usage.

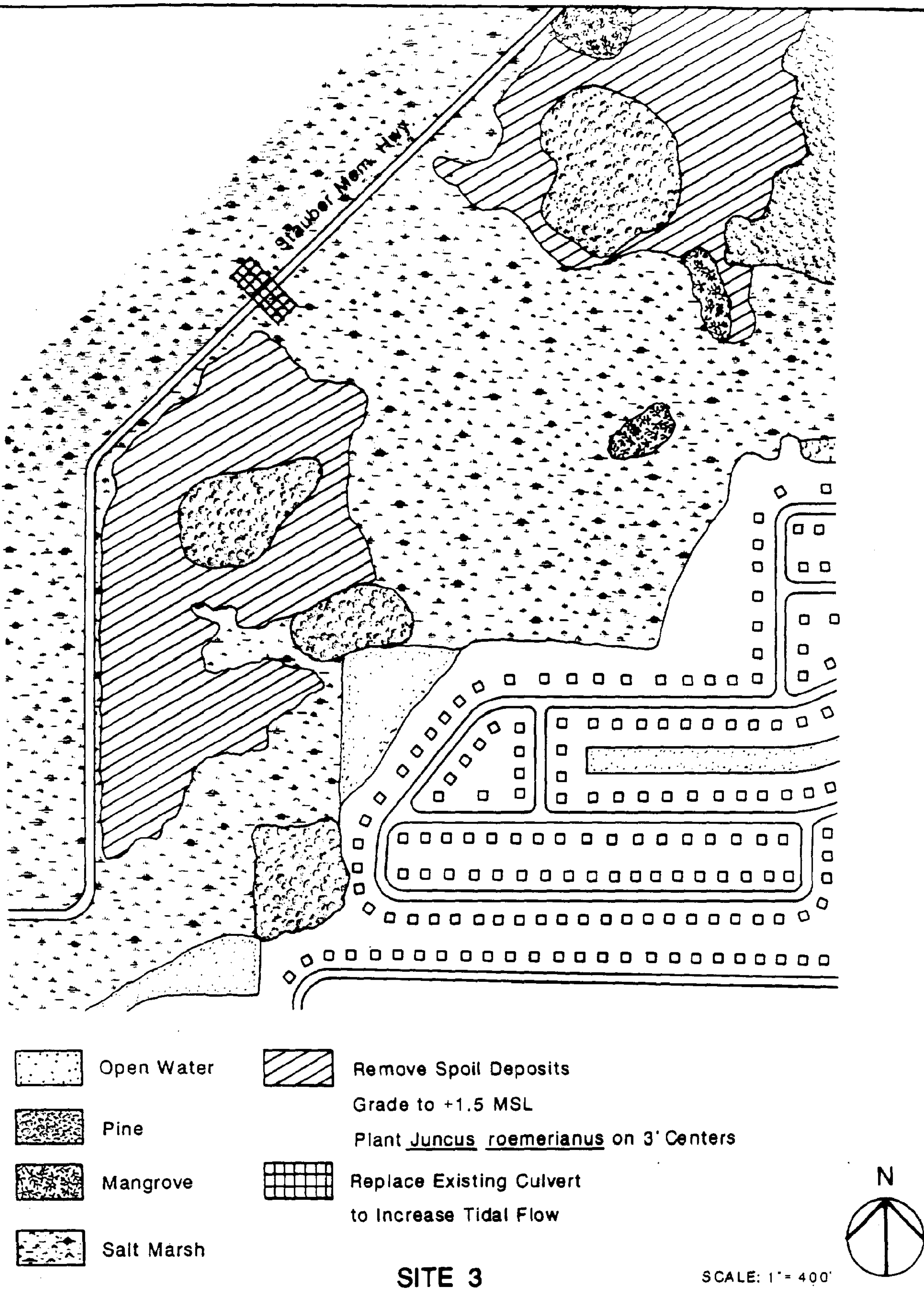

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Figure 45

Mickler Property Restoration Plan

Site 4: Winkalt Property

Site Description: The Winkalt property is located on Stauber Memorial Highway just south of Trouble Creek (Figure 46). The property consists of uplands divided by three dredged finger canals, as well as an extensive monotypic J. roemerianus marsh. Approximately 16 acres of historic J. roemerianus marsh has been impacted by the deposition of dredged spoil material, presumably from the dredging of the adjacent finger canals. The spoil deposits are primarily denuded, but in lower areas that receive more frequent flooding, high marsh species, including B. maritima, S. virginica and Baccharis sp. occur. The central portion of the spoil deposit area is composed of a historic upland island vegetated with cabbage palms and slash pines. The dredged finger canals are steep sloped and support little or no productive intertidal or subtidal habitat. Although the depth of these canals is not known it is presumed that they are poorly flushed and contribute to water quality problems in Trouble Creek. The surrounding uplands are primarily vegetated by terrestrial pioneer species.

Land Ownership: The site is owned by the Winkalt estate. Although the uplands appear to have been recently prepared for development, no subdivision plans are currently on file with Pasco County. It is unlikely that any development of the impacted marsh area will ever occur because of its jurisdictional status.

Restoration Plan: As shown in Figure 46, the goal of the restoration plan is two-fold and includes the re-establishment of the historic J. roemerianus marsh in the spoil impacted areas, as well as the filling of the dredged finger canals. The spoil deposits are to be removed and the material is to be used to fill the finger canals to upland limits. Upon removal of the material, the spoil impacted areas are to be graded to +1.5' MSL and replanted with J. roemerianus on 3' centers. If implemented, the proposed plan will result in the restoration of 18.16 acres of intertidal wetlands.

Site 5: Green Key Park

Site Description: Green Key Park is located due west of the City of New Port Richey and directly abuts the Gulf of Mexico. The park includes a small swimming beach and a covered picnic area. The proposed restoration site is located along the southern shore of the park and involves an area previously vegetated with mangroves which has been bulldozed and illegally filled with large volumes of organic debris from beach raking operations. A. germinans exclusively covers those areas still vegetated with mangroves. A small semi-isolated tidal pond exists landward of the mangrove fringe and is primarily vegetated by S. alterniflora. D. spicata is the dominant high marsh grass.

Land Ownership: Green Key Park is owned by the City of New Port Richey. The submerged land is owned by the Federal Government.

Restoration Plan: The goal of the restoration plan is to remove the organic debris and to re-establish the historic mangrove fringe and tidal pond vegetation. Figure 47 shows the extent of the proposed restoration plan. Upon removal of the fill the impacted area is to be graded to +0.5'

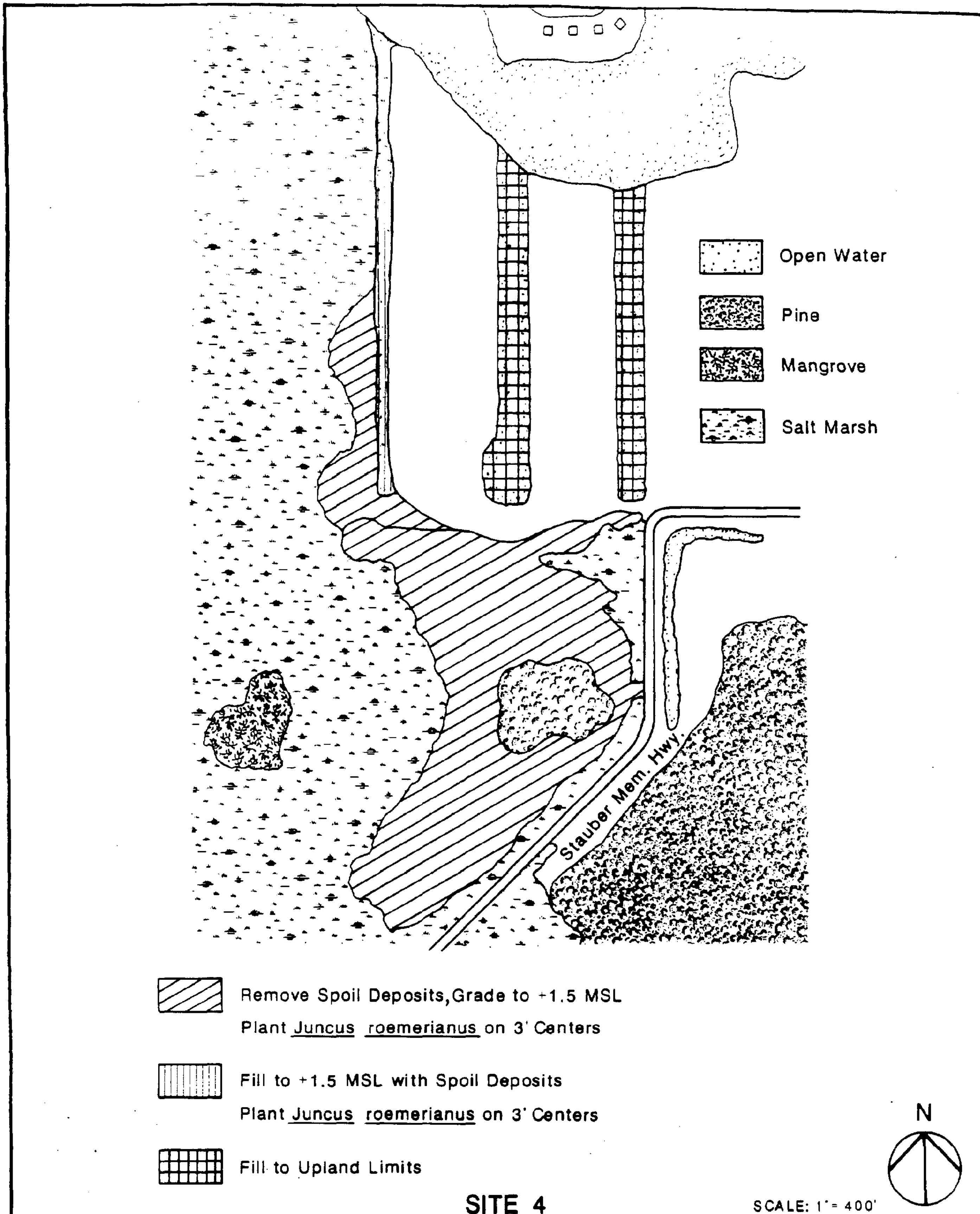

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Figure 46

Winkalt Property Restoration Plan

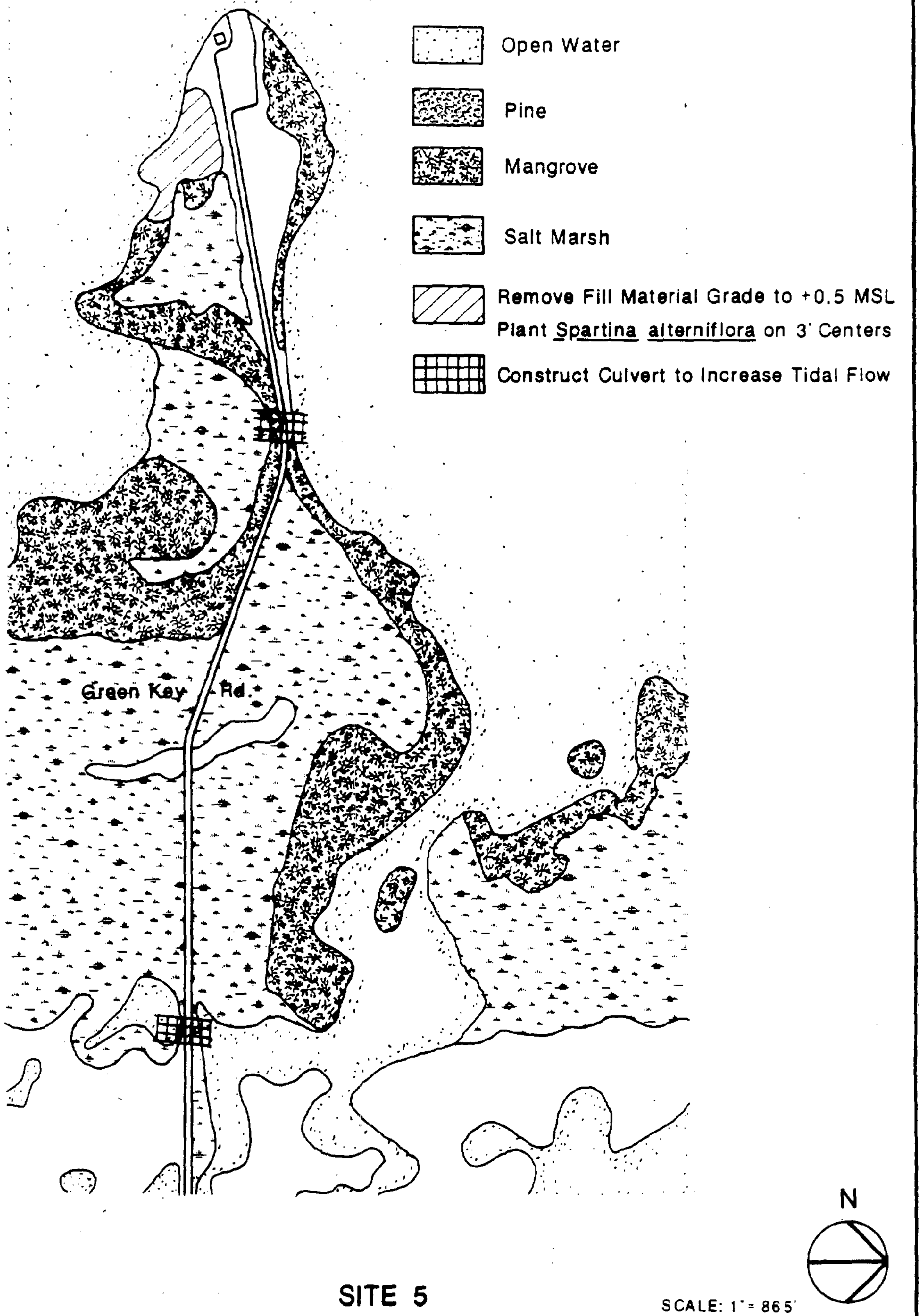

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Figure 47

Green Key Park
Restoration Plan

MSL and replanted with S. alterniflora on three-foot centers. It is expected that the pioneering characteristic of S. alterniflora will lead to the floral succession of mangroves where conditions are advantageous. In addition, it is recommended that two culverts be placed under Green Key Road to improve tidal circulation in, and around the park. Currently, no culverts exist under the unpaved shell road which extends a distance of approximately 1.3 miles westward from an upland residential development. If implemented, this plan will result in the restoration of approximately 1.23 acres of intertidal wetlands.

Site 6: Ritter Point

Site Description: Ritter Point is located at the western terminus of Bay Boulevard in the City of Port Richey (Figure 48). The northern cusp of Ritter Point consists of uplands which have been raised by spoil material generated from the illegal dredging of an adjacent finger canal. A large monotypic stand of J. roemerianus occurs immediately east of the finger canal. Although the depth of the finger canal is not known, it is presumed that it does not flush well and is thus characterized by poor water quality conditions. The canal is steep sloped and does not support significant stands of either intertidal or subtidal vegetation. The uplands are vegetated with Australian pines and other terrestrial pioneer species.

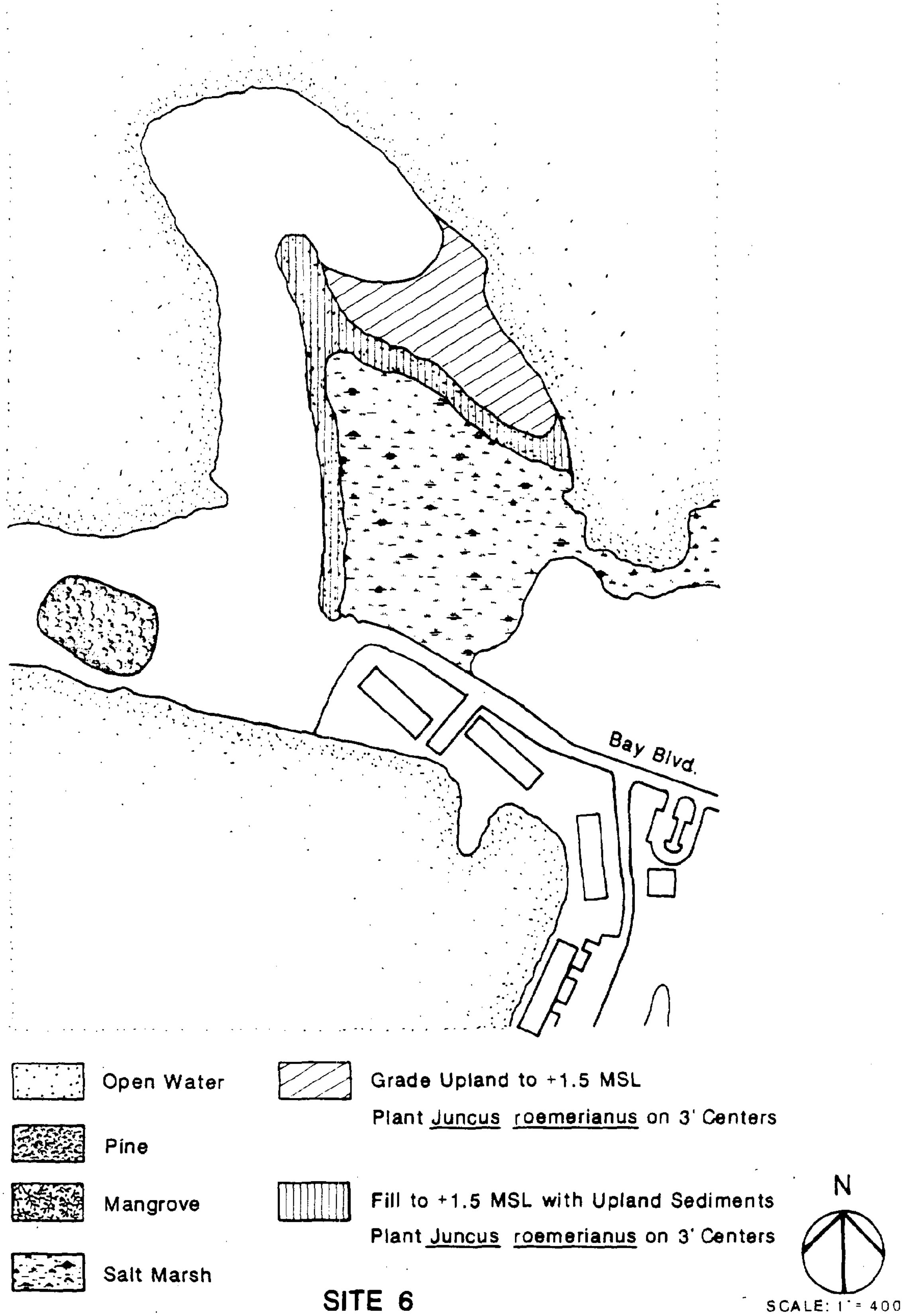
Land Ownership: Land ownership of the illegally created uplands is not clear as no taxes have been paid to Pasco County on this property. The submerged lands are owned by the Federal Government.

Restoration Plan: The goal of the restoration plan is to fill the illegally dredged finger canal and to re-establish the historic extent of the J. roemerianus marsh. As shown in Figure 48, a portion of the created uplands is to be graded down to +1.5 MSL to provide material to fill the finger canal to +1.5' MSL. After being properly graded, these areas are to be planted with J. roemerianus on three-foot centers. If implemented, this plan will result in the restoration of approximately 6.46 acres of intertidal wetlands.

Site 7: City of Port Richey Park

Site Description: This small city recreation area is located off Old Post Road in the City of Port Richey and consists of a boat ramp, a small swimming beach and a covered picnic area (Figure 49). The park, and the shell road leading to it, have been built on fill material deposited over an extensive J. roemerianus marsh. Surrounding the park site is a sparse fringe of S. alterniflora. Lime rock rip-rap has been used to reinforce the banks of the park fill. A large spoil mound has been deposited on the adjacent J. roemerianus marsh approximately 1000' east of the park. The spoil mound is vegetated with terrestrial pioneer species. A small roadside ditch running along the south side of the park road is assumed to be the source of this material, which appeared to be composed of clean course sand.

Land Ownership: All uplands on the site are owned by the City of New Port Richey. The submerged lands adjacent to the park are presently under private ownership.



SITE 6

THE STEWART CORPORATION - ENGINEERS **201 E. KENNEDY BLVD., SUITE 334 TAMPA, FL 33602**	Figure 48 Ritter Point Restoration Plan

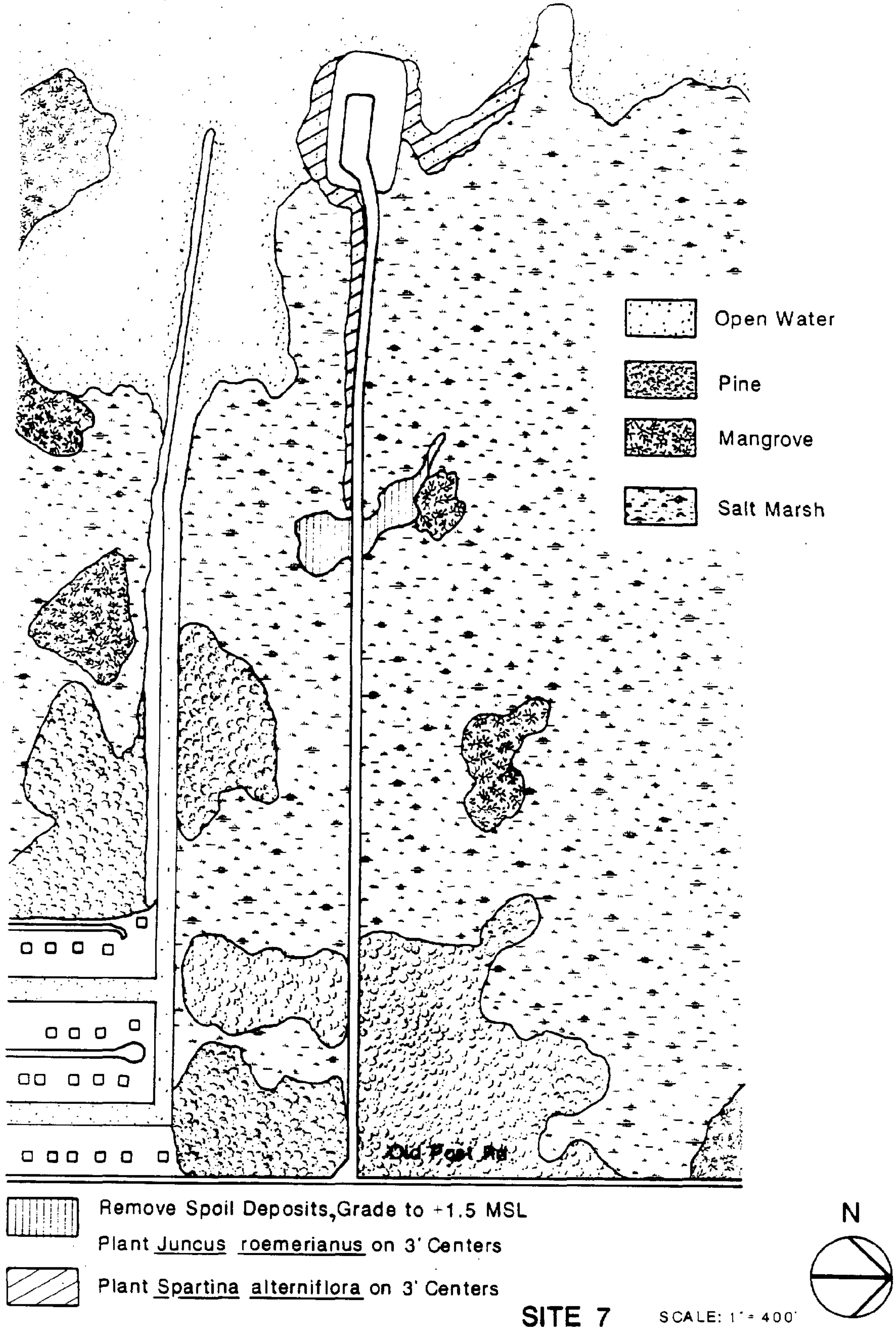


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Figure 49

City of Port Richey
Park Restoration Plan

Restoration Plan: The goal of the restoration plan is to remove the large spoil mound and re-establish the historic extent of the Juncus marsh. In addition, the S. alterniflora growth currently fringing the park perimeter is to be enhanced by additional plantings of that species. The spoil mound is to be removed and graded to +1.5' MSL, and re-planted with J. roemerianus on three-foot centers, as shown on Figure 49. The roadside ditch and north and south fringes of the park are to be planted with S. alterniflora on three-foot centers. The existing grade and energy environment in these areas is apparently suitable for such plantings by virtue of the natural re-establishment occurring there. If implemented, this plan will result in the restoration/enhancement of 2.35 acres of intertidal wetlands.

Site 8: Dunedin Causeway

Site Description: Located in northwestern Pinellas County, the Dunedin Causeway provides access across St. Joseph Sound to Dunedin Beach and Honeymoon Island (Figure 50). The northern side of the causeway is mostly void of vegetation due to heavy public usage and lack of controlled access. The sediments contain some large rubble mixed with finer sands.

The causeway was constructed by dredge and fill activity within St. Joseph Sound. The present shoreline configuration of Dunedin Causeway is controlled by erosional forces derived from current velocities through the causeway passes. Tidal action, boat traffic and human interferences have limited the amount of natural vegetation establishments.

Land Use: Currently the Dunedin Causeway is under the jurisdiction of the Florida Department of Transportation and Pinellas County. The area serves as an unregulated beach area for picnicking, sailing and other water oriented uses.

Restoration Plan: The Florida Department of Natural Resources (FDNR) is currently reviewing the Dunedin Causeway for creation of an intertidal marsh. The site reviewed for planting is approximately 1000 ft. in length on the east and west end approach (Figure 50).

The described restoration plan (FDNR draft, 1985a) entails planting three rows of smooth cordgrass (*Spartina alterniflora*) on one-foot centers with one row of black mangrove (*Avicennia germinans*) seedlings on ten-foot centers. This will require 10,000 cordgrass sprigs and 500 black mangrove seedlings. The FDNR (Draft, 1985a) calculated the cost for planting a salt marsh fringe on the Dunedin Causeway to range from $17,500 to $20,000. The price can be reduced by planting only smooth cordgrass and allowing natural volunteer mangroves into the area.

Site 9: Belleview Island

Site Description: Belleview Island is located in Clearwater Harbor, south of Memorial Causeway (Figure 51). The Intracoastal Waterway travels along the western side of the island. The island is presently undeveloped with only an access road traveling around the island perimeter. Belleview Island provides a protected cove on the southeastern side. Isolated seagrass beds exist in adjacent subtidal areas.

Land Use: The upland portions of Belleview Island is presently privately owned. The ownership of subtidal lands in the vicinity of Belleview Island has not been determined. All waters of the state are under the jurisdiction of the FDER.

Restoration Plan: The shallow subtidal area on the southeastern side of Belleview Island can be planted with *Halodule wrightii* seagrass (Figure 51). Proper planting elevation should be determined from adjacent beds. *H. wrightii* sprigs are recommended to be planted on two-foot centers with the total acreage calculated from the available area occurring at proper elevation.

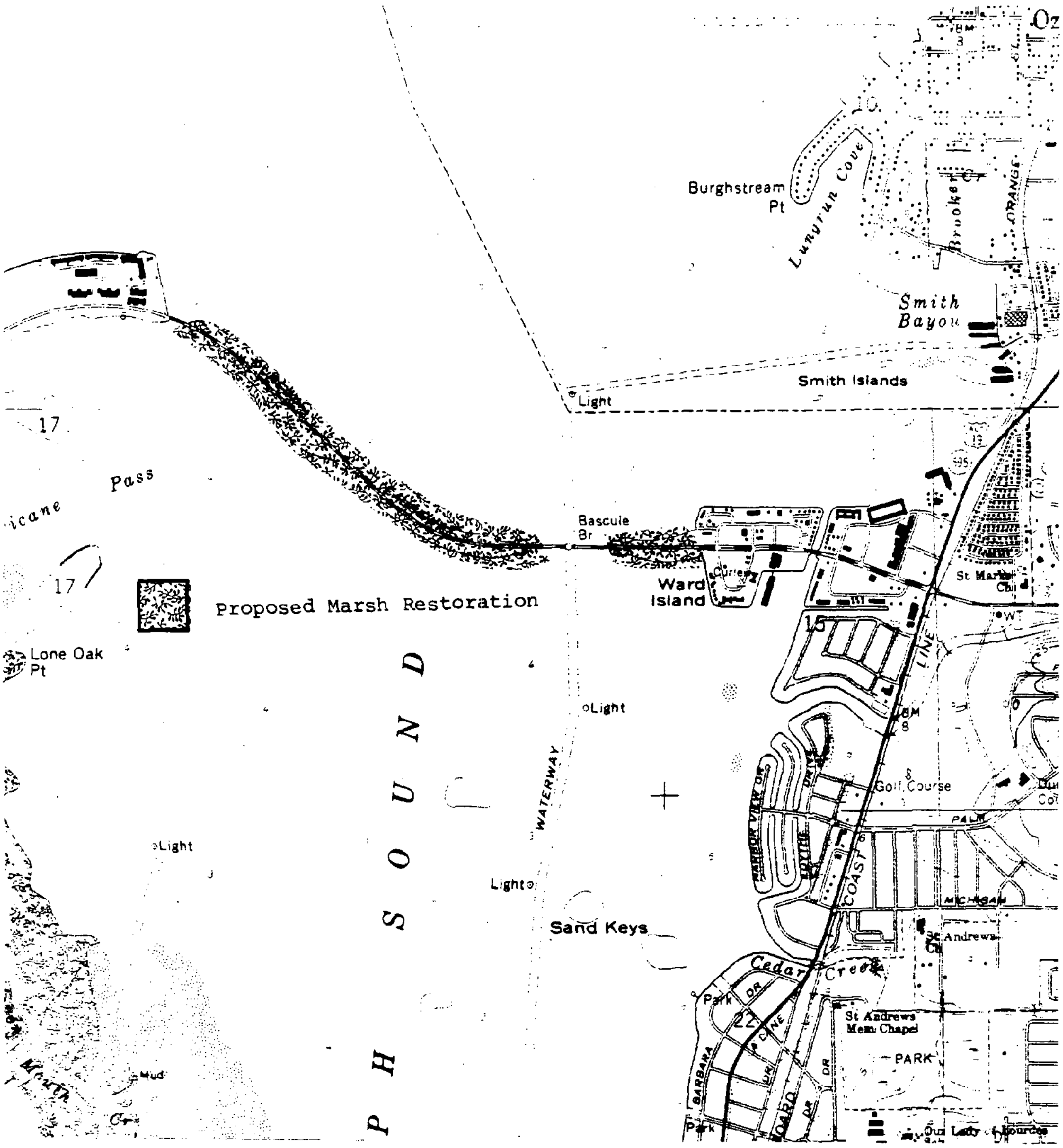


Figure 50

Dunedin Causeway Restoration Site

Adapted from 7.5 Minute Quadrangles
U. S. Geological Survey
Department of the Interior
and Fl. Dept. of Natural Resources
(Draft, 1985a)

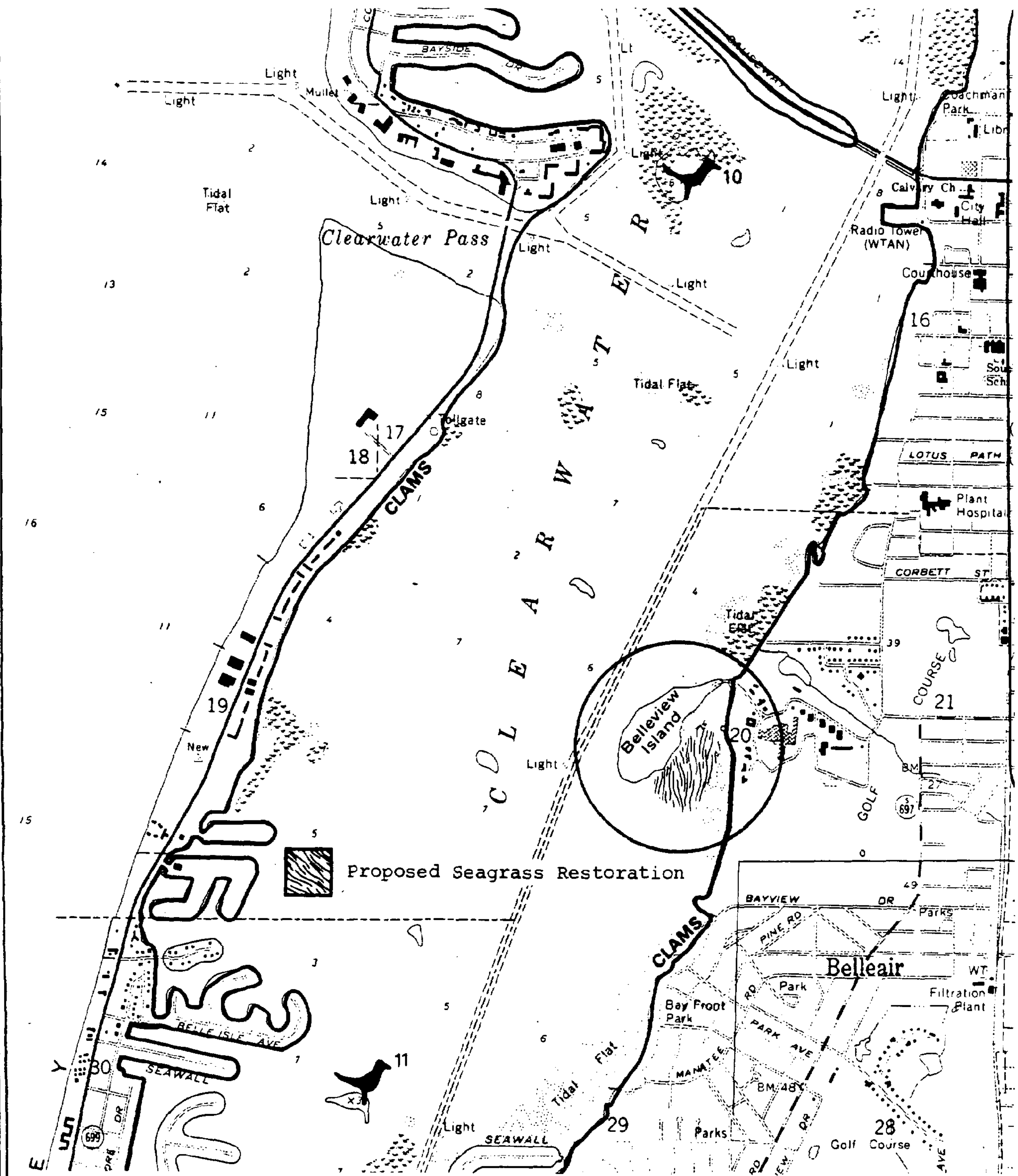


Figure 51

Belleview Island Restoration Site

Adapted from 7.5 Minute Quadrangles
Tampa Bay Environmental Atlas
U. S. Fish and Wildlife Service (1985)
and Dept. of Natural Resources Draft (1985a)

Site 10: Belleair Causeway

Site Description: The Belleair Causeway travels between Belleair Bluffs to Belleair Shores in southern Clearwater Harbor, north of the Narrows. Similar to the Dunedin Causeway, the Belleair Causeway was created by dredge and fill activity to gain access to the Gulf barrier islands. In addition, the Causeway is heavily utilized as a recreational area, which in-turn limits natural vegetation establishment.

Land Use: Belleair Causeway is maintained by the Florida Department of Transportation.

Restoration Plan: Presently the FDNR is reviewing the Belleair Causeway as a restoration site for Pinellas County Marine Habitat Restoration Program (Draft, 1985a). The recommended plan includes establishment of 5,000 cordgrass sprigs in three rows on three-foot centers and 100 black mangroves on 10-foot centers. Planting will be in areas devoid of natural vegetation and in areas where exotic species have been removed (Figure 52).

A major consideration for the success of restoration of Belleair Causeway will be to limit public access from planted areas. It will be necessary to erect physical barriers and signs identifying the project and potential benefits. This restoration site will provide high visibility for additional public education and awareness on habitat restoration programs.

Site 11: Dog Leg Key

Site Description: Dog Leg Key is located within Boca Ciega Bay at the intersection with Long Bayou (Figure 53). The Key is a large spoil island with several smaller spoil islands existing to the south. Dog Leg Key is currently sparsely vegetated with black mangroves and is normally inundated on higher tides.

The Key is located within an area of poor water quality, offering the opportunity to create a salt marsh/mangrove intertidal fringe which would potentially filter pollutants and provide fish and wildlife habitat.

Land Use: The ownership of Dog Leg Key and the adjacent spoil islands has not been determined to date. The area is under the jurisdiction of the FDER.

Restoration Plan: It is recommended that the perimeter of Dog Leg Key and the smaller adjacent spoil islands be planted with smooth cordgrass (Figure 53). Cordgrass can be planted on a maximum of three-foot centers in three rows within the intertidal zone of each of the islands. Due to its close proximity to the Long Bayou boat channel, it may be necessary to increase planting densities (sprigs or plugs on two-foot centers in four rows) or establish a wave dampening barrier just off shore. Dog Leg Key is not utilized actively by the public, but if properly marked, may provide an ideal location for boaters and fishermen to identify with restoration sites.

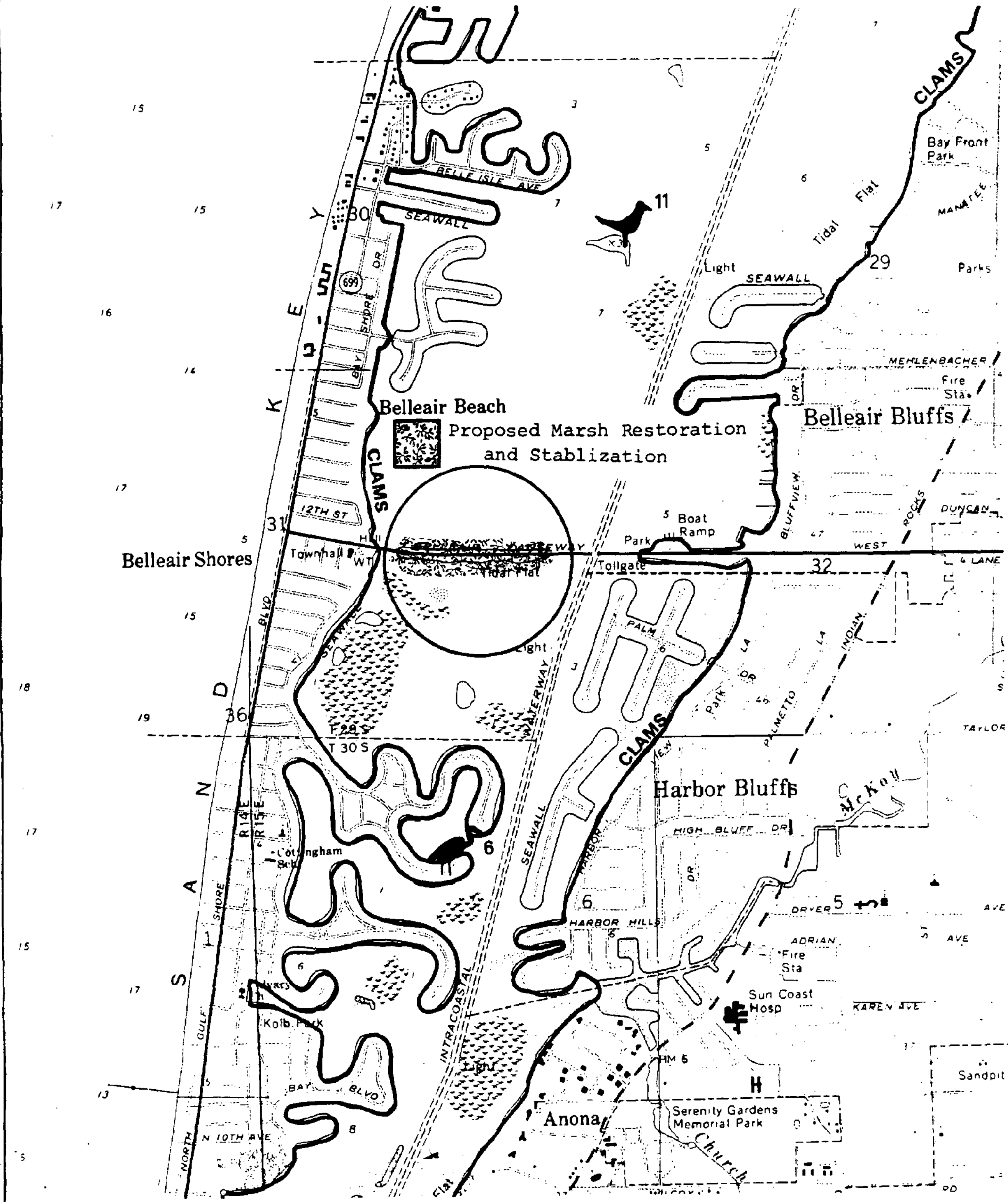


Figure 52

Belleair Causeway Restoration Site

Adapted from 7.5 Minute Quadrangles
Tampa Bay Environmental Atlas
U. S. Fish and Wildlife Service (1985)
and Dept. of Natural Resources Draft (1985a)

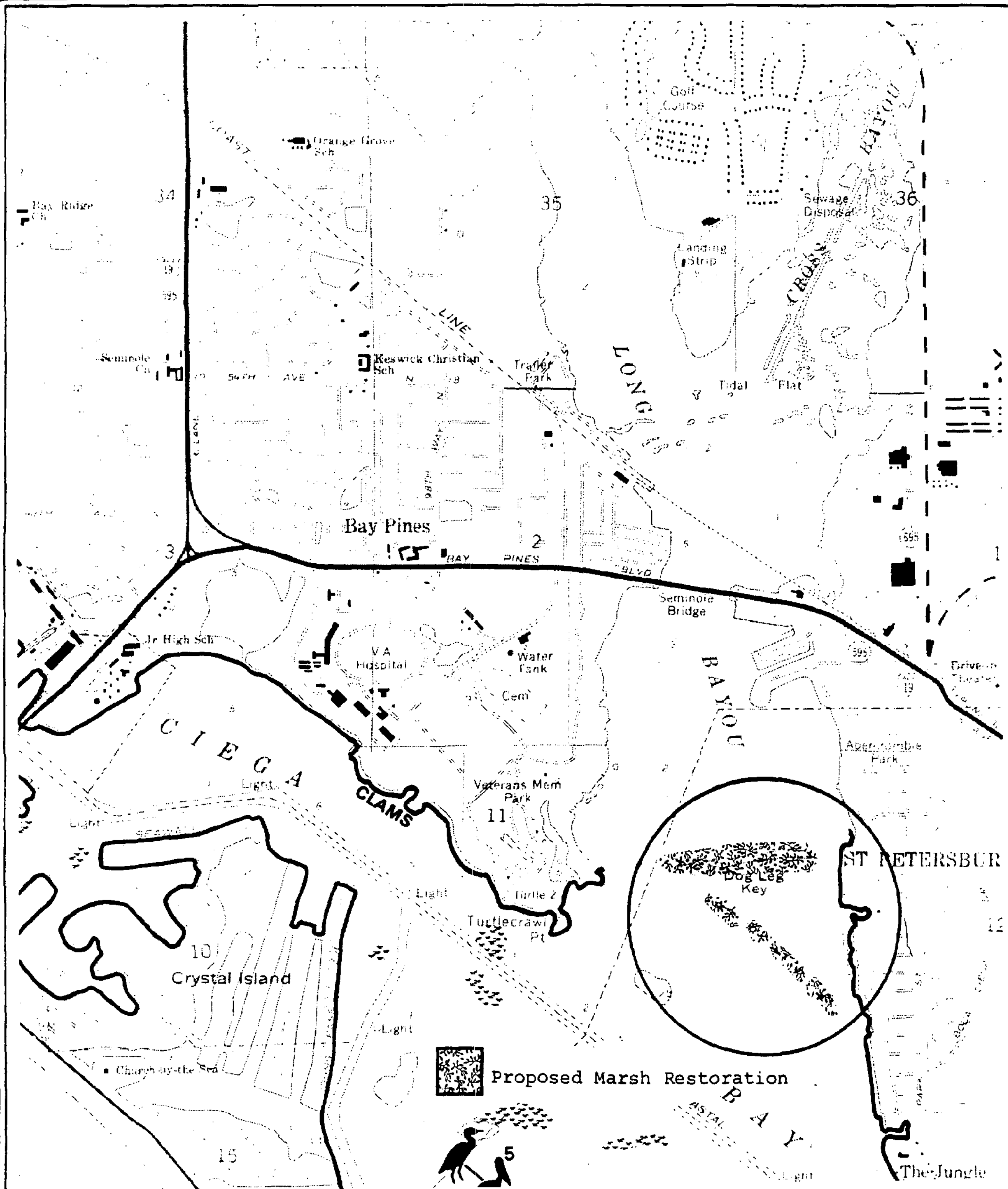


Figure 53

Dog Leg Key Restoration Site

Adapted from 7.5 Minute Quadrangles
Tampa Bay Environmental Atlas
U. S. Fish and Wildlife Service (1985)
and Dept. of Natural Resources Draft (1985a)

Site 12: Skyway Bridge - Intertidal

Site Description: The Sunshine Skyway Bridge travels between southern Pinellas County and Manatee County, near the mouth of Tampa Bay. The causeway approach on the Pinellas County (northern) side was created by dredging bay bottom sediments and spoiling the material for causeway construction (Figure 54). Two circulation cuts are maintained through the Pinellas Skyway causeway, north of the main span.

Presently, the causeway is used extensively for passive recreation. Travelers on Interstate 275 can pull off the road, unimpeded, for picnicking and fishing. A small park is maintained at the southwestern terminus of the Pinellas causeway.

Small areas of mangrove and salt marsh vegetation occur in areas along the causeway. The existing vegetation is limited in extent by public degradation, wave energy and elevational requirements.

Currently, the Florida Department of Transportation, as part of the interstate improvement programs, will limit public access points on the causeway. This will be accomplished by controlling vehicle access via fencing the roadway. Public access will be limited to pedestrian traffic for most of the causeway length.

The 1957 wetland inventory (Figure 55) for lower Pinellas County identify a portion of the Skyway Causeway. The causeway is reported as upland with open water and estuarine aquatic vegetation in adjacent areas. In 1982, (Figure 56) the causeway has been expanded and identified as urban developed. Review of the wetland trend (Figure 57) reveals lost and new seagrass growth and associated upland development.

Land Use: The Sunshine Skyway Bridge and causeway are the ownership of the Florida Department of Transportation.

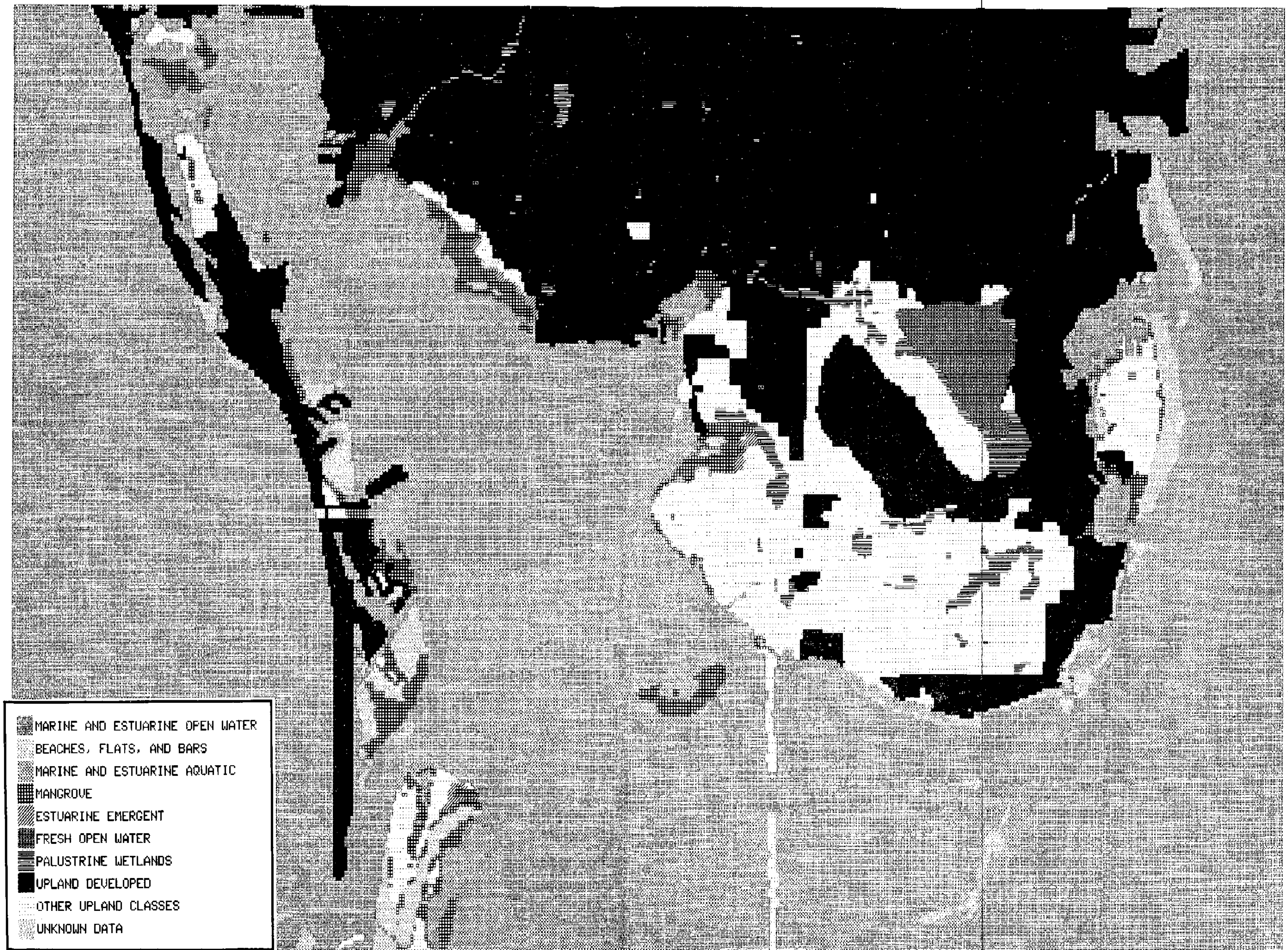
Restoration Plan: The proposed improvements along the Skyway Bridge offer an ideal situation for habitat restoration and enhancement. There are approximately seven miles of shoreline available for revegetation. Conditions for establishment of native vegetation will be improved by limiting vehicular traffic and creating additional public awareness.

The majority of the existing natural intertidal vegetation occurring along the causeway shoreline can be enhanced by additional saltmarsh or mangrove plantings. It is recommended that the remainder of the available open space be marked by signs and planted with S. alterniflora on three-foot centers. The adjacent natural areas will provide a seed source for mangrove colonization.

Site 13: Skyway Bridge Artificial Reef

On May 9, 1980, the western span of the Skyway Bridge was struck by the vessel Summit Venture during extreme weather conditions. Portions of the middle span fell into Tampa Bay. The FDOT has constructed a new span across the mouth of Tampa Bay to the east of the existing span. The existing causeway alignment will be preserved and used in conjunction with the new span. Upon completion of the new span, portions of the old bridge

Figure 55 Wetland Inventory of the St. Petersburg Area - 1957



D - 1957 INVENTORY

Figure 56 Wetland Inventory of the St. Petersburg Area - 1982

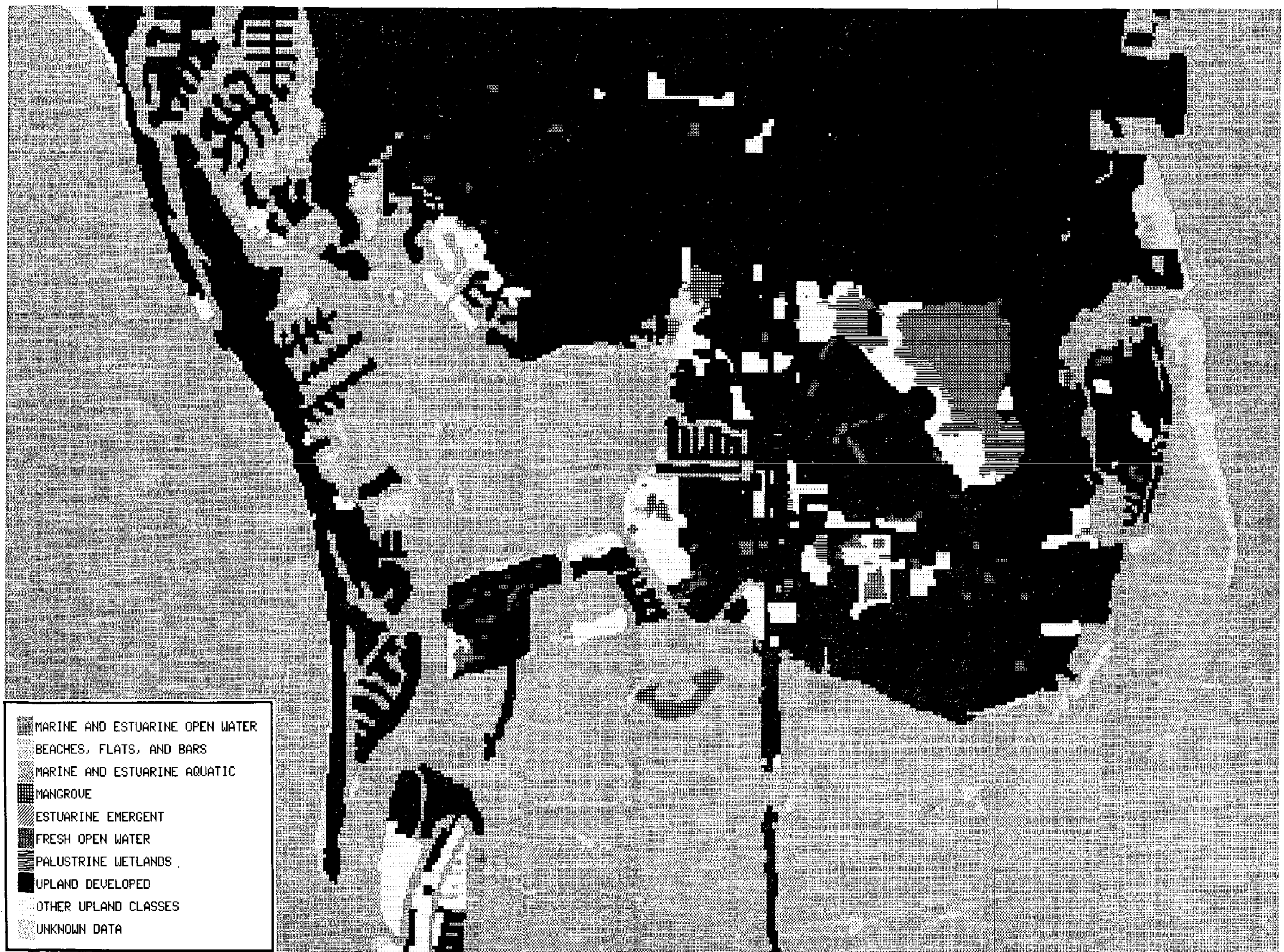
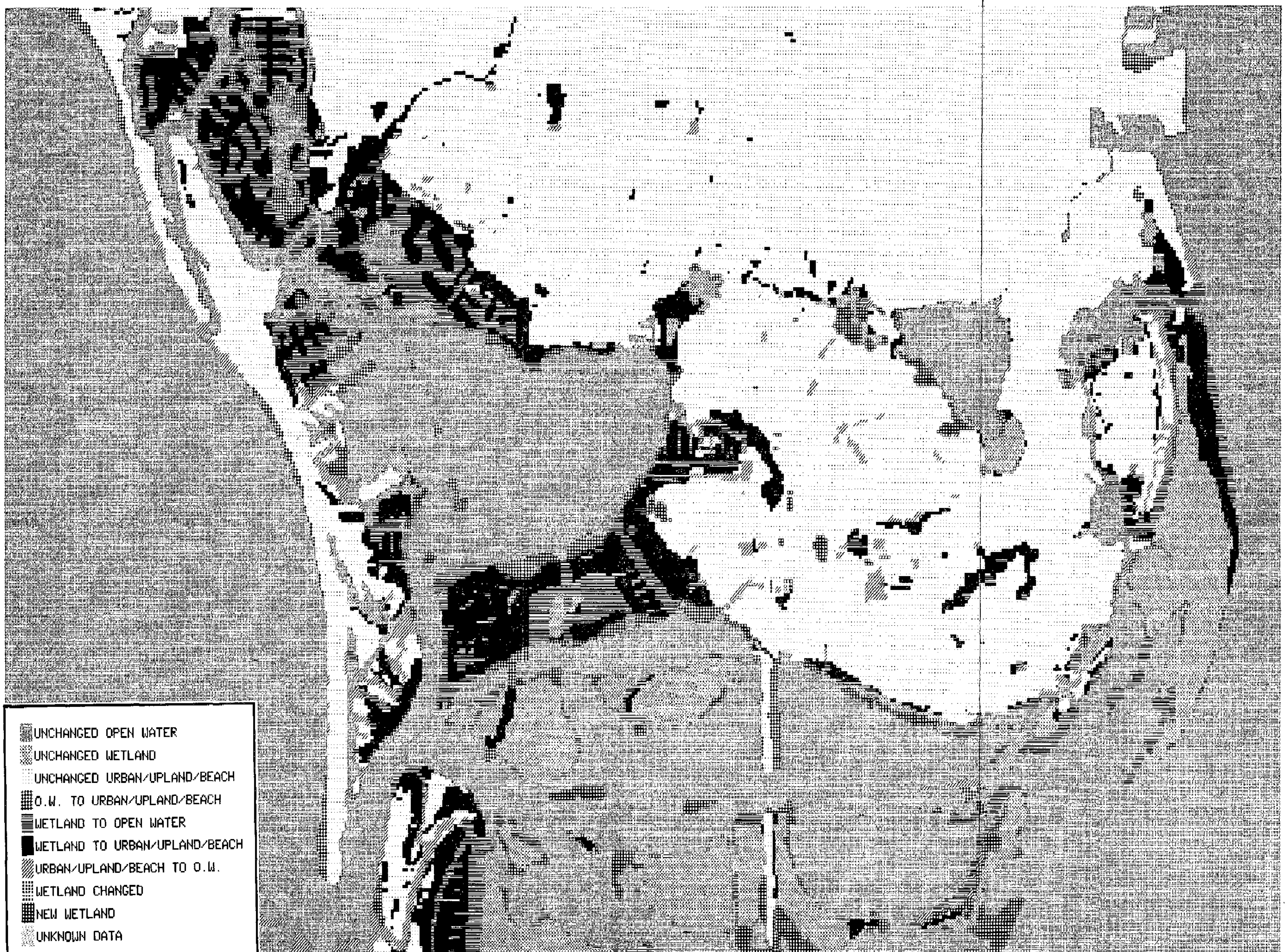


Figure 57 Wetland Trend Analysis of the St. Petersburg Area



D - WETLAND TRENDS

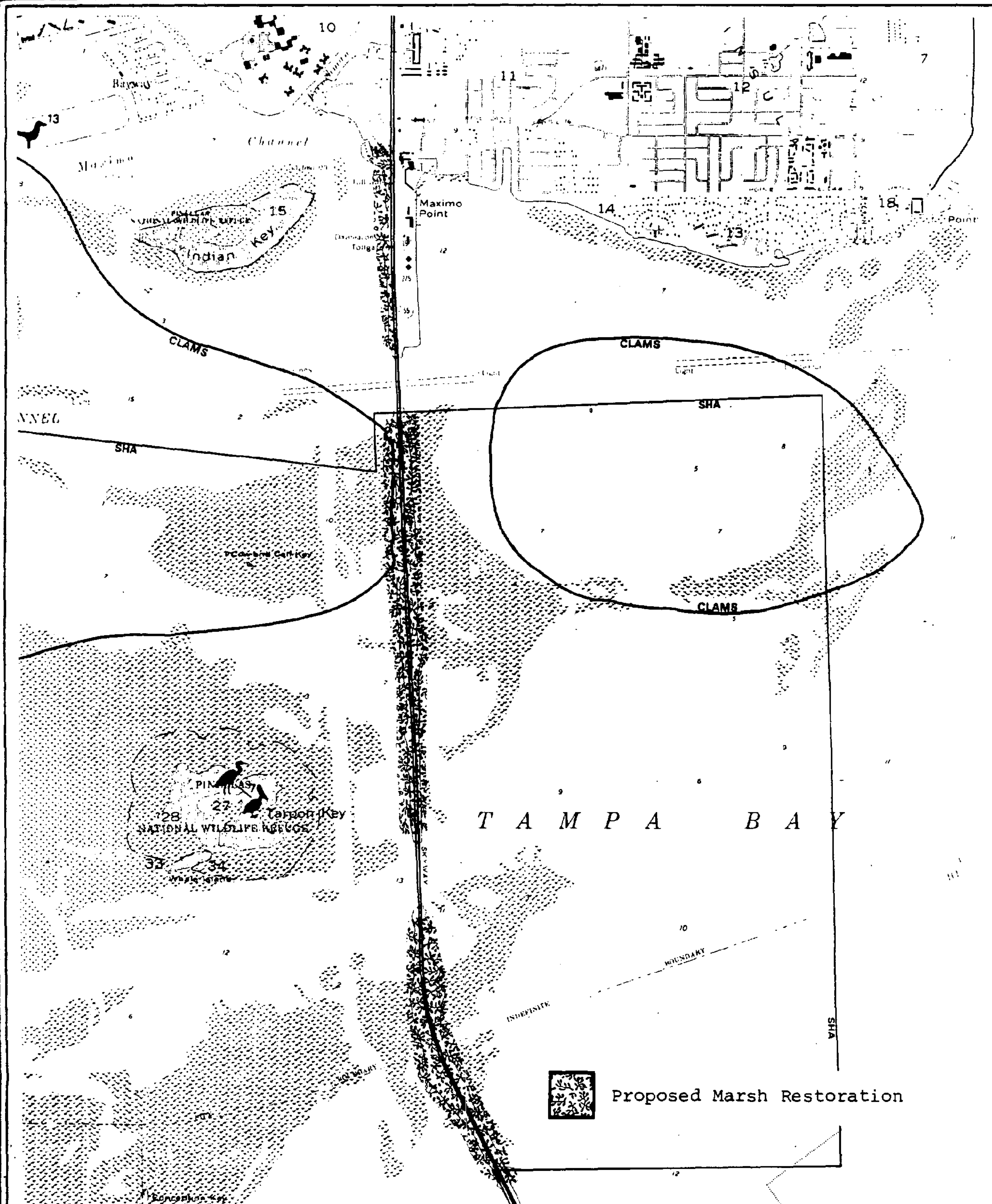


Figure 54
Skyway Bridge Restoration Site

Adapted from 7.5 Minute Quadrangles
Tampa Bay Environmental Atlas
U. S. Fish and Wildlife Service (1985)

are expected to be demolished to remove a potential navigation hazard for commercial shipping.

Land Use: The old span is currently owned by the FDOT.

Restoration Plan: The demolition of the old span of the Skyway Bridge will provide large quantities of concrete slabs and other construction debris. The recommended plan is to leave one roadway on the Pinellas and Manatee side in place for a fishing pier (Figure 58). A turn-a-round will be constructed at the extreme tips. The demolished roadway material can be piled in areas along the piers to serve as an artificial reef. Any remaining material can be used for other artificial reef projects in the Gulf of Mexico and regional estuaries.

Site 14: Pinellas Point - Intertidal

Site Description: The extreme southern extent of Pinellas County is defined as Pinellas Point (Figure 59). The area contains residential development upland of a narrow open shoreline bordering middle Tampa Bay. The fringe area contains scattered mangrove and cordgrass areas that have been impacted by Hurricane Elena (September 1985) and human activities. Restoration of the area is recommended to speed revegetation from the hurricane and provide treatment at existing stormwater outfalls.

The wetland inventories for the area (Figure 55 and 56) identifies the encroachment of urban development and the changes in estuarine vegetation. The trend analysis (Figure 57) between 1957 and 1982 shows new seagrass growth on a tidal bar reported in 1957, and wetlands that have been converted to open water or upland classes by 1982.

Land Use: Presently, the area identified for restoration contains parcels of land in public and private ownership. The areas containing estuarine vegetation are under the jurisdiction of FDER.

Restoration Plan: The recommended restoration/enhancement proposal is to plant smooth cordgrass at suitable elevation and tie in existing stands of natural vegetation (Figure 59). Additionally, mangrove seedlings can be monotypically planted or intermixed with the cordgrass. Successful restoration will be contingent upon controls of wave action and erosion during initial establishment, and limited public access.

A portion of the area in Pinellas Point has been planted using funds derived from the gill net licensing fees distributed through the FDNR. The area is expected to be monitored extensively over the next several years to determine success and utilization of the restored area in comparison with adjacent natural areas. Suitable locations remain along Pinellas Point for additional restoration or enhancement.

Site 15: Pinellas Point - Subtidal

Site Description: Pinellas Point is located at the southern tip of Pinellas County east of the Skyway approach. Figure 60 identifies the location of Site 15 and adjacent areas.

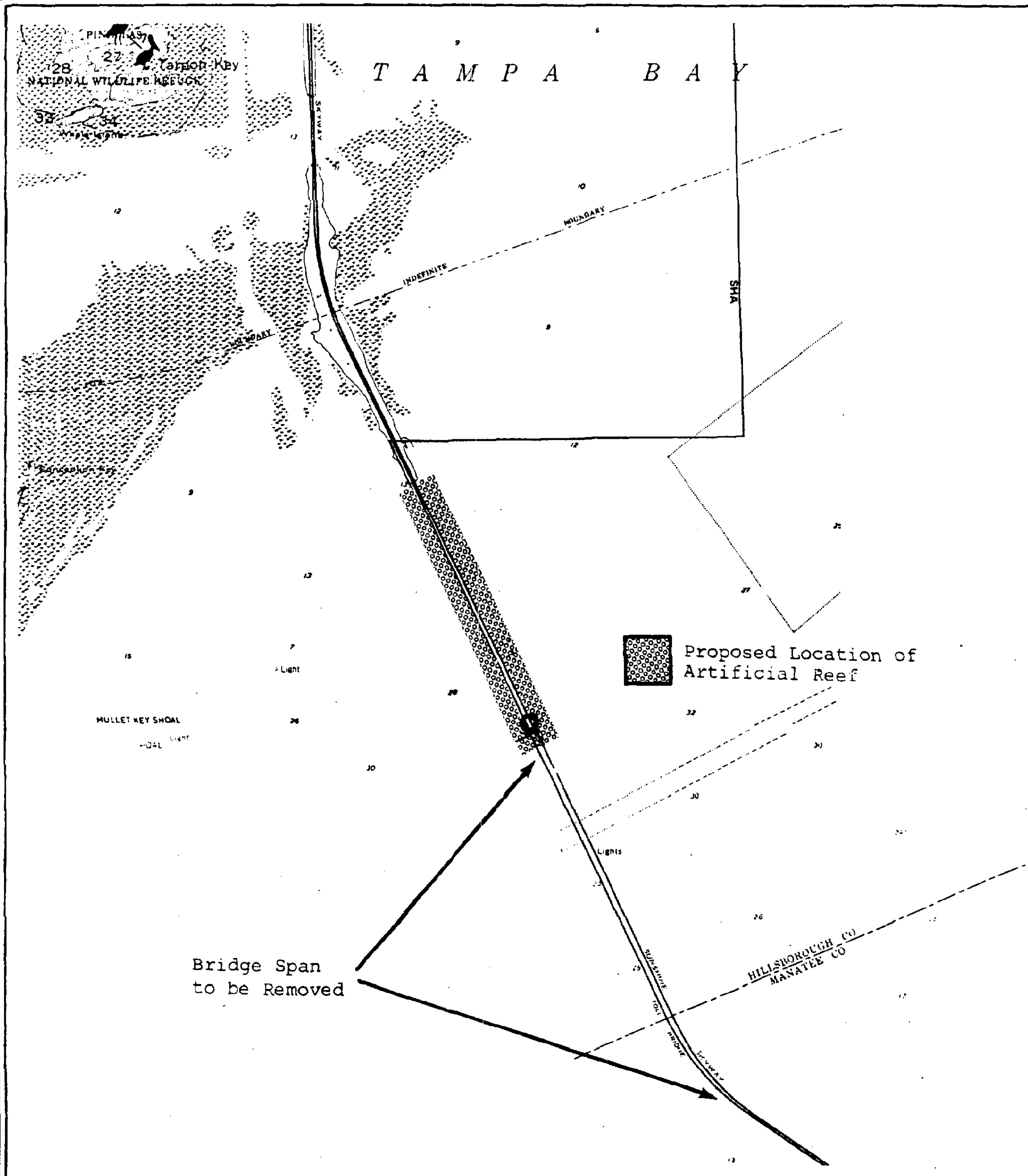


Figure 58
Skyway Bridge Artificial Reef Creation Site

Adapted from 7.5 Minute Quadrangles
Tampa Bay Environmental Atlas
U. S. Fish and Wildlife Service (1985)

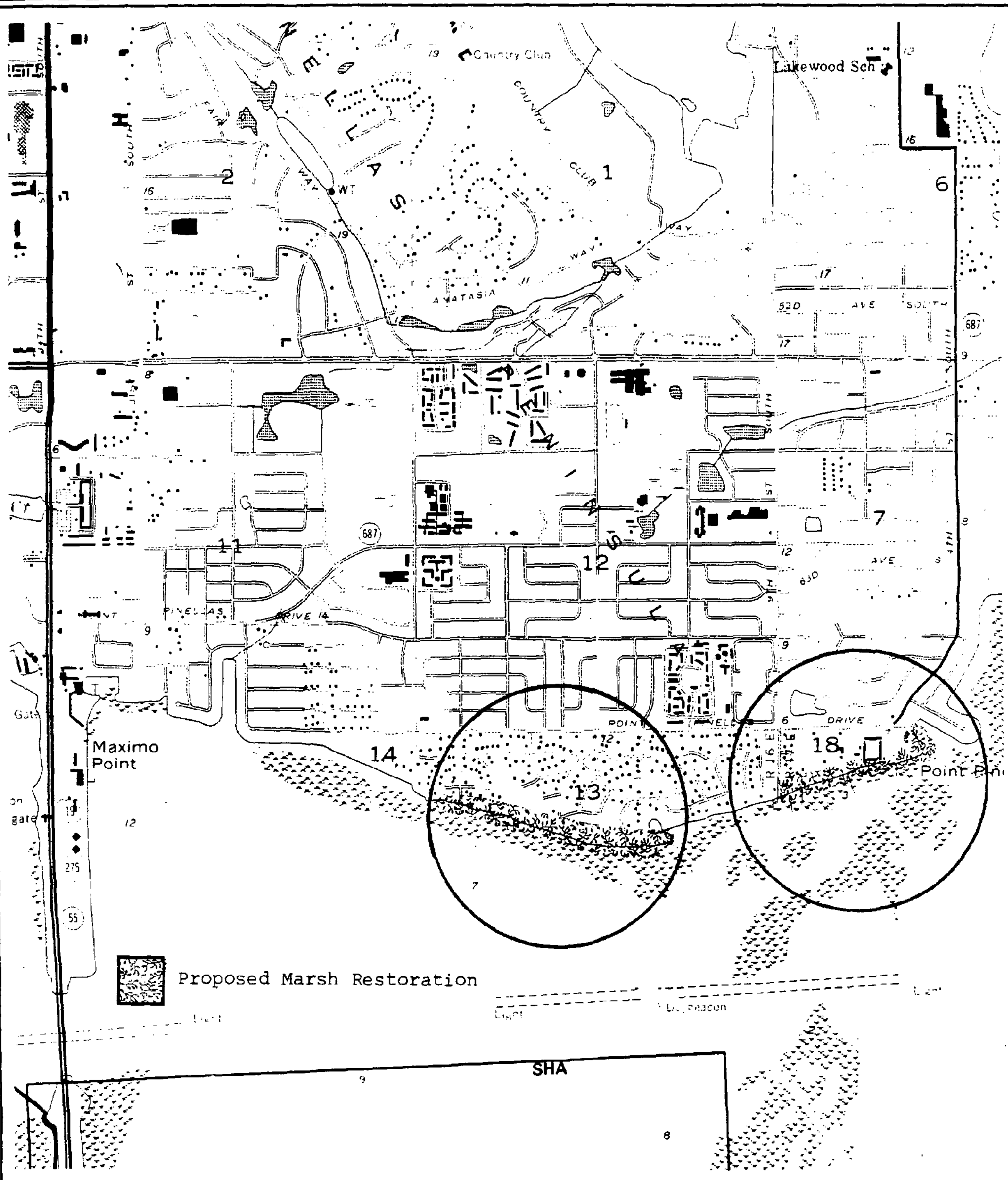


Figure 59

Pinellas Point Intertidal
Restoration Site

Adapted from 7.5 Minute Quadrangles
Tampa Bay Environmental Atlas
U. S. Fish and Wildlife Service (1985)
and Dept. of Natural Resources Draft (1985a)

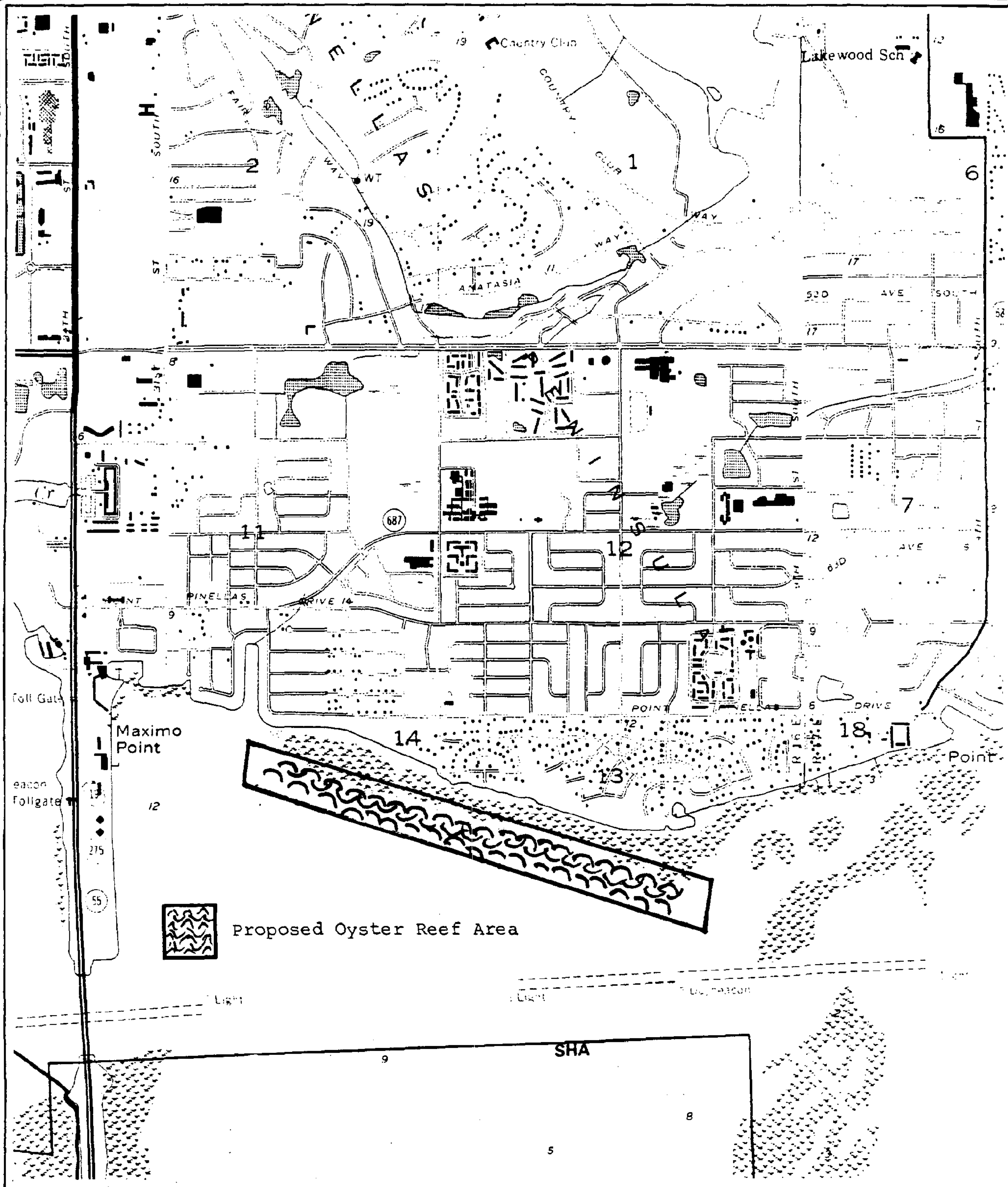


Figure 60

Pinellas Point Subtidal

Restoration Site

Adapted from 7.5 Minute Quadrangles
Tampa Bay Environmental Atlas
U. S. Fish and Wildlife Service (1985)
and Dept. of Natural Resources Draft(1985a)

A fringe of seagrass beds, protected by a subtidal estuarine bar, occurs just offshore of Pinellas Point. The estuarine bar consists of sand or natural oyster deposits. The shoreline receives erosion from boat traffic and storm events. The estuarine bar can be enhanced by the deposition of oyster shells to facilitate attachment of larval oysters.

The trend analysis for the Pinellas Point subtidal areas has been reviewed for Site 14 (Pinellas Point Intertidal). With new seagrass growth identified on the wetland trend (Figure 57), the submerged vascular aquatic vegetation can be protected from future erosional forces by the enhancement/creation of a subtidal oyster bar. Additionally, this will benefit the ecosystem by providing diverse habitat for fish and wildlife populations.

Land Use: Ownership of the subtidal area south of Pinellas Point has not been determined. The area is not in waters currently approved for shellfish harvesting.

Restoration Plan: The existing oyster reef south of Pinellas Point can be nourished by the placement of cultch (oyster shell or material suitable for larval attachment) (Figure 60). This would assist the continuing growth of existing oyster bars which, although not harvestable, are efficient biological filtering agents and create valuable fisheries habitat. In addition, with proper placement, the subtidal oyster bars can protect adjacent grass beds from erosional forces.

A program of collecting oyster shell from restaurants specializing in "raw oysters" could generate significant quantities of cultch material to be used in enhancement efforts. The feasibility of using oyster shell for restoration may be dependent upon transportation and placement expenses.

Site 16: Lassing Park

Site Description: Lassing Park is located between Bayboro Harbor on the north and Big Bayou to the south in Pinellas County (Figure 61). In August 1984, Lassing Park was the site of an emergency dredge and fill operation when 42,000 cubic yards of spoil was deposited into a nine-foot deep hole to remove a public hazard. The elevation of the bottom into the photic zone allows the opportunity for seagrass restoration. Adjacent areas of natural seagrass beds exist to the south.

The wetland inventory in 1957 and 1982 for Lassing Park are illustrated in Figures 55 and 56, respectively. The trend analysis (Figure 57) between the two time periods indicates loss of seagrasses due to dredge and fill activities for urban development. The barren subtidal flat and isolated seagrass bed are illustrated east of the Lassing Park area.

Land Use: Lassing Park is in the City of St. Petersburg's jurisdiction. The recreational park is located due west of the restoration site.

Restoration Plan: The FDNR has planned a restoration program at Lassing Park. Shoalgrass (*H. wrightii*) was selected due to the spreading rate of the seagrass and because it currently grows in the adjacent natural bed (Figure 61). The shoalgrass will be planted at the same elevation as the adjacent bed at assorted planting densities to evaluate coalescent rates.

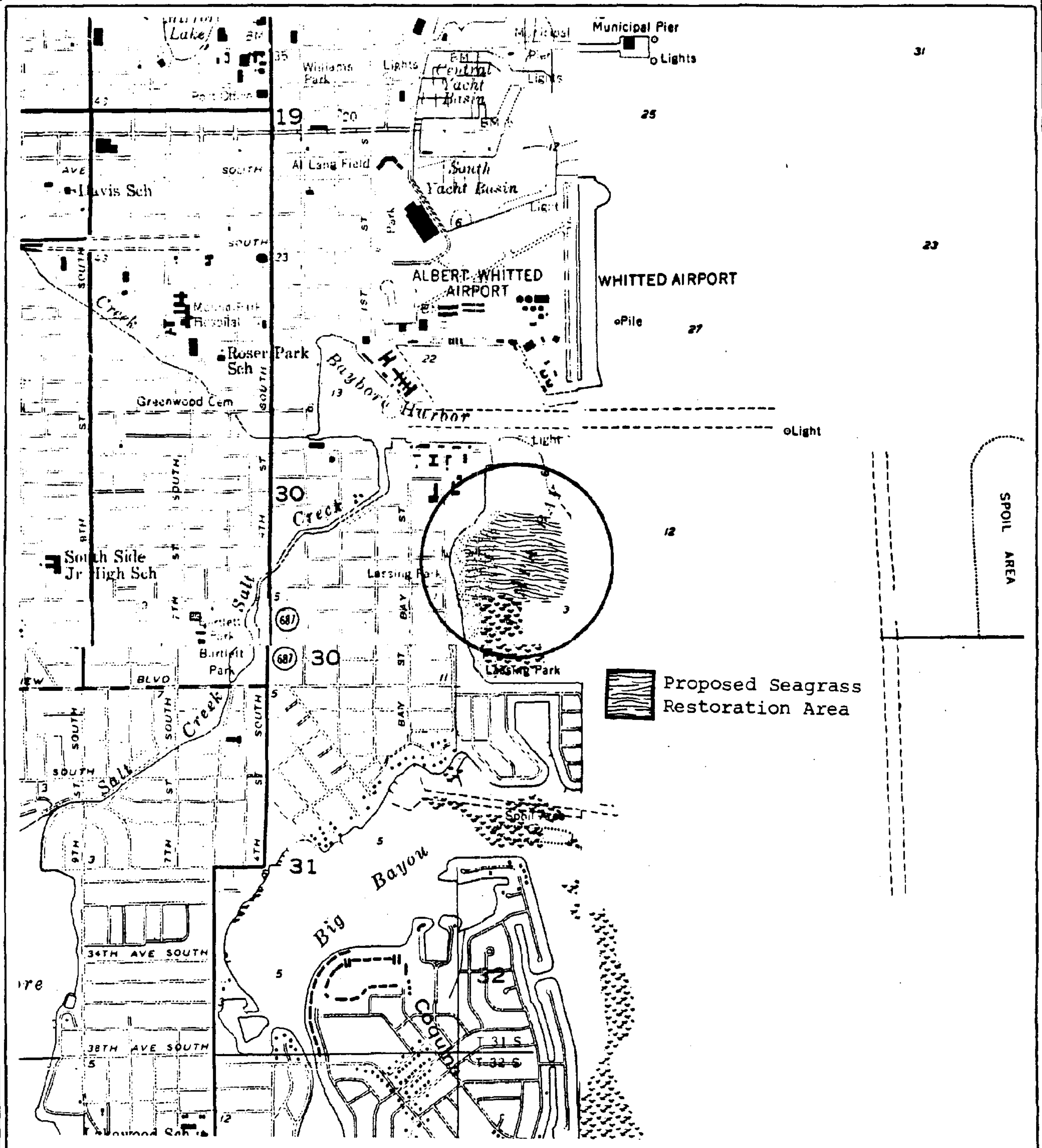


Figure 61

Lassing Park restoration site

Adapted from 7.5 Minute Quadrangles
Tampa Bay Environmental Atlas
U. S. Fish and Wildlife Service
and Fl. Dept. of Natural Resources
Draft (1986a)

The FDNR program will monitor the created bed for several years for success and organism utilization. In addition, plantings at Lassing Park will be orientated, both to test suitability of the dredged material for seagrass restoration and to enhance disturbed or barren areas.

The pilot project is expected to be started in the spring of 1987. Additional area exists for further revegetation efforts.

Site 17: Salt Creek

Site Description: Salt Creek travels from Lake Maggiore to Bayboro Harbor in Pinellas County (Figure 62). The creek is characterized with residential development in the middle segment, and industrial development in the lower segment and within Bayboro Harbor. Salt Creek is classified as a stressed tidal tributary of Tampa Bay (TBRPC, 1986b). A small, undeveloped area at the mouth of Salt Creek will benefit from revegetation with estuarine intertidal species. Small areas of scattered mangroves occur in adjacent locations within Salt Creek and Bayboro Harbor.

The wetland inventories (Figure 55 and 56) for Salt Creek identify the area as urban or open water. The isolated mangroves previously described do not occur in sufficient quantity to be identified at the scale used in the mapping project. No change in this designation has occurred since 1957.

Land Use: The area is currently within the City of St. Petersburg's jurisdiction. The project may be contingent upon rezoning of the Bayboro Redevelopment Area.

Restoration Plan: The area under the ownership of the City of St. Petersburg will require regrading to acquire suitable acreage for planting (Figure 62). The recontoured area can be planted on three-foot centers with smooth cordgrass. Mangroves can be allowed to establish naturally during maturation of the cordgrass plantings.

The Salt Creek shoreline restoration will additionally provide floral enhancement for stormwater treatment within an urbanized embayment.

Site 18: Coffee Pot Bayou

Site Description: Coffee Pot Bayou is a small embayment located on middle Tampa Bay, north of St. Petersburg in Pinellas County (Figure 63). The embayment is characterized by an almost continuous seawall around the perimeter. The bayou is encircled by residential development. Coffee Pot and Brightwaters Boulevards separate the residential development from the bayou. Numerous oyster bars exist within Coffee Pot Bayou and where elevations allow, mangroves have grown from the oyster bars or sediments.

Land Use: Currently the area along Coffee Pot and Brightwaters Boulevards are in public ownership. Numerous privately owned docks extend from the seawall into the bayou. Lands within private ownership extend into the bayou from facing residential units.

Restoration Plan: There is approximately 1.4 linear miles available for littoral shelf creation along Coffee Pot and Brightwaters Boulevards (Figure 63). The construction of the littoral shelf within a planters box

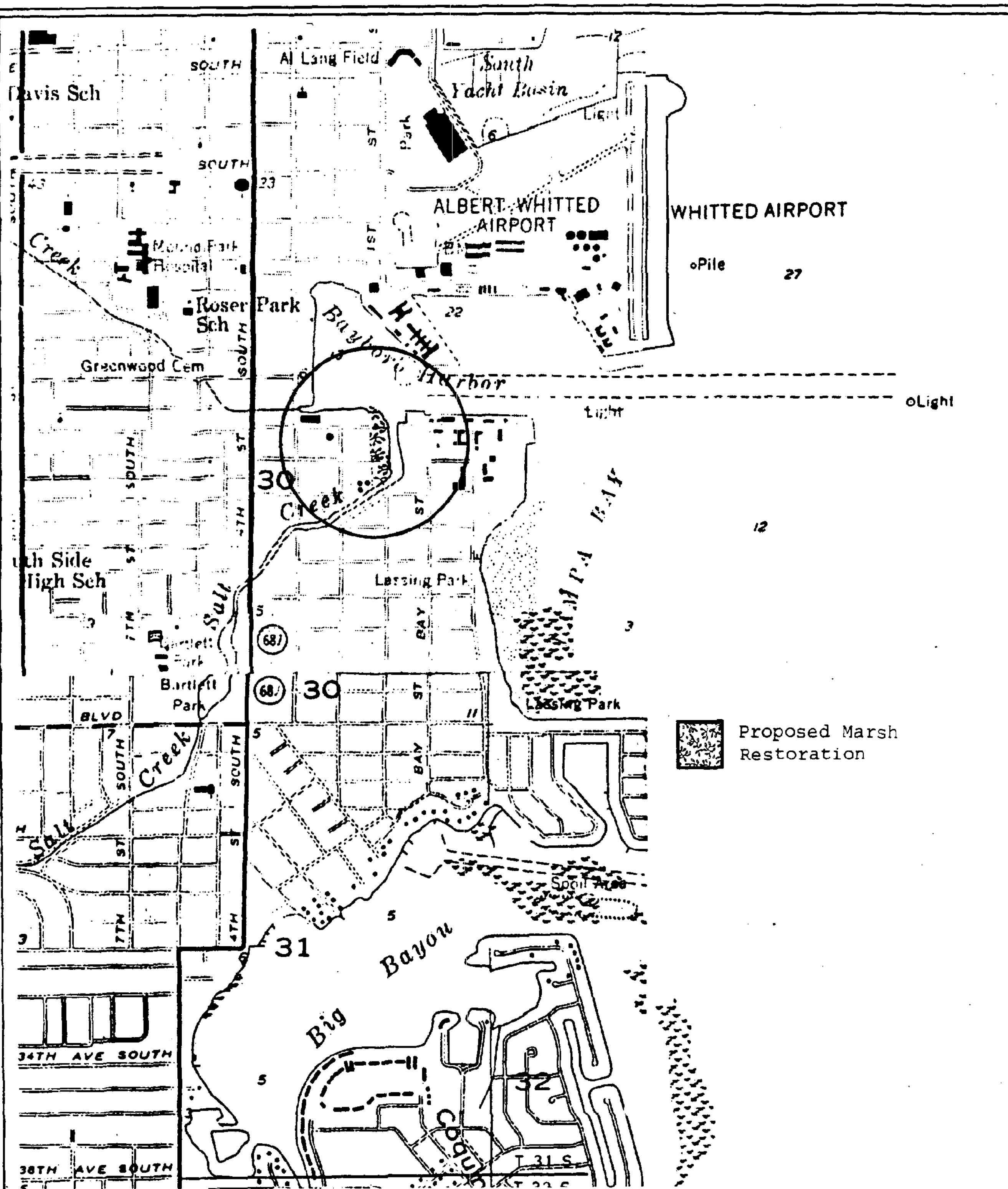


Figure 62

Salt Creek Restoration Site

Adapted from 7.5 Minute Quadrangles
Tampa Bay Environmental Atlas
U. S. Fish and Wildlife Service (1985)

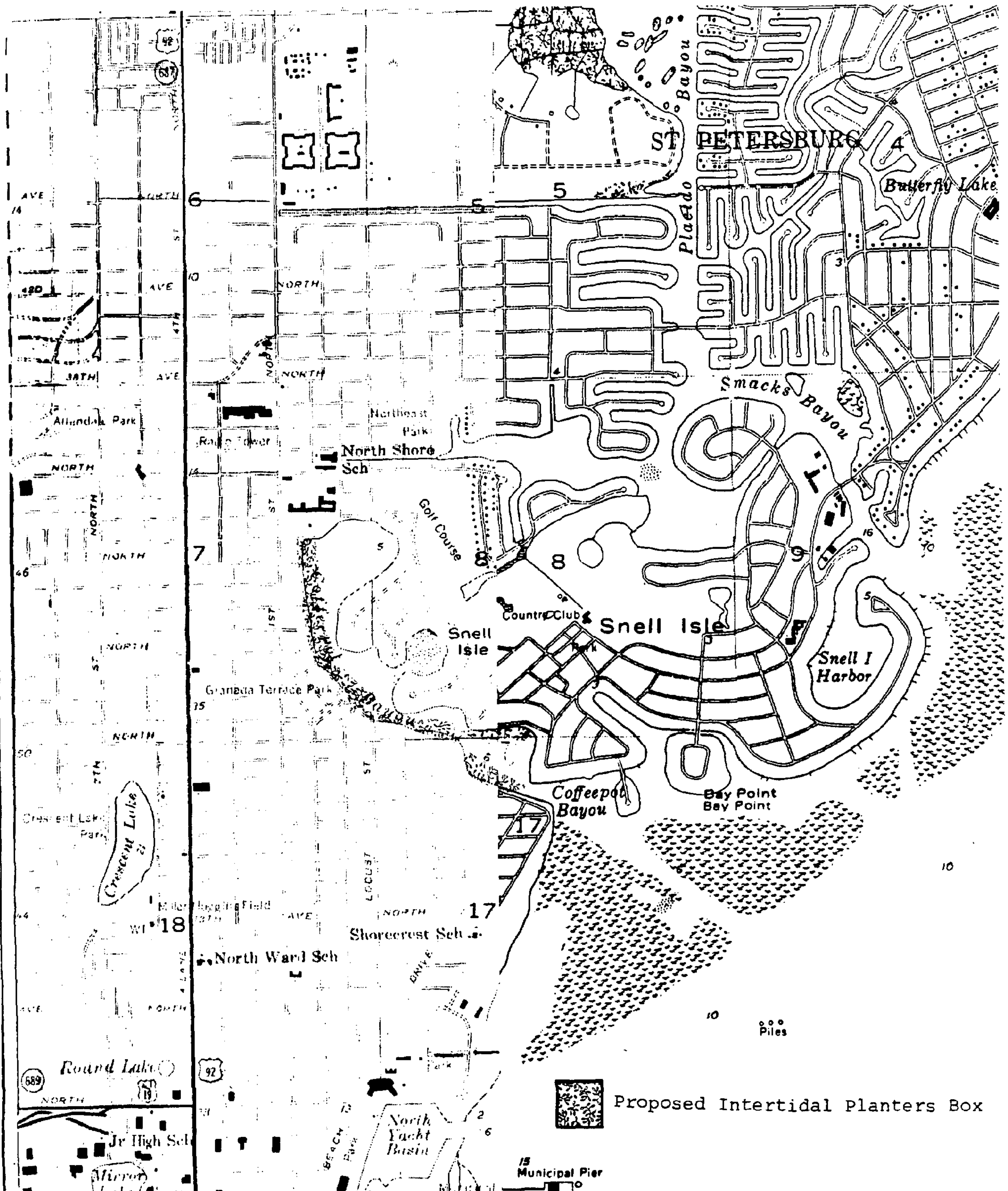


Figure 63

Coffee Pot Bayou Restoration Site

Adapted from 7.5 Minute Quadrangles
Tampa Bay Environmental Atlas
U. S. Fish and Wildlife Service (1985)
and Dept. of Natural Resources Draft (1985a)

will require fill material (clean sand or oyster shell) to be deposited at the seawall toe at the proper elevation for mangrove or salt marsh establishment. Smooth cordgrass sprigs can then be planted on two-foot centers with mangrove seedlings on 10-foot centers.

Proper placement of the fringe littoral shelf will be required to prevent alterations of existing oyster beds. In addition, the vista of residential units will need to be maintained and future trimming of mangroves may also be necessary.

Numerous stormwater outfalls enter Coffee Pot Boulevard from adjacent streets and parking lots. The revegetation project can promote stormwater pollution assimilation while providing fish and wildlife habitats. The area west of Snell Island Bridge is designated as a no wake zone (residential and manatee protection area). Revegetation of the area will additionally aid in wave dampening.

Site 19: Gandy Causeway

Site Description: The Gandy Causeway was constructed by dredge and fill activities to minimize the bridging of Tampa Bay between Hillsborough and Pinellas Counties. The causeway on the Pinellas County side extends approximately two miles in a northeastern direction into Old Tampa Bay (Figure 64).

Presently, the southern side and northeastern tip of the causeway is used extensively for recreational purposes (picnic, sailing, fishing, recreational vehicle rental, etc.). A deteriorating boat ramp exists on the southeastern corner of the causeway; otherwise no other public facilities are available.

Extensive stands of mangroves occur along the northern shoreline and extend northward into the Gateway area. The southern shoreline and northeastern tip contain scattered mature trees that are encroached by heavy public utilization. Shallow, subtidal oyster bars occur in patches and on derelict cement slabs along both sides of the causeway.

Wetland inventories for 1957 and 1982 are provided in Figure 65 and 66, respectively. The trend analysis in Figure 67 identifies the increase in mangrove coverage along the northern shoreline of the Gandy Causeway. Figure 67 further illustrates the loss of mangroves and seagrass (replaced by uplands and beach) and loss of seagrass (identified in 1957) to open water by 1982.

Land Use: Currently, the Gandy Bridge Causeway is regulated by the Florida Department of Transportation.

Restoration Plan: The limiting factor for additional establishment of intertidal vegetation along the causeway is public access and associated degradation. The recommended plan will require the creation of a recreational park on the southeastern side of the causeway. Benefits resulting from the establishment of a public park include:

- Controlled public access in natural or restorable areas

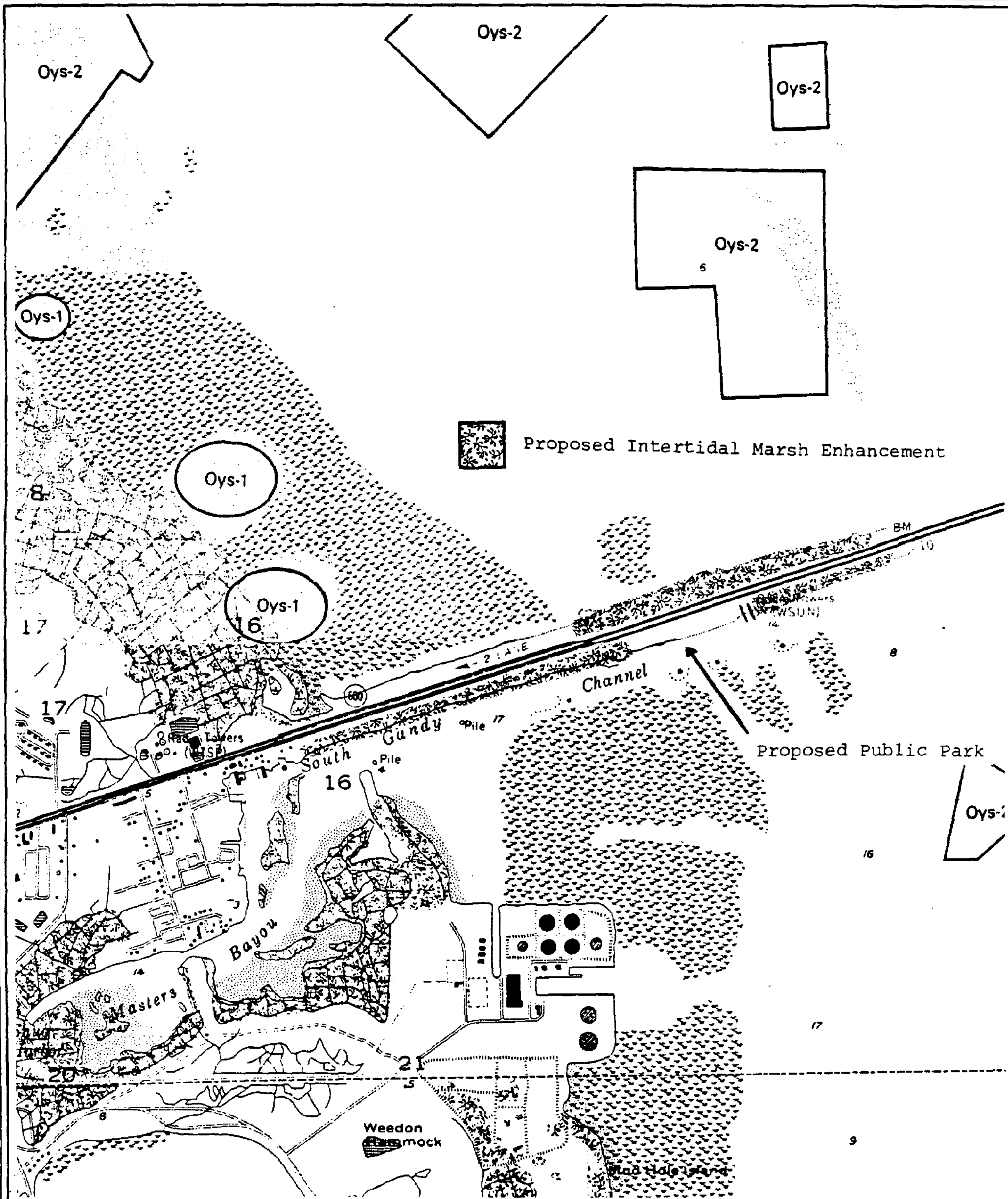
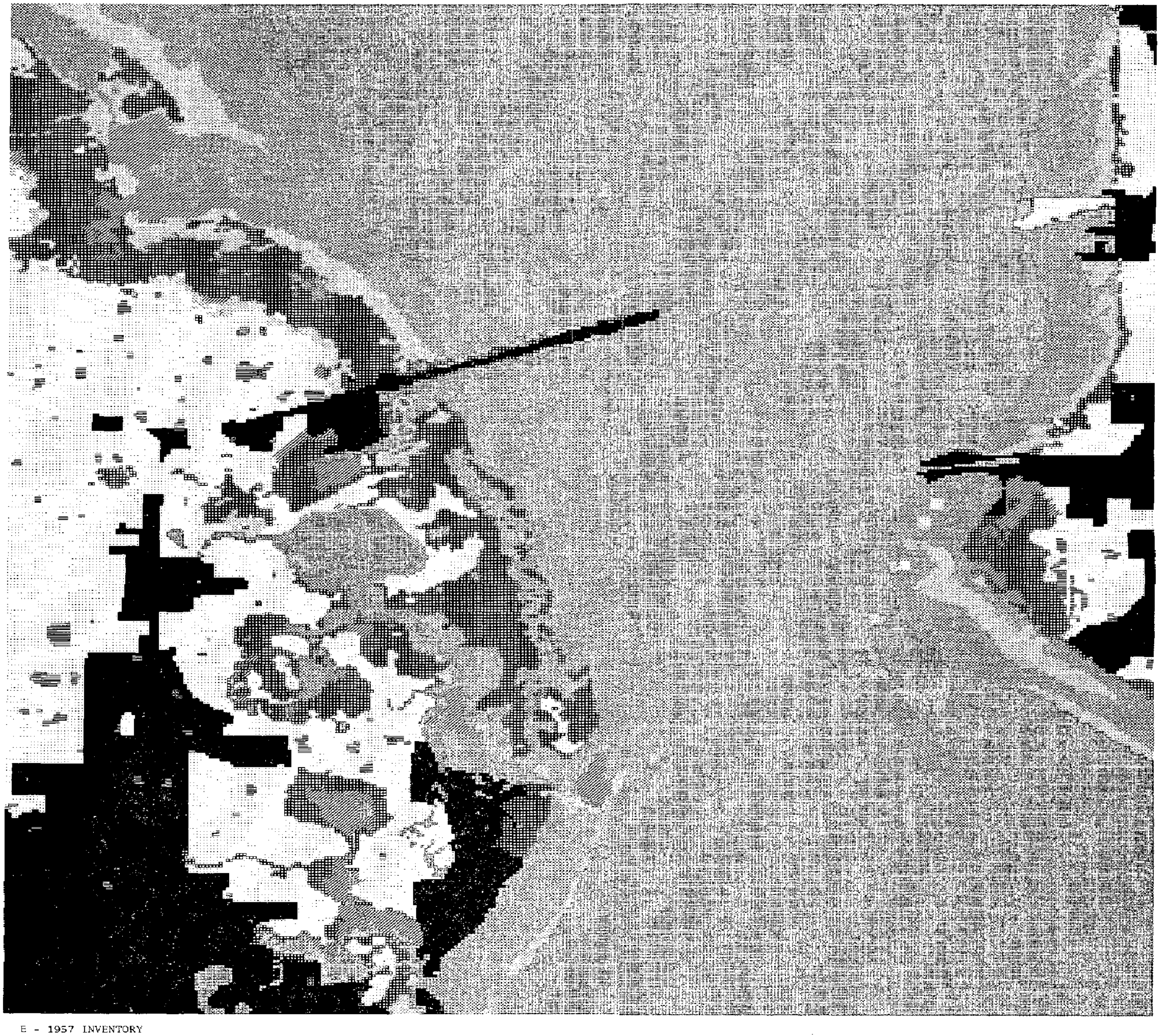


Figure 64

Gandy Causeway Restoration Site

Adapted from 7.5 Minute Quadrangles
Tampa Bay Environmental Atlas
U. S. Fish and Wildlife Service (1985)

Figure 65 Wetland Inventory of the Gandy Bridge Area - 1957



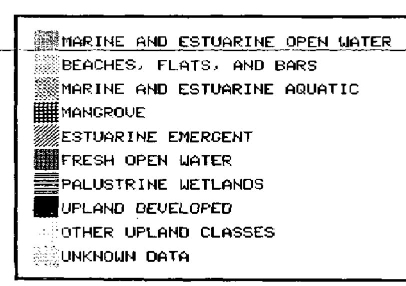


Figure 66 Wetland Inventory of the Gandy Bridge Area - 1982

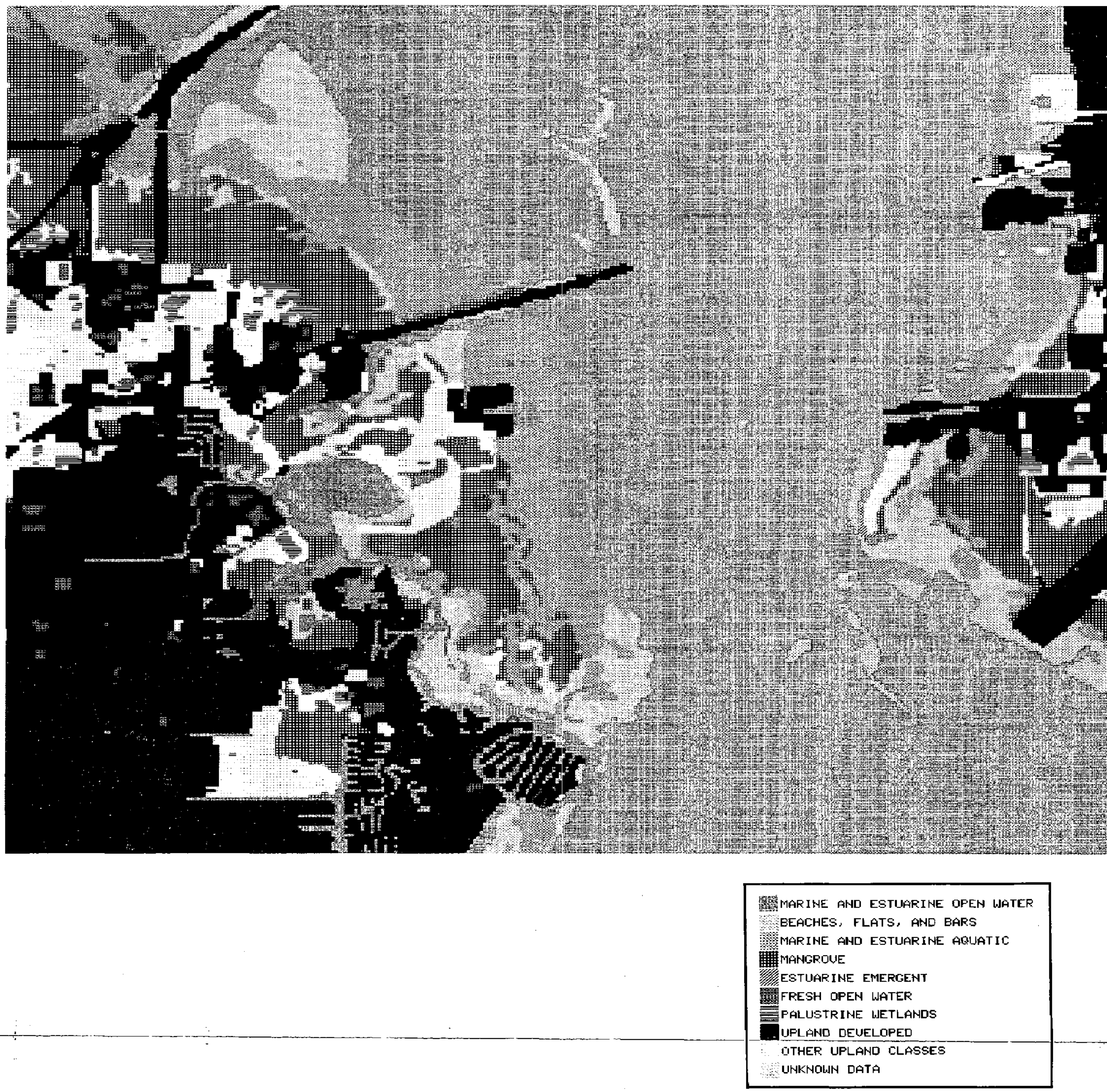
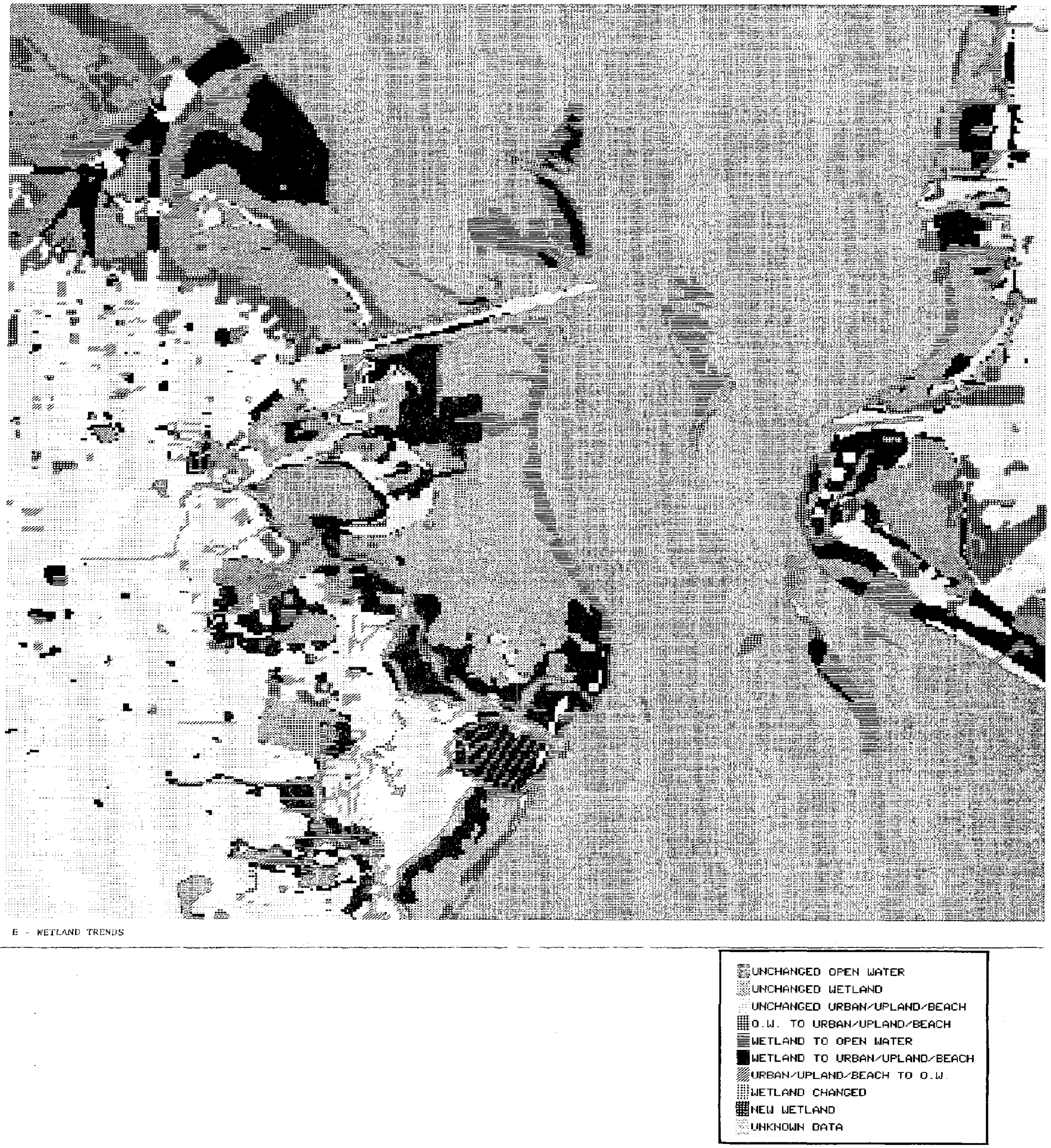


Figure 67 Wetland Trend Analysis of the Gandy Bridge Area



- Control of swimming activities near navigational channel and high velocity areas

- Improved boat ramp facilities

- Control of septage waste generated from public usage

- Trash collection, and

- Controlled parking areas and access onto Gandy Boulevard.

The creation of a public park limiting public access will provide an improved recreational area, with expansive areas along the causeway available for intertidal restoration. Approximately one linear mile along the southern shoreline will be suitable for revegetation or enhancement of existing vegetation (Figure 64).

In areas currently denuded of vegetation, S. alterniflora is recommended to be planted on two-foot centers. Proper elevation should be determined from adjacent natural areas. With the extensive areas of mangroves existing in the Weedon Island and the Gateway tract, it is expected that mangrove propagules will establish naturally within the planted S. alterniflora.

Site 20: West End Howard Frankland Causeway

Site Description: The West End Howard Frankland Causeway is located between the Courtney Campbell Causeway on the north, and the Gandy Bridge to the south, in Pinellas County (Figure 68). Construction of the causeway in 1958 created adjacent borrow pits to provide causeway fill material. The depths within the borrow areas range from 3.7 to 4.9 meters with bottom sediments consisting of silty sand and mud (CSA, 1986). Currently, the borrow areas and Fourth Street bridge are utilized by recreational and commercial fishermen.

Water quality, especially dissolved oxygen, within the lower portion of the borrow areas is expected to be poorer than natural undisturbed areas. This can be attributed to decreased mixing rates and settling of organics and other fine matter within the borrow pits. The bottom of the pits are generally below the photosynthetic zone, prohibiting seagrass growth. The benthic community would also be expected to be less diverse in the borrow areas than in the surrounding shallower subtidal flats. The fish and wildlife usage of these borrow pits has not been documented.

The wetland inventory for 1957 (Figure 65) identified conditions before construction of the Howard Frankland Causeway. Figure 66 inventories the remaining wetlands and upland construction for the causeway and secondary roads in 1982. The trend analysis between the time periods 1957 and 1982 reflect the direct losses experienced by the wetland communities for roadway construction (Figure 67). In addition a large seagrass bed has been lost on the southeastern corner of the estuarine shelf. This is speculated to be caused by burial or overshadowing of the seagrass beds by sediments during dredging operations for causeway construction.

Land Use: The submerged land is owned by the State of Florida, with the water body receiving a Class II designation. The Howard Frankland Bridge

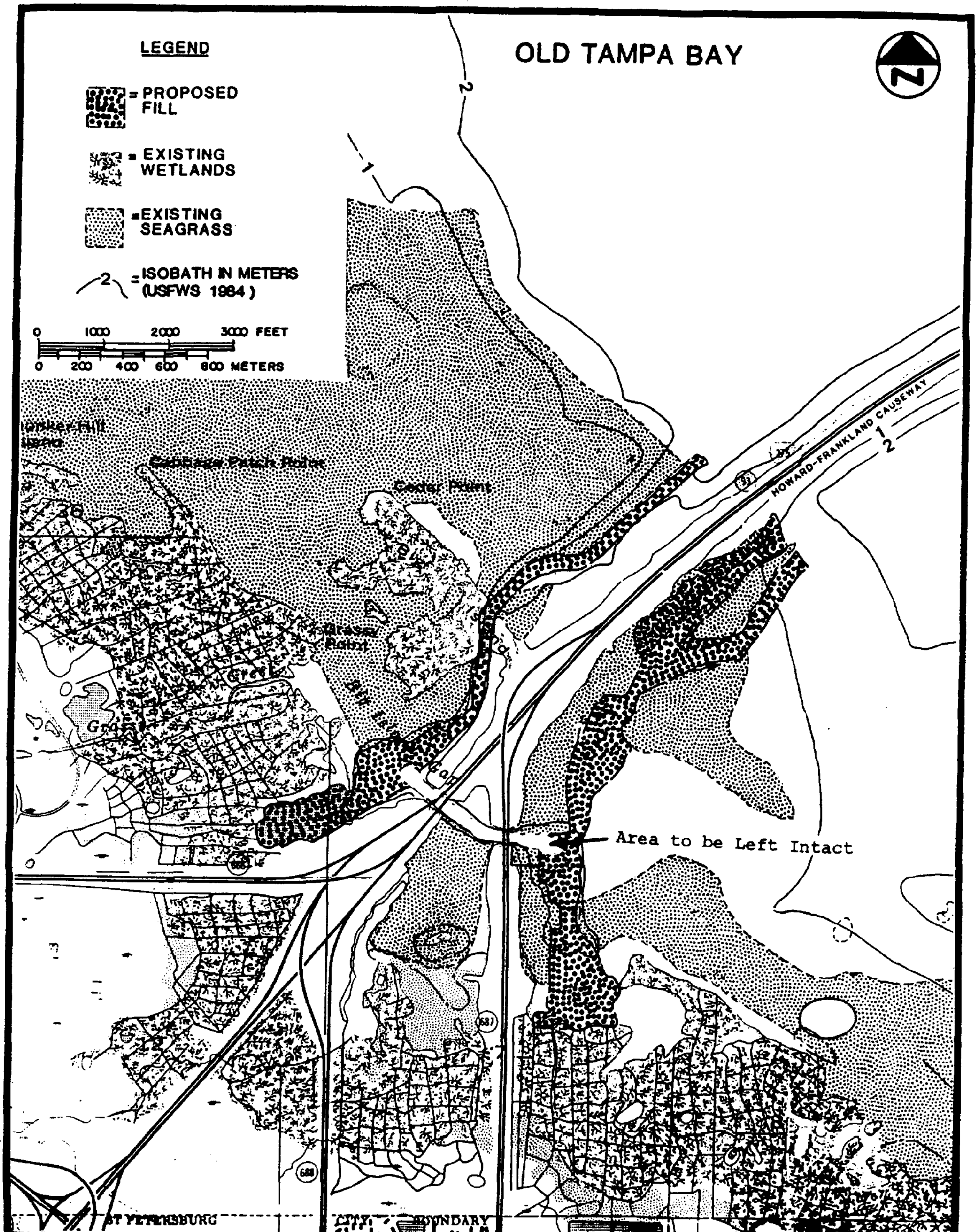


Figure 68 West end Howard Frankland Causeway Restoration Site (Adapted from CSA, 1986)

and causeway is also under state ownership and jurisdiction of the Florida Department of Transportation.

Restoration Plan: The primary objective of the restoration plan would be to raise the bottom of the borrow areas into the photic zone. This will allow seagrass establishment and potentially remove a source of water quality degradation.

High quality, construction grade spoil material is recommended to be placed within the pit. As a variation, large rubble can be placed in areas to provide hard surface attachment sites and bottom relief. Spoil and/or rubble placement should be done in a manner to prevent degradation to remaining adjacent seagrass beds.

The placement of spoil material will require overfilling to allow subsidence of the sediments. The area can then be planted with H. wrightii or benthic algal to accelerate natural seagrass establishment.

CSA (1986) recommended the filling of the dredged borrow areas under the Fourth Street bridge and Interstate 275 overpass (Figure 68). This portion of the borrow area is recommended to be retained to maintain circulation rates through Big Island Gap while continuing to provide deeper areas for recreational and commercial fishermen.

Site 21: The St. Petersburg - Clearwater International Airport

Site Description: The St. Petersburg - Clearwater International Airport is located on the western side of Old Tampa Bay just south of Largo Inlet, in Pinellas County (Figure 69). The Cross Bayou Canal enters Old Tampa Bay on the north side of the airport.

Portions of the airport were constructed by dredging bay bottom sediments and filling in mangrove marsh and open water for runway extensions. Pockets of natural mangrove and salt marsh systems have been retained.

A sand/shell beach grades into a silty sand substrate offshore. Subtidal borrow pits are located just offshore, evidence of past dredging operations. Sparse Ruppia maritima and drift algal occur in the subtidal areas west and east of the airport extension (CSA, 1983 and 1986).

Land Use: The upland portion of this site is presently owned by Pinellas County. The submerged lands are owned by the State of Florida. The waters are designated as Class II, Outstanding Florida Waters. Adjacent land use includes undeveloped property east of the airport, and residential and commercial land west of the airport and canal.

Restoration Plan: Habitat restoration proposed for the St. Petersburg - Clearwater International Airport include the shoreline northwest of the end of the north-south runway, the upland and intertidal fringe along the northeastern shoreline, and the two subtidal borrow pits east of the north-south runway. A restoration project in this area is likely to be

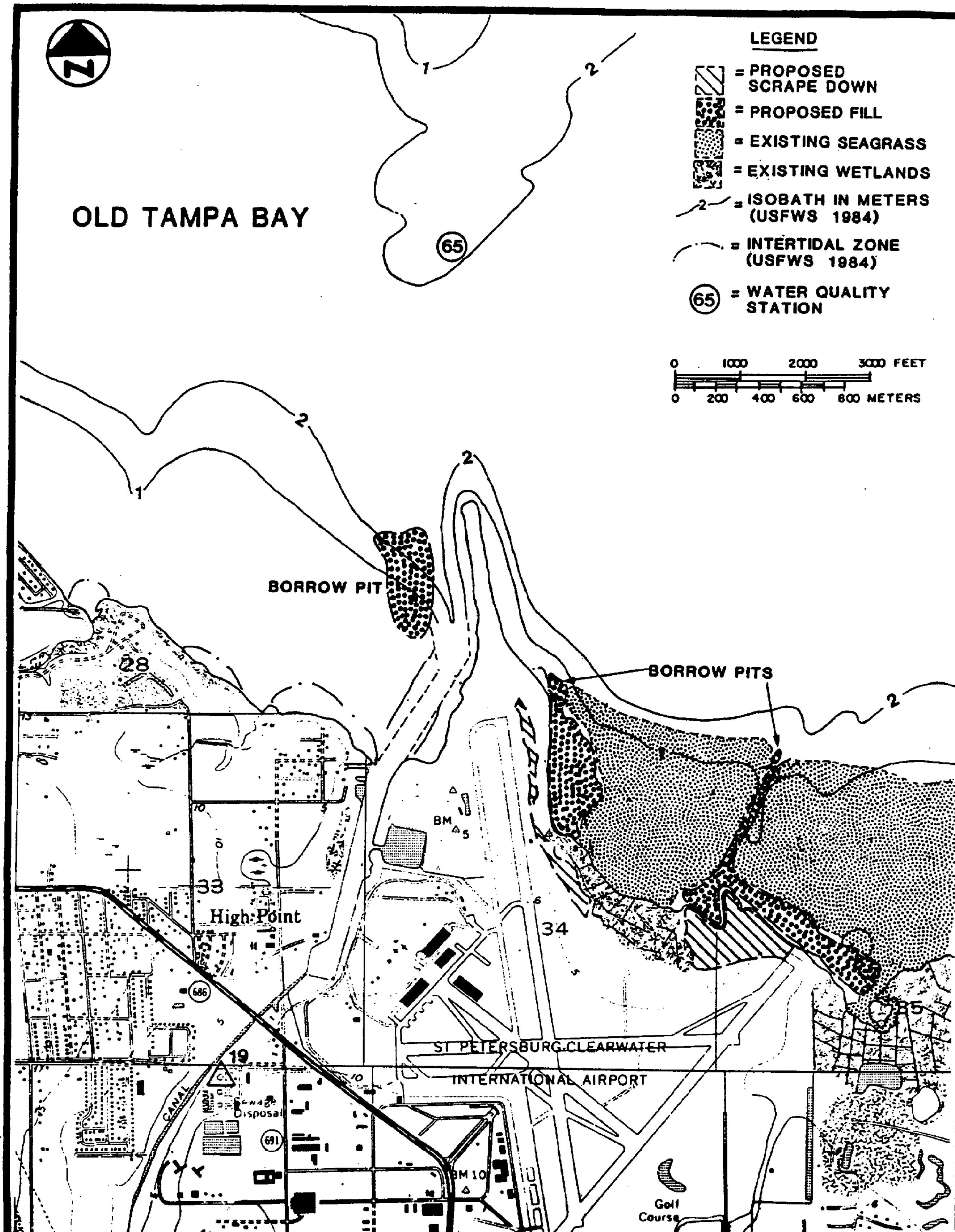


Figure 69 St. Petersburg-Clearwater International Airport restoration site (CSA, 1986)

successful because the airport site is not accessible to the general public. The creation of intertidal marsh and shallow subtidal habitat available for seagrass or benthic algal colonization can be accomplished in three locations. CSA (1986) describes the restoration plan for the area (Figure 69) as follows:

1. Create 8 hectare (ha) of marsh habitat along the west side of the runway terminus by pumping spoil material along the shoreline; stabilize the fill material; and plant with S. alterniflora sprigs. Spoil material could be obtained through upland sources, port dredging, or from dredging a shoal located west of the channel.

2. Create 10 ha of shallow subtidal habitat suitable for seagrass colonization by filling in a dredged borrow pit (2.4 to 3.0 m deep) located east of the north end of the runway. Fill material could be scraped from adjacent upland, pumped in from a barge or brought in from an off-site sand source. In addition, 4 ha of marsh habitat could be created by scraping down upland.

3. Create 6 ha of marsh habitat northeast of the east end of the east-west runway by scraping down sparsely vegetated upland and also 17 ha of subtidal habitat by filling an existing borrow pit. The excavated upland and filled borrow pit could then be planted with S. alterniflora sprigs.

The restoration plan in three areas can total 46 hectares (ha) of habitat created for fish and wildlife usage.

Site 22: Booth Point

Site Description: Booth Point is a peninsula in Old Tampa Bay which separates the smaller embayment of Safety Harbor and Mobbly Bay. Mobbly Bay receives freshwater input from Mobbly Bayou, with tidal influence derived from Old Tampa Bay. Thermal effluent from the steam generated electrical power plant at Higgins Point is discharged into lower Mobbly Bay (Figure 70).

In the northern portions of Old Tampa Bay, tidal flushing is considered poor, with net tidal currents of 3.4 to 60 cm/s (CSA, 1986). HCEPC (in press) recently determined that particles dispersed in northern Old Tampa Bay may take up to 20 months to flush (Palik, 1984).

The tidal marshes adjacent to Mobbly Bay consist of saltmarsh and mangrove vegetation. Mosquito ditches have traversed across the marsh area to improve circulation. Ditching operations have cast spoil material on adjacent marsh systems. The uplands consist of pine flatwood, pine oak-scrub, and a high marsh fringe (CSA, 1986).

Land Use: The tidal wetlands and adjoining uplands are owned by the Florida Power Corporation (FPC). The Higgins Point electric plant and transmission corridor occupy most of their land. Adjacent land includes residential areas, State submerged lands, and land owned by the City of Oldsmar's sewage treatment plant located north of the FPC site. Access to

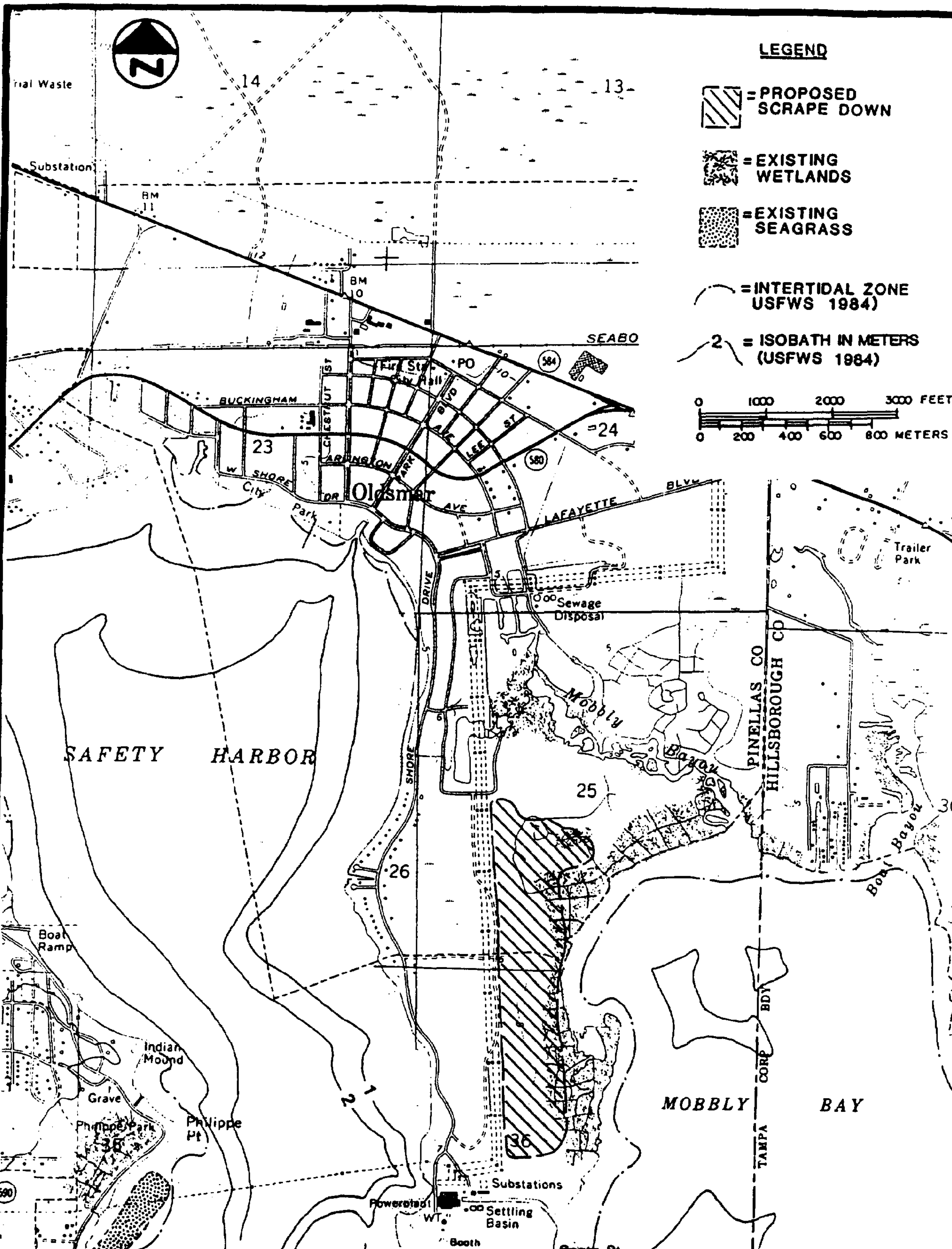


Figure 70 Booth Point restoration site (CSA, 1986)

the area is limited and bounded by the transmission lines to the west of the site, FPC to the south, and the Oldsmar sewage treatment plant to the north (CSA, 1986).

Restoration Plan: The selected locations for restoration include uplands and tidally ditched wetlands located along the southeastern end of the peninsula, specifically those located east of the transmission line corridor from Higgins Power Plant. The recommended plan will include habitat creation by selectively scraping down or excavating the spoil mounds and levees adjoining the ditched tidal creeks. Approximately 9 ha of land is available to scrap down to intertidal elevations and plant with S. alterniflora. An additional 40 ha of adjacent upland area can be excavated and revegetated to create a high marsh zone between the intertidal zone and the pine flatwood communities. The high marsh areas can be planted with Distichlis spicata and Salicornia virginica. The creation of high marsh area can offset some of the loss experienced baywide and provide a buffer zone for intertidal vegetation to travel during a rise in sea level.

HILLSBOROUGH COUNTY SITE EVALUATION

Site 23: Channel "A"

Site Description: Channel "A" is located in northwestern Hillsborough County between Double Branch and Rocky Creeks (Figure 71). The channel was constructed during the late 1960's and originally was part of a large-scale agricultural drainage system designed by the Soil Conservation Service (Massey, 1986). A salinity barrier was added in 1978, north of Hillsborough Avenue to prevent saltwater intrusion into the underlying Floridan Aquifer (SWFWMD, 1979).

The channel was dredged through an extensive tidal marsh system with spoil material piled along the sides. Currently the canal serves as a flood water diversion for Rocky Creek and for boat access to residential developments.

The extensive marsh systems are composed primarily of S. alterniflora and A. germinans (CSA, 1986). The spoil berms are used for vehicular access and are vegetated by exotic species encroachment. The spoil berms prevent waters of Channel "A" from mixing with adjacent tidal marsh areas. In particular, Cabbagehead Bayou has become isolated from the larger tidal marsh systems and reflects poor water quality (Massey, 1986).

Land Use: The submerged lands are currently under ownership and jurisdiction of the Tampa Port Authority. The Southwest Florida Water Management District (SWFWMD) currently owns the upland canal easement and spoil banks along Channel "A".

Restoration Plan: Continental Shelf and Associates, Inc. (1986) and TBRPC (1984, 1986b) has recommended lowering of spoil berms to allow flushing of adjacent marsh and provide additional acreage for wetland restoration. Currently, the FDOT is reviewing the area for potential mitigation for jurisdictional impacts created by the Courtney Campbell Causeway expansion project.

Ross (1986a) has since modeled the effect of Channel "A" and associated berms on mixing and dispersion of freshwater in the area using hydraulic and water quality modeling. A follow-up report (Ross, 1986 b) recommended that removal of both berms would promote sedimentation within Channel "A". However, a small opening in the east berm will promote flushing in Cabbagehead Bayou. Massey (1986) reviewed the environmental conditions within Channel "A" and recommended:

- Breaching the east berm to Cabbagehead Bayou will improve the biological health
- Berms should be planted after public access has been limited, and
- Monitoring program to determine project success.

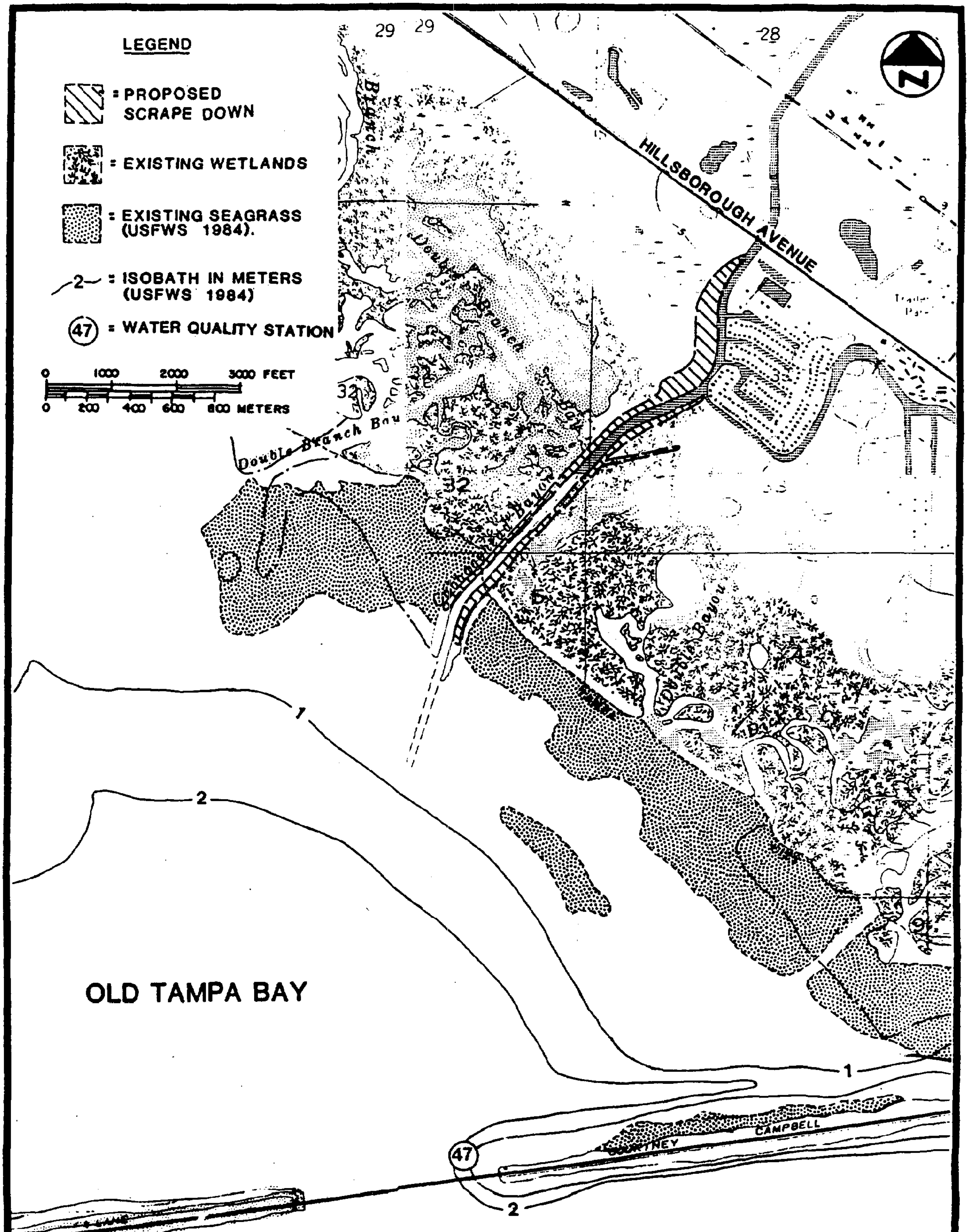


Figure 71 Channel "A" restoration site (CSA, 1986)

Upon review of available literature it is necessary to improve circulation within Cabbagehead Bayou. In addition, Massey (1986) identified that little sedimentation is occurring around the berm extension into Old Tampa Bay. Recommended restoration of Channel "A" includes:

1. Creation of a 40-foot breach in the east berm into Cabbagehead Bayou. Revegetation of the appropriate intertidal area

2. Regrade the Channel "A" extension into Old Tampa Bay to intertidal elevations and plant with S. alterniflora

3. Limit public access

4. Removal of exotic plant species along the berms

5. Revegetate intertidal and upland areas along both Channel "A" berms, and

6. Monitor project success for future restoration information.

The recommended plan is designed to improve circulation and create additional habitat without degrading the function of Channel "A".

Monitoring of the 40-foot opening into Cabbagehead Bayou should evaluate the effects of berm opening on sedimentation in the channel. If conditions are suitable, it is recommended to continue berm removal for additional intertidal habitat restoration and enhancement (Figure 71).

Site 24: Fish Creek

Located within Hillsborough County and discharging into Old Tampa Bay south of the Courtney Campbell Causeway is Fish Creek (Figure 72). The creek is approximately 2.3 miles in length with the lower segment oriented in an east to west direction.

The mouth of Fish Creek is surrounded by a tidal marsh system. The creek has been channelized, placing spoil piles upon adjacent marsh areas. The lower segment is used for drainage of the highway interchange of State Road 60, Eisenhower Boulevard and the Tampa Airport access roads. The majority of the middle and upper segments have been realigned to serve as drainage ditches for Tampa International Airport.

Within the intertidal elevations near the mouth of Fish Creek, marsh vegetation occurs, but is limited in extent by adjacent developments. The upper and middle segments that have been channelized contain steep banks which limit available area for vegetational establishment. Seagrass beds containing H. wrightii and R. maritima exist offshore in Old Tampa Bay in areas that have not been previously dredged.

Land Use: The majority of the middle and upper segments of Fish Creek is under the Tampa International Airport Authority jurisdiction. The lower middle segment is controlled by the Florida Department of Transportation.

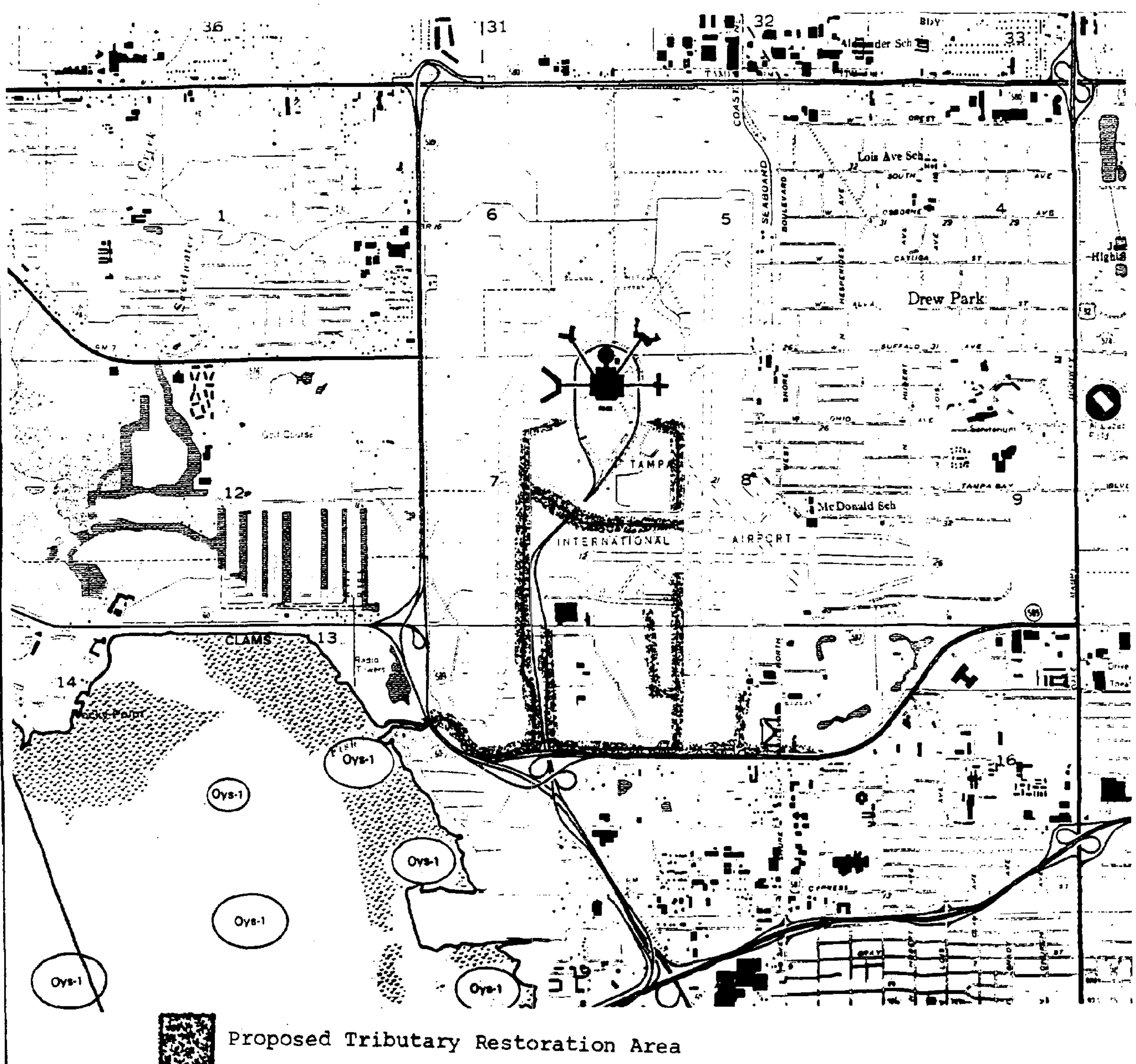


Figure 72

Fish Creek Restoration Site

Adapted from 7.5 Minute Quadrangles
Tampa Bay Environmental Atlas
U. S. Fish and Wildlife Service (1985)

The upland areas surrounding the mouth of Fish Creek are in private ownership.

Restoration Plan: The channelization and realignment of Fish Creek has impacted the function of the minor tributaries as a nursery and feeding areas for fish and wildlife, and the ability to remove pollutants. The recommended restoration plan is an outgrowth of the Future of Tampa Bay (TBRPC, 1984) and Ecological Assessment, Classification and Management of Tampa Bay Tidal Creeks (TBRPC, 1986b).

The plan calls for berm removal and regrading of the creek side slopes to allow sufficient area for revegetation of estuarine and freshwater plant species (Figure 72). The creek can then be realigned to meander through the restored marsh area. The estuarine portion of Fish Creek is recommended to be planted with S. alterniflora, and D. spicata in the high marsh zone. Freshwater dominated portions are recommended to be planted with J. roemerianus, Sagittaria sp. or water lilies.

The restoration plan is expected to:

- Maintain run-off volumes while providing additional retention and treatment of stormwater pollutants

- Provide additional fish and wildlife habitat

- Stabilize shoreline by constructing with gradual side slopes and then revegetating, and

- Provide an example of a restored tidal tributary for public education and awareness.

Site 25: East End Howard Frankland Causeway

Site Description: The east end of the Howard Frankland Causeway is located south of Tampa International Airport and west of the City of Tampa, in Hillsborough County (Figure 73). Interstate 275 travels down the center of the causeway and public access is controlled by a fence to the waters edge.

Scattered mangroves exist on site, predominantly along the northern side. The southern shoreline has recently been cleared (spring, 1986) of debris deposited by Hurricane Elena. A shallow flat extends offshore and is periodically exposed during lower low tides. Areas of seagrass exist along the causeway and upon the estuarine shelf in areas not previously altered by dredging activities.

Land Use: The causeway is under the jurisdiction of the Florida Department of Transportation. The bottom lands adjacent to the causeway are regulated by the Tampa Port Authority.

Restoration Plan: Habitat restoration of the Howard Frankland Causeway can be accomplished on the southern side (Figure 73). The area cleared of debris provides proper elevation for salt marsh plantings. Some regrading may be necessary to provide proper elevation and additional acreage for intertidal salt marsh establishment.

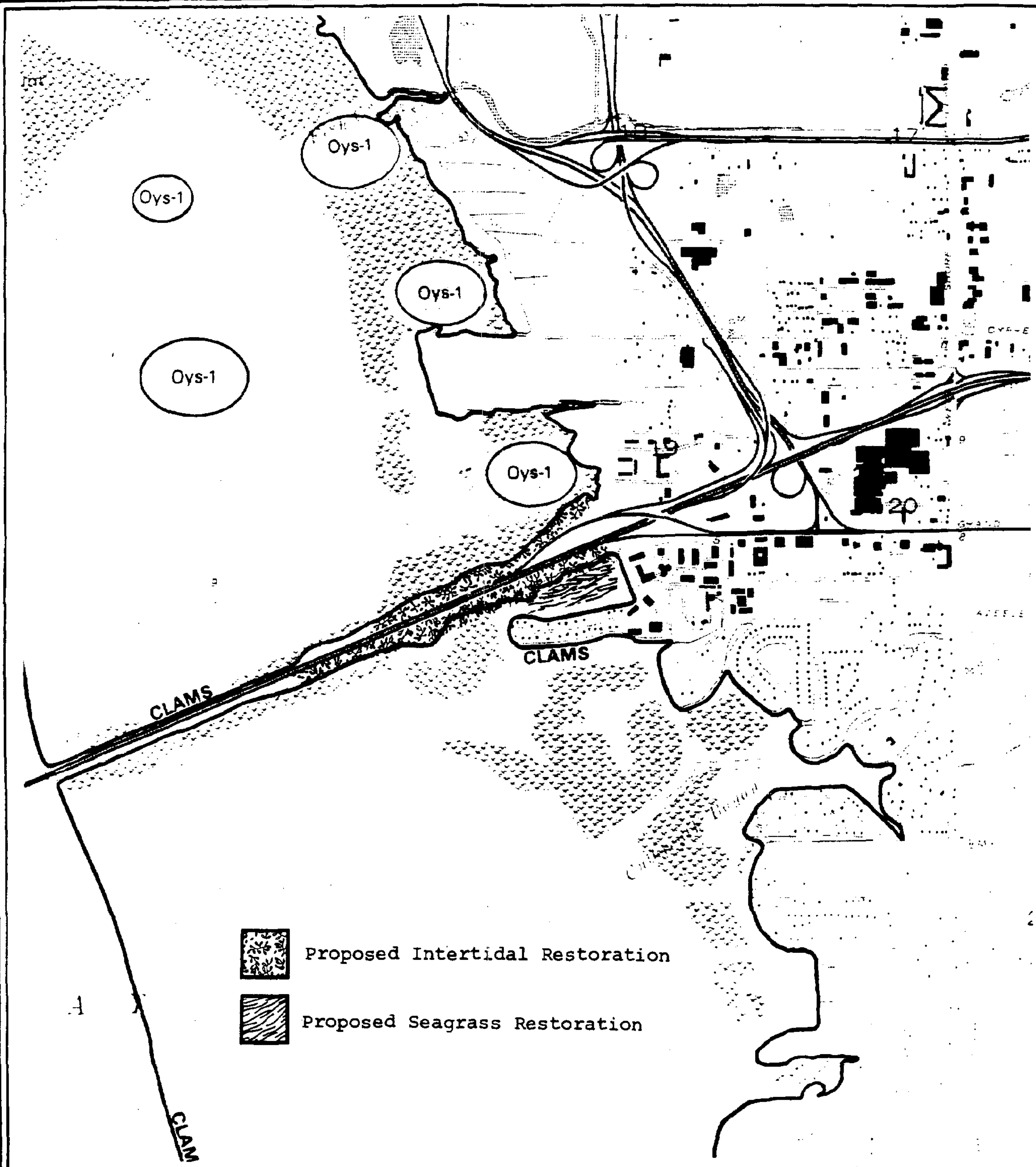


Figure 73

East End Howard Frankland Causeway Restoration Site

Adapted from 7.5 Minute Quadrangles
Tampa Bay Environmental Atlas
U. S. Fish and Wildlife Service (1985)

Just off shore from the southern side of the causeway the shallow subtidal area is denuded of seagrass growth. This is speculated to be caused by poor water quality and flushing, and dredge and fill activity. When local water quality and seagrass planting techniques improve, the area can provide a suitable site for seagrass restoration. The recommended seagrass for restoration is H. wrightii. The area is protected from wave erosion, provides appropriate depths and has limited public access.

Habitat enhancement can occur along the northern shoreline. Many of the existing mangroves have been cold shocked. S. alterniflora sprigs or R. mangle seedlings can be planted in barren areas to enhance natural vegetation.

Site 26: Kaul Fill Site

Site Description: The Kaul fill site is located immediately north of the Gandy Bridge in Hillsborough County (Figure 74). The fill area was created by dredging adjacent bay bottom areas and piling the spoil material to create waterfront property in Old Tampa Bay. The site contains upland fill material with five small finger canals and a central lagoon. A large subtidal borrow pit to the west of the bay fill and a smaller pit to the south are approximately 6 m in depth and devoid of submerged vegetation (CSA, 1986).

The upland area of the fill site contains upland grasses with some exotic species encroachment. The interior lagoon contains a fringe of S. alterniflora and D. spicata. The small finger fills on site are lined with mangroves and a small intertidal marsh exists on the northeast corner of the fill area.

Review of the 1957 wetland inventory (Figure 65) in the area north of Gandy causeway identifies seagrass beds offshore rising to a subtidal/intertidal estuarine beach with a mangrove fringe. The 1982 inventory (Figure 66) portrays the development within the area. The trend analysis (Figure 67) further reflects the loss of seagrass and mangrove by direct bay filling or channel excavation of adjacent areas. CSA (1986) reported that dredging of the west borrow pit removed 10 ha of Tampa Bay seagrasses.

Land Use: The fill site is owned by Mr. Ralph Kaul, who plans to build a residential waterfront community. The submerged bottom lands are owned by the Tampa Port Authority. Adjacent land use includes a residential development (Mr. Kaul's) to the east, and navigational channels for recreational boat use.

Restoration Plan: The plan for habitat restoration has been proposed by CSA (1986) as a mitigation option for port development. The plan described by CSA is as follows:

> "The goal is to create approximately 35 ha of marsh habitat and 10 ha of shallow subtidal bay bottom by scraping down uplands and filling in the adjacent borrow site to -4 ft MSL (Figure 74). To increase chances for success, public access can be limited by excavating a shallow north-south cut on the east side of the site.

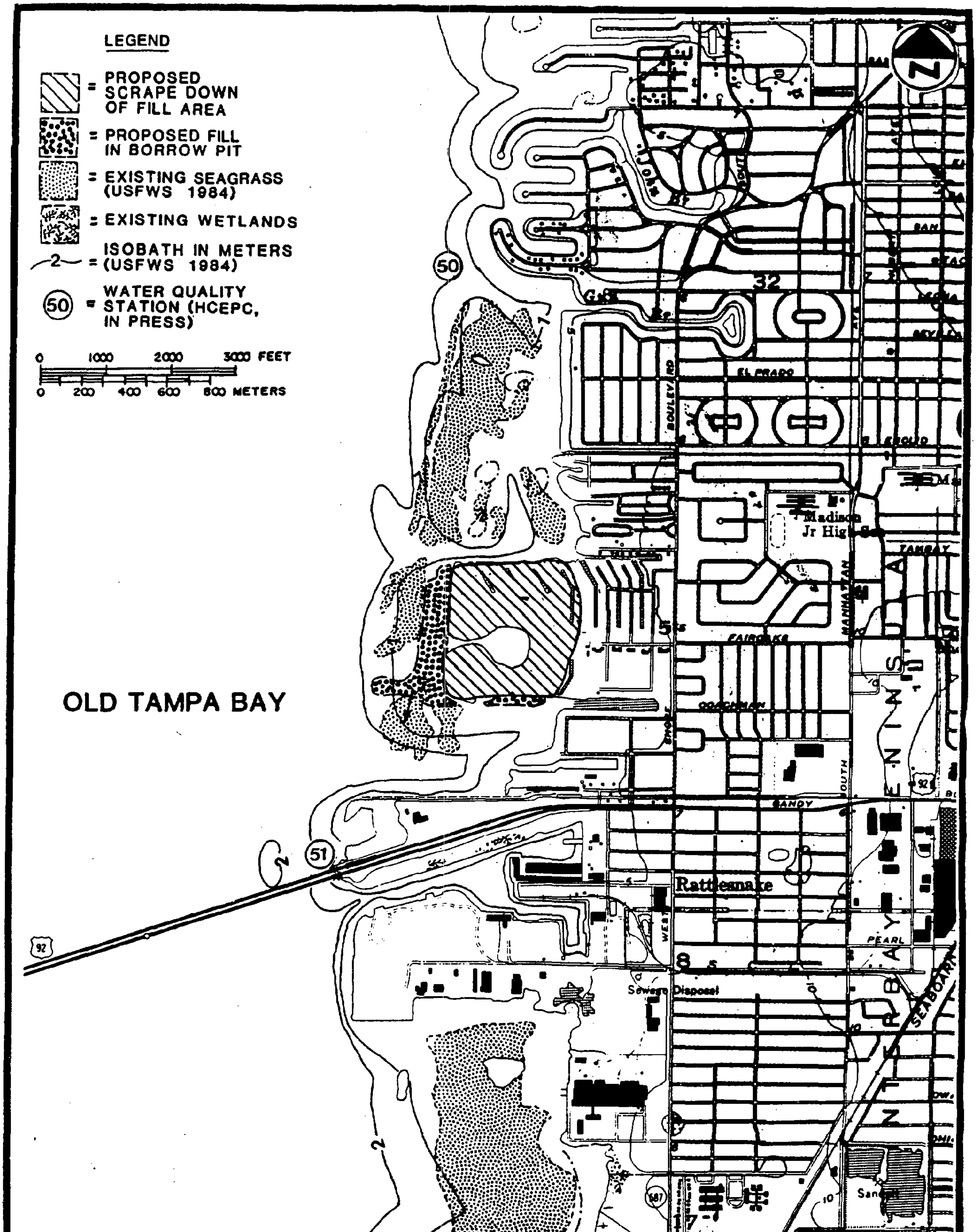


Figure 74 Kaul Fill restoration site (CSA, 1986)

The interior lagoon could be preserved and enhanced by planting additional S. alterniflora sprigs. The subtidal fill area could eventually be colonized by neighboring seagrass beds. This site could also serve as a location for experimental seagrass planting. The site, following habitat creation and enhancement, is envisioned to be an island surrounded by a S. alterniflora marsh, with an interior lagoon and central high marsh for nesting shorebirds. It will be necessary to determine that erosion would not destroy the island. Small areas of native upland vegetation could also be planted for bird nesting."

The plan can be accomplished on a restoration (as opposed to mitigation) basis if the land can be purchased (example: CARL Program) for public ownership. With the degree of bay filling activities that have historically occurred, it is beneficial to the fish, wildlife and water quality of Tampa Bay to restore undeveloped fill sites.

Site 27: Rattlesnake Spoil Island

Site Description: The Rattlesnake Spoil Island is located south of Gandy Bridge and north of Port of Tampa in Hillsborough County (Figure 75). The spoil island was created by dredging of the Westinghouse turning basin and access channel. The island is vegetated with mangroves and exotic plant species. Seagrass beds occur on the western and southern sides of the island. Aerial photography (MPSI, 1984) indicates that Rattlesnake Spoil Island is migrating toward the southwest. In the process, sediments are burying the seagrass beds.

Review of the wetland inventories in 1957 and 1982 (Figure 65 and 66, respectively) indicate that this area remained relatively undeveloped before 1957. The 1982 inventory and trend analysis (Figure 67) portray the channel excavation and open water filling for Rattlesnake Spoil Island formation. Dredging and filling in this area have displaced seagrass beds and mangrove fringe growth.

Land Use: The spoil island and adjacent bay bottom is owned by the Tampa Port Authority. Industrial and commercial operations exist in adjacent areas for the Port of Tampa. The spoil island to the east is categorized as a colonial bird nesting site for the American Oystercatcher, Willet and Great Egret (USFWS, 1984).

Restoration Plan: The recommended plan for Rattlesnake Spoil Island is to:

1. Stabilize sediments to prevent further migration and degradation to seagrass beds

2. Restore seagrass coverage by replanting the submerged spoil delta.

Stabilization of the island "footprint" can be accomplished by planting the intertidal fringe with S. alterniflora with the higher elevational zone planted with P. vaginatum or D. spicata. Monitoring will be required to determine success of intertidal plants and island stabilization.

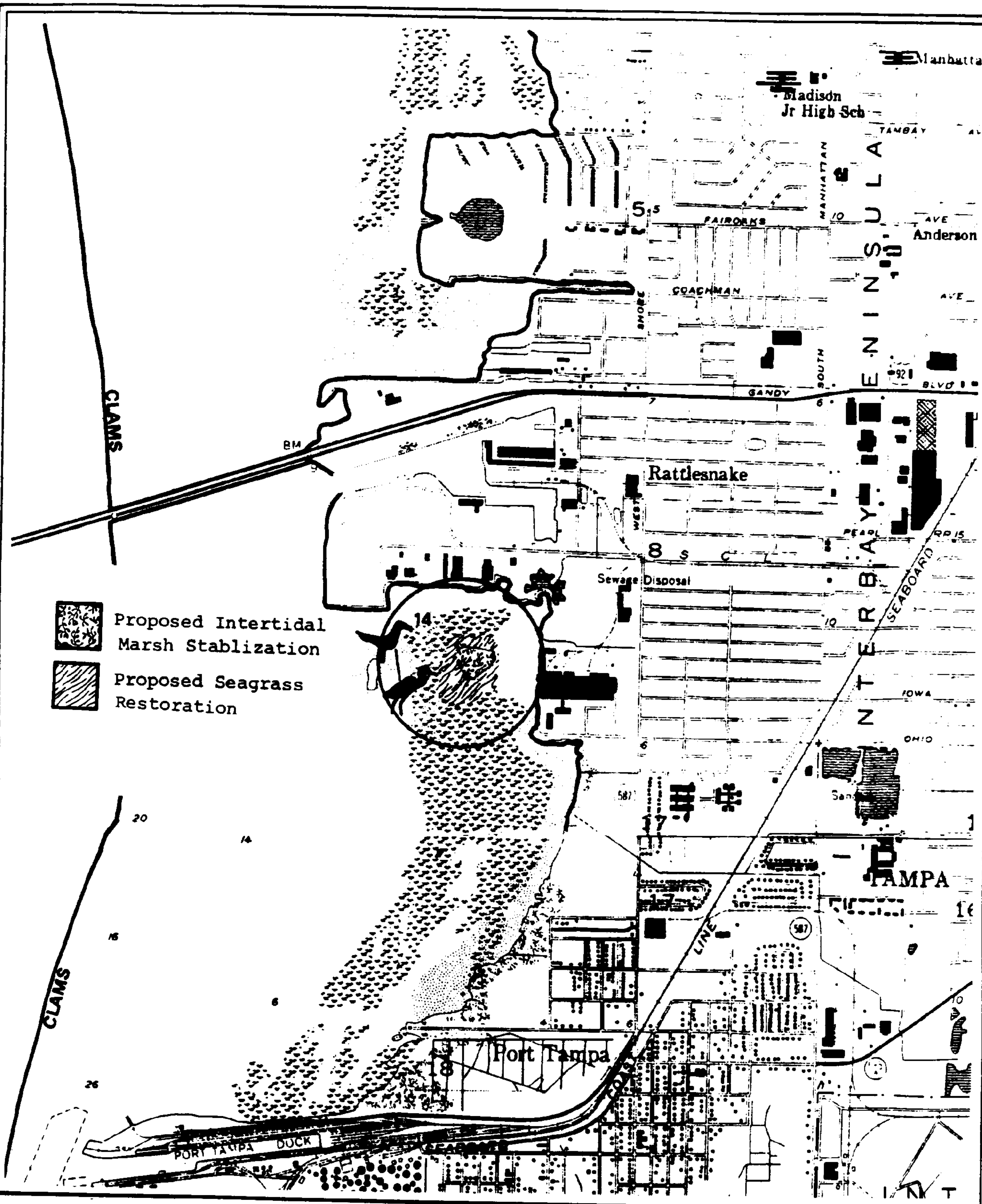


Figure 75

Rattlesnake Spoil Island Restoration Site

Adapted from 7.5 Minute Quadrangles
Tampa Bay Environmental Atlas
U. S. Fish and Wildlife Service (1985)

The spoil delta is recommended for revegetation to further prevent spread of fill material. Revegetation of subtidal areas can be accomplished in two ways:

1. H. wrightii occurs in adjacent areas and is the current seagrass of choice for planting in Tampa Bay. H. wrightii plugs can be transplanted or cultured for planting on two-foot centers at appropriate subtidal elevations.

2. Benthic algal exists in subtidal areas around the Interbay Peninsula. Little experimentation in transplanting techniques or succession by seagrass has occurred. However, transplanting of Caulerpa sp. was accomplished by Mangrove Systems, Inc. for MacDill Air Force Base, and initial observations indicate successful establishment (Rob Mattson, Personnel Communications). Restoration and stabilization of the spoil delta can be attempted with Caulerpa sp., and monitored for future restoration projects.

The recommended plan is necessary to prevent further loss of natural seagrass beds and provide additional fish and wildlife habitat.

Site 28 and 29: MacDill Sites

Site Description: The MacDill sites are located in the southwestern corner of the Interbay Peninsula in Hillsborough County (Figure 76). Site 28 consists of an area of disturbed uplands and transitional wetlands located northwest of MacDill Air Force Base. Site 29 consists of two subtidal borrow pits located off the south end of the MacDill Air Force Base runway extension.

The runway extension into Tampa Bay was constructed from dredging out the two borrow pits at Site 29. The borrow pits average three to five meters in depth. The substrate of the pits consist of fine sand with an overburden of silty sand (CSA, 1986). Although no submerged aquatic vegetation exists within the borrow pits, seagrasses and drift algae presently occur on the shallow subtidal areas adjacent to the borrow pits (CSA, 1983).

The upland area located in the northwest corner of the MacDill Air Force Base property includes 13 ha of disturbed upland and transitional wetland habitat. CSA (1986) surveyed Site 28 and described the area in detail.

> "The vegetational communities observed during our survey of the site consist of a mosaic of an "old field" stage of grasses and forbs and a pioneer scrub stage, characterized by Lantana sp., groundsel (Baccharis haliminifolia), vines and forbs are remnants of an old cabbage palm hammock, pine flatwoods, and low lying patches of J. roemerianus. Invasion by brazilian pepper (Schinus terebinthifolia) has been substantial throughout most of the area. An old pipeline right-of-way and access road are sparsely vegetated with salt pan plant species and stunted black mangroves.

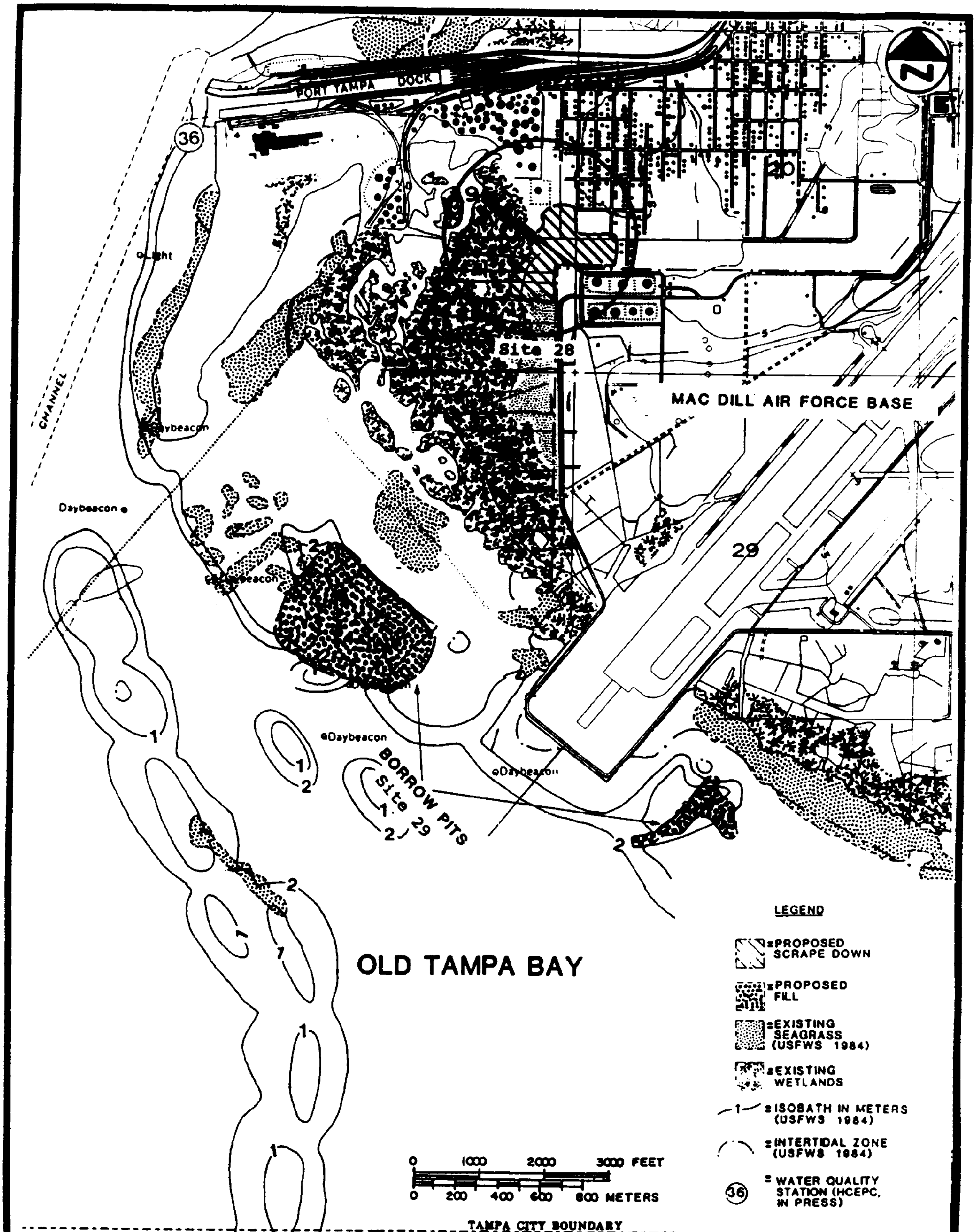


Figure 76 Mac Dill restoration site (CSA, 1986)

A small spoil mound at the northwest end of the right-of-way is covered with brazilian pepper. Mature mangrove habitats and extensive salt barrens border this site to the south and west. These areas are ditched by a network of small tidal creeks with adjacent spoil mounds.

Birds observed during our field survey in wetlands adjacent to this site included White Ibis (Eudocimus albus), Short-billed Dowitcher (Limnodromus griseus), Red-winged Blackbird (Agelaius phoeniceus), and Great Egret (Casmerodius albus). Large populations of fiddler crabs (Uca sp.) were observed along the pipeline right-of-way. Fish utilization in the tidal creeks adjacent to the upland site consists largely of euryhaline killifishes and live bearers."

The 1957 wetland inventory (Figure 65) identify undisturbed areas of seagrass, estuarine beaches and bars, emergent marsh, mangrove areas and upland classes. The 1982 (Figure 66) and wetland trend analysis (Figure 67) reflect the landward encroachment of mangrove coverage and the effects of development on the local wetland habitats. The runway has been extended into the bay with the associated creation of the subtidal borrow pits (Site 29). A large quantity of seagrass coverage has been lost in this area with only a few scattered patches remaining.

Land Use: The submerged lands, including the two subtidal borrow pits, is owned by the Tampa Port Authority. The majority of Site 28, including the pipeline right-of-way, is owned by the Atlantic Land Improvement Corporation. Site 28 is currently undeveloped and used for unauthorized dumping of trash.

Adjacent land use include the military facilities at MacDill Air Force Base and residential development north and east of Site 28. Industrial and commercial operations exist at the Port of Tampa, northwest of the area.

Restoration Plan: Site 28 consists of disturbed or transitional wetland communities and continues to be impacted by illegal activities (Figure 76). A marsh creation project can include scraping down approximately 13 ha of disturbed uplands to adjacent wetland elevation. The area then can be planted with S. alterniflora and/or mangroves. A small "feeder" tidal creek is recommended to be included within the project in the area of the pipeline right-of-way.

Site 29 requires the bottom elevation of the two borrow pits be raised into the photic zone. CSA (1986) identified that fill material may be available from the emergency anchorage that has been proposed near Gadsden Point. The filling of the borrow pits (a total of 39 ha) will allow natural recolonization of seagrass or benthic algal or can be planted with seagrass sprigs after sediment consolidation.

Fish and wildlife usage within the subtidal borrow pits is speculated to be minimal. Elevation of the bottom and revegetation of the area will provide additional habitat for fish and wildlife as identified in adjacent areas. Marsh creation (Site 28) is designed to provide additional feeding and nursery area in Tampa Bay for fish and wildlife populations.

Site 30: Broad Creek

Site Description: Broad Creek is located at the extreme southern tip of the Interbay Peninsula in Hillsborough County (Figure 77). The lower segment meanders through an extensive mangrove tidal marsh into Middle Tampa Bay. Coon Hammock Creek receives some freshwater flow from Broad Creek and travels through the contiguous marsh system to the west. Mosquito ditches traverse through the mangrove marsh system.

The middle and upper segments of Broad Creek have been channelized to provide drainage for MacDill Air Force Base. The spoil material from ditching operations have sidecast sediments onto the adjacent marsh system. This buries underlying marsh vegetation and limits tidal circulation behind the spoil piles. The dendritic upper ditches currently contain steep side slopes with a minimum of littoral vegetation.

The natural tidal marsh in the lower segment combined with the open space available in the upper and middle segment offer the opportunity to improve creek conditions. In addition, TBRPC (1986b) has classified Broad Creek in restorable condition in their review of tidal tributaries to Tampa Bay.

Land Use: The upland area surrounding Broad Creek is contained on MacDill Air Force Base and is owned by the federal government. The submerged bottom lands are owned and regulated by the Tampa Port Authority. The extensive mangrove marsh and tidal ditches are under the jurisdiction of the Florida Department of Environmental Regulation. Currently, the waters off the southern end of the Interbay Peninsula are classified as Class II Waters.

Restoration Plan: Historic channelization operations have limited the extent of marsh habitat and buried portions of historic systems. The recommended plan is to improve circulation, create additional marsh coverage and maintain drainage for the Air Force Base (Figure 77).

Circulation can be improved in areas where spoil deposition has been placed within marsh systems. The lowering of spoil berms will create additional marsh acreage for creation and promote tidal water inundation.

The drainage canals in the middle and upper segments can be broadened to allow for fringe marsh creation. The alignment and existing channel depth can be maintained to continue run-off transmission. Upland parcels are recommended to be preserved to provide a transition between habitat types.

This restoration project provides an excellent opportunity for:

- Tidal creek restoration, and
- Stormwater pollution assimilation by marsh systems.

Proposed Tributary Restoration Area

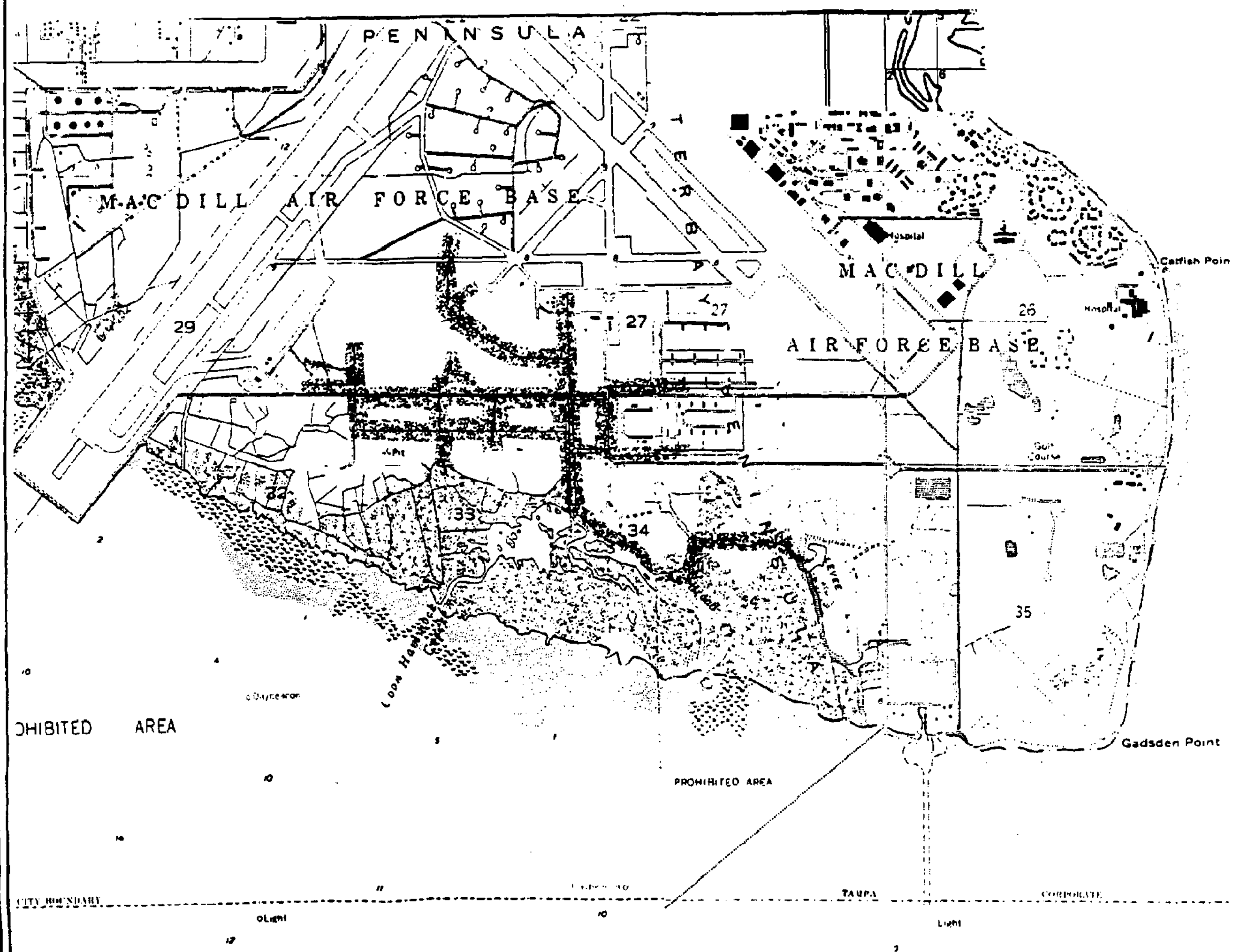


Figure 77

Broad Creek Restoration Site

Adapted from 7.5 Minute Quadrangles
Tampa Bay Environmental Atlas
U. S. Fish and Wildlife Service (1985)

The project is expected to be successful for the following reasons:

- Limited public access
- Area in public ownership
- Land is predominantly undeveloped
- Drainage conditions will be maintained, and
- Adjacent natural areas.

<u>Site 31: Bayshore Boulevard</u>

Site Description: Bayshore Boulevard parallels the shoreline of Hillsborough Bay from MacDill Air Force Base to the City of Tampa (Figure 78). One area of residential development located around Ballast Point separates Bayshore Boulevard from the bay. The shoreline along Bayshore is entirely seawalled.

Issue number 41 in the <u>Future of Tampa Bay</u> (TBRPC, 1984) addresses the odor problem reported along Bayshore Boulevard. The report indicates that the decay of the algae <u>Gracilaria sp.</u> was the cause. Large concentrations of <u>Gracilaria sp.</u> occur from excessive nutrients created by increased eutrophication of Hillsborough Bay (TBRPC, 1984). Nutrient loadings into Hillsborough Bay are created by the urbanization of the City of Tampa and surrounding area.

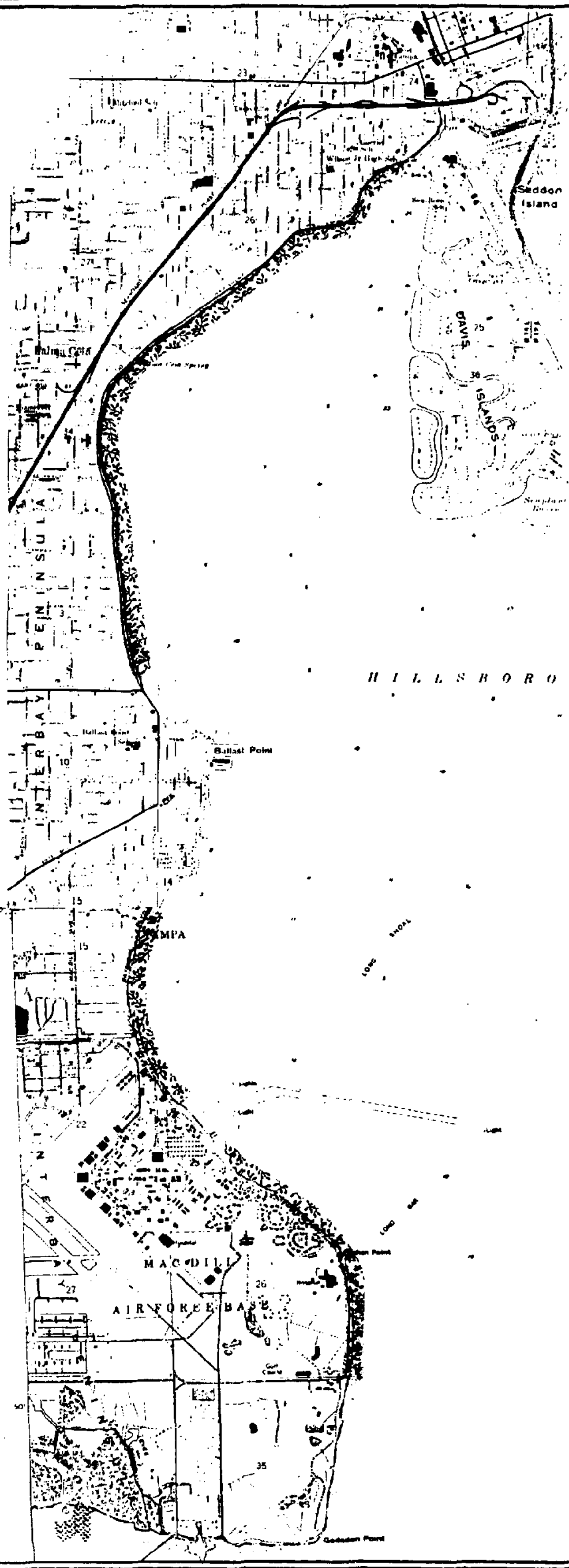
The shoreline along Bayshore Boulevard offers the opportunity for habitat creation and potentially can improve water quality conditions within the urbanized Hillsborough Bay area.

Figure 79 represents the wetland inventory for the northern portion of Bayshore Boulevard in 1957. At that time the upland area is urbanized with a narrow strip of estuarine aquatic vegetation. No mangrove or salt marsh are identified. Figure 80 and Figure 81 represent the 1982 inventory and wetland trend for the time period, respectively. The loss of fringe seagrass coverage and gain in the tidal flat area are identified.

Land Use: The length of Bayshore Boulevard shoreline extending along MacDill Air Force Base is regulated by the federal government. The City of Tampa maintains the remaining portion of Bayshore Boulevard. The submerged bottom lands are owned by the Tampa Port Authority. The waters of Hillsborough Bay are classified as Class III Waters.

Restoration Plan: The restoration plan for Bayshore Boulevard utilizes the creation of littoral planting box for intertidal marsh revegetation. Approximately 7.2 linear miles of seawall are available for littoral plantings.

The recommended plan will require deposition of clean fill or other suitable material against the seawall toe. The fill material should be placed with a gentle slope (recommended six-to-one gradient) from the seawall to a fixed erosion control structure. Permanent erosion control



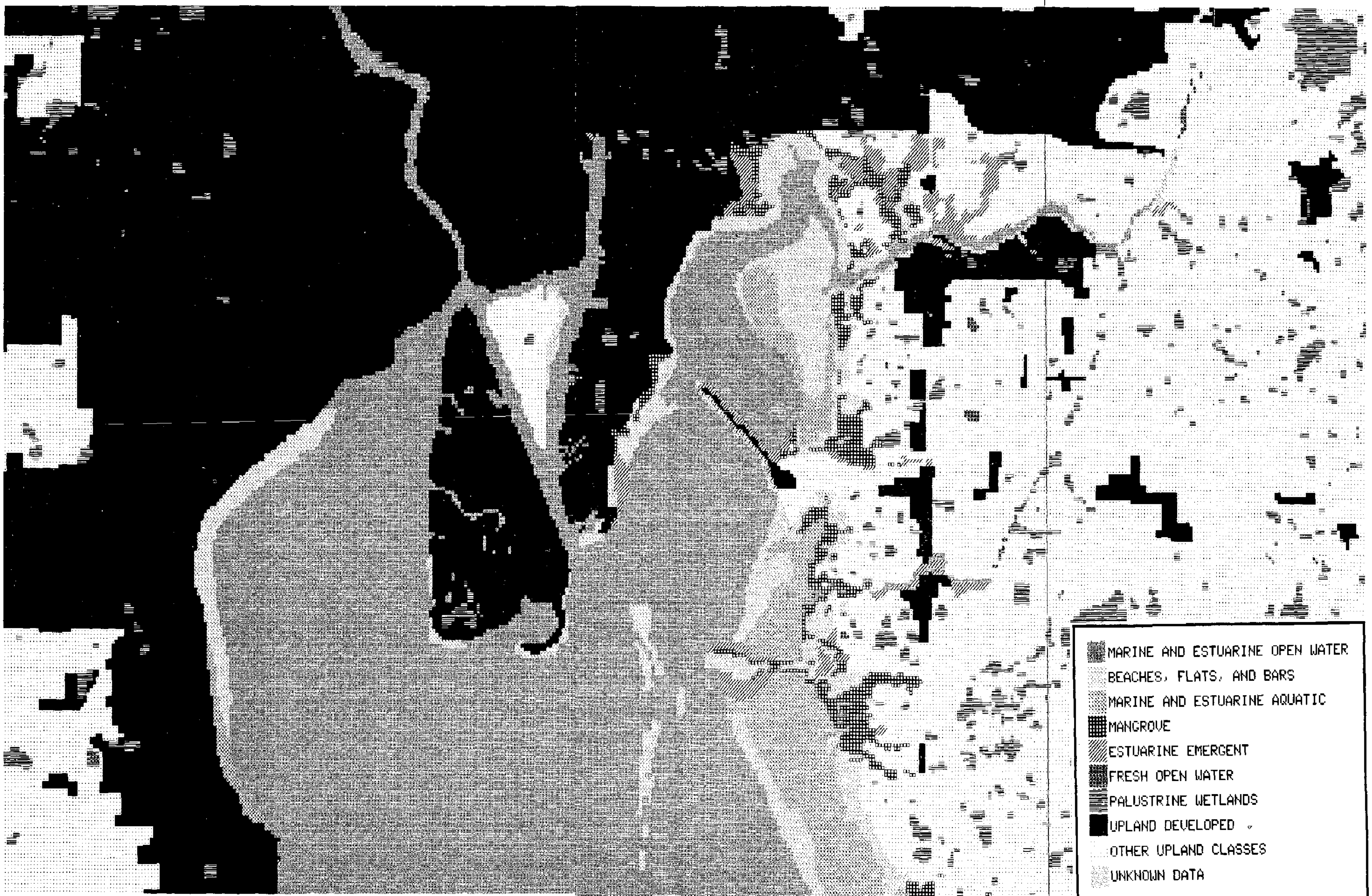
Proposed Intertidal Planters Box

Figure 78

Bayshore Boulevard Restoration Site

Adapted from 7.5 Minute Quadrangles
Tampa Bay Environmental Atlas
U. S. Fish and Wildlife Service (1985)

Figure 79 Wetland Inventory of the Tampa Area - 1957

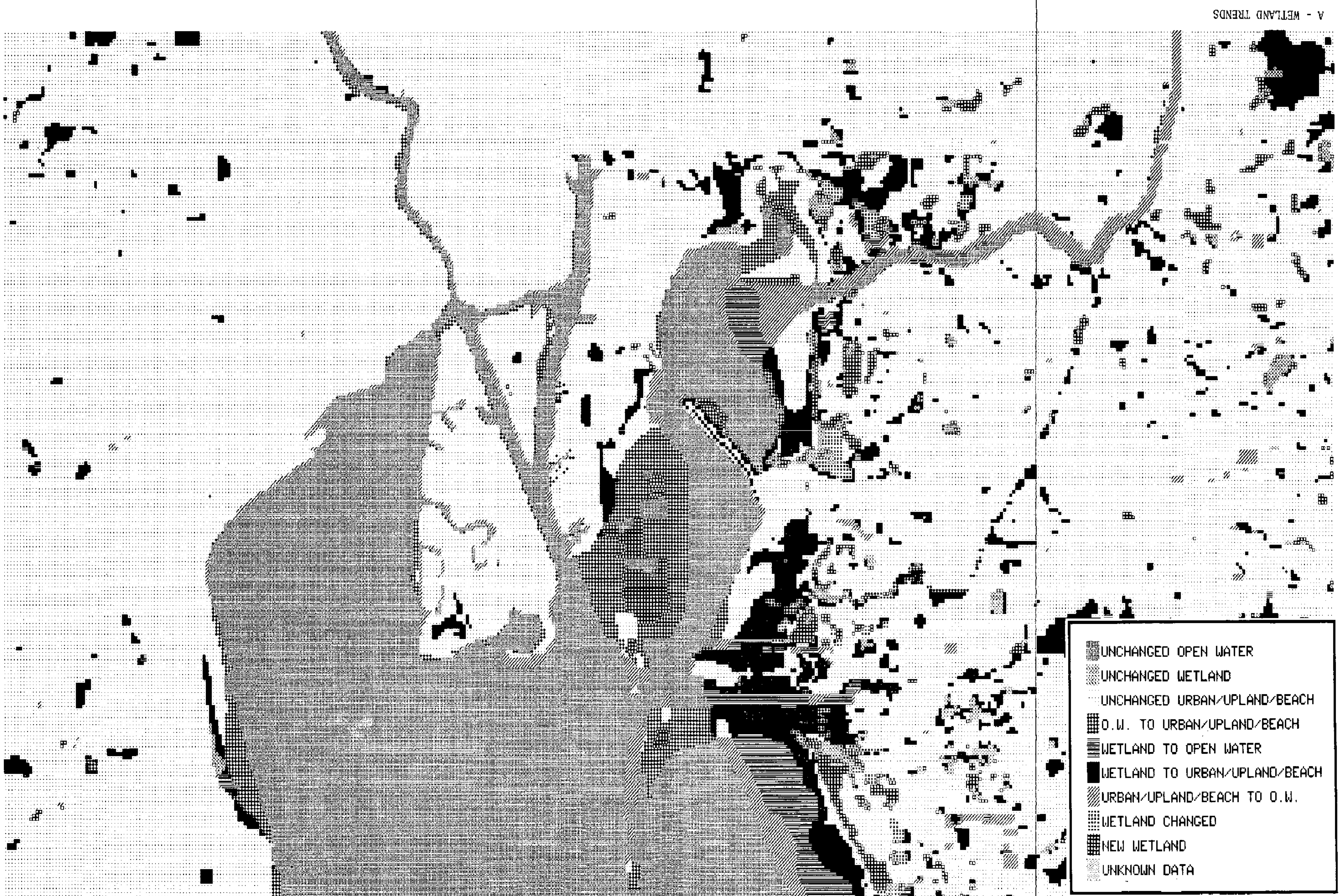


A - 1957 INVENTORY

Figure 80 Wetland Inventory of the Tampa Area - 1982

A - 1982 INVENTORY

Figure 81 Wetland Trend Analysis of the Tampa Area



structure will be required on the seaward side of the fill material to prevent loss of fill and planting units. The erosion control structure (or wave dampening device) can be constructed from rip-rap, cement bags or other permanent material.

The completed planter box can be vegetated with S. alterniflora at a high planting density (one- to two-feet separation over the appropriate intertidal zone. Mangrove seedlings should be interspersed amongst the S. alterniflora. The success of the planting may be dependent upon the speed of vegetation establishment to bind the sediments. Therefore, R. mangle is the recommended mangrove for planting within the S. alterniflora units due to the binding ability of the prop roots.

Hillsborough Bay has historically lost a major portion of its wetland habitat (Figure 81). In addition, the urbanized nature of the area requires innovative methods for habitat restoration. The planter box marsh creation project identified for Bayshore Boulevard can be implemented to provide the habitat available for fish and wildlife in the area, while promoting water quality.

Site 32: McKay Bay

Site Description: McKay Bay is a small (4 km2) sheltered embayment in the northeast portion of Hillsborough Bay (Figure 82). Some areas have been dredged to 3.7 and 4.5 m depth, but most of the bay is very shallow (< 1.5 m depth) (Lewis and Courser 1972). The sediment is fine sand and silt (Taylor et al. 1970; in CSA, 1986).

The bay receives freshwater from the Palm River/Tampa Bypass Canal and tidal flood waters from Hillsborough Bay via East Bay and the Port of Tampa. Tidal flow through the bay and freshwater outflow are constricted by the 22nd Street Causeway; the flow in the Tampa Bypass Canal is controlled by artificial structures.

Fish and wildlife usage of McKay Bay has been reported for birds and fishes. Lewis and Courser (1972) and Courser and Lewis (1975) reported that the mangroves, mud flats and waters of McKay Bay are important to migrant and wintering shorebirds and waterfowl. Paul and Woodfenden (1985) reported that McKay Bay may be one of the most important wintering areas for shorebirds in the United States; a winter average count of 25,000 birds per day was reported, of which half were shorebirds. Price and Schlueter (1985) sampled the fishes and found 10 dominant species: tidewater silverside (Menidia peninsulae), striped mullet (Mugil cephalus), longnose killifish (Fundulus similis), bay anchovy (Anchoa mitchilli), spot (Leiostomus xanthurus), scaled sardine (Harengula jaguana), pinfish (Lagodon rhomboides), sheepshead minnow (Cyprinodon variegatus), gulf killifish (Fundulus grandis) and blackdrum (Pogonias cromis). The authors reported that, "Although McKay Bay is environmentally stressed, it provides a rearing and developmental area for a number of commercially important fish species as well as many forage species that serve as food for marketable ones (in CSA, 1986)".

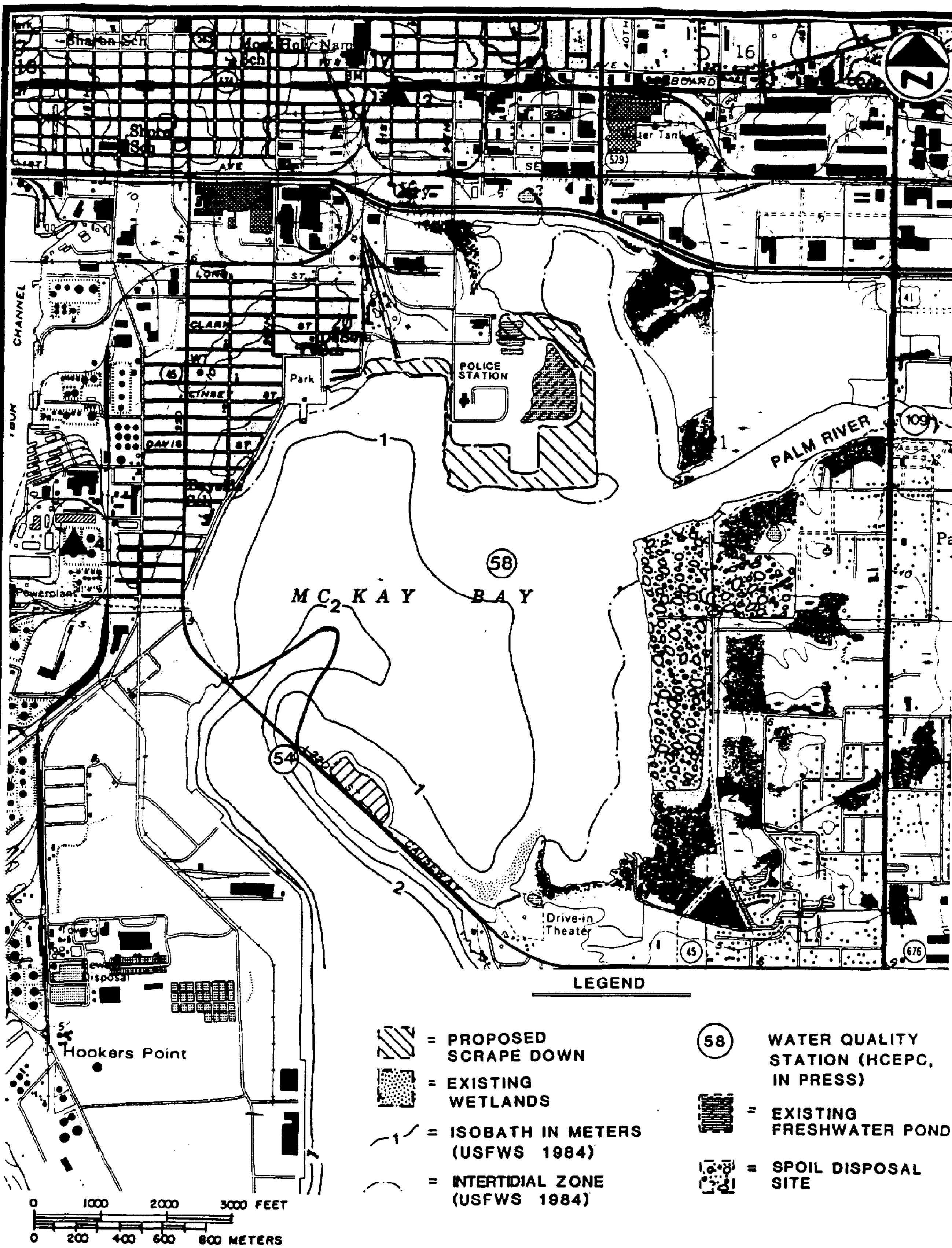


Figure 82 McKay Bay Restoration Site (CSA, 1986)

Review of the wetland inventories (Figures 79 and 80) and trend analysis (Figure 81) between 1957 and 1982 identifies the change in wetland acreage and associated development in the area. All of the seagrass beds have disappeared by 1982. The upper reaches of McKay Bay appear to have shoaled in. Dredge and fill activities have pinched off upper McKay Bay, reinforced the 22nd Street Causeway and excavated the Palm River/Tampa Bypass Canal.

Land Use: Current ownership of land around McKay Bay is identified in TBRPC (1984). The TPA owns all of the submerged land and some of the upland acreage in McKay Bay. Approximately 50% of the shoreline is in public ownership. The area east of the resource recovery project is comprised of disturbed wetlands/uplands with ponded areas. The area south of the City of Tampa Police Department currently appears to be a spoil area littered with construction debris. The Southwest Florida Water Management District site is currently being diked and excavated for use as a spoil disposal site (CSA, 1986).

Restoration Plan: The Future of Tampa Bay (TBRPC, 1984) describes the development of a management plan for McKay Bay. The recommendations include the establishment of a McKay Bay Bird Sanctuary. The creation of the urban sanctuary can best be accomplished with management of the area by local agencies and property owners through a cooperative agreement and possible designation of a lead agency.

Disturbed areas within McKay Bay are available for habitat restoration. CSA (1986) developed a mitigation plan that can be used as restoration for fish and wildlife resources in McKay Bay.

> "Large areas of land (26 ha) south of the police department and east of the resource recovery plant could be scraped down and planted with S. alterniflora and/or mangroves (Figure 82). However, the pond and its associated wetland habitats should be left remaining since this provides important wildlife habitat, and the mitigation plan should ensure its continued health. Along the 22nd Street Causeway there is an area of 4 ha that could be scraped down and planted."

In addition, the existing mangrove system has been stressed by several "back-to-back" cold winters. The natural mangrove areas that have been cold-shocked can be enhanced by planting mangrove seedlings or propagules.

Site 33: Palm River/Tampa Bypass Canal

The Palm River/Tampa Bypass Canal is a man-made waterway connecting the Hillsborough River (above the dam) and McKay Bay in Hillsborough County (Figure 83). The artificial waterway was constructed by the U.S. Army Corps of Engineers to divert and control freshwater in the Hillsborough River. The canal follows a portion of the Palm River natural alignment east of McKay Bay.

The Palm River/Tampa Bypass Canal was constructed for water transmission. The canal has been reinforced with rip-rap material, in portions, to prevent erosion of steep banks.

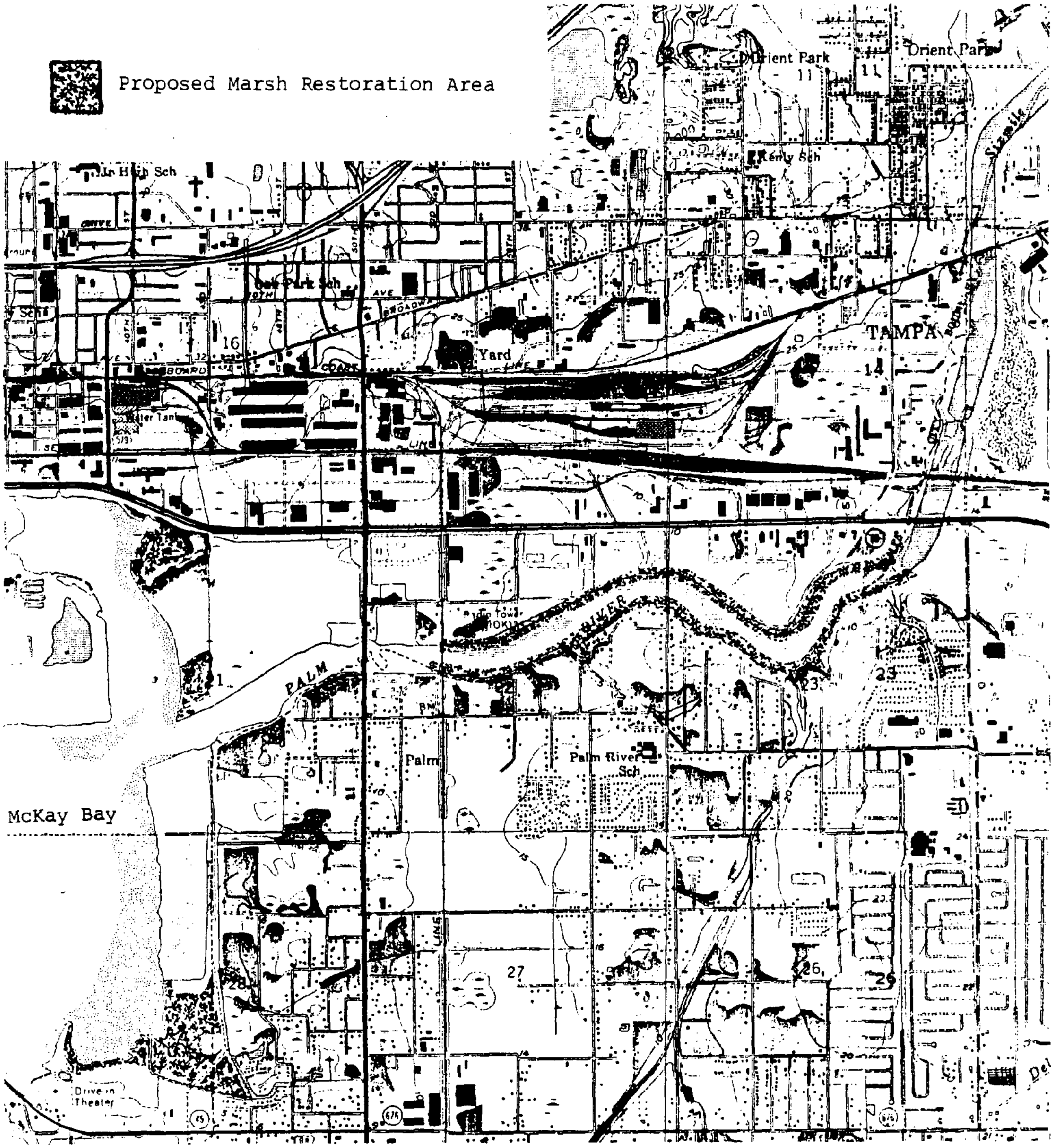


Figure 83

Palm River/Tampa Bypass Canal Restoration Site

Adapted from 7.5 Minute Quadrangles
U. S. Geological Survey
Department of the Interior

The wetland inventory (Figure 79) portrays the original alignment and habitat of the relatively undisturbed Palm River in 1957. The 1982 inventory (Figure 80) and trend analysis (Figure 81) identify the creation of the Tampa Bypass Canal and associated wetland impacts. By 1982, no estuarine wetlands are identified east of McKay Bay in quantities large enough to be graphically illustrated.

Land Use: Portions of the Palm River/Tampa Bypass Canal are under the jurisdiction of the United States Army Corps of Engineers USACOE, Tampa Port Authority (TPA), and the Southwest Florida Water Management District (SWFWMD). Additional parcels are in private or commercial ownership.

Restoration Plan: The recommended plan is to provide habitat for fish and wildlife in the artificial waterbody through revegetation of the littoral fringe (Figure 83). Existing steep slopes are required to be regraded to provide sufficient acreage for marsh establishment and diminish erosional energies.

The regraded restoration sites can then be planted with S. alterniflora on three-foot centers. Additionally, mangrove seedlings are recommended to be planted on ten-foot centers. Inclusion of mangrove revegetation is necessary, since a natural seed source is not located in the immediate vicinity.

Site 34 and 35: Delaney Creek Pop-Off Canal to the Alafia

Site Description: This site consists of two areas (Figure 84): (1) the Delaney pop-off canal (Site 34), and (2) the shoreline west of the Gardinier, Inc. gypsum pile (Site 35).

The Delaney pop-off canal (Figure 84) is a drainage canal cut through the extensive wetlands area extending south to the Gardinier, Inc. gypsum pile, east to Route 41 (and beyond in areas) and west into Hillsborough Bay. The spoil berms created during channel construction have impounded portions of the marsh, preventing exchange with the tidal waters of Hillsborough Bay at Site 34. A fringe of salt marsh, predominantly A. germinans and S. alterniflora, presently exists along the spoil banks (CSA, 1986). The Gardinier, Inc. gypsum stack was constructed primarily on bayland. A small fringe of wetlands has developed to the west of the stack. The Future of Tampa Bay (TBRPC, 1984) describes the issue of the Gardinier, Inc. gypsum stack.

Issue #15 Gypsum Field Decommissioning

Issue Analysis: The Gardinier, Inc., gypsum field located west of U.S. Highway 41, and north of the Alafia River, represents a continuing source of contamination to Tampa Bay through leaching of acidic waters, flouride and radionuclide enrichment, and sedimentation (see Figure 84). Past leaching has resulted in the formation of an extensive calcium flourite delta upon the adjacent bay bottom. Benthic epifaunal and infaunal productivity and diversity in the vicinity of this delta has thus been significantly reduced.

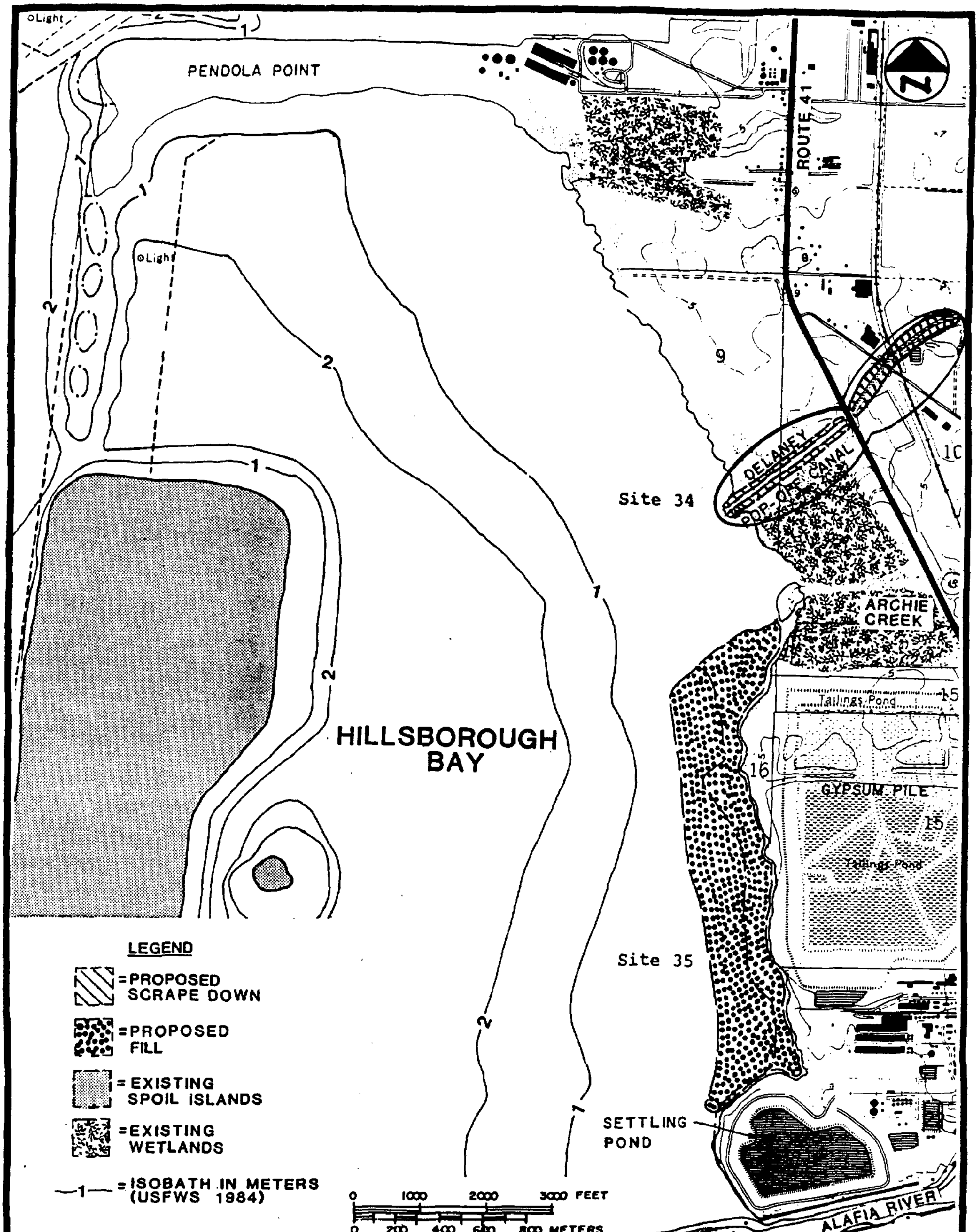


Figure 84 Delaney Creek Pop-off Canal to the Alafia River restoration site (Adapted from CSA, 1986)

In 1983, Gardinier, Inc., applied for development approval, through the Development of Regional Impact (DRI) process (Chapter 380, Florida Statutes), for a new gypsum field to be located east of U.S. Highway 41. Many of the conditions of approval related to the decommissioning of the old gypsum field were incorporated into the Development Order, including the following:

No. 3 - TBRPC

"To assure that the existing stack is properly and adequately decommissioned and closed, Gardinier shall prepare and present for review and approval to Hillsborough County and TBRPC a plan prepared pursuant to the U.S. Environmental Protection Agency regulations. This plan shall identify the manner proposed to close the top of the stack and the existing collection system for leachate and shall address Gardinier's commitment to maintain and/or improve this system over future years. This plan shall also require a commitment to maintain vegetation on the existing stack over future years." (TBRPC Recommended Order, 3)

No. 42 - HCEPC

"Decommissioning of the existing gypsum stack shall include restoration and revegetation of the shoreline of the bay." (HCEPC Report, p. 7)

Gardinier, Inc., is committed to the conditions described above in accordance with Chapter 380, F.S. The DRI monitoring process implemented by the Department of Community Affairs and the Tampa Bay Regional Planning Council will allow for long-term observation of progress with regards to decommissioning of the old gypsum field.

The 1957 wetland inventory is located on Figure 85 for the Gardinier area. Review of the 1982 wetland inventory (Figure 86) and concurrent trend analysis (Figure 87) identifies the alteration in wetland coverage from adjacent development. The Delaney Creek pop-off (Site 34) was constructed through a mangrove fringe. The gypsum stack filled in a portion of a large mangrove stand and required realignment of Archie Creek. The seagrass beds that existed in the 1957 inventory are replaced by a tidal flats designation in the 1982 wetland inventory (Site 35).

Land Use: The TPA owns the submerged lands to the Alafia River, while Gardinier, Inc. owns the upland property in the vicinity of the Delaney pop-off canal. The only planned land use of the area is the eventual decommissioning of the gypsum pile by Gardinier.

Restoration/Mitigation Plan: The Tampa Port Authority has recommended a mitigation plan for the Delaney Creek pop-off canal (CSA, 1986). The objective is to dechannelize the canal by excavation and then revegetate the spoil berms (Site 34). This action will create additional vegetational habitat and allow overwash circulation in adjacent marsh areas.

In addition to the Tampa Port Authority mitigation plan, the artificial canal east of U.S. 41 can be improved through habitat restoration. Spoil berms within this area can be removed to promote marsh inundation and increase the area available for revegetation. The construction of artificial waterbodies and waterways in the region has degraded naturally occurring ecosystems. Proper design of new activities and restoration of stressed man-made waterways can greatly improve conditions necessary for maintenance of fish and wildlife populations.

The mitigation/restoration plan for the Gardinier shoreline (Site 35) is to fill 60+ m bayward to MSL and plant with S. alterniflora to increase the amount of salt marsh in Hillsborough Bay (Figure 84). This action would have the dual purpose of increasing habitat and improving water quality in the bay. However, the habitat value of the benthic habitats may prevent or limit filling in shallow bay bottom. This factor will require further evaluation before such a trade-off is permissible. The proposed plan for Site 35 will result in the filling of 65 ha of bay bottom and borrow pits (CSA, 1986).

Site 36: Spoil Island 2-D

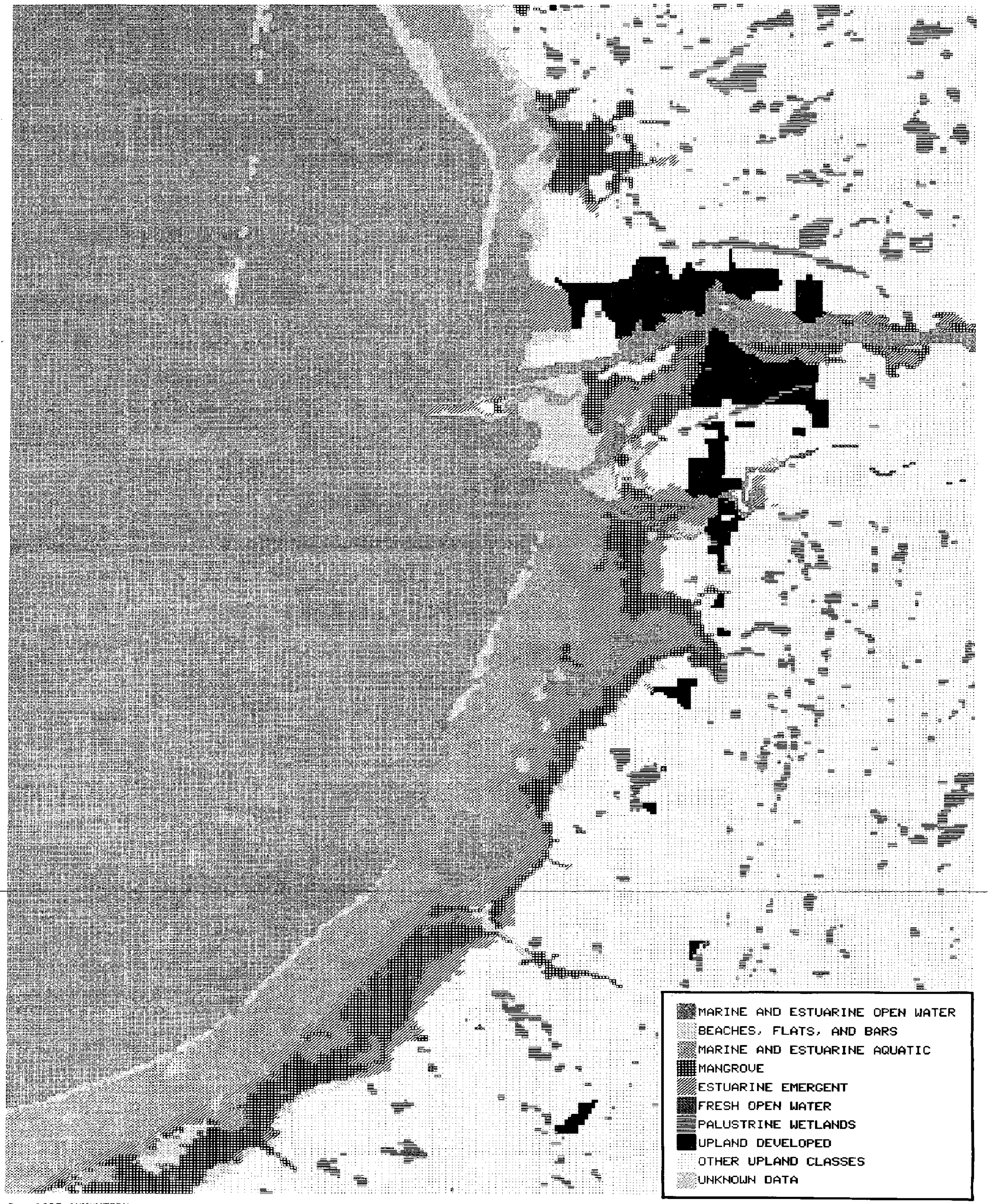
Site Description: Spoil Island 2-D is located within Hillsborough Bay, north of the Alafia River (Figure 88). The diked island is approximately 220 ha in size. The island, constructed largely of coarse limestone rock and rubble, was built in 1978, by the USACE for spoil containment as a part of the Tampa Harbor deepening project. In 1979, an attempt was made to plant the eastern shoreline of the island with Spartina patens and S. alterniflora.

CSA (1986) observed that the S. alterniflora had become established on only the northeastern end of the island. Mangroves, predominantly A. germinans, have become established in the area. S. patens, however, forms a 6- to 15-m wide band along a shelf waterward of the containment dike P. vaginatum has become established landward of the S. patens, and Iva fruitescens grows on the sides and top of the containment dike. Grasses and shrubs have invaded the interior of the containment area.

Bird usage of the island has been extensive and is described in CSA (1986):

> "The island contains probably the largest Laughing Gull colony in the state, with numbers conservatively estimated at 20,000 pairs in 1984 (S. R. Patton and L. A. Haners, personal communication in Lewis and Paul, 1984). Nests of Least Terns (Sterna albifrons) and Black Skimmers (Rynchops nigra) were seen on the island in 1979, and in 1981, the colonial nesters were Gull-billed Terns (Gelochelidon nilotica) (4 pairs), Least Terns (60+ pairs), and Black Skimmers (200 pairs) (Lewis and Paul, 1984). American Oystercatchers (Haematopus palliatus), Black-necked Stilt (Himantopus mexicanus), Wilson's Plover (Charadrius wilsonia), and Snowy Plover (Charadrius alexandrinus) were also noted (Lewis and Paul, 1984). Because of the marginal nature of the wetlands on the east side of the island, few fishes are able to use the wetland areas surrounding the island."

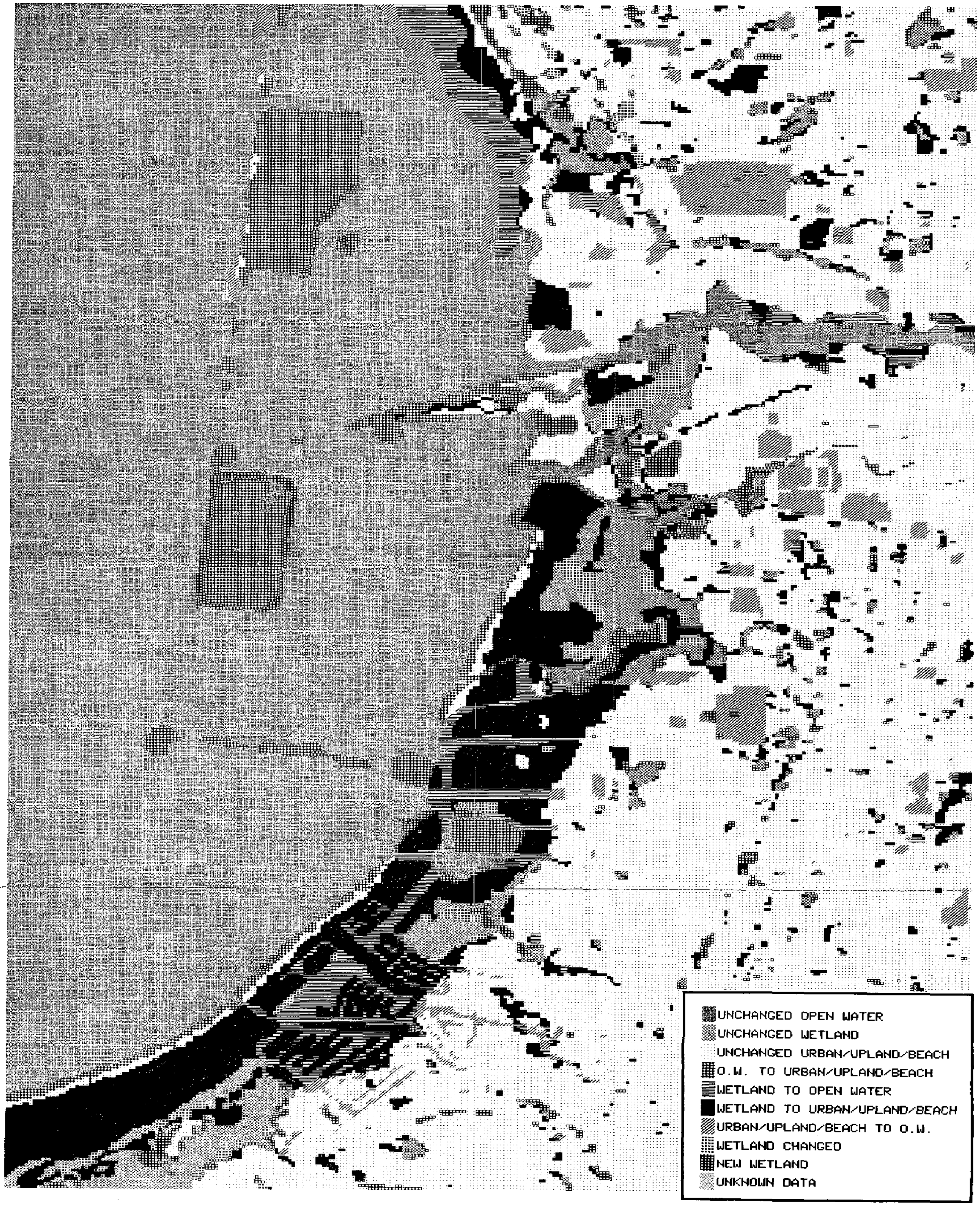
Figure 85 Wetland Inventory of the Alafia River Area - 1957



R - 1957 INVENTORY

Figure 86 Wetland Inventory of the Alafia River Area - 1982

Figure 87 Wetland Trend Analysis of the Alafia River Area



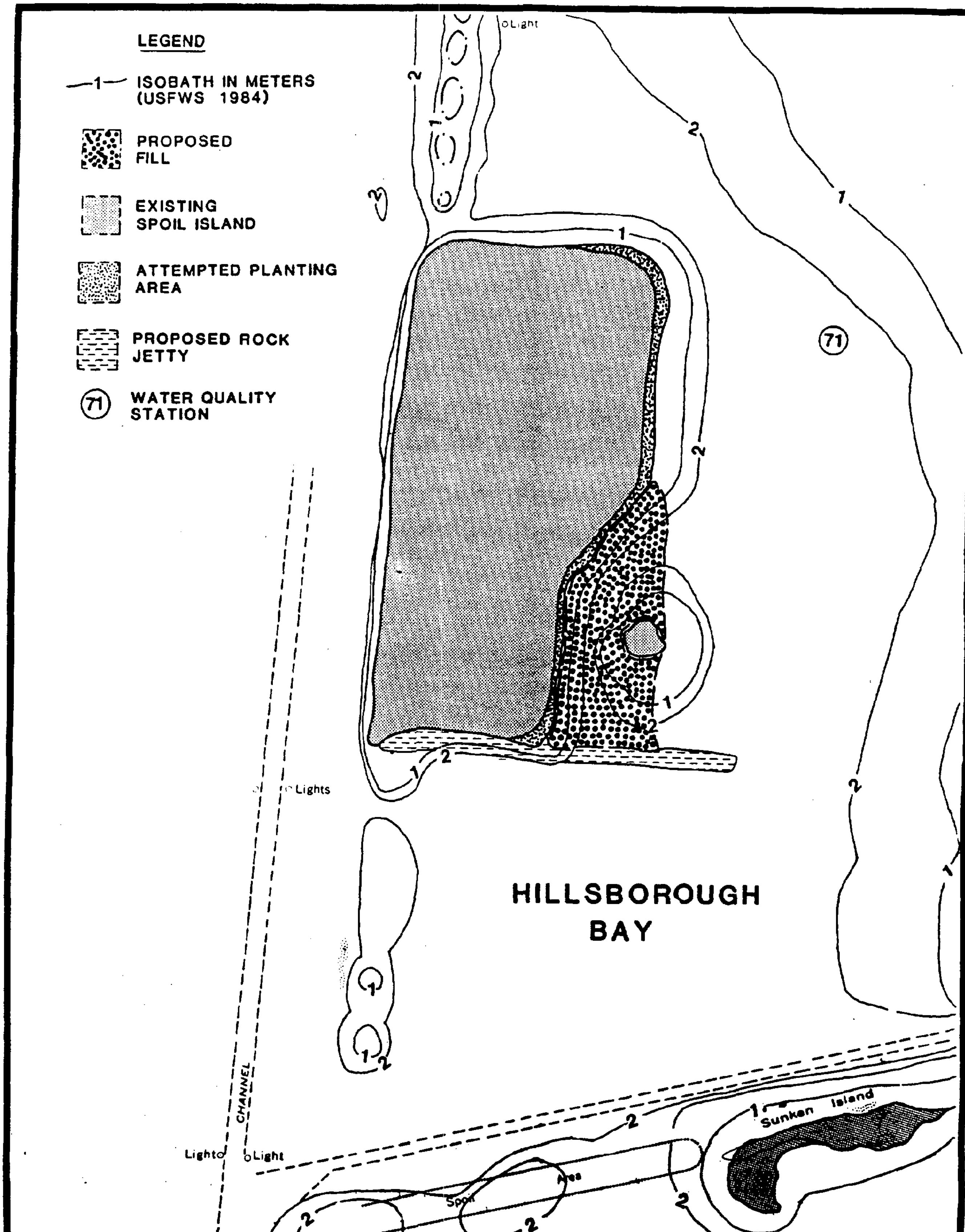


Figure 88 Spoil Island 2-D restoration site (CSA, 1986)

Review of the 1957 (Figure 85) and 1982 (Figure 86) wetland inventory, and the trend analysis (Figure 87) for Spoil Disposal Islands 2-D and 3-D show the placement of the islands in open estuarine waters of Hillsborough Bay. Scattered small spoil islands are identified on the 1957 inventory in a linear orientation adjacent to the shipping channel. The 1982 inventory reflects the increase in open water filling with the creation of 2D and 3D spoil islands from dredging operations into the Port Redwing/Big Bend facility, and expansion of spoil islands at the mouth of the Alafia River. A large emergent estuarine marsh identified in the 1957 inventory at the mouth of the Alafia River is colonized by mangroves in the 1982 wetland inventory analysis. A large quantity of seagrass coverage noted in the 1957 inventory has been lost in the area by 1982.

Land Use: The USACE plans to use Spoil Islands 2-D and 3-D for the next 25 years. The islands have been estimated to contain sufficient capacity for the maintenance of the main ship channel northeast of the Gadsden Point widener and the inner harbor branch channels for that period. The TPA owns the surrounding submerged lands (CSA, 1986).

Mitigation Plan: A mitigation plan has been proposed by the Tampa Bay Management Study Commission for the Tampa Harbor, Alafia River, and Big Bend Channel deepening project. The mitigation would have two objectives: (1) to create habitat for waterfowl and shorebirds, and (2) to lessen erosion of the island and the related water quality problems. The plan would require rip-rap erosion protection for the southern, western, and northern shores of the island and extend the southern rip-rap eastward to form a rock jetty in order to provide conditions necessary for the proposed restoration plan. The Study Commission's plan calls for creation of 9 ha of marsh. CSA (1986) recommended filling approximately 50 ha of bay bottom to +1.0 NGVD on the eastern side of the island (Figure 88) and planting with S. alterniflora at a minimum of 1-m centers. The proposed fill area is approximately 2 to 3 m in depth, and the slope from the shoreline to bay bottom is steep. The proposed rock jetty would protect the planting area from erosion. However, the value of the subtidal habitat would have to be determined before filling could be recommended.

Site 37: Spoil Island 3-D

Site Description: Spoil Island 3-D is located in Hillsborough Bay south of the Alafia River, and north of the channel to Port Redwing (Figure 89). The diked island is approximately 150 ha in size. The island, constructed largely of sand and fine shell, was built in 1981 by the USACE for spoil containment as a part of the Tampa Harbor deepening project. No vegetation has been planted on the island, which is eroding rapidly (Lewis and Paul, 1984). Observations by CSA (1986) indicate that the entire island base is eroded at the southwest corner, forming a 6-m cliff from the eroded dike. The eastern shoreline, however, has a 6- to 10-m shelf between the dike base and the MHW line (Figure 89). This area has become vegetated with grasses [e.g., P. vaginatum and Ipomea pes-caprae (railroad vine)]. The interior of the island is only partially vegetated with grasses and low shrubs.

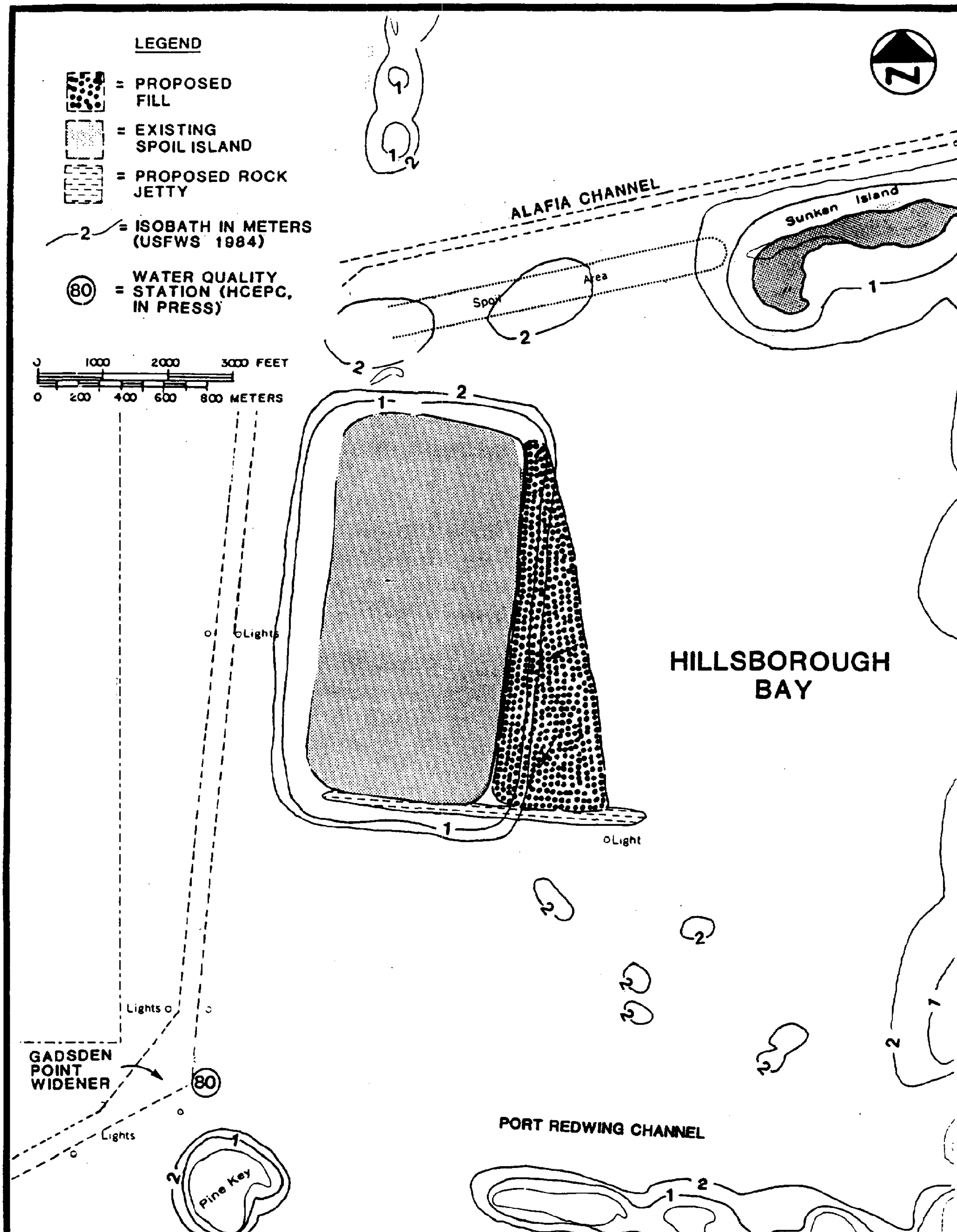


Figure 89 Spoil Island 3-D restoration site (CSA, 1986)

Colonial bird use on Spoil Island 3-D has been documented by Lewis and Paul (1984) and is described in CSA, 1986. Since 1982, the barren sand dikes have been used by 400 nesting pairs of Black Skimmer (Rynchops nigra) and 50 to 60 pairs of Least Tern. In 1984, the Caspian Tern (Sterna caspia) numbered 45 pairs, the largest colony ever in Florida for this species, and 200 pairs of Laughing Gull (Larus atricilla) were observed. Other species observed nesting in small numbers included the Gull-billed Tern (Gelochelidon nilotica), American Oystercatcher (Haematopus palliatus), Black-necked Stilt (Himantopus mexicanus), Wilson's Plover (Charadrius wilsonia), and possibly Snowy Plover (Charadrius alexandrinus). As at Spoil Island 2-D, there are many migrant shorebirds but few waterfowl because of the lack of wetland habitat.

The wetland trend analysis for the area surrounding Spoil Island 2-D and 3-D is provided in the Site 36 section (Spoil Island 2-D). The estuarine emergent class designation on Spoil Disposal Island 3-D perimeter (Figure 86) should also be noted. The majority of 3-D shoreline area was barren or exhibited patches of grasses, as identified in CSA, (1986). The designation may not accurately depict the actual extent of estuarine intertidal vegetation existing on Spoil Island 3-D.

Land Use: The spoil island was built and is regulated by the U.S. Army Corps of Engineers. The submerged lands are owned by the Tampa Port Authority. The surrounding water is categorized as Class III Waters.

Restoration Plan: A mitigation plan has been proposed by the Tampa Bay Management Study Commission for the Tampa Harbor, Alafia River and Big Bend Channel deepening project. The proposal is similar to the one identified for Spoil Island 2-D (Site 36). The eastern shoreline of Spoil Island 3-D drops off quickly to a water depth of 3 to 4 m. The proposal is to provide rip-rap erosion prevention for the southern, western and northern shorelines of the island to slow the ongoing severe erosion (Figure 89). The spoil islands located along the channel to Port Redwing provide minimal protection to the island; therefore, a jetty extending eastward from the southern edge of the island would provide protection for filling and S. alterniflora planting project similar to the one proposed for Spoil Island 2-D (Figure 88). The project could result in the creation of up to 50 ha of marsh/mangrove habitat, however, as with all shallow subtidal fills, the value of the subtidal benthic community would have to be considered before proceeding with a plan (CSA, 1986).

Site 38: Port Redwing

Site Description: Port Redwing is located within Hillsborough County, south of Bullfrog Creek and north of Apollo Beach (Figure 90). The recent (9 March 1984) Big Bend Study by the TPA for the Coastal Energy Impact Program describes in detail the area around Port Redwing (NUS Corporation et al. 1984 in CSA, 1986). The areas of concern for this study are the northern shoreline of Port Redwing and two old dredge cuts north of the port in the vicinity of Whiskey Stump Key and Green Key (two natural islands which are currently National Audubon Society Sanctuaries). The northern shoreline of Port Redwing currently has a 6- to 15-m fringe of S. alterniflora and mangroves (predominantly A. germinans). Green Key is a low-lying mangrove island. Whiskey Stump Key has slightly higher elevation

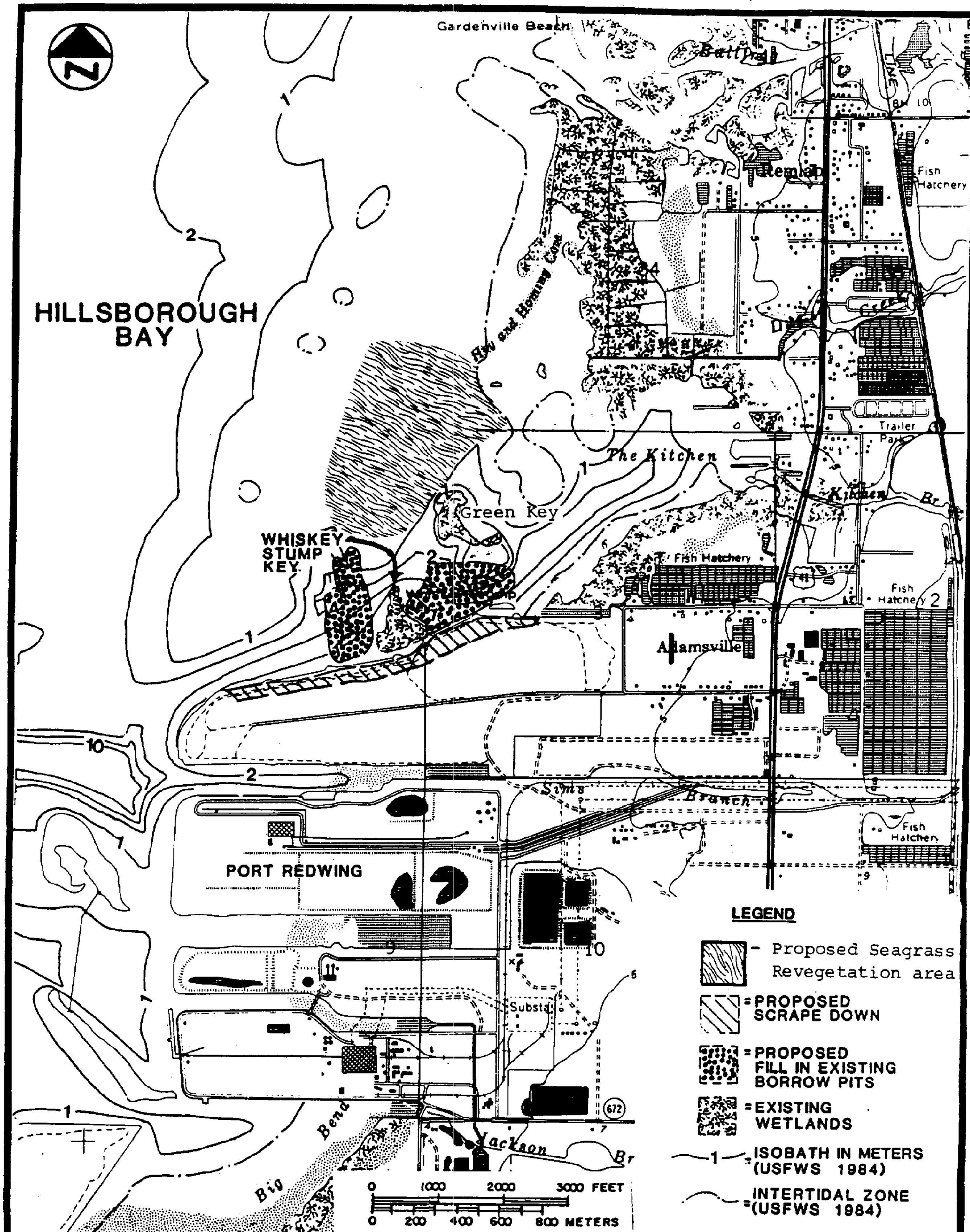


Figure 90 Port Redwing restoration site (Adapted from CSA, 1986)

with a perimeter of marsh and mangroves. Both old dredge cuts, located west of and between Whiskey Stump Key and Green Key, are approximately 3 m deeper than the surrounding bottom.

Water quality in the area north of Port Redwing was evaluated extensively in 1983, during the Big Bend Study (NUS Corporation et al. 1984). Station D, located in the borrow pit west of Whiskey Stump Key, was sampled on alternate months during January through November 1983. Station E, located in the borrow pit between the two keys, was sampled periodically for in-situ dissolved oxygen concentrations. The study found frequent low dissolved oxygen values within the two borrow pits, with the lowest dissolved oxygen value noted at Station D. All other water quality parameters studied were within normal ranges (in CSA, 1986).

Because the two islands are National Audubon Society Sanctuaries, bird usage has been recorded extensively. Green Key was a major nesting area for wading birds, pelicans and cormorants from the 1920s until the early 1960s (NUS Corporation et al. 1984). Extensive filling around the islands in the middle to late 1960s and freeze damage to the mangroves on Green Key in the early 1960s caused movement of the colonial nesting birds to Bird Island and the then newly created Sunken Island (Lewis 1977). During the 1983 Big Bend Study, four shoreline areas were studied for bird usage: (1) the north Redwing shoreline, (2) Fishhook Spoil, (3) Whiskey Stump Key, and (4) Green Key. The Redwing shoreline was found to have high bird usage but no nests. Whiskey Stump and Green Key both had low but consistent bird usage. Whiskey Stump Key had nine pairs of Green Herons (Butorides striatus) nesting in the mangrove fringe on the east side of the island, whereas Green Key had no colonial bird nesting activity (in CSA, 1986).

The 1957 wetland inventory (Figure 85) portrays the future Port Redwing area in relatively undisturbed condition. This location, in 1957, is dominated by an extensive salt marsh and mangrove fringe with seagrass beds extending to the edge of the estuarine shelf. The 1982 wetland inventory (Figure 86) and trend analysis (Figure 87) show the creation of the major bay fills of Port Redwing and Apollo Beach. The open water fill operations are constructed upon and up to the edge of the estuarine shelf. Port Redwing development directly destroyed salt marsh, mangrove and seagrass beds by filling for creation of upland acreage, while adjacent seagrass coverage has been reduced dramatically. Subtidal and estuarine emergent vegetation zonation in the Green Key area have migrated landward into shallower waters and decreased in extent of coverage.

Land Use: The upland fill area is currently owned by the Port Redwing facility. Green and Whiskey Stump Keys are regulated by the National Audubon Society. The submerged lands and borrow pits are owned by the Tampa Port Authority.

Restoration/Mitigation Plan: CSA (1986) reports that Port Redwing has plans to expand the existing port facility. Mitigation for environmental impacts may include the north shore intertidal area and submerged borrow pits. The mitigation plan is as proposed in the Big Bend Study (NUS Corporation et al. 1984 in CSA, 1986). The proposed mitigation plan can be used for partial restoration of historic habitat losses, without additional vegetation displacement.

The problems of poor water quality in the old submerged borrow pits and decreased bird usage on Whiskey Stump and Green Key are identified in the study. The northern shoreline of Port Redwing is recommended to be scraped down to MSL and planted with S. alterniflora to increase the potential forage and nesting areas for colonial bird species (Figure 90). According to the mitigation plan in the Big Bend Study (NUS Corporation et al. 1984), approximately 7.2 ha are available for scrape-down and planting. The submerged borrow pits could also be filled to the same (or a shallower) depth as the surrounding bottom to alleviate the water quality problem caused by the pits. The borrow pits occupy an approximate eight-ha area. An additional benefit of filling would be raising the bottom into the photic zone, which could encourage the growth of benthic algae and seagrasses. One potential problem that needs evaluation is the amount of sedimentation upstream from the borrow pits and a determination that filling these may not lead to increased turbidity in this region (CSA, 1986).

In addition to the mitigation plan, the site offers the opportunity for seagrass restoration (Figure 90). The area west of Green Key has recently shown natural recruitment of seagrass (H. wrightii). In the early summer of 1986, the Florida Conservation Association, Florida DOT and Mangroves Systems, Inc., attempted a joint seagrass transplanting experiment west of Green Key. H. wrightii and R. maritima plugs were acquired from the Courtney Campbell Causeway (slated to be destroyed) by volunteers and transplanted into the area. Initial observations (Rob Mattson, personal communication) indicate establishment with some expansion of the plugs. Additional acreage is available for continued seagrass restoration efforts.

Site 39: Newman Branch

Site Description: The subtidal area designated for restoration is located west of the mouth of Newman Branch tidal tributary, south of the Big Bend Power Plant and north of Apollo Beach (Figure 91). Historic dredge and fill activity has played a major role in the geography of the area. Dredged borrow pits occur adjacent to the fill areas for Big Bend and Apollo Beach. An area of undisturbed estuarine shelf exists between the major fills and Newman Branch.

Seagrass beds have historically occurred in this area along the shallow subtidal estuarine shelf as identified in the wetland trend analysis (Figure 87). Major contributions to the loss of the seagrass beds in this area are increased turbidity, indirect burial from dredge and fill operations and thermal discharges from the TECO Big Bend power facility.

A tidal marsh occurs around the mouth of Newman Branch and is limited in extent by the large bay fill sites (Figure 91). The tidally influenced portion of Newman Branch has been channelized.

Land Use: The bay bottom in this area is owned by the Tampa Port Authority. The Big Bend power facility to the north is owned by Tampa Electric Company. The Apollo Beach development is under private ownership. The water is categorized as Class III Waters.

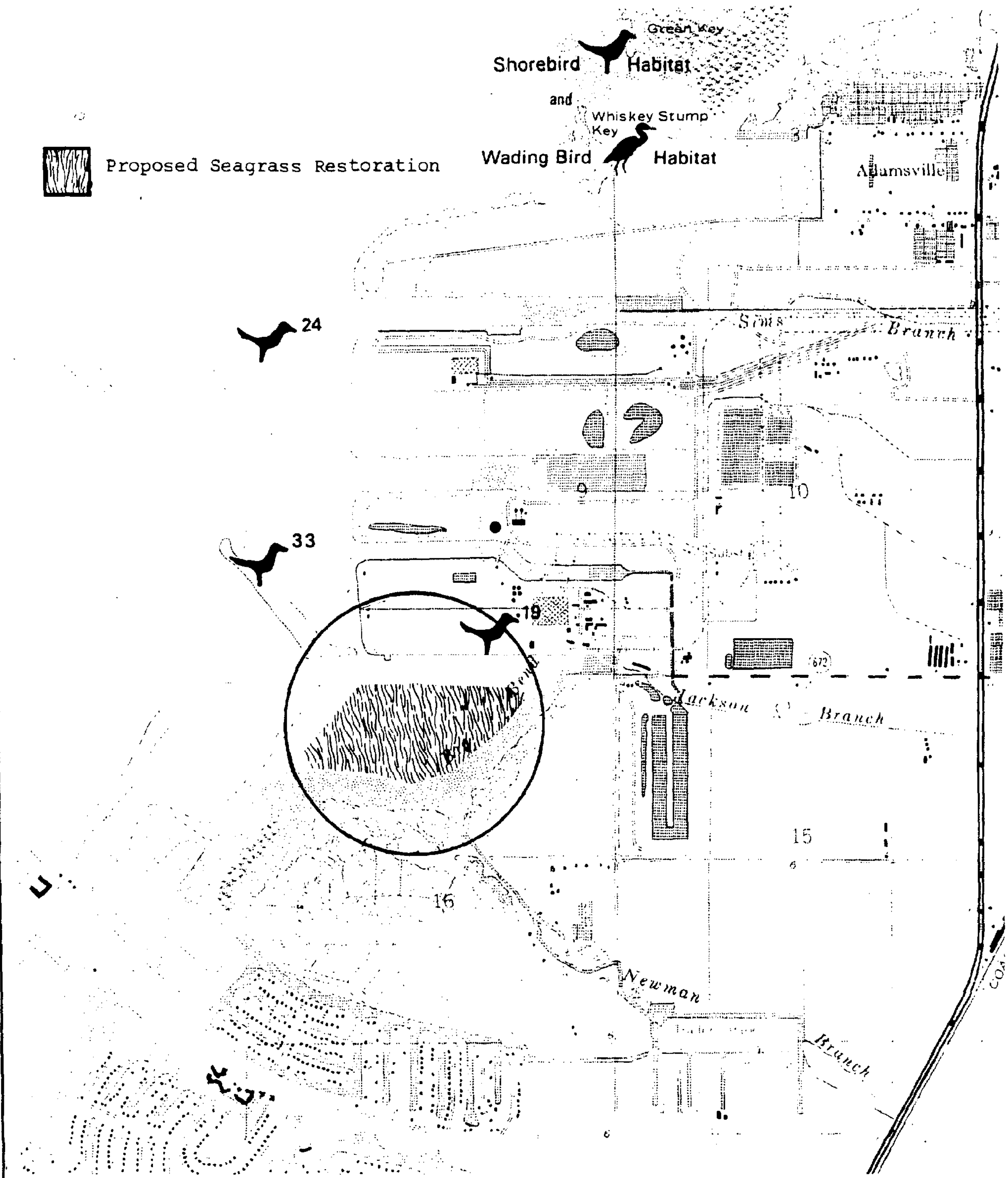


Figure 91

Newman Branch Restoration Site

Adapted from 7.5 Minute Quadrangles
Tampa Bay Environmental Atlas
U. S. Fish and Wildlife Service (1985)

Restoration Plan: The recommended plan is to revegetate the estuarine shelf with seagrass. The project may be dependent on water quality conditions in the area. H. wrightii sprigs can be planted on two-foot centers and monitored for spreading.

The fetch in the area is limited by the large bay fills, preventing wave erosion. Public usage of the area is predominantly along undeveloped portions of Apollo Beach and the Big Bend effluent point for fishing and picnicking. Restoration of historic seagrass coverage on the estuarine shelf will provide additional habitat in the area and compliment existing natural intertidal areas.

Site 40 and 41: E.G. Simmons Park

Site Description: E.G. Simmons Park (Site 40, Figure 92) is located in southern Hillsborough County, north of the Bahia Beach development. The park is located on a dredge and fill development, with areas of mangrove marsh existing to the north and east.

Due to high public usage and erosion, portions of the shoreline are denuded of vegetation. Patches of S. alterniflora and mangroves occur onsite that have established naturally upon completion of filling activities.

The subtidal area (Site 41, Figure 92) on the estuarine shelf northeast of E.G. Simmons Park to Apollo Beach has lost the majority of seagrass coverage. Review of the area on the 1957 wetland inventory (Figure 85), 1982 inventory (Figure 86) and associated trend analysis (Figure 87) identifies the decline in seagrass coverage on the estuarine shelf area.

Recent observations have reported that seagrass growth is starting to volunteer in naturally (Lewis, personal communications) into the area from adjacent beds.

Land Use: E.G. Simmons Park is regulated by the Hillsborough County Parks and Recreation Department. Portions of the subtidal estuarine shelf are under private and Tampa Port Authority ownership. E.G. Simmons Park and adjacent estuarine waters receive a Class II Waters designation which extends approximately half the distance to Apollo Beach. The remaining waters adjacent to Apollo Beach receive a Class III Waters designation.

Restoration Plan: Numerous plots of denuded intertidal area in E.G. Simmons Park exist for habitat creation or enhancement (Site 40). In areas where erosion has created steep slopes, regrading is recommended (Figure 92). This will provide additional acreage for revegetation and prevent further erosion. Since S. alterniflora occurs naturally on site, the vegetation can be transplanted from healthy donor beds to the revegetation areas. Mangroves are expected to colonize the planted S. alterniflora areas with natural succession by the species.

The site is ideal for additional public education and awareness, however, physical protection will be required to prevent public degradation.

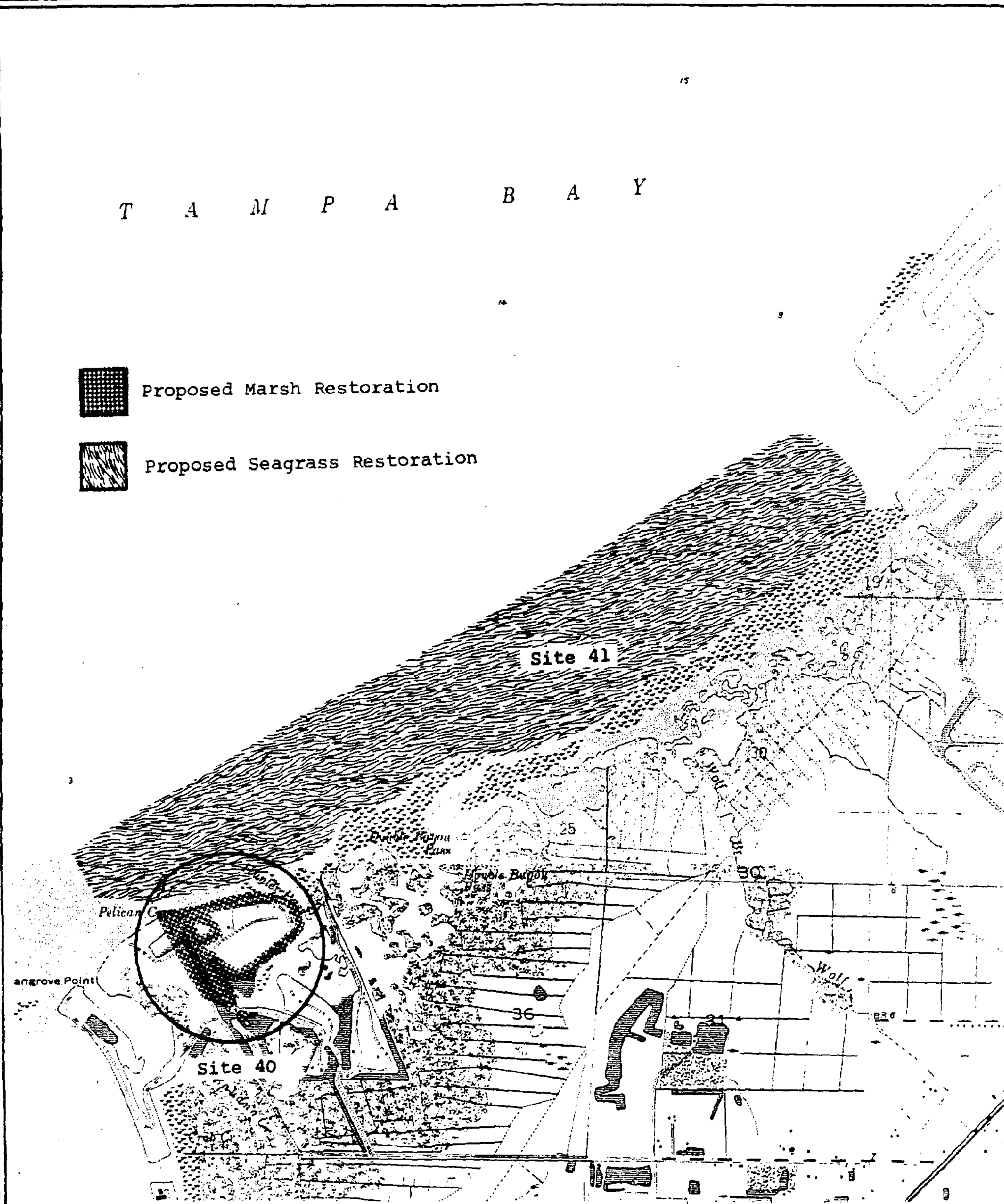


Figure 92

E. G. Simmons Park to Apollo Beach
Restoration Sites

Adapted From 7.5 Minute Quadrangles
Tampa Bay Environmental Atlas
U. S. Fish and Wildlife Service (1985)

It is recommended that the subtidal estuarine shelf (Site 41) be revegetated with seagrasses to aid in the apparent recolonization (Figure 92). The area will require elevational transects to determine suitable areas for planting within the photic requirements identified in adjacent seagrass beds.

After determination of suitable planting locations, it is recommended to transplant *H. wrightii* plugs on a higher density (two-foot spacing). The density of plantings is required due to the large fetch in the area and anticipated erosion. As an alternative, physical wave dampening devices can be installed to protect planted areas until coalescence. The location is commonly used for fishing and will require navigational marking in shallow areas.

MANATEE COUNTY SITE EVALUATION

Site 42: Piney Point

Site Description: Piney Point is located in the extreme northern corner of Manatee County on Tampa Bay, just north of Port Manatee (Figure 93). Before the construction of the bay bridges, Piney Point was used as a ferry landing for water-bound transportation, between Pinellas and Manatee Counties. Currently the area provides unregulated boating access to Tampa Bay for local residents.

Historically, Piney Point was reinforced by dredge and fill operations for construction of the ferry landing. The tip of Piney Point is eroding southward creating a sand spit. The migration of the tip requires stabilization which can be accomplished by habitat restoration.

Extensive areas of mangroves extend along the shoreline north, through the Piney Point embayment. Seagrass beds exist just off shore on undisturbed bay bottom.

In the area south of Piney Point, Port Manatee was created by filling on the bay shoreline, dredging an entrance channel and spoiling the remainder of the material on an island west of the port. Agricultural and industrial development are the dominating land uses to the east.

In the area around Piney Point, the 1957 wetland inventory (Figure 94) identifies the small channel into the ferry landing. Extensive seagrass beds exist north and south of the site. The 1982 inventory (Figure 95) and trend analysis (Figure 96) for Piney Point show the infilling of portions of the Piney Point channel and landward retreat of subtidal seagrass beds into shallower waters. In addition, salt marsh coverage to the north have been replaced with mangrove vegetation. The major development of Port Manatee is identified to the south.

Land Use: Piney Point is currently under private ownership. Approximately 8.5 acres of upland and 8.0 acres of submerged lands are in private ownership.

Restoration Plan: The erosion on the tip of Piney Point will require stabilization to prevent seagrass burial or undercutting of intertidal vegetation (Figure 93). The shoreline is recommended to be planted with S. alterniflora in areas lacking natural vegetation on two-foot centers with a minimum of three rows. The pristine areas to the north are expected to provide a mangrove seed stock for natural recruitment into Site 42.

A small impounded lagoon, located along the south shoreline, will benefit via the establishment of a larger connection to Tampa Bay. The shallow subtidal area can be planted with H. wrightii. Adjacent H. wrightii beds can be used for transplanting of plugs after approval by the appropriate jurisdictional agencies.

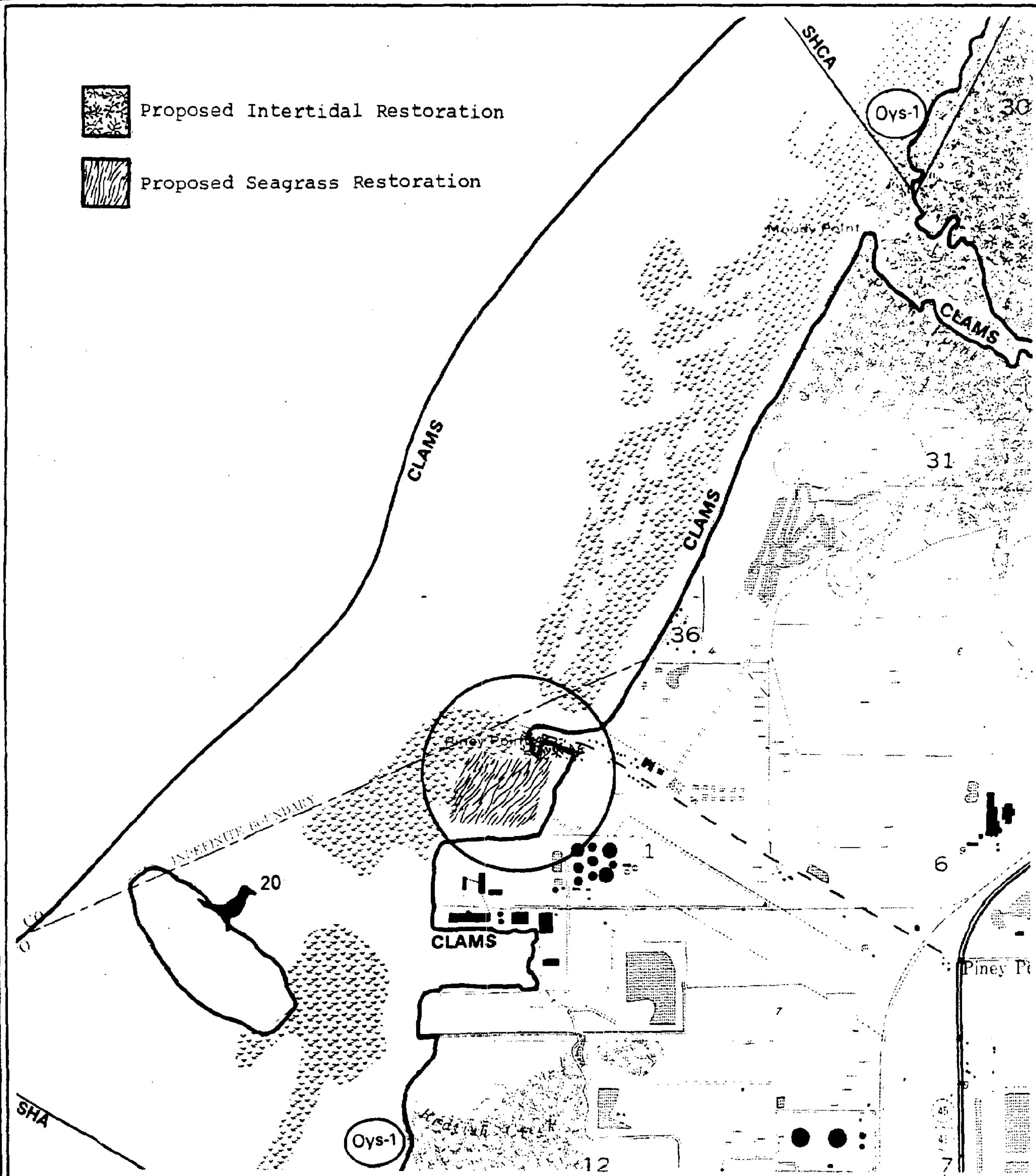


Figure 93

Piney Point Restoration Site

Adapted from 7.5 Minute Quadrangles
Tampa Bay Environmental Atlas
U. S. Fish and Wildlife Service (1985)

The area receives moderate public use, predominantly by local fishermen. Although little supportive documentation exists, adjacent seagrass beds have been impacted by propeller cuts. Restoration of the seagrass beds will require marking with signs to prevent loss of plantings and existing natural areas.

Sites 43 and 44: Hendry Site

Site Description: The Hendry Site is located adjacent to the southern property line of Port Manatee, in Manatee County (Figure 97). In 1969, the Hendry Corporation illegally filled 71 acres of pristine submerged and intertidal lands adjoining Bishops Harbor, in Manatee County. The fill material was generated from the initial excavation of the main ship channel entering Port Manatee. In 1980, after years of litigation, a settlement was finally reached between the state and the Hendry Corporation. In the settlement,the state received title to the disturbed lands, an additional 452 acres of adjacent undisturbed lands and $80,000 in fines, paid by the Hendry Corporation (TBRPC, 1984).

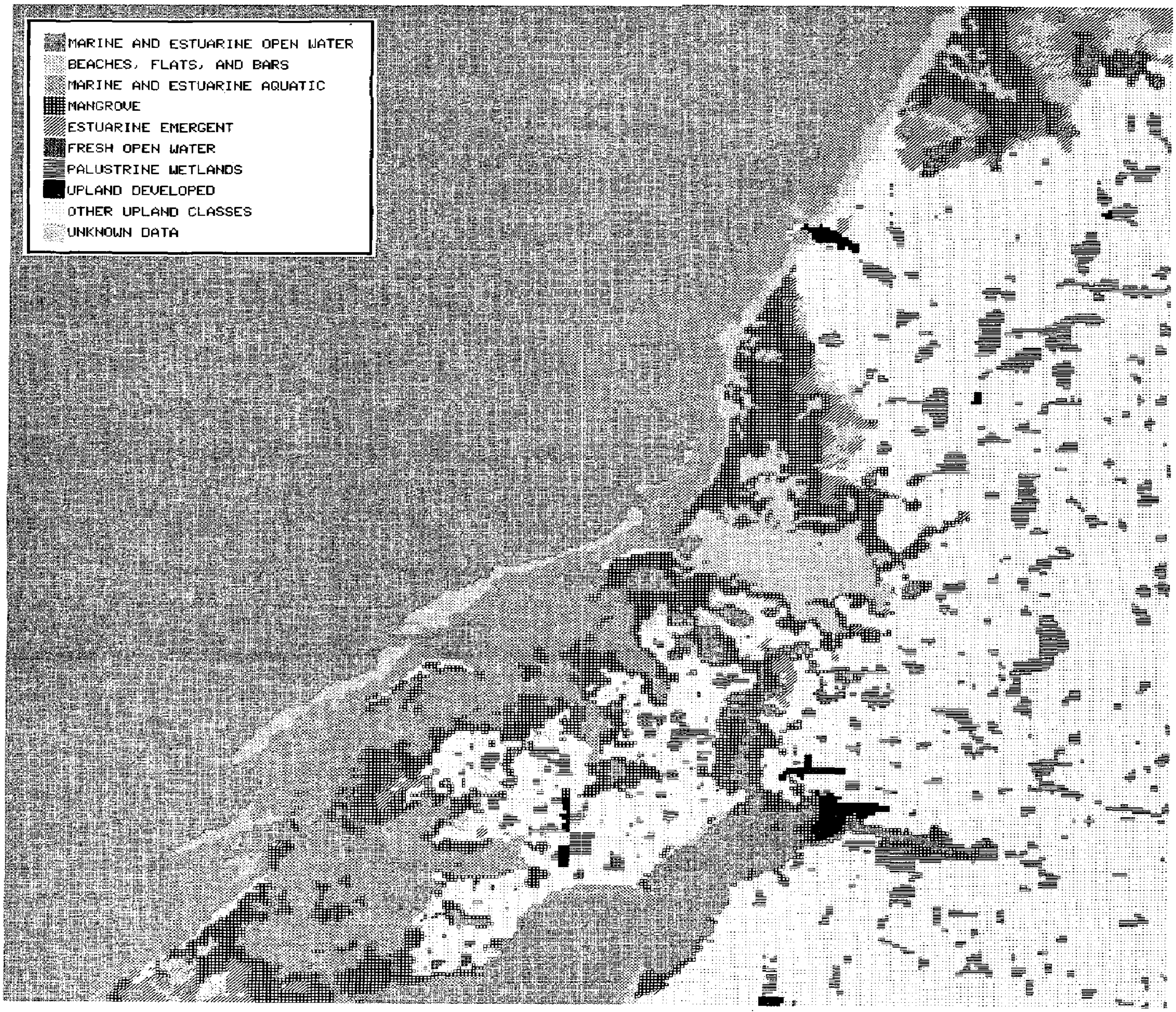
The spoiled material formed a delta to the south, filling in the mangrove marsh and Redfish Creek, and silting in Little Redfish Creek. The silted area is currently overgrown with B. maritima, while small mangroves occur where proper elevation allows. Several small lakes (Peanut and Round Lakes) have lost the normal tidal connection and are only inundated during extreme high tides. The construction of the Port Manatee Spoil Island has buried natural seagrass beds to the south of the island. North and south of the area seagrass beds composed of H. wrightii, T. testudinum, and R. maritima exist.

Review of the 1957 and 1982 wetlands inventory (Figures 94 and 95, respectively) and associated trend analysis (Figure 96), identifies the impact on wetland resources from port development. The extensive seagrass coverage has been severed by channel excavation and spoil island formation. The seaward edge of the estuarine shelf is denuded of seagrass growth by 1982. The spoiled intertidal area is observed south of the port and is classified as estuarine emergent with a mangrove perimeter. In addition, the illegal fill activity has created an estuarine beach along Tampa Bay that was reported as seagrasses in the 1957 wetland inventory.

Land Use: The Hendry site is presently in state ownership. The Port of Manatee and adjacent lands are under private ownership. The surrounding estuarine waters are designated as Class III.

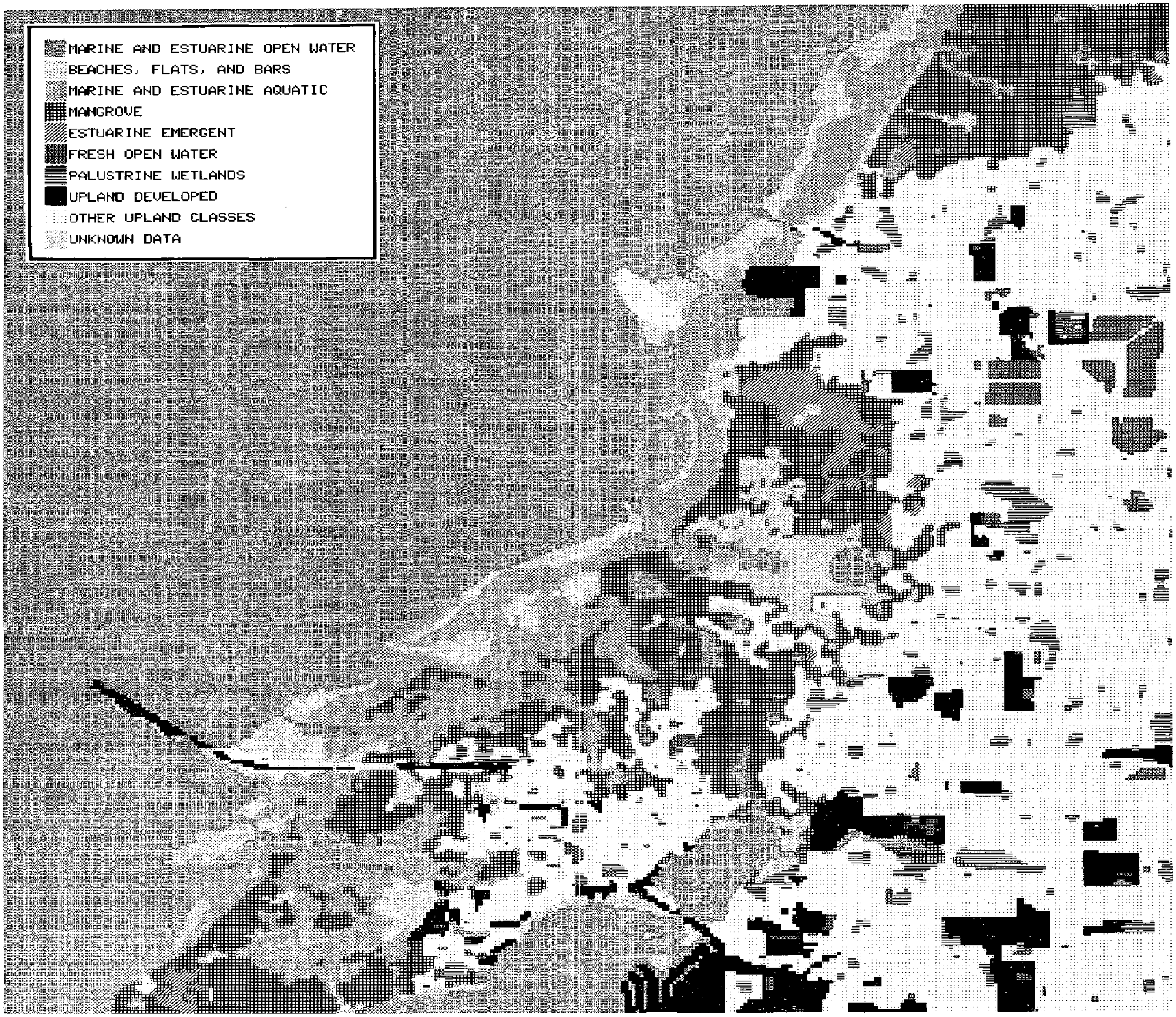
Restoration Plan: Currently, the Florida Department of Environmental Regulation has released monies from the Pollution Recovery Trust Fund for restoration of the Hendry Site. Additional funds and restoration have been planned through the Manatee County Gill Net License Fees (FDNR Draft, 1985b).

Figure 94 Wetland Inventory of the Bishop Harbor Area - 1957



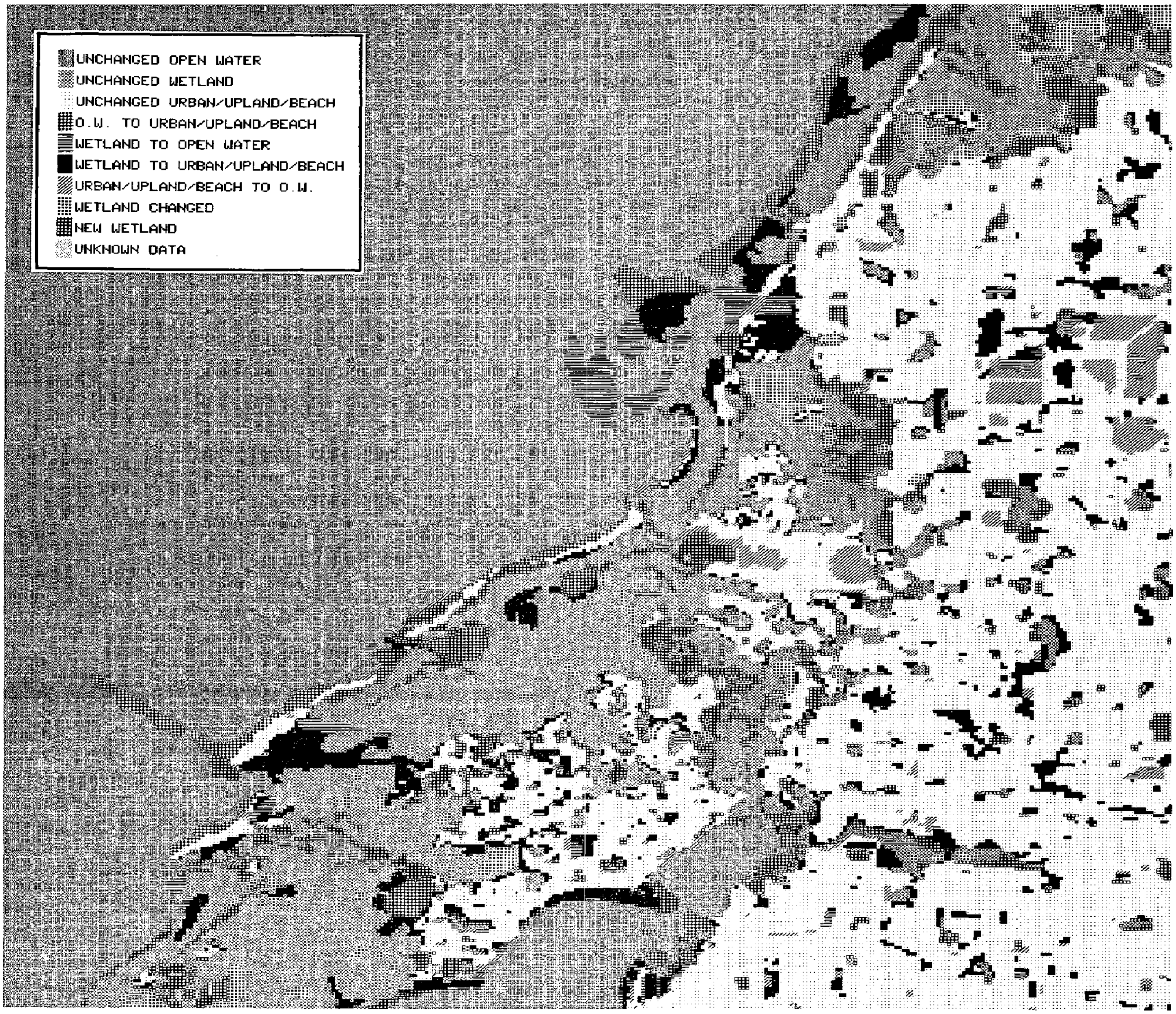
C - 1957 INVENTORY

Figure 95 Wetland Inventory of the Bishop Harbor Area - 1982



C - 1982 INVENTORY

Figure 96 Wetland Trend Analysis of the Bishop Harbor Area



C - WETLAND TRENDS

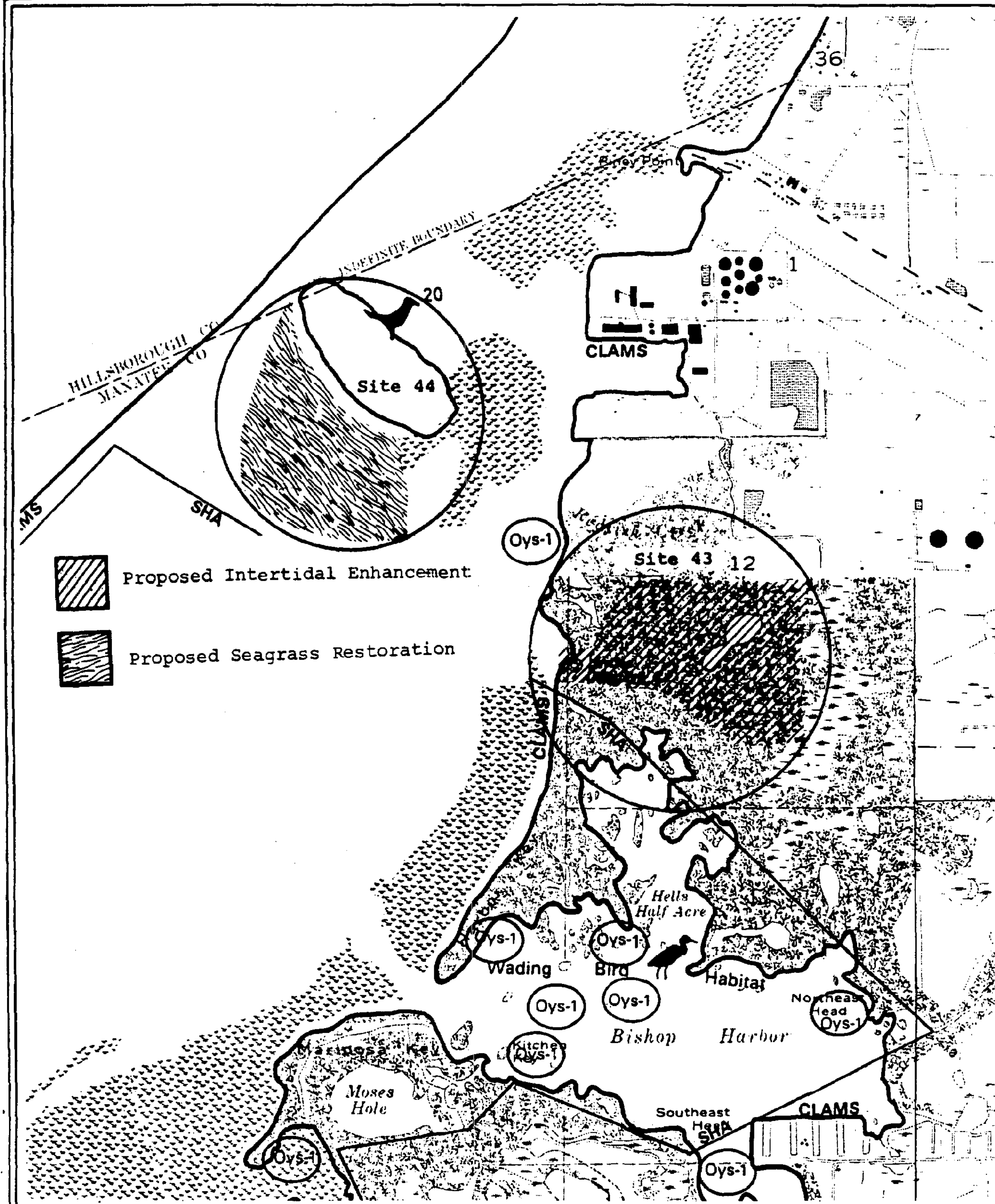


Figure 97

Hendry Restoration Sites

Adapted from 7.5 Minute Quadrangles
Tampa Bay Environmental Atlas
U. S. Fish and Wildlife Service (1985)

The main thrust of the planned restoration of Site 43 is to restore tidal circulation throughout the impacted areas, including Peanut and Round Lakes (Figure 97). This is anticipated to be accomplished by a rotary ditcher, normally used for mosquito control ditching operations. Once circulation has been established, the created ditches are expected to transport some of the fine sediments and provide additional area available for mangrove establishment. The ditches will promote access for aquatic organisms to utilize the area and provide wading bird feeding habitat.

Seagrass restoration can additionally be undertaken at Site 44, on the southern side of the spoil island (Figure 97). The shallow depths created by spoiling provide suitable subtidal elevations for planting. Seagrass plugs are available for transplanting from adjacent healthy donor beds, with appropriate approval from the jurisdictional agencies.

The goals outlined by the FDER (Patrick, personal communication, 1986) for the Hendry Site restoration include:

1. Increase area "productivity"
   - wetland biomass
   - habitat for marsh faunal species

2. Improve water quality and circulation in small ponds

3. Maintain established endangered habitat (salt barriers)

4. Post restoration monitoring

5. Reconnection with tidal ditches along Port property line, and

6. Replanting of spoil delta along shoreline.

Restoration of the Hendry Site is being actively approached through the Florida Department of Environmental Regulation and the Florida Department of Natural Resources. Restoration of the area will require a variety of techniques to be employed. Suitable habitat enhancement sites are available for continued restoration efforts in the area.

<u>Site 45: Bishop Harbor</u>

Site Description: Bishop Harbor is located south of Port Manatee and northeast of the Skyway Bridge causeway, in Manatee County (Figure 98). The area is a small embayment of Tampa Bay, containing extensive oyster bars and mangrove islands, contiguous with Terra Ceia Bay to the south.

Periodic releases of toxic ammonia and agricultural runoff have destroyed approximately 70 acres of seagrass vegetation in Bishop Harbor. Approximately 30% of the seagrass coverage has returned naturally (Lewis, personal communication, 1986).

Figure 98

Bishops Harbor Restoration Site

Adapted From 7.5 Minute Quadrangles
Tampa Bay Environmental Atlas
U. S. Fish and Wildlife Service (1985)

Review of the 1957 wetland inventory (Figure 94) identifies Bishop Harbor with the beaches, flats and bars designation. The designation of the open water embayment is probably due to the shallow nature of the area. However, the designation does not allow for accurate trend analysis of seagrass coverage within the embayment. Mangrove coverage has increased into other upland classes as identified in the 1982 inventory (Figure 95). A patch of seagrass near the mouth of Bishop Harbor is lost by 1982. An upland finger fill development is observed in the 1982 inventory in the southeastern corner of Bishop Harbor.

Land Use: Ownership of the submerged lands has not been determined. The waters of Bishop Harbor are categorized as Class III and the majority of the area is presently classified as approved for shellfish harvesting.

Restoration Plan: Water quality in Bishop Harbor is expected to increase with engineering improvements to the phosphate processing plant's treatment facility and rerouting the drainage ditches. Seagrass planting is recommended to enhance natural establishment into the area (Figure 98).

Site 46: Palmetto Point

Site Description: Palmetto Point is a residential development located on the Terra Ceia Bay, in Manatee County (Figure 99). The development is the product of dredge and fill operations within the bay. The residential fill area is hardened by means of a contiguous seawall.

Areas north and south remain relatively undeveloped with fringe mangrove marsh areas and agricultural plots. The Skyway approach travels across Terra Ceia Bay just northeast of the development. Water quality within the area is affected by septic systems used in the Palmetto Point development.

The 1957 inventory (Figure 94) portrays Terra Ceia Bay before construction of Palmetto Point and the Skyway Bridge approach. The Palmetto Point area in 1957 contained a mangrove marsh with subtidal grass beds occurring offshore. The 1982 wetlands inventory (Figure 95) and trend analysis (Figure 96) identify the extensive dredge and fill operations of the Palmetto Point development and the causeway over Terra Ceia Bay. The 1982 inventory reflects a decline in mangrove coverage and elimination of grass beds in the immediate area. Apparent shoaling is observed on either side of the Skyway Bridge causeway.

Land Use: The ownership of the submerged land has not been determined. The residential parcels are under private ownership. The waters are categorized as Class III Waters. The development is located within the Terra Ceia Aquatic Preserve.

Restoration Plan: The seawalled area of Palmetto Point provides the opportunity for littoral shelf creation. This will require a planter box construction technique to provide a suitable revegetation environment.

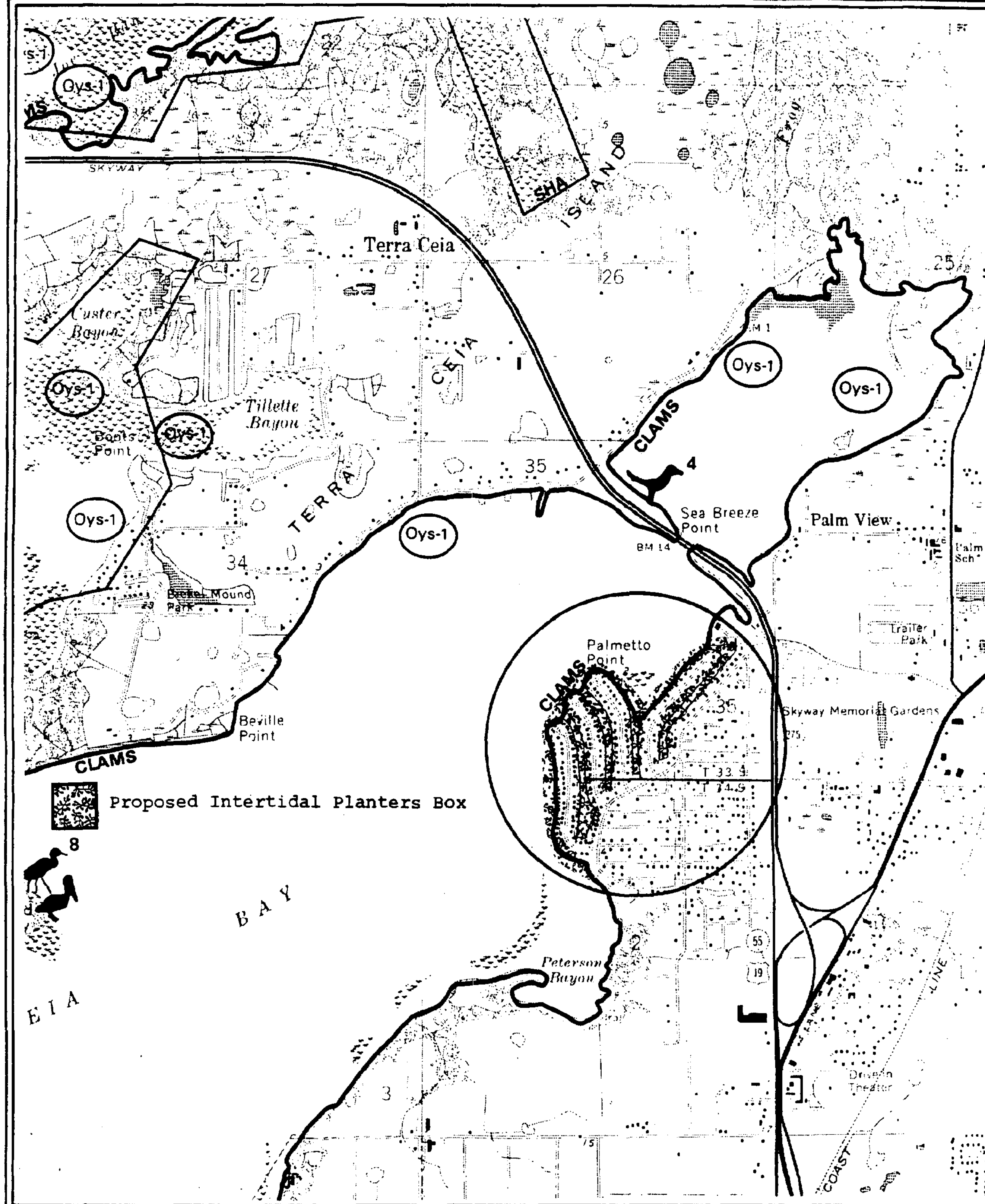


Figure 99

Palmetto Point Restoration Site

Adapted From 7.5 Minute Quadrangles
Tampa Bay Environmental Atlas
U. S. Fish and Wildlife Service (1985)
and Dept. of Natural Resources Draft (1985b)

It is recommended that clean fill material be placed at the toe of the seawall behind a permanent erosion control structure. S. alterniflora can then be planted on two-foot centers. Adjacent areas containing extensive mangrove growth are expected to provide a seed source into the planted area.

This site has previously been recommended by the FDNR as part of the Manatee County Marine Habitat Restoration Plan (FDNR, Draft 1985b). FDNR concluded that littoral shelf creation will enhance the Aquatic Preserve and would provide the opportunity to "investigate the potential for vegetation to filter septic leachate."

The restoration of the Palmetto Point development will require participation and acceptance by residential land owners. In addition, the scenic vista will need to be maintained, which may hinder restoration efforts.

Site 47: Perico Bayou

Site Description: Perico Bayou is located between Palma Sola and Tampa Bay, west of the mouth of the Manatee River in Manatee County (Figure 100). The area is characterized by an agricultural levee line with several one-way culverts allowing runoff to flow seaward. The levee surrounds a large mangrove area which receives tidal inundation from a small creek on the northeastern corner of the site. The levee currently limits tidal flushing within the salt barren area on the south. The salt barren has dried and is being invaded by upland grasses (CSA, 1986).

A tidal flushing and modeling study indicates that the area has a low flushing exchange in its present state, as evidenced by the stressed mangroves (Patton and Associates, Inc. 1985; in CSA, 1986). The modelers recommended that the tidal inlet at the northeast end be widened from nine to 30 m decrease the stagnant waters in the mangrove preserve. Removal of the levees has not been evaluated as an alternative. Modeling results indicate that increasing the size of the culverts would not significantly improve flushing. Water entering the tidal creek at the northeast end is predominantly influenced by water quality in the Manatee River and Tampa Bay.

Site vegetation, as observed by CSA (1986), includes a mature mangrove swamp (R. mangle, L. racemosa, A.germinans and Conocarpus erecta) bordering the west and north levees and interior fringe adjacent to the levees; expansive offshore seagrass beds and tidal flats (CSA 1983; Lewis et al. 1984) (Figure 100); a salt marsh or salt pan community (D. spicata, Salicornia bigelovii, S. virginica, B. maritima, Iva fruitescens); and an upland plant community dominated by S. terebinthifolia, Casuarina equisetifolia and Andropogon sp.

Land Use: Most of the upland areas at this site are currently owned by the Wilbur Boyd Corporation (River Bay, Inc.) and are included in plans for a golf and waterfront residential development. Wetland habitat north and

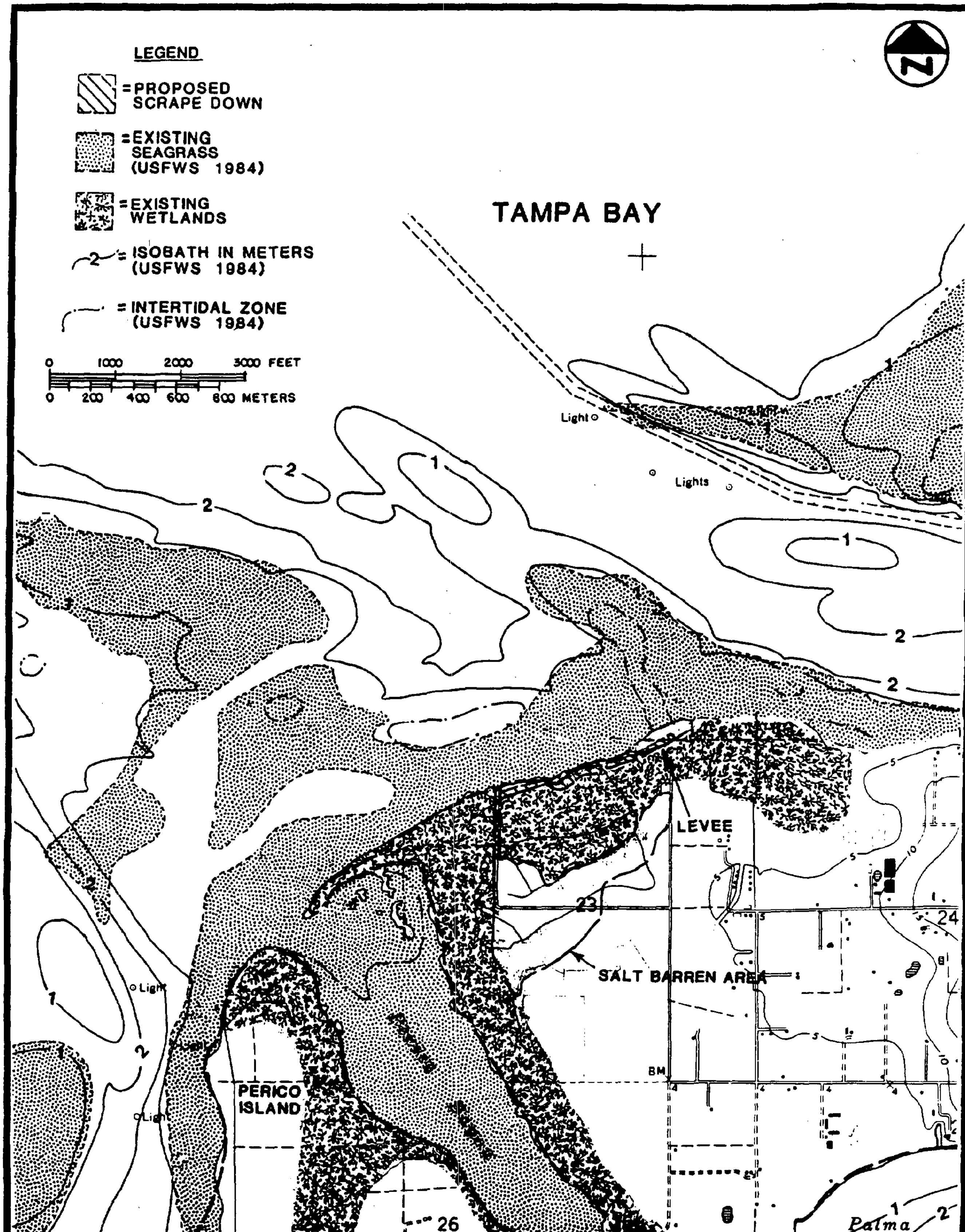


Figure 100 Perico Bayou restoration site (CSA,1986)

west of the site is state-owned and under jurisdiction of the FDER. The property east of the site is agricultural and low density residential land. The interior mangrove habitat is under FDER jurisdiction.

Restoration Plan: The restoration plan has been developed by CSA (1986) as part of the mitigation options available for port development. The goal of restoration is to improve the tidal connections with the impounded mangrove marsh and salt barrens (Figure 100).

The excavation of the historic levee line to adjacent wetland elevation can enhance a total of approximately 31 ha of mangrove and salt barrens. The lowering of the berms will result in a 2.5 ha area for marsh creation. The excavated area can be revegetated or natural recruitment can be allowed from adjacent seed sources. CSA (1986) further concluded that levee removal should restore natural flushing between the impounded mangrove habitat and adjacent wetlands, however, additional tidal creeks or ditches may be necessary.

Increased flushing, additional revegetation and tidal creek creation will serve to enhance and expand habitats for fish and wildlife. The site offers potential for multiple restoration techniques. Portions of the tract are under private ownership. This issue will need to be resolved.

Site 48: Anna Maria Island

Site Description: Anna Maria Island is a densely populated barrier island east of Bradenton and south of Passage Key Inlet, in Manatee County (Figure 101). Northern Anna Maria Island contains the largest system of bulkheaded canals within the county (FDNR Draft, 1985b).

The majority of the area is developed for residential purposes. However, undeveloped parcels still exist that retain mangrove marsh communities. On the eastern side of the barrier island, seagrasses occur within large beds in shallow areas. The large quantity of residential seawalls and substrate elevations offer the opportunity for additional habitat, littoral shelf creation. Areas for evaluation include the town of Anna Maria, Holmes Beach, School Key and Bimini Bay.

Land Use: The area encompasses numerous jurisdictions, and involves public and private ownership.

Restoration Plan: The vast area of finger fill development provides the opportunity for littoral shelf creation using the planters box technique. Test areas should be initiated on public property with high visibility. Additional public promotion can stimulate private land owners to volunteer areas along seawalls that will not infringe on the residential vista. *S. alterniflora* plantings, in most cases, will not block a landowner's view. However, the establishment of mangroves will require a maintenance program to limit tree height without jeopardizing the vegetation.

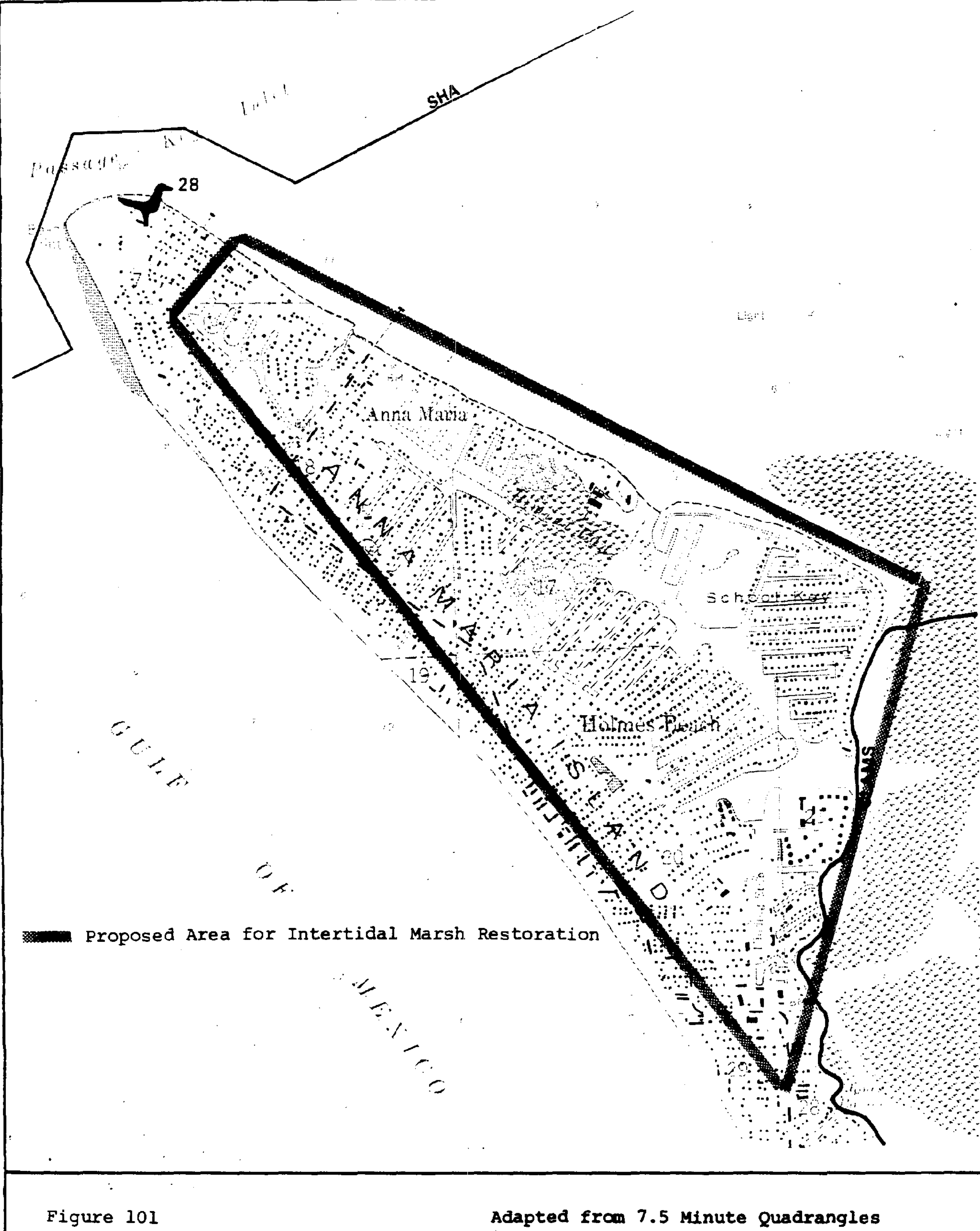


Figure 101

Anna Maria Island Restoration Site

Adapted from 7.5 Minute Quadrangles
Tampa Bay Environmental Atlas
U. S. Fish and Wildlife Service (1985)
and Dept. of Natural Resources Draft (1985b)

Site 49: Oneco Landfill/Gap Creek

Site Description: The Oneco Landfill/Gap Creek Site is located on the southern side of the confluence of Gap Creek and the Braden River, in Manatee County (Figure 102). The mouth of Gap Creek has been channelized and straightened with the relocated channel adjacent to the closed Oneco Landfill. No specific water quality problems have been reported from the landfill or the residential/industrial area upstream on Gap Creek (FDNR Draft, 1985b).

Land Use: The site, and Oneco Landfill, are owned by Manatee County.

Restoration Plan: The county-owned land allows for the intertidal restoration of a tidal tributary. It is recommended that the area be regraded to adjacent wetland elevation and planted with S. alterniflora or J. roemerianus (Figure 102). The higher intertidal elevation zone should be planted with P. vaginatum , to minimize erosion on-site.

Site 50: Tidy Island to Longbar Point

Site Description: The Tidy Island to Longbar Point area of Manatee County is located on the eastern side of Sarasota Bay (Figure 103).

The shoreline of Sarasota Bay in this area contains a healthy fringe of mangroves. However, the area has been the subject of numerous water quality complaints (FDNR Draft, 1985b). The water quality problem arises from numerous ditches that drain an area of gladiola fields and then penetrate through the mangrove fringe. Irrigation of the fields with treated sewage effluent, and utilization of sewage sludge for fertilization, creates extremely nutrient-enriched runoff.

Land Use: Currently, the upland tract is under private ownership and is used for agricultural purposes. The wetlands in the area are under the jurisdiction of the Florida Department of Environmental Regulation.

Restoration Plan: The area between Tidy Island and Longbar Point offers the opportunity to create additional fish and wildlife habitat and improve water quality conditions in the area. The recommended plan is to create a spreader system for the existing ditches and then allow the runoff to trickle filter through created wetlands.

The plan will require a lateral swale to tie into the existing runoff ditches. This area should be planted with S. alterniflora or J. roemerianus. Then, at a predetermined elevation, the runoff would be allowed to pop-over the swale into another created wetland, and filter through slowly before entrance into the mangrove fringe of Sarasota Bay.

This restoration plan will require additional acreage to be scraped and contoured. The resultant product will enhance the water quality of runoff before transmission into the estuary. In addition, the created acreage will increase the available fish and wildlife habitat in the area.

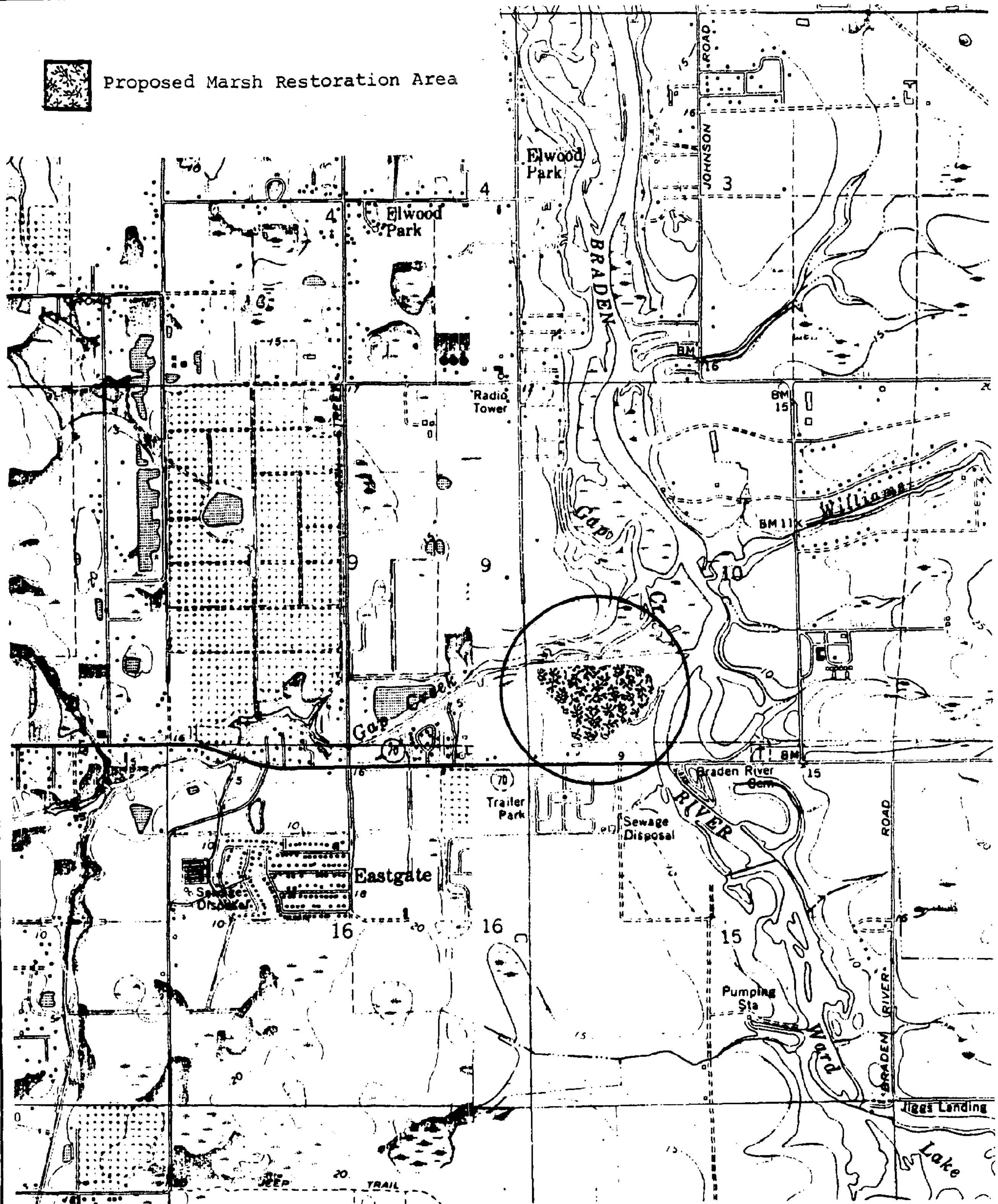


Figure 102

Oneco Landfill/Gap Creek Restoration Site

Adapted From 7.5 Minute Quadrangles
Tampa Bay Environmental Atlas
U. S. Fish and Wildlife Service (1985)
and Dept. of Natural Resources Draft (1985b)

Proposed Marsh Creation and Enhancement Area

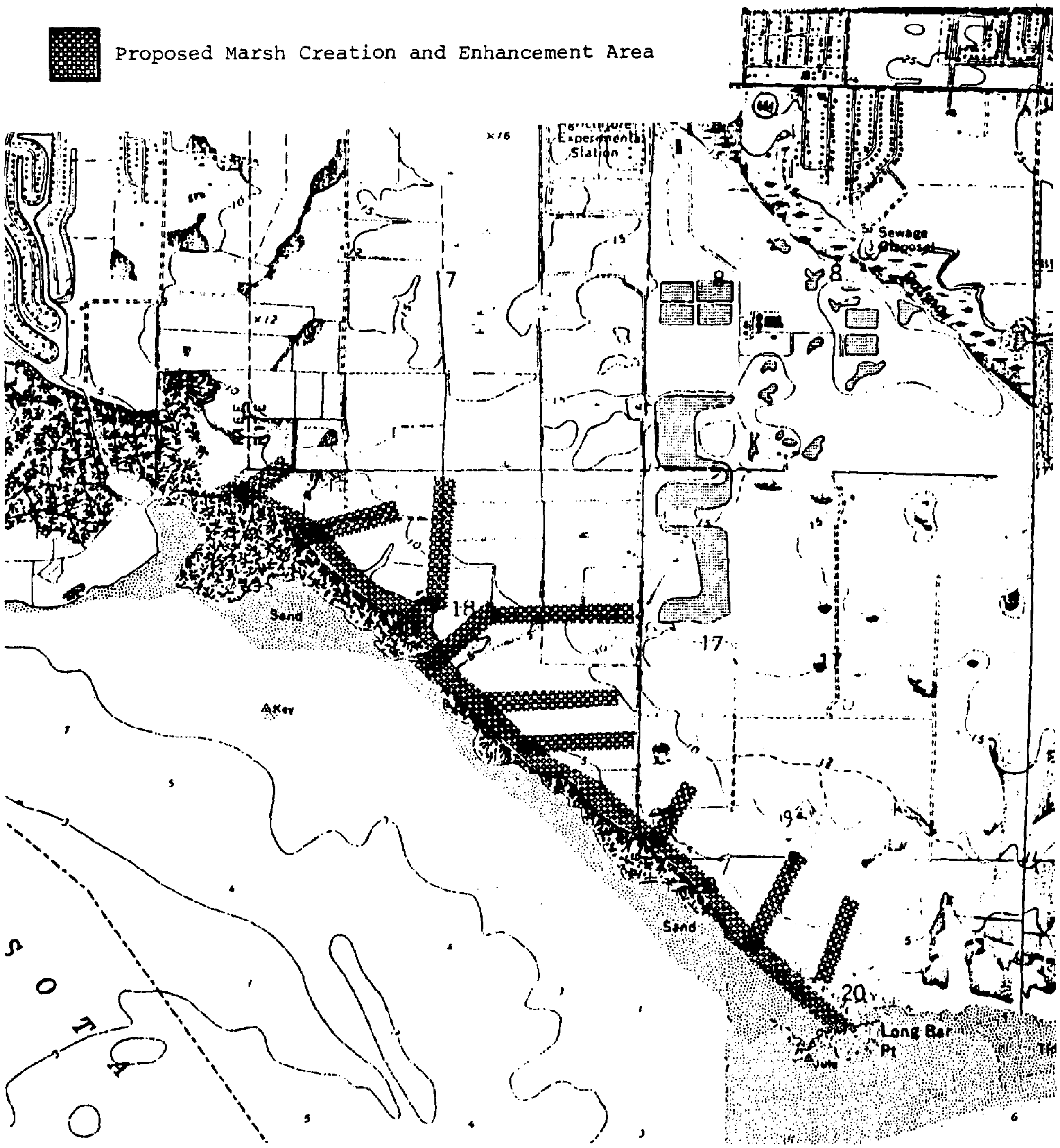


Figure 103

Tidy Island to Longbar Point Restoration Site

Adapted from 7.5 Minute Quadrangles
U. S. Geological Survey
Department of the Interior
and Dept. of Natural Resources Draft (1985b)

RESTORATION SITE SUMMARY

A total of fifty habitat restoration sites have been identified. The sites proposed for restoration have been categorized into intertidal or subtidal groupings for ease in classification (Figure 104, Table 32).

Pasco County habitat restoration sites are all proposed for intertidal restoration on or adjacent to the Gulf of Mexico. In addition, all of the sites recommended for restoration are in areas previously degraded by man's development. Techniques proposed for restoration include:

- marsh creation - seven sites
- spoil removal - five sites
- improved circulation - four sites

If fully implemented, the proposed plan will result in the restoration/enhancement of 69.36 total acres of intertidal wetland habitat.

A total of 15 restoration sites are proposed for Pinellas County. Intertidal restoration is planned for ten of the sites and six subtidal sites. Recommended restoration plans identified for Pinellas County include:

- marsh restoration - 10 sites
- causeway enhancement - five sites
- seagrass restoration - four sites
- borrow pit filling - three sites
- dredge islands - two sites
- artificial reefs - two sites
- planters box - one site
- tidal tributary - one site

The total acreage of the proposed sites in Pinellas County cannot be calculated due to extent of available area and degree of restoration efforts.

In Hillsborough County, a total of 19 habitat restoration sites are proposed on Hillsborough, Old and Middle Tampa Bays. Sixteen of the sites are recommended for intertidal restoration, with an additional seven identified for subtidal restoration. Review of all the recommended plans for Hillsborough County illustrate the assortment of recommendations for restoration and site locations:

- marsh restoration - 15 sites
- seagrass restoration - seven sites
- tidal tributaries - five sites
- spoil islands - four sites
- borrow pit filling - three sites
- planters box - one site

A wide variety of conditions within Hillsborough County (i.e. developed, undeveloped) allow a multiplicity of techniques to be employed for restoration of habitat.

Figure 104. Location of Recommended Habitat Restoration Sites in the Tampa Bay Region.

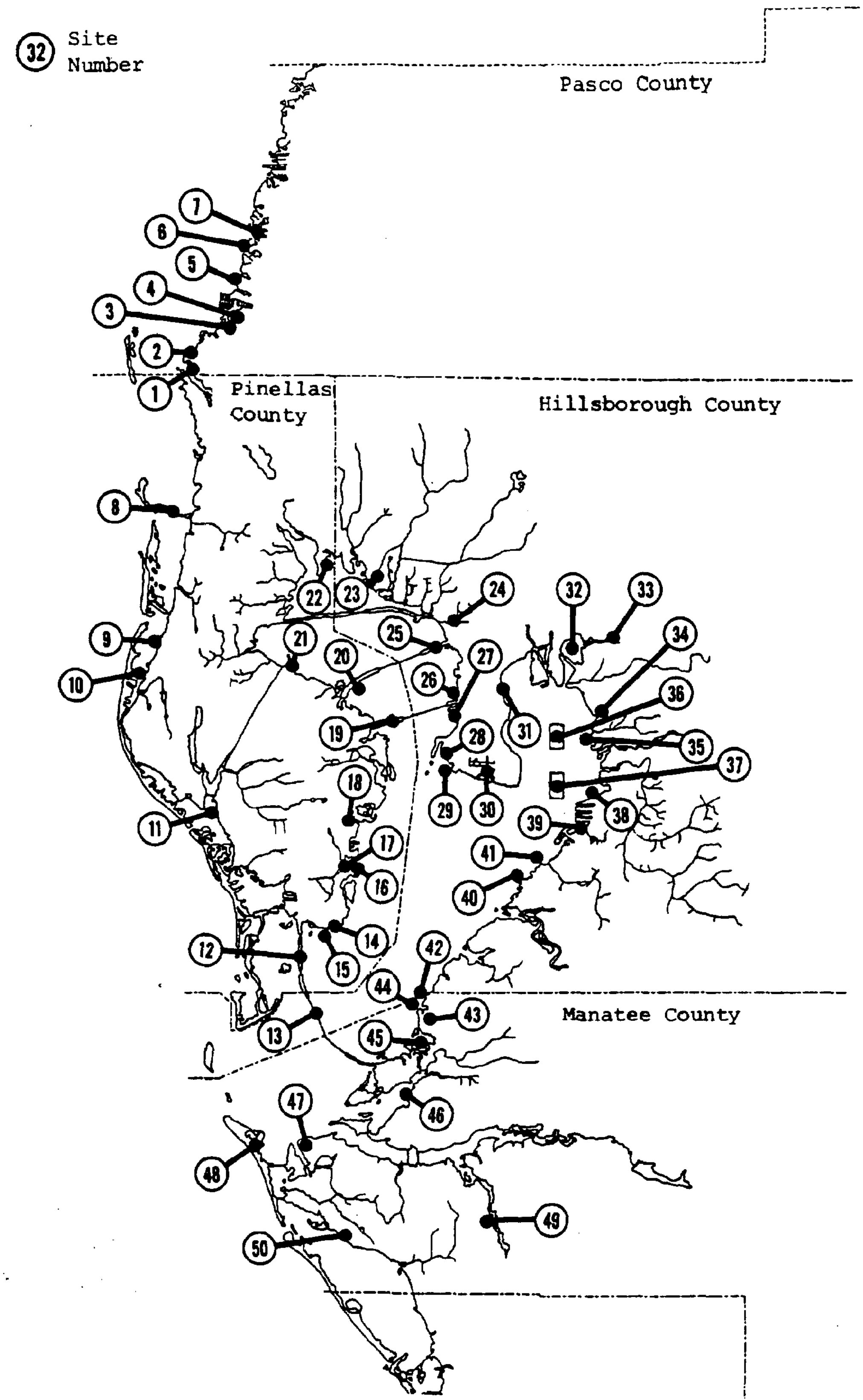


Table 32: Recommended Restoration Sites

Site Number	Restoration Site	*Restoration Description
	Pasco County	
1.	Anclote River Park	I
2.	FPC Spoil Disposal Site	I
3.	Mickler Property	I
4.	Winkalt Property	I
5.	Green Key Park	I
6.	Ritter Point	I
7.	City of Port Richey	I
	Pinellas County	
8.	Dunnedin Causeway	I
9.	Belleview Island	S
10.	Belleair Causeway	I
11.	Dog Leg Key	I
12.	Skyway Bridge	I
13.	Skyway Bridge Artificial Reef	S
14.	Pinellas Point - Intertidal	I
15.	Pinellas Point - Subtidal	S
16.	Lassing Park	S
17.	Salt Creek	I
18.	Coffee Pot Bayou	I
19.	Gandy Causeway	I
20.	West End Howard-Frankland Causeway	S
21.	St. Petersburg - Clearwater International Airport	I,S
22.	Booth Point	I

Table 32 continued

Site Number	Restoration Site	*Restoration Description
	Hillsborough County	
23.	Channel "A"	I
24.	Fish Creek	I
25.	East End Howard-Frankland Causeway	I,S
26.	Kaul Fill Site	I,S
27.	Rattlesnake Spoil Island	I,S
28.	Mac Dill Site - Intertidal	I
29.	Mac Dill Site - Subtidal	S
30.	Broad Creek	I
31.	Bayshore Boulevard	I
32.	McKay Bay	I
33.	Palm River/Tampa Bypass Canal	I
34.	Delaney Creek Pop-off Canal	I
35.	Delaney Creek Pop-off Canal to the Alafia River	S
36.	Spoil Island 2-D	I
37.	Spoil Island 3-D	I
38.	Port Redwing	I,S
39.	Newman Branch Site	S
40.	E. G. Simmons Park	I
41.	E. G. Simmons Park to Apollo Beach	S
	Manatee County	
42.	Piney Point	I,S
43.	Hendry Site - Intertidal	I
44.	Hendry Site - Subtidal	S
45.	Bishops Harbor	S
46.	Palmetto Point	I
47.	Perico Bayou	I
48.	Anna Maria Island	I
49.	Oneco Landfill/Gap Creek	I
50.	Tidy Island to Longbar Point	I

*Restoration Description

I = Intertidal
S = Subtidal

Proposed restoration sites in Manatee County are located on Tampa Bay, Sarasota Bay and the Brandon River. A total of nine sites are reported within the county. Seven sites are slated for intertidal restoration with three sites proposed for subtidal efforts. Restoration plans include:

- marsh creation - three sites
- tidal tributaries - four sites
- seagrass - three sites
- planters box - two sites

The available area for restoration/creation of habitat in Manatee County has not been calculated. The acreage of the restoration projects cannot be calculated due to the feasibility and size of proposed planting area (e.g., Anna Maria Island, Palmetto Point).

A large quantity and variety of habitat restoration/creation/enhancement sites are proposed for the Tampa Bay Region. The list is not complete, and many areas are not identified due to sheer numbers or feasibility. All proposed projects are expected to provide additional habitat for the fish and wildlife population, and increase water quality within the region.

CHAPTER V

MANAGEMENT OF ESTUARINE HABITAT

CURRENT HABITAT MANAGEMENT IN THE TAMPA BAY REGION

Management can be defined as the "judicious and coordinated use of various means to accomplish a desired end." In light of the marked declines in estuarine wetland habitat it is fair to say that coastal resource management in the Tampa Bay Region has been both misdirected and ineffectual. Prior to the late 1960s, it can be argued that bay management simply did not exist, and that the dominant public agenda was coastal resource exploitation for the sake of economic development (Simon, 1975). During the late 1960s and early 1970s, a proliferation of environmental legislation was passed, both at the federal and state level. The driving force behind much of this legislation was a growing public awareness of ecological relationships, as well as a general public acknowledgment of the environmental degradation that had taken place. As a result of this legislation, numerous agencies and programs were created for the purpose of regulating the use and misuse of the regions' natural resources.

Currently, management of the Tampa Bay estuarine system and adjacent coastal waters is fragmented amongst a multitude of federal, state and regional regulatory agencies, as well as seventeen local governments bordering the bay (see Figure 105). Management is accomplished through the implementation of various monitoring, permitting and regulatory programs. However, under the existing management framework, jurisdictions are often overlapping, interests are often conflicting, and no one agency has overview authority for the bay, or manages it as a holistic natural resource.

The major agencies currently involved in the management of estuarine wetland habitat in the Tampa Bay region include the following:

Federal -
- U.S. Army Corps of Engineers (USACE)
- U.S. Fish and Wildlife Service (USFWS)
- U.S. Environmental Protection Agency (EPA)
- National Marine Fisheries Service (NMFS)

State -
- Florida Department of Environmental Regulation (FDER)
- Florida Department of Natural Resources (FDNR)
- Florida Game and Freshwater Fish Commission (FGFFC)

Regional and Local -
- Southwest Florida Water Management District (SWFWMD)
- Tampa Bay Regional Planning Council (TBRPC)
- Tampa Port Authority (TPA)
- Counties and Municipalities

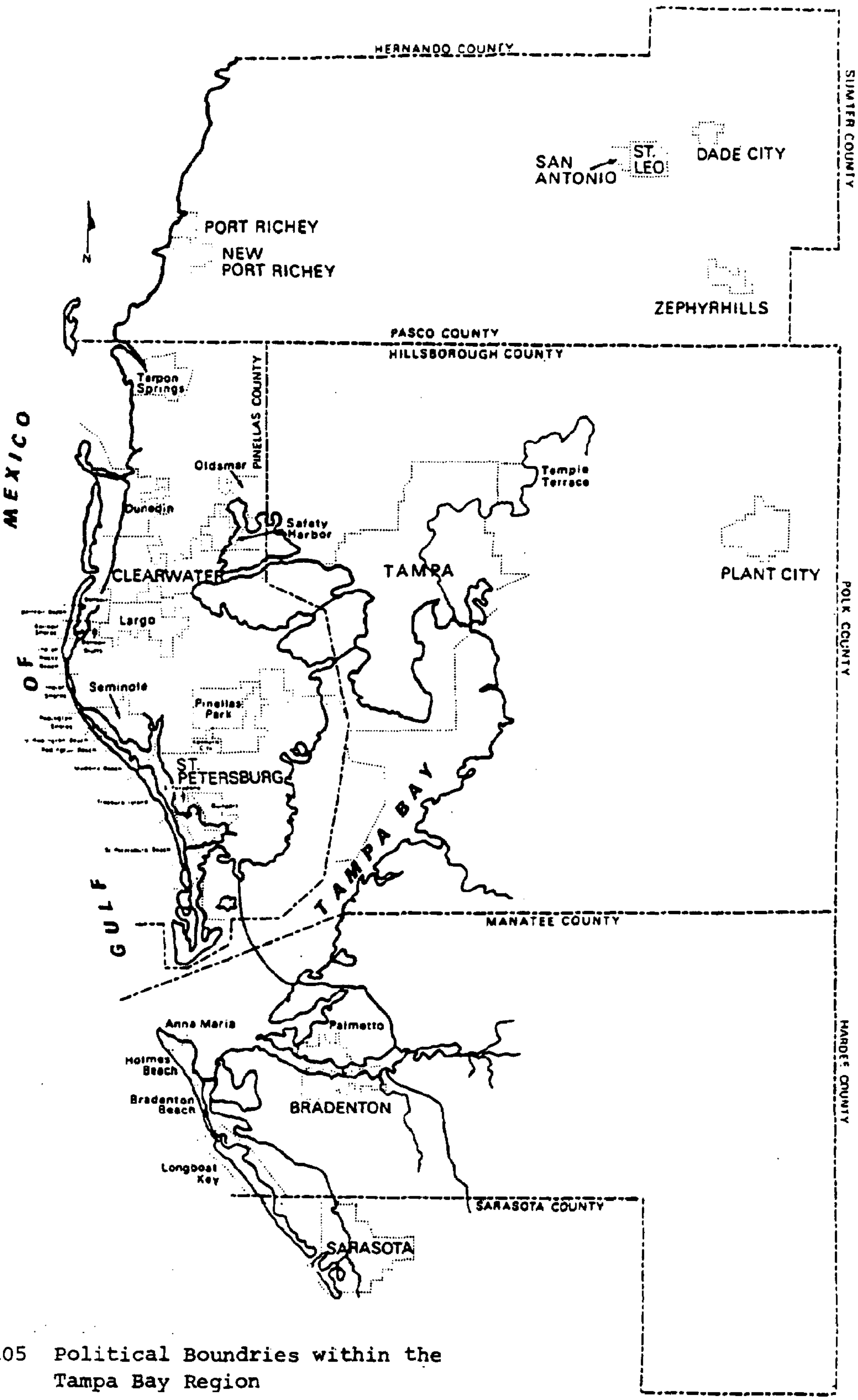


Figure 105 Political Boundries within the Tampa Bay Region

The U.S. Army Corps of Engineers (USACE) has a broad range of regulatory and permitting authority for dredge and fill projects within estuarine waters. Jurisdiction and regulatory functions are based on Section 10 of the Rivers and Harbor Act of 1899, and Section 404 of the Clean Water Act of 1977. During the permitting process, the USACE solicits recommendations on the permissibility of projects from the U.S. Fish and Wildlife Service (USFWS), the National Marine Fisheries Service (NMFS), and the Environmental Protection Agency (EPA). The USFWS reviews and provides recommendations on the impact of projects on fish and wildlife habitat, pursuant to authority granted by the Fish and Wildlife Coordination Act (FWCA), Endangered Species Act, and the Marine Mammal Protection Act. The NMFS, under the Magnuson Fisheries Conservation and Management Act and the FWCA, is responsible for habitat protection and fisheries management for estuarine and marine fishes. The NMFS advises the USACE concerning the impact of projects on fish and wildlife habitat under these acts and provisions of the Endangered Species Act and the Marine Mammal Protection Act. Although the EPA has the responsibility for establishing and enforcing national water pollution control standards, through the Clean Water Act and the National Pollutant Discharge Elimination System, the USACE is the permitting agency for dredge and fill projects and can veto permits under the authority granted in Section 404(c) of the Clean Water Act. The EPA provides comments to the USACE on the permissibility of projects with respect to water quality impacts.

In addition to providing comments on dredge and fill permit applications, the USFWS manages public use of three National Wildlife Refuges within the Tampa Bay Region including Egmont Key, Passage Key and the Pinellas Wildlife Refuge (six mangrove islands, including Tarpon Key in Boca Ciega Bay).

The U.S. Department of Commerce, National Oceanic and Atmospheric Administration's Office of Coastal Zone Management (CZM) has a planning and review role in the coastal zone. Under the Coastal Zone Management Act, the CZM has the responsibility to preserve, protect, develop, and, where possible, restore and enhance the resources of the coastal zone. The CZM grants money to states with approved coastal zone management plans, and has the responsibility of reviewing large projects for consistency with those plans.

Most of the regulatory and permitting authority for dredge and fill projects within estuarine waters of Florida is held by the Florida Department of Environmental Regulation (FDER), although approval by the Florida Department of Natural Resources (FDNR) is required on many permits. Chapters 253 and 403, Florida Statutes, with further definition in the Florida Administrative Code, Rules 17-3, 17-4, and 17-12, are the basis of the jurisdiction and regulatory function of the FDER. As part of the permit processing, the FDER solicits comments from affected parties and local governments. Comments are also received from either the Florida Game and Freshwater Fish Commission (FGFFC) or the FDNR concerning the effects of the project on fish and wildlife habitat and endangered or threatened species (as authorized by the Florida Endangered and Threatened Species Act of 1972). The role of the FDNR in this process is to administer and enforce regulations for use of submerged and tidal land belonging to the

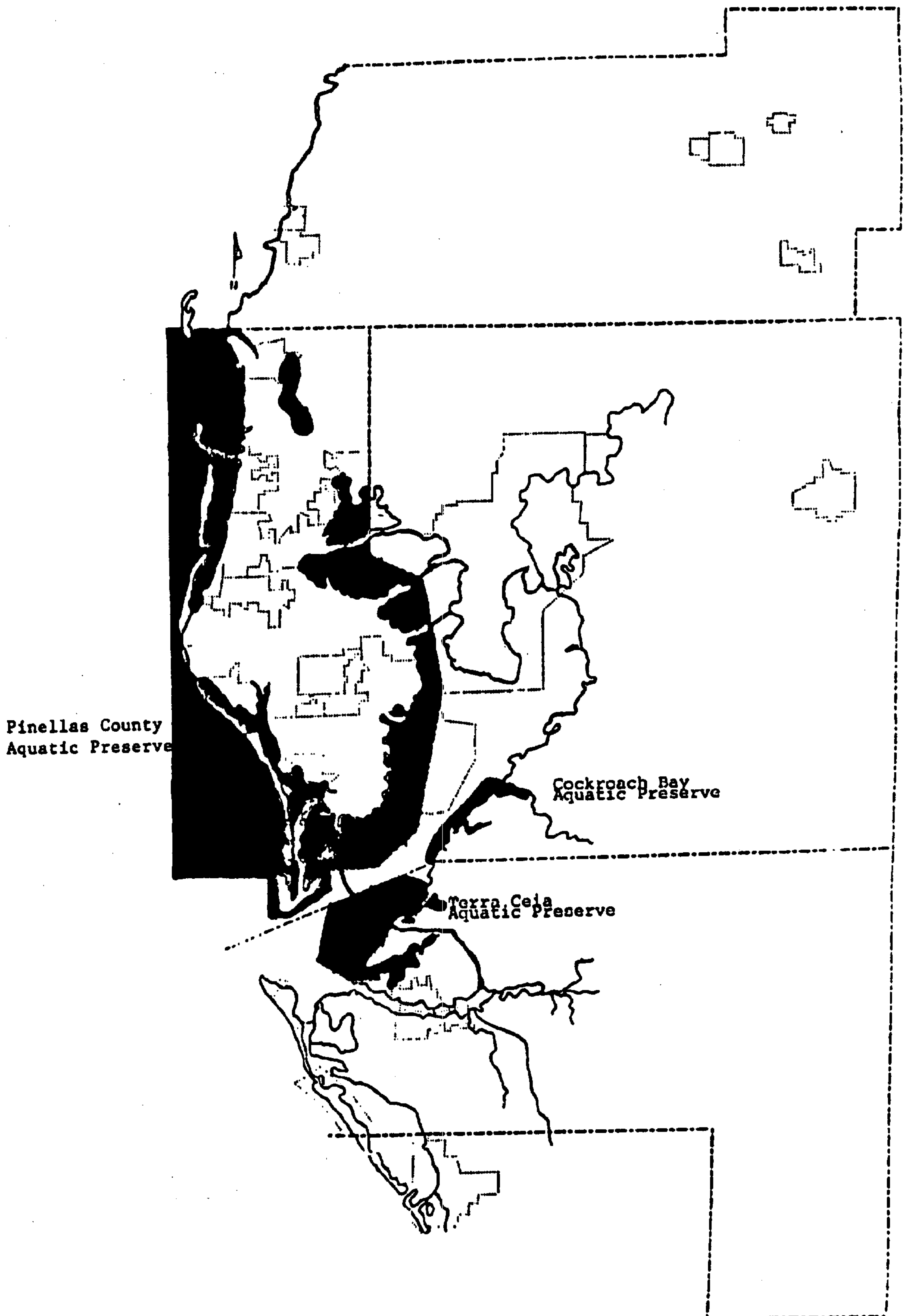
State as authorized in Chapter 253, Florida Statutes, with administrative procedures in Florida Administrative Code, Rule 160-17. The FDNR comments on the use of state-owned submerged lands, but the title and administrative control is still held by the Board of Trustees of the Internal Improvement Trust Fund - currently represented by the Governor and Cabinet. Use of state-owned submerged land is typically not granted if the comments are unfavorable.

As part of the responsibility for the regulation and management of fish and wildlife habitat in marine and estuarine waters, FDNR manages the four Aquatic Preserves in the Tampa Bay Region, including the Cockroach Bay Aquatic Preserve, the Pinellas County Aquatic Preserve, the Boca Ciega Bay Aquatic Preserve and the Terra Ceia Aquatic Preserve (Figure 106). Aquatic Preserve designation limits the extent of dredging, filling and construction in the reserve in accordance with Section 258.42, Florida Statutes. Basically, beyond "reasonable ingress or egress by riparian owners," only projects clearly in the "public interest" can be permitted within an Aquatic Preserve. The FDNR is also responsible for acquisition of lands for preservation as wildlife habitat and recreational areas. An example is the Bower Tract, a 627-ha tract in northern Old Tampa Bay, which has been purchased under the Conservation and Recreation Land Program (CARL). In addition, FDNR administers funds collected from gill net license fees in Manatee, Pinellas and Pasco Counties for the sole purpose of performing estuarine fisheries habitat research and restoration.

Both the FDER and FDNR are responsible for protection of water quality. While the FDNR has only limited responsibility for direct discharges, the FDER, through broad regulatory and enforcement powers defined by the Clean Water Act, has the permitting and enforcement responsibility to protect and improve water quality. Both the FDER and the Southwest Florida Water Management District (SWFWMD) regulate the flow of surface water into Tampa Bay and coastal estuaries. Surface water runoff is managed and permitted by both agencies, while the SWFWMD controls ground water levels by issuing and monitoring consumptive use permits (CUPs), and controlling discharges from upland canals. In addition, the SWFWMD permits construction within, and uses of, the waters of canal systems within their district, and sets minimum flow levels for coastal rivers and tributaries.

The Tampa Bay Regional Planning Council (TBRPC) has the leading natural resource planning role in the Tampa Bay Region. Pursuant to the provisions of the Clean Water Act, TBRPC was delegated the responsibility for preparing the Areawide Water Quality Plan (AWQP) and numerous related studies, including a Reservoir Protection Plan and a Groundwater Protection Plan. In 1984, the Florida legislature established the Tampa Bay Management Study Commission, which was given a one year mandate to develop a management plan for Tampa Bay. The commission, which was to be housed within, and staffed by TBRPC, completed its final report entitled the Future of Tampa Bay (TBRPC, 1984) and submitted it to the Legislature in 1985. In addition to numerous special planning studies, the TBRPC also performs technical reviews, coordinates all agency comments, and issues recommended Development Order conditions for Developments of Regional Impact within the region.

Figure 106: State Designated Aquatic Preserves
Located in Tampa Bay



The Florida Department of Community Affairs (FDCA) has a limited planning role in the Tampa Bay Region, primarily with the Development of Regional Impact (DRI) process. FDCA is also responsible for designating Areas of Critical State Concern (ACSC).

The Tampa Port Authority (TPA) has permitting authority and jurisdiction pursuant to Chapter 84-447, Florida Statutes, Special Acts of 1984. The prime mandate of the TPA is to promote and manage the navigable waters of Tampa Bay for port development. TPA sponsored the Tampa Harbor Deepening Project. Jurisdictional waters include all tidal waters of Hillsborough County, Lake Thonotosassa, Lake Keystone, the Alafia River, the Hillsborough River and the Little Manatee River. Involvement in dredge and fill projects includes assessments of the engineering, hydrographic, and biological aspects of various dredge and fill and construction projects by the TPA Environmental Affairs Department. In addition, TPA performs limited research and sponsors habitat restoration projects.

Most local government organizations in the Tampa Bay area have the opportunity to review and comment on applications during the state and federal permitting process. The TBRPC and county governments surrounding Tampa Bay (Hillsborough, Pinellas, and Manatee) comment on the permissibility of applications to the federal, state and local permitting agencies according to their local regulations. Hillsborough County receives money from the TPA permit fees to pay for review of applications by the county Environmental Protection Commission and planning commission. The FDER has delegated some responsibilities for water quality programs to the county agencies, and most of the local governments have developed ordinances or policies aimed at controlling the impact of development on water quality. Manatee and Hillsborough Counties have conducted routine monitoring studies within Tampa Bay and its tributaries. Local governments have a limited role or jurisdiction over habitat management. At this level, the emphasis has primarily been on county managed parks including: Upper Tampa Bay Park (Hillsborough County); E.G. Simmons Park (Hillsborough County); and Fort Desoto Park (Pinellas County). The Hillsborough County Environmental Protection Commission (HCEPC), however, issues a separate permit for dredge and fill projects in both tidal and isolated wetlands.

Most of the municipal governments in the Tampa Bay Region require construction permits for structures constructed in the coastal zone. The local permit process typically does not include an environmental assessment, and municipal governments generally do not have adequate staff to review federal and state applications.

In summary, responsibility for the management of coastal and estuarine resources in the Tampa Bay Region is fragmented along legal and political lines, and no ecosystem level management currently exists. Although numerous permits must be obtained before a proposed project can proceed, there is no overall plan to ensure consistency between agencies in the issuance of permits, nor are the overall cumulative impacts of several projects considered during the review process.

MANAGEMENT OBJECTIVES

Although much of the catastrophic losses of estuarine wetland habitat in the Tampa Bay Region occurred prior to the existence of the present regulatory framework, ongoing habitat destruction can be blamed primarily on the lack of a unified, ecosystem level, regulatory approach. Because the various review and permitting authorities approach their regulatory responsibilities with different legal authorizations and objectives, holistic estuarine management is not possible. In recognition of this fact, the legislatively mandated Tampa Bay Management Study Commission established a set of management goals and objectives to serve as a framework, around which a unified estuarine management program could be built (TBRPC, 1984). Those goals and objectives were stated as follows:

Primary Goal -
To develop and implement a unified regional management plan for the entire Tampa Bay estuarine system, including its tributaries, adjacent wetlands, embayments and contiguous developed shorelands, in a manner that will maintain, or enhance where feasible, those physical, chemical, biological, economic and aesthetic qualities that encompass the basic character and potential value of Tampa Bay.

Ecology Goal -
To restore and/or maintain Tampa Bay as an estuarine ecosystem in which commonly recognized ranges of scientifically valid parameters - in comparable, healthy estuaries, are consistently present.

- To avoid irreversible or irretrievable commitments of the bay's natural resources

- To provide protection for endangered, threatened or rare species of plants and animals that exist within the waters of Tampa Bay or the adjacent coastal wetlands, and

- To optimize the quality and quantity of marine life.

Economy Goal -
To quantify the economic value of Tampa Bay, and promote the contribution of those public and private enterprises that provide goods and services to the community, and are dependent upon Tampa Bay as a resource essential for their existence.

- To provide a wide array of water oriented opportunities at the water's edge, consistent with the primary goal, and

- To protect the bay as a valuable natural and economic resource for the benefit of present and future generations.

Industry Goal -
To achieve a balance between the commercial uses of Tampa Bay and its natural environment, for their mutual benefit.

- To promote water transportation and enhance the bay's contribution to the economic health of the community through marina development and other appropriate measures consistent with the primary goal, and

- To develop the bay and its shoreline to their highest potential with a minimum of dredging and/or filling.

Recreation Goal -
To maximize present and future recreational benefits for the public, with due concern for the environment.

- To maintain, or enhance where necessary, water quality that permits safe water contact, recreation and propagation of fish and wildlife, and

- To enhance physical and visual access, thereby increasing the potential for environmentally sound utilization and attractiveness of Tampa Bay for the public at large.

Institutions Goal -
To provide a suitable regulatory framework for the implementation of the Tampa Bay Management Study Commission recommendations.

- To address and resolve the jurisdictional issues relating to Tampa Bay in order to provide a long-term management capability

- To seek funding for activities which are necessary to achieve the primary goal, and

- To provide continuing monitoring of the Bay in order to assemble an adequate data base for bay management.

Within the framework of these broader goals, specific management objectives for estuarine wetland habitat should be established. In light of the historic declines in estuarine habitat in the Tampa Bay Region, a four-point approach is recommended in the following order of priority:

(1) Preservation of existing unimpacted habitat in its natural state through conversion to public ownership, wherever possible

(2) Restoration of degraded habitat, wherever feasible, through specially funded restoration projects as well as the permitting process

(3) Mitigation of future unavoidable impacts to the greatest extent possible through sound preliminary planning, and the implementation of an objective, scientifically defensible mitigation policy, and

(4) Monitoring of all preserved, restored or created habitat to ensure optimal ecological functioning.

The primary management approach should be one of preventative conservation, designed to protect an ever decreasing base of estuarine habitat, in relation to an ever increasing demand for coastal development. Where adequate funds are available, restoration of degraded or dysfunctional habitat held in public ownership should be attempted when positive results can be reasonably expected. When proposed projects will result in unavoidable impacts, habitat creation or restoration using proven methods with predictable, quantifiable results should be required to at least off-set project impacts. Finally, estuarine habitat should be periodically quantified and assessed on a regional basis to maintain an updated data base upon which to fine tune the management approach.

MANAGEMENT TOOLS

While the above recommended approach defines the general management components essential to effective conservation of estuarine habitat, regional variability necessitates that different specific objectives be realistically set for different areas. For example, in the highly urbanized areas of Hillsborough Bay, where little natural habitat exists, the emphasis should obviously be on restoration rather than preservation. Conversely, along the extensive coastal marshes of Pasco County, where relatively little development has occurred, the emphasis should be on preservation.

Segmentation is one procedure that has been used in other estuaries for the purpose of refining the management approach. The segmentation process is a management tool which recognizes that an estuary, like Tampa Bay, is an interrelated ecosystem composed of chemically, physically, and biologically diverse areas. It assumes that an ecosystem as diverse as Tampa Bay cannot be effectively managed as only one unit, since different water quality and habitat objectives will be appropriate and feasible for different regions of the bay. The segmentation approach to water quality management has been successfully applied to several large receiving water bodies, most notably the Chesapeake Bay, the Great Lakes, San Francisco Bay and the Thames River (CDM, 1985). Because seagrass health is so intimately tied to water quality, this approach is especially useful in setting management objectives for subtidal habitat.

In the absence of water pollution, physical characteristics of different regions of the bay influence the suitability for major water uses. Therefore, one major objective of segmentation is to subdivide the bay into segments with relatively homogeneous physical characteristics so that differences in the biological communities among similar segments may be related statistically to man-made alterations. Once the segment network is established, each segment can be subjected to an analysis of the relationship between use attainability and water quality. In addition, the segment network offers a useful management structure for focusing local citizen involvement and monitoring conformance with water quality goals in future years.

A potential source of concern about the construction and utility of the segmentation scheme is that estuaries are fluid systems with only a few obvious boundaries, such as the sea surface and the sediment-water interface. Boundaries fixed in space are to be imposed on an estuarine system where all components are in communication with each other following a pattern that is highly variable in time. Fixed boundaries seem unnatural to scientists, managers, and users, who are more likely to view the estuary as a continuum, than as a system composed of separable parts. The best approach to dealing with such concerns is a segmentation scheme that stresses the dynamic nature of the estuary. The scheme should emphasize that the segment boundaries are operationally defined and delineated to assist in the understanding of a changeable intercommunicating system of channels, embayments and tributaries.

In order to account for the dynamic nature of the Tampa Bay estuarine system, it is recommended that estuarine circulation patterns be a prominent factor in delineating the segment network. This approach would seem warranted for St. Joseph Sound as well, where extensive seagrass losses have occurred. Circulation patterns control the transport of, and residence times for, heat, salinity, phytoplankton, nutrients, sediments, and other pollutants throughout Tampa Bay. Salinity should be another important factor in delineating the segment network. While the range for salinity concentrations in Tampa Bay is not as wide as in some other major U.S. estuaries, the variations from head of tide to the mouth undoubtedly produce some separation of biological communities based upon salinity tolerances or preferences. After developing a network based upon physical characteristics, segment boundaries can be further refined with available chemical and biological monitoring data to maximize the homogeneity of each segment.

To illustrate how circulation and salinity data could be used to segment the Tampa Bay estuary, a sample segment network for the portion of the bay above the Sunshine Skyway is shown in Figure 107 (CDM, 1985). The segment boundaries have been delineated on a map showing net current velocities for a single tidal cycle as simulated by the USF Tampa Bay model in studies from the 1970s (Ross and Jerkins, 1978). The segment network shown in Figure 107 shows one possible approach to segmenting Tampa Bay with available hydrodynamic data. The final network developed for water quality and habitat management purposes should rely upon updated hydrodynamic model outputs that reflect the most recent bathymetric data for the estuary, and "particle tracer" studies with mass transport models.

Another management tool that is perhaps better suited for the protection of intertidal habitat is the designation of critical areas. This concept was developed in 1984 in Maryland as a component of the Chesapeake Bay Restoration and Protection Plan (EPA, 1985). Pursuant to the Critical Areas Statute, Maryland has designated a strip of land extending 1,000 feet landward of the mean high water line of the bay, and all tidal tributaries as "critical areas," and has enacted strict land use and drainage criteria for its use. Although Tampa Bay currently contains four state designated Aquatic Preserves, many other sensitive and ecologically important areas are not afforded such protection. Furthermore, the designation of an area as an Aquatic Preserve is often a political process which does not necessarily provide the additional level of protection intended. To date, no management plans have been approved for the four Tampa Bay Aquatic Preserves, and development has, in many cases, proceeded relatively unimpeded (e.g. Boca Ciega Bay). The "critical areas" approach would seemingly be far more effective in the Tampa Bay Region because it defines management boundaries at the watershed and ecosystem level rather than along artificial political boundaries. Where eutrophication is a critical

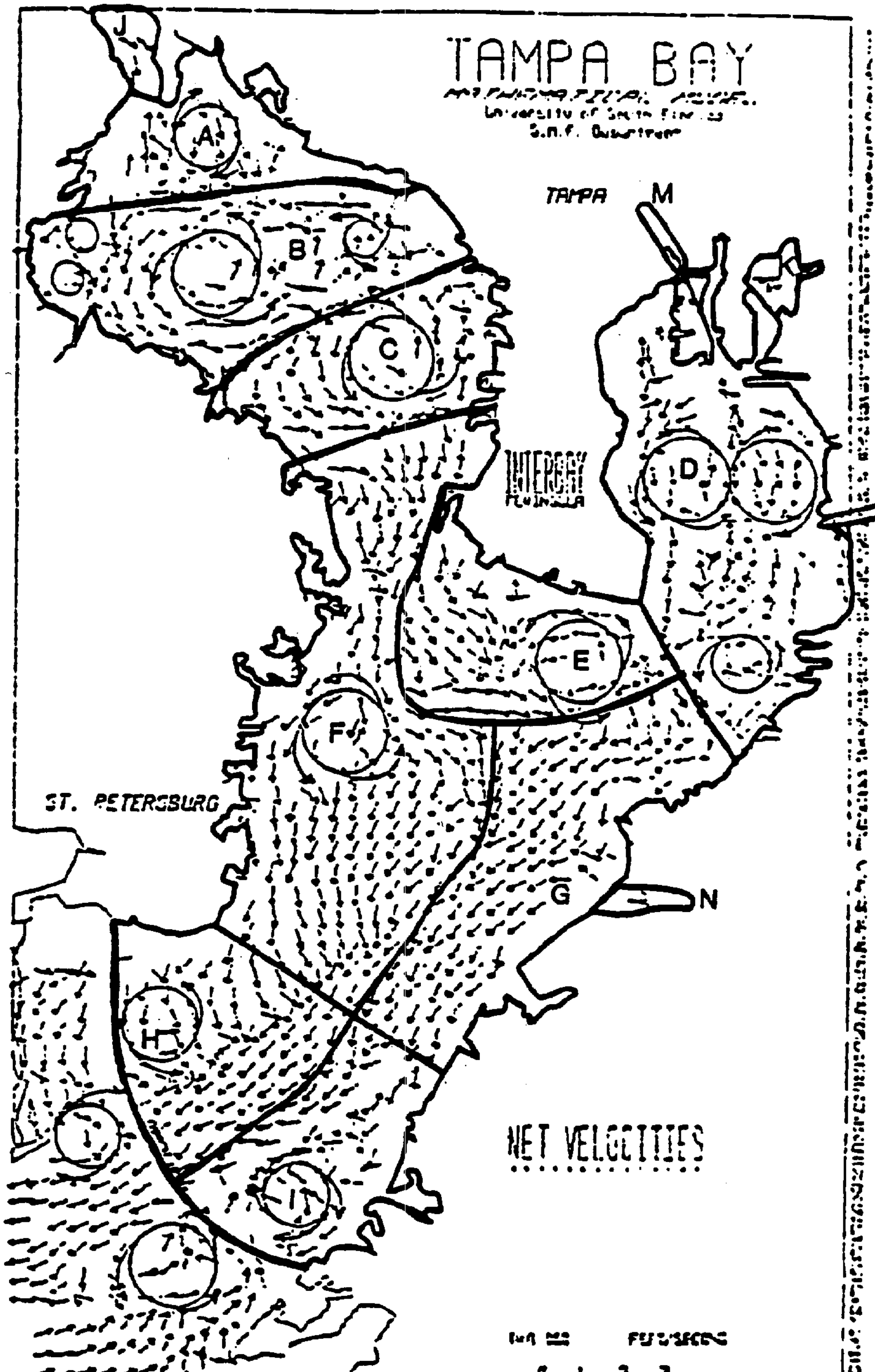


Figure 107 Map of Tampa Bay Showing Sample Estuary Segments (A through N) and Net Current Velocities for a Single Tidal Cycle

SOURCE: Ross & Jerkins, 1978

management problem, as is the case for subtidal habitat in Tampa Bay, management at the watershed level is essential for controlling nutrient inputs.

Once management boundaries have been designated, and specific management objectives defined, efforts to preserve restore and/or mitigate estuarine habitat can be more clearly directed. As previously discussed, preservation of existing habitat is the primary goal of the recommended management approach. Preservation of large tracts of undeveloped coastal lands can probably be best achieved through conversion to public ownership. Under the current management scheme, funding to acquire privately held lands has come almost exclusively from the state through the Conservation and Recreation Lands (CARL) program. Chapter 259 of the Florida Statutes established a procedure for the issuance of state bonds not to exceed $240 million, for the public purchase of environmentally sensitive lands. The CARL program assisted in the purchase of the Gateway tract in Pinellas County and the Bower Tract in Hillsborough County. The decision regarding which properties are eventually selected for purchase in a given year is, however, determined through a competitive statewide ranking process, which is often subject to political manipulation. Furthermore, the length of time involved in the ranking and negotiation process may stall the purchase of a particular tract indefinitely leaving it vulnerable to eventual development.

One local solution to the problem of public acquisition of environmentally sensitive lands is the creation of a land bank. This concept has been used successfully on Nantuckett Island, Massachusetts, since 1983. The program imposes a two percent transfer tax on the sale of real estate with the buyer paying the tax. A five-member locally elected commission uses the proceeds to acquire fee or less-than-fee interest in open space, which it can do without prior approval of a higher authority - an important feature of the state law establishing the bank. The commission also has the power of eminent domain, although such condemnations require a two-thirds vote by the town meeting. Finally, the commission can borrow money to buy property. Lands acquired through the program must be left predominantly in a natural state, but may be used for passive or active recreation.

The land bank fund is a revolving account that can be drawn upon to pay for land acquisitions, debt service, staff support, professional services and planning. Besides the real estate tax, the fund may also accept contributions, appropriations by the town, and grants the proceeds of bonds, notes and interest earned on investments. In addition, the commission may issue revenue bonds or, with town approval, general obligation bonds. Approximately 65 percent of all real estate transactions are taxable with the remainder being exempt for various reasons (i.e. first time home buyers and foreclosure proceedings).

To date, the land bank has acquired, or is under agreement to acquire, 714 acres of land for $14.9 million - or about 2.5 percent of the total acreage of the island. The acquisitions include a 158 acre abandoned golf course, several tidal wetlands, almost 90 acres of moors, 10 acres of ocean beach and an in-town park. Four of the 11 acquisitions involve land for which subdivision plans were pending.

While the land bank concept has been very successful on Nantuckett Island, there is still some question as to how it would be applied elsewhere. First, the local or regional jurisdiction must have a mechanism in place to collect the property transfer fee. In addition, state enabling legislation is needed to allow the local or regional entity to impose a special tax. Most important, the idea must have strong local support. To be effective, a land bank must be able to raise adequate funds to be competitive with other real estate interests.

Despite these concerns, statewide enabling bills have been proposed in at least five other northeastern states. Where it has been implemented, the land bank concept has been embraced as a useful new compensatory growth management tool. Contrary to expectations it has been viewed by the public as an inclusionary, not exclusionary, measure which guarantees public access to the shoreline and preserves sensitive coastal habitat. Although the creation of a Tampa Bay land bank on a multi-jurisdictional, regional scale would present new and unprecedented legal challenges, the concept represents an innovative new tool for habitat management at the ecosystem and watershed levels.

Coordinating efforts to restore degraded habitat, or create new habitat, either as an isolated project or as compensatory mitigation for unavoidable impacts, has proven to be very difficult under the current Tampa Bay management scheme. The problems hindering such efforts include: (1) the lack of adequate recurring funds to initiate and monitor restoration/creation projects, and (2) confusing jurisdiction as to who should have the lead role in coordinating such projects.

Under the current management scheme, estuarine habitat restoration/creation projects in the Tampa Bay Region are primarily administered by the FDNR and the FDER. The FDNR Marine Research Laboratory in St. Petersburg has been authorized to develop and implement estuarine habitat restoration programs pursuant to Chapters 83-504 and 84-471, Laws of Florida, which establish a fund generated from commercial gill-net license fees collected in Pinellas and Manatee Counties, respectively. Pasco County has recently passed a similar act. The acts specifically require that the monies are to be spent by the FDNR for "marine research and restoration" in the respective counties from which the funds are collected. To date, approximately $220,000 has been collected, and restoration plans have been prepared for Pinellas and Manatee Counties. FDNR is currently in the process of implementing some of the recommended projects in the two plans. Although these funds are presently recurring, the special acts creating them are scheduled to sunset in the near future. In addition, the level of funding created by these acts is not adequate to fully implement and monitor significant projects.

The FDER has been involved with habitat restoration/creation projects primarily through its dredge and fill permitting authority, and secondarily through its administration of the Pollution Recovery Trust Fund. Although the FDER was granted the legal authority to consider structural mitigation for dredge/fill proposals in 1984, with the passage of the Warren S. Henderson Wetlands Act, they have informally approved numerous habitat restoration/creation projects as a form of mitigation for many years prior.

Most of these projects, however, were initiated without specific goals or scientific criteria, and few have even been monitored and assessed for success (CSA, 1986). In addition, the FDER has the authority to institute habitat restoration projects utilizing the Pollution Recovery Trust Fund, which is maintained by fines collected from pollution (e.g., dredge/fill) violations. To date, however, monies from this fund have only been specifically set aside for one site - the Hendry fill site in Manatee County - and those monies have only been used for plan formulation. No actual habitat restoration/creation projects have ever been accomplished using the Pollution Recovery Trust Fund.

An assortment of other agencies have been involved with various estuarine habitat restoration/creation projects in the Tampa Bay Region including the U.S. Army Corps of Engineers, the Southwest Florida Water Management District and the Tampa Port Authority. However, as with the majority of the efforts described above, these projects suffered from poor design, the lack of a-priori objectives, and little or no follow up monitoring and assessment. Where these projects were required as mitigation to offset quantifiable habitat impacts of construction proposals, few, if any achieved this goal, even on a one-for-one replacement basis (CSA, 1986).

As discussed above, the creation or restoration of substitute habitats in Florida (e.g., marsh creation) has become a common condition placed upon the issuance of dredge and fill permits for projects in jurisdictional wetlands. Most of this mitigation is done by individual property owners and is customarily required to be performed on property owned by the applicants. As a result of this policy, the great majority of mitigation projects undertaken involve relatively small acreages (less than 1 acre), thus driving the restoration/creation per acre costs quite high ($10,000 - $15,000 per acre including excavation of uplands as needed). In addition, this policy often excludes off-site mitigation, even in cases where restoration or creation of larger contiguous or more ecologically valuable, systems could be accomplished. In the Tampa Bay Region it can only be concluded that habitat restoration/creation efforts under this policy have been poorly funded and coordinated, and have been largely unsuccessful at offsetting or mitigating the losses of comparable habitat over the same time period.

An alternative management concept for funding and coordinating habitat restoration/creating efforts is <u>mitigation banking</u>. Mitigation banking is a relatively new concept which combines the advantages of providing an economically viable method of mitigating unavoidable impacts while ensuring that the restoration/creation objectives are successfully implemented prior to the loss of wetlands to development. As defined in the USFWS mitigation policy (USFWS, 1981), mitigation banking "means habitat protection or improvement actions taken expressly to compensate for unavoidable losses from specific future development actions". In simplified terms, a mitigation bank is similar to a bank account in that created or restored wetland habitat is used as the credits from which habitat debits are drawn.

Measures to create, restore, enhance or preserve fish and wildlife habitat are done by the developer or bank sponsor in concert with the responsible regulatory or planning agency in advance of anticipated unavoidable losses from proposed projects. Projects requiring mitigation for unavoidable losses, and for which on-site mitigation is neither desirable nor feasible, may draw upon the created mitigation bank account for offsetting project impacts. The bank sponsor may sell habitat credits to others requiring compensation in the region, provided their project meets the necessary criteria to use the bank. Habitat unit values (e.g., Habitat Evaluation Procedure) or some other quantitative methodology for the evaluation credits and losses is needed. This scheme may be considered for an area-wide mitigation bank managed by a central authority responsible for evaluating the losses and initiating the creating, restoration and enhancement efforts with the money provided.

The mitigation banking concept is useful for agencies and large corporations that plan for development several years in advance, provide for advance funds to set up the mitigation bank, have reasonable assurance of obtaining the necessary permits for development, and have the ability to acquire and provide for the restoration and management of property. Port authorities, transportation departments, and other organizations and large corporations performing functions in the public interest, and requiring periodic expansion, are examples of potential uses for a mitigation bank.

One of the major arguments in support of mitigation banking is that given a certain level of funding for wetland restoration or creation, greater acreages (often contiguous) of better quality habitat will result through an organized banking effort. In addition, mitigation banking provides a mechanism for requiring "up-front" mitigation. "Up-front mitigation" implies that the mitigation activity (usually wetland creation or restoration) is accomplished and approved as successful, prior to the permitted destruction of another wetland. The concept is attractive since it insures that the reviewing agencies have an opportunity to assess and approve another wetland, instead of losing the wetland in question and then waiting for the mitigation activity to be completed. Major arguments against mitigation banking, as well as against the concept of mitigation in general, include the idea that it could lead to the "selling" of permits for normally unacceptable habitat destruction, especially in the case of non-water dependent projects. In addition, there are no "environmental performance criteria" to determine if a wetland mitigation effort is successful, and there is, as yet, no truly objective method of rating the "relative value" of one habitat type over another. Because the mitigation banking concept encompasses the assessment of "credits" and "debits", a quantitative rating system for various habitat types, as well as for restoration/creation success, is necessary. (This concept is discussed in greater detail in Chapter 6).

The applicability of the mitigation banking concept in the Tampa Bay Region has been considered in recent years (TBRPC, 1984; CSA, 1986). The few mitigation banks that have been established elsewhere offer useful comparative examples. The Tenneco LaTerre (TLT) Corporation established a mitigation bank in a wetlands area of coastal Louisiana to mitigate for unavoidable impacts to fish and wildlife resources resulting from oil and gas development in the marshes of Louisiana. The bank provided for management of coastal marshes owned by TLT. Wetland loss in Louisiana has been high, in part caused by channelization for oil and gas development. The management plan would increase freshwater and sediment inflow to maintain the growth and health of the freshwater marshes and reduce saltwater intrusion. The TLT established a 25-year management program in 2,024 ha of coastal marsh in Louisiana. The USFWS, using the Habitat Evaluation Procedures, calculated the average annual habitat units gained by the management program. It was estimated that the established mitigation bank would be capable of offsetting the damages of approximately 60 to 120 "typical" oil and gas exploration canals (CSA, 1986).

The Port of Los Angeles and the Port of Long Beach developed mitigation banks in 1984. The banks were created through a Memorandum of Understanding (MOU) entered into by federal and local government agencies. The purpose of creating the banks was to allow development of the ports while assuring that the mandates of the USFWS and the NMFS were fulfilled. The MOU agreed upon for the Port of Los Angeles was created to offset submerged bottom losses resulting from fill within the port. Simply stated, the agreement was that creation of new submerged bottom by excavation of upland would offset losses of submerged bottom resulting from filling of submerged bottom land. The comparison of the habitat value of the submerged bottom area created to that lost was considered to be equal if the water depths were equal. The port created a net habitat gain and loss accounting system which included a summary of gains and losses from projects undertaken within the port boundary since the inception of the federal permitting program. As a result, the port has begun the MOU with a credit of +7.2 ha of area. The MOU is valid until the balance of the created habitat value is consumed (CSA, 1986).

The MOU agreed upon for the Port of Long Beach was created by the port in anticipation of harbor developments that would result in approximately 16 ha of submerged land being filled. The reserve site in Newport Bay was considered the most feasible restorable site and the agencies considered coastal wetlands restoration as a desirable mitigation measure, because 75% of these habitats have been lost in southern California. The bank was created within the 300-ha Upper Newport Bay Ecological Reserve located in Orange County and managed by the California Department of Fish and Game. The plan called for the port to restore tidal influence to a predominantly barren area above the reach of the tides, presently providing minimal habitat value. Relative habitat values for the areas loss (filled) and gained (restored) were formulated by using a modified HEP because of the absence of species models for appropriate marine and estuarine species, and the unavailability of HEP trained personnel. Bird and fish sampling data including shared species, common biological functions, productivity values, fish nursery value, ecosystem physiography and areal extent for both areas considered - were summarized and analyzed in planning reports prepared by the USFWS (CSA, 1986).

General recommendations for development of a mitigation bank by the Tampa Port Authority (TPA) can be drawn from the banks developed for the Ports of Los Angeles and Long Beach. The type of bank developed for the Port of Los

Angeles would not result in an improvement of wetlands habitat. The need to reverse the trend of habitat loss in Tampa Bay is well documented (TBRPC, 1984). Therefore, to consider past port development actions as any form of mitigation for credits for future projects would not lead to a net improvement of this trend.

The mitigation bank approved for the City of Long Beach closely approaches the type of bank required in Tampa Bay to reverse the trend toward habitat loss. The mitigation action in Long Beach, however, represents enhancement of an existing but degraded wetland area. In general, enhancement of existing wetlands is considered an unacceptable alternative to mitigate direct wetlands losses occurring during development because it usually results in a net loss of habitat unless the restored area is significantly larger than the area proposed for destruction.

RECOMMENDED MANAGEMENT SCHEME

In 1982, the first symposium on Tampa Bay was held at the University of South Florida. The Tampa Bay Area Scientific Information Symposium (BASIS) lasted four days and involved topical presentations by 50 invited speakers. Major conclusions of the Symposium were that (1) Tampa Bay can and should be comprehended, and managed, as a single ecological system; (2) the bay is remarkably resistant to the environmental challenges; (3) a clear pattern of decline is evident in some measures of ecological condition; and (4) the management needs of Tampa Bay are relatively clear and, if implemented in a comprehensive and baywide basis would result in tangible improvements to the bay and its usefulness to people. It was further concluded that, at the present time, state and federal regulatory agencies, local governments surrounding the bay, and an array of industries and user groups often carry out their respective activities independently. The effect of bay management by a multitude of overlapping and often conflicting interests and jurisdictions had contributed to a number of environmental and growth management problems in the bay area.

The conclusions reached at the BASIS conference underscored the importance of approaching estuarine management at the ecosystem level. In recognition of the need for a credible and structural forum within which to pursue a more unified management scheme, BASIS organizers urged local legislators to introduce a Bill creating a special task force to review and make recommendations regarding the management of the Tampa Bay estuarine system. During the 1984 session, the Florida Legislature created the Tampa Bay Management Study Commission under a special act. The Commission received a one year mandate to develop a recommended bay management plan and work program to address priority bay management issues in conjunction with ongoing efforts by Congress, the U.S. Fish and Wildlife Service, state agencies, port authorities, and other regulatory entities, for submittal prior to the 1985 legislative session.

In its final report to the Florida Legislature, entitled the Future of Tampa Bay (TBRPC, 1984), the Tampa Bay Management Study Commission recommended the establishment of a 40 member coordinating and advisory committee as an interim solution to the management inconsistencies plaguing

Tampa Bay. The committee, to be entitled the Agency on Bay Management, became an official arm of the Tampa Bay Regional Planning Council with membership from the following groups:

- The Florida Senate representing the Tampa Bay Region
- The Florida House of Representatives representing the Tampa Bay Region
- The Tampa Bay Regional Planning Council
- The U.S. Army Corps of Engineers
- The National Marine Fisheries Service
- The Florida Department of Natural Resources
- The Florida Department of Environmental Regulation
- The Florida Department of Community Affairs
- The Florida Department of Transportation
- The Southwest Florida Water Management District
- Environmental interests in the Tampa Bay Region
- Commercial interests in the Tampa Bay Region
- Industrial interests in the Tampa Bay Region
- Science and academic interests in the Tampa Bay Region
- Recreational interests in the Tampa Bay Region
- Hillsborough, Manatee, and Pinellas Counties
- The Tampa, Manatee and St. Petersburg Port Authorities
- The Cities of St. Petersburg and Tampa
- Two other municipalities bordering Tampa Bay, and
- The Tampa Bay Region at large.

The Council's Agency on Bay Management first convened in September of 1985 and continues to meet on a bi-monthly basis. To date, the Agency has served as a useful forum for the sharing and discussion of information related to bay management issues. The Council's Agency on Bay Management has been very successful in facilitating communication between responsible agencies and affected interests, providing coordinated recommendations regarding environmentally sensitive projects within the Tampa Bay watershed, establishing a vital link between Tampa Bay interest and the

State legislature, and implementing the recommendations set forth in the Future of Tampa Bay (TBRPC, 1984).

Tangible results that have been accomplished by the Council's Agency on Bay Management within the first year include:

- Public Education
  - Boat-a-cades
  - Bay Days and State of the Bay Symposium
  - Future of Tampa Bay Presentations
  - Brochures - Tampa Bay Estuarine System
  - Stormwater Management Workshop

- Recommended Regional Resource Documents
  - Documenting the Economic Importance of Tampa Bay (TBRPC, 1986a)
  - Ecological Assessment Classification and Management of Tampa Bay Tidal Creeks (TBRPC, 1986b)
  - The present study

- Active in state legislature to introduce, monitor and support legislative initiatives
  - Saltwater fisheries license
  - Pollution Recovery Trust Fund
  - Stormwater legislation
  - Staffing of State Aquatic Preserves

- Coordinating consistency between counties on environmental rules and regulations

- Recommended to HCEPC to initiate Artificial Reef Program

- Establishment of the Terra Ceia Aquatic Preserve

- Allocation of $200,000 for additional seagrass research through FDNR

- Working with SWFWMD and FDOT for habitat restoration on Channel "A", and

- Collection of bay management literature to provide a regional data base of material within the Tampa Bay Regional Planning Council's Regional Information Center.

In its closing remarks, the Tampa Bay Management Study Commission stated:

> "It is recognized that the ultimate success of the recommended Agency on Bay Management within the Tampa Bay Regional Planning Council will be dependent upon the overall strengthening of state growth management legislation..."

Protective measures developed within the Wetlands Protection Act of 1984, and the growth management legislation of 1985 will provide safeguards to coastal and estuarine resources. However, these measures provide no viable mechanisms for the reversal of environmental degradation (i.e. restoration).

Nationally, the concept of an empowered bay management agency is not without legal precedent. Established in 1965, the San Francisco Bay Conservation and Development Commission (BCDC) was the first intergovernmental committee created to manage a coastal resource in the United States. The BCDC was originally given a four-year life span and was assigned the task of preparing a bay management plan for San Francisco Bay. In 1969, the Commission was granted permanent status and three major areas of responsibility leading to the implementation of the bay management plan including: (1) permitting authority for all filling, dredging and changes in existing uses on the bay; (2) veto power over any significant development activity within 100 landward feet from the shoreline; and (3) jurisdiction over any proposed filling of salt ponds and other wetland adjacent to the bay.

On a much grandeur scale, the U.S. Environmental Protection Commission established a multi-jurisdictional regional management structure, including the states of Maryland, Virginia and Pennsylvania, and the District of Columbia to coordinate the management of Chesapeake Bay.

The Chesapeake Bay Agreement of 1983 recognized the need for a regional management structure to support and enhance a regional cooperative approach for the environmental management of the Chesapeake Bay. Toward this end, the Agreement established an Executive Council, an Implementation Committee, and a Chesapeake Bay Liaison Office. This regional management structure was instituted in 1984, and a multi-faceted restoration and protection program was begun.

Many benefits can be cited for giving similar powers to the Council's Agency on Bay Management. Probably foremost among these benefits would be the consolidation and subsequent streamlining of certain environmental permitting programs for proposed activities in and around the Bay. Examples of the types of resource management responsibilities that such an Agency within the Regional Planning Council could assume include: sewage disposal and other point source discharges to the bay; stormwater management systems involving tidal waters; dredge and fill activities in the bay; shoreline development; aquatic preserve management; mosquito control projects; classification of sanitary shellfishing areas; and habitat restoration projects. Presently these programs are managed by an array of state, regional and local agencies. Local assumption and consolidation of these programs in a one-step operation agency would streamline the permitting process for all potential users of the bay and, more importantly, would result in a more unified management overview of the Tampa Bay estuarine system as a holistic natural resource.

In addition, consolidation ownership of all bay bottoms by a single entity would greatly simplify the regulatory framework and would significantly augment management capabilities for Tampa Bay. This concept is consistent with the primary approach to resource management programs employed at the state level where outright ownership is usually the case. The "Save Our Rivers," and CARL programs are relevant examples. An entity which owns title to the submerged lands under Tampa Bay would be able to affect every resource management decision occurring within the bay either through overview with veto power or through direct regulatory authority. The most significant of these would be dredge and fill activities; in particular, the channels. Finally, under such a scenario the accountability for the success or failure of the bay management program would reside essentially in one agency.

Despite the numerous advantages of regional, ecosystem level management operation, political arguments against the establishment of the Council's Agency on Bay Management with regulatory powers remain quite strong. The proposal is still primarily viewed by many powerful interest around the bay, as adding "another layer of bureaucracy" to an already complex and sluggish environmental permitting system. In addition, the numerous agencies which currently have jurisdiction in Tampa Bay are reluctant to relinquish or delegate that jurisdiction to an untested entity. Nevertheless, the effectiveness of such an approach has been proven in other estuaries and should be explored as a viable management alternative for the Tampa Bay estuarine system.

Depending upon the enabling legislation, it is proposed that the Agency be funded on a recurring basis through legislative initiatives, as well as saltwater fishing license fees, collected in Pinellas, Hillsborough and Manatee Counties. The primary objectives of the Council's Agency on Bay Management would be to coordinate and, wherever feasible, consolidate review and permitting functions, as well as monitoring and research efforts, under one regional umbrella agency. Through interagency coordination and, in some cases, the outright delegation of authority, the primary goal would be to provide a more efficient and effective regulatory framework for the Tampa Bay estuarine system and adjacent coastal waters.

The jurisdictional boundaries would include all tidal waters, and all tributaries which flow to those waters, of Pinellas, Hillsborough and Manatee Counties. The upland limit of this jurisdiction would be mean high water line, while the upstream limit would be the point at which freshwater intertidal vegetation is dominant over saltwater vegetation. This management area essentially encompasses the tidal watershed of the Tampa Bay estuarine system, as defined by Lewis and Whitman (1985), and further includes Palma Sola Bay, Clearwater Harbor, St. Joseph Sound and the Anclote River estuary. Because the Pasco County coastline is hydrologically and geologically dissimilar from the Tampa Bay estuarine system, and because habitat losses there have been far less significant, this area is not included in the proposed jurisdiction of the Agency. Rather, it is concluded that the coastal and estuarine resources of Pasco County can be adequately protected under the existing regulatory framework, and that extensive restorative measures are not indicated.

The primary functions are proposed as follows:

- Management and administration of a Land Bank to acquire and preserve existing estuarine habitat

- Management and administration of a Mitigation Bank to create new, or restore impacted, estuarine habitat, and to offset future development impacts

- Development and implementation of a segmented management plan for the proposed jurisdictional area

- Coordination and consolidation of research and monitoring efforts for water quality and biological resources in the proposed jurisdictional area

- Coordination and consolidation of all dredge and fill permitting functions in the proposed jurisdictional area

- Coordination and consolidation of stormwater and point source discharge permitting functions in the proposed jurisdictional area, and

- Consolidation and organization of all relevant water quality and biological resource data bases from the proposed jurisdictional area.

The recommendations as stated above, have no legal precedent in the State of Florida. For this management concept to become a feasible alternative, enabling legislation must be passed to include the following provisions:

- Allows the development of land banks through the creation of special taxing authorities

- Allows the development of mitigation banks through the use of Memoranda of Understanding and other interagency agreements

- Allows the creation of "Special Management Districts" as an alternative to the "Area of Critical State Concern" (Chapter 380, F.S.) process, and

- Allows consolidation of ownership of submerged land under one regional authority.

With the passage of appropriate enabling legislation as described above, the development of an "ecosystem level" management scheme for estuarine and coastal resources in the State of Florida becomes an achievable goal.

CHAPTER VI

ESTUARINE HABITAT MITIGATION POLICY

DEFINITION OF MITIGATION

The term "mitigation" was first used in connection with wildlife and other natural resources in the Fish and Wildlife Coordination Act of 1934 (Rappoport, 1979). However, mitigation and the philosophy behind it have never been consistently or clearly defined by all agencies connected with its use.

According to the dictionary definition, mitigation is the "abatement or diminution of something painful, harsh, severe, afflictive..." This definition implies that mitigation involves corrective action (compensation, restoration, replacement, etc.) only after impact has occurred.

The above definition is valid; however, it only goes part of the way in dealing with impact-related issues. What is missing is the concept of prevention, which would avert or limit impact effects prior to occurrence. "Mitigation" has thus evolved to include avoiding and minimizing project impacts on natural resources during project planning and implementation, as well as corrective action following impact. This broader definition is stated in the National Environmental Policy Act (NEPA; Section 1508) and includes:

- Avoiding the impact altogether by not taking a certain action or parts of an action
- Minimizing impacts by limiting the degree or magnitude of the action and its implementation
- Rectifying the impact by repairing, rehabilitating, or restoring the affected environment
- Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action, and
- Compensating for the impact by replacing or providing substitute resources or environments.

In short, mitigation means avoiding or lessening losses through the use of preventative measures, and offsetting losses through the use of other structural and non-structural compensatory measures (Krulitz, 1979). In this section, the term "mitigation" will be used in the general sense as defined in the NEPA Regulations.

MITIGATION CONCEPTS

Historically, the concept of mitigation has been associated almost exclusively with the direct physical destruction of habitat through dredge and/or fill activities. Furthermore, the actual practice of mitigation has been most often applied to dredge and fill activities in wetland habitats to facilitate land and water developments. In this context it is important to note that the order of the actions encompassing mitigation, as defined and intended by the National Environmental Policy Act, indicates their preferred priority of implementation. Avoidance is generally preferred to minimizing impacts while compensation should be used only after all other alternatives have been exhausted.

Actions that avoid, minimize, or reduce the adverse impacts of a land or water development usually occur in the planning stages of a project or are the product of an alternative plan. These actions alone may mitigate for the adverse effects resulting from the project. However, because these types of mitigation occur within the early planning stages, they are usually not specifically identified as mitigation. Therefore mitigation, as most commonly used, has come to mean compensation for an unavoidable loss of habitat with the requirement that the same or comparable habitat be recreated elsewhere. Less commonly, mitigation is applied as rectification or the repair of the affected habitat. This application is usually found in after-the-fact court orders to restore an illegally destroyed habitat.

The primary mitigative (or management) approach should be one of preventative conservation, designed to protect an ever-shrinking base of certain habitats and avoid costly man-assisted restoration efforts. It should be founded on preventing adverse, predictable and irreversible trends or changes in aquatic and terrestrial natural systems. The objective is to maintain as much of the existing ecosystems as possible, even if the structure, function and relative importance of these ecosystems are not fully known (Jahn, 1979). The mitigative approach to meet this objective is to pursue feasible and prudent alternatives to a proposed project and/or examine all feasible measures to reduce or counteract adverse impacts associated with that project. Where compensatory action is indicated, it should be of sufficient size and properly designed so as to demonstrably offset the adverse impacts of a proposed project.

Steps in the mitigative approach (evaluation method) should include (compiled from Hall and Vogt, 1979; Rappoport, 1979; Wood and Swift, 1979):

- Preliminary planning, which is often the key to minimizing or avoiding conflicts over development. This includes the early and coordinated involvement of all interests (national, regional and local; public and private) in plan formation and implementation to establish a team effort.

- Development of a soundly conceived mitigative plan to satisfy legitimate human needs and/or desires while maximizing fish and wildlife habitat values. This plan must be verified as technically sound and objective; data generated must be documented, replicable and compatible in detail with other elements of the planning process; the plan must be compatible with project design and scheduling, including timing of plan presentation; and the validity of the plan must be accepted by those interests involved.

- The mitigative method(s) developed must be implementable within the planning framework. Perseverance and follow-through is required by the team to ensure plan implementation and operation.

The use of compensatory mitigation should only be considered after all other alternatives of impact avoidance and minimization have been exhausted. If a proposed development will result in unavoidable impacts, then that development should at least meet the following criteria:

- Public Interest - There should be a demonstrated public need for the project, and its expected socio-economic benefit should outweigh foreseeable adverse impacts on fish and wildlife resources

- Water Dependency - The proposed project should absolutely require proximity or access to the aquatic environment in order to be feasible.

Ashe (1980, 1982) has classified previously attempted estuarine mitigation concepts requiring compensation for unavoidable adverse impacts in the United States into the following six categories:

- Increased public access

- Land acquisition

- Single purpose mitigation

- Indemnification or "in-lieu of" payments

- Acquisition and management, and

- Restoration of previously altered resources.

Although increased public access to natural resources has been a priority with urban and regional planners, it is not acceptable as habitat compensation unless mitigating for recreational losses such as loss of a fishing area. This category serves to subsidize only economic and social objectives at the expense of increasingly scarce and valuable wildlife resources (Ashe, 1982).

The acquisition and subsequent preservation of an area to compensate for the loss of another area has been used, although acquisition alone is not usually considered as an adequate form of compensation. Acquisition of habitat may provide mitigation credit if the habitat is vulnerable to development and is considered to be a critical habitat type. In most cases, an applicant relinquishes ownership on one portion of a wetland in return for the right to develop another less sensitive portion of the wetland. The donated area usually becomes a "conservation easement" filed with the county tax assessor, which is transmitted to and held, in public ownership. It should be noted, however, that acquisition alone results in a net loss of wetland habitat when it is proposed as mitigation to compensate for destruction of habitat.

Single purpose mitigation is probably the most common type of mitigation used as compensation. It may involve the creation or restoration of a preferred habitat type (e.g., salt marsh, mangrove, sea grass), or habitat for a key species or group of species, in return for the right to develop a parcel of comparable habitat elsewhere. The habitat is usually restored or created adjacent to the area proposed for destruction. Although this type of mitigation has generally been accepted by the regulatory agencies, its success has often suffered from a lack of a-priori biological objectives as well as a minimum of follow-up monitoring and maintenance of the restored or created habitat area. Furthermore, the creation of small isolated pockets of critical habitat is usually biologically insignificant in light of documented losses of large contiguous tracts.

Indemnification, or "in lieu" payments, involves the placement of monetary value on ecological resources and the exchange of money for the destruction of that resource. The payment is made to a public agency which may use the funds to somehow rebuild or replace the resource. This method of compensation has been used extensively in the past for after-the-fact assessment of fines in enforcement cases. An example was the donation of $50,000 to the Biscayne Bay Restoration and Enhancement Program (managed by Dade County Environmental Resources Management [DERM]) by Quayside, a condominium development in north Biscayne Bay, to dredge for a marina development. The money, in this case, did not replace the habitat lost during marina construction. Environmental interests have criticized this type of mitigation as a way for developers to "buy permits" while development interests have feared the device as a way for agencies to extort large sums of money for development rights. As mitigation requiring a-priori compensation becomes more common, after-the-fact exactions as a form of mitigation will become less acceptable.

Simple acquisition, as previously described, should not be considered by regulatory and/or planning agencies to be a viable form of compensation, but acquisition in conjunction with active management of fish and wildlife habitat within the acquired system has been shown to be a successful means of offsetting project impacts in some cases. However, critics argue that the management component of this compensation method has been consistently inadequate and difficult to enforce over a long period of time (Farmer, 1979; Ashe, 1982). Although management may improve the habitat values of an area, this type of compensation will still result in a net loss of habitat acreage for a select cover type.

The restoration of previously disturbed habitat as compensation for the development of another comparable habitat area is probably the second most common type of mitigation and has been permitted in a number of cases. Restoration measures usually involve the removal of spoil mounds within wetlands, restoration of tidal flow to isolated wetlands and planting wetland species on regraded intertidal slopes. One major advantage to this type of mitigation is that the area to be restored is often contiguous with larger tracts of similar habitat types which aids in species recolonization once the pre-existing topographic and hydrological regimes have been recreated. It should, however, be noted that unless the area to be functionally restored is at least as large as the area to be developed, a net loss of habitat will still result.

In conclusion, the actual practice of mitigation is most often associated with measures which compensate for unavoidable impacts. In the case of estuarine wetlands, the most common measures involve habitat creation and/or restoration through physical or structural means. While such measures have been shown to effectively offset project impacts in many cases, critics contend that the recent proliferation of compensatory mitigation has undermined efforts to avoid or minimize project impacts at the early planning stages, thus giving false credibility to projects which would normally be considered unpermittable. There is a general fear that such an approach could lead to wholesale destruction by substituting natural systems with artificial wetlands of inferior diversity and productivity. The future of compensatory mitigation is, however, clear; there will continue to be a need for it as long as socio-economic pressures for coastal development continue to generate unavoidable impacts on wetland habitats.

EXISTING MITIGATION POLICIES

As discussed previously, the federal government essentially defined mitigation and established a general mitigation policy with the passage of the National Environmental Policy Act of 1969. Since then countless federal, state, regional and local agencies have embraced the concept of mitigation, and have attempted to incorporate it, both formally and informally, into their regulatory frameworks. Few agencies have, however, been able to advance the mitigative process beyond the general, qualitative guidelines contained in NEPA. As a result, over the past fifteen years environmental impact assessment and mitigation have been practiced in an arbitrary and inconsistent manner, both between and within all levels of jurisdiction.

With regard to coastal wetlands, only five states have adopted legislation specifically addressing mitigation and/or restoration. These include California, Louisiana, Maryland, Florida and Oregon (ASWM, 1985). The California Coastal Conservancy was created in 1976 to address problems which could not be readily solved through existing coastal regulations. Its mandate and complimentary bond issues provided the authority and capacity to underwrite the acquisition of land, to design restoration projects, to develop and monitor mitigation projects for coastal developments, and to complete necessary capital improvements. In assessing mitigation requirements for coastal development proposals, the Conservancy takes a site-specific approach, often retaining local experts in wetland ecology, hydrology, engineering and landscape architecture for plan formulation. Although the Conservancy generally requires three acres of wetlands to be restored or created to every one acre impacted, the actual mitigation required for a particular project may be quite variable, both in quantity and quality, depending on site specific conditions and perceived impacts.

Coastal regulatory programs in Florida, Louisiana and Maryland, although quite different from California in terms of legal authority and capacity, are similar in that mitigation requirements are determined qualitatively. Mitigation for projects that are deemed to have unavoidable impacts are often based upon such factors as estimated habitat equivalence or anticipated functional improvement, and tempered by such factors as landownership and applicant cooperation. The State of Louisiana allows great latitude in assessing mitigative measures often requiring hydrologic improvements such as the construction or reconstruction of levees for wetland management purposes. On the other hand, the State of Florida, in an effort to reduce the present degree of subjectivity in assessing mitigation requirements, is currently developing rules which would essentially limit mitigative options to in-kind replacement of habitat cover at a ratio of two acres created or enhanced for every acre lost or impacted.

The subjective nature of assessing coastal impacts and mitigative requirements has led to a high degree of uncertainty on the part of the development community, and has generally fostered the adversarial relationship that often exists between project sponsors and regulators. In an effort to better assess project impacts and mitigative requirements, and to eliminate the perception of inequity on the part of the development community, a few agencies have attempted to develop more quantitative methods for evaluating and mitigating wetland losses.

The U.S. Fish and Wildlife Service (USFWS) formulated its mitigation policy and Habitat Evaluation Procedures (HEP) (USFWS, 1981) to eliminate many sources of dispute by providing an objective system of analysis previously agreed upon by the principal interested parties--including the project sponsor, at least one key state resource agency and one key federal resource agency--each represented on the evaluation team. This attempts to identify and resolve most of the potential conflicts during the evaluation rather than much later during the review process. The HEP analysis consists of the selection of a set of species to represent key features of the project area. Documented relationships between habitat quality and environmental variables are then used to determine a habitat suitability index (HSI) scaled from 0.0 for unsuitable to 1.0 for optimal. The product of HSI and the area of available habitat in the project area then provides a measure of the capability of the project area to support each of the evaluation species. The compensation requirement is the difference in the product computed for existing and future conditions without the project, and existing and future conditions with the project. Alternative project plans and plans to compensate for project losses are evaluated by comparisons between the products of HSI and area as projected for the different options.

Recognizing that not all resources are of equivalent values, the USFWS designated four Resource Categories, each with a specific mitigation goal (Table 33). Resource Category designations are to be made early in the mitigation planning process in coordination with other Federal, State and local agencies. The determination of the Resource Category for a given habitat is based upon the designation criteria which are in turn based on the values of habitat for species designated by the involved agencies, and its rarity and importance on a national and regional level. Resource

Categories 1 and 2 are for habitats that are of high value and irreplaceable or scarce on a national or regional level. The mitigation goals for these categories are to allow no loss of habitat values for Resource Category 1 and no net loss of in-kind habitat value for Resource Category 2. Important Resource Problem areas (IRP), as defined by the various USFWS regions, may be given special consideration and include such areas as floodplains, wetlands, mudflats, vegetated shallows and coral reefs. Other types of areas given special protection are wildlife management areas, hatcheries and refuges.

Table 33. USFWS Resource Categories, designation criteria, and mitigation goals (from USFWS 1981).

Resource Category	Habitat Designation Criteria*	Mitigation Goal
1	High value for evaluation species and unique and irreplaceable	No loss of existing habitat value
2	High value for evaluation species and scarce or becoming scarce	No net loss if in-kind habitat value
3	High to medium value for evaluation species and abundant	No net loss of habitat for value while minimizing loss of in-kind habitat value
4	Medium to low value for evaluation species	Minimize loss of habitat value

* Based on selected species used to characterize the habitat.

Because current HEP methodology has been developed primarily for application to terrestrial and inland aquatic systems, it has not been extensively applied, and is of questionable usefulness in estuarine systems. Because it does not evaluate all values or functions of wetlands (i.e. hydrologic functions) HEP has often been criticized for being too narrow in scope, with the focus being at the species level rather than at the ecosystem level. Furthermore, the actual practice of HEP methodology requires a thorough understanding of the underlying mathematics and theory for it to be applied effectively. Because of this, it is often considered to be too cumbersome for everyday use by untrained field personnel and wetland regulators. HEP is probably most useful when applied to special endangered species or critical habitat studies rather than as a general tool for wetland impact and mitigation assessment.

Perhaps the most innovative mitigation policy advanced to date is that currently implemented in the State of Oregon. Oregon Statute 541.626 requires mitigation as a condition for all dredge and fill proposals within the estuaries of the state. The Division of State Lands administers the mitigation program with a defined purpose of "maintaining the functional characteristics and processes of the reference estuary--including biological productivity, habitat and species diversity and water quality--when intertidal or sub-tidal resources are destroyed by dredge and fill activities."

In the formulation of rules, habitat types found in Oregon estuaries were evaluated and compared in terms of natural biological productivity and species diversity. The result of this evaluation is a set of relative values which are used to determine how much area of one habitat is needed to mitigate one acre of another habitat lost to dredging or filling. The base relative values range from 1.0 to 6.0 (see Figure 108) and may be adjusted by up to 25 percent depending upon unique site-specific conditions. The actual area required for mitigation is determined by dividing the adjusted relative value of the development site by the adjusted relative value of the mitigation site, and multiplying this quotient by the area of the development site. In addition, mitigation credits attributable to any created or restored habitat may be obtained by multiplying the adjusted relative value of the created or restored habitat by the number of acres affected, providing the action occurs anywhere within the same estuary as proposed dredging or filling. Although in-kind replacement is generally encouraged, the policy is flexible enough to allow for alternatives which will most benefit the particular affected estuary.

The ability of the Oregon policy to equalize habitat gains and losses has not been adequately tested because the program has only been in existence since 1984. Critics argue that, with any ranking system, personal bias is introduced into the relative values assigned to various habitat types. Furthermore, the time required for created wetlands to achieve functional equivalence with natural systems is extremely variable, and often not known. However, regardless of these deficiencies, the Oregon process is far superior to other mitigation policies currently being implemented

Figure 108

RELATIVE VALUES[1] OF SELECTED ESTUARINE HABITAT TYPES

OREGON ESTUARIES (EXCEPT THE COLUMBIA RIVER)

Generalized Substrate Characteristics	Subtidal Habitats: Unvegetated	Subtidal Habitats: Algae	Subtidal Habitats: Seagrasses	Intertidal Habitats: Unvegetated	Intertidal Habitats: Algae	Intertidal Habitats: Seagrasses	Intertidal Habitats: Low Marsh	Intertidal Habitats: High Marsh	Intertidal Habitats: Forested Wetland	Salinity Regime[2]
ROCKY - BEDROCK (Max. Grain Size >256 mm)	1.0	2.0	▬	1.0	2.0	▬	▬	▬	▬	FRESH
	2.0	3.0	▬	2.0	3.0	▬	▬	▬	▬	BRACKISH
	2.0	3.0	▬	2.0	3.0	▬	▬	▬	▬	MARINE
COBBLE - GRAVEL (Grain Sizes From 1.0mm to 256 mm)	1.0	2.0	4.0	1.0	2.0	4.0	4.0	3.0	3.0	FRESH
	2.0	3.0	6.0	2.0	3.0	6.0	5.0	4.0	▬	BRACKISH
	2.0	3.0	6.0	2.0	3.0	6.0	5.0	4.0	▬	MARINE
SAND (75% Grain Sizes From 0.0625mm to 1.0mm)	2.0	3.0	4.0	2.0	3.0	4.0	4.0	3.0	3.0	FRESH
	3.0	4.0	6.0	3.0	4.0	6.0	5.0	4.0	▬	BRACKISH
	3.0	4.0	6.0	3.0	4.0	6.0	5.0	4.0	▬	MARINE
SANDY - MUD	2.0	3.0	4.0	2.0	3.0	4.0	4.0	3.0	2.0	FRESH
	3.0	4.0	6.0	3.0	4.0	6.0	5.0	4.0	▬	BRACKISH
	3.0	4.0	6.0	3.0	4.0	6.0	5.0	4.0	▬	MARINE
MUD (75% Grain Sizes <0.0625 mm)	2.0	3.0	4.0	2.0	3.0	4.0	4.0	3.0	3.0	FRESH
	3.0	4.0	6.0	3.0	4.0	6.0	5.0	4.0	▬	BRACKISH
	3.0	4.0	6.0	3.0	4.0	6.0	5.0	4.0	▬	MARINE

COLUMBIA RIVER ESTUARY

Generalized Substrate Characteristics	Subtidal Habitats: Flats	Intertidal Habitats: Flats	Intertidal Habitats: Low Marsh	Intertidal Habitats: High Marsh	Intertidal Habitats: Shrub-Forested Swamp	Salinity Regime[2]
SAND 0.0625mm to 1.0mm	3.0	3.0	3.0	1.0	3.0	FRESH
	3.0	4.0	5.0	3.0	3.0	BRACKISH
	3.0	3.0	1.0	▬	▬	MARINE
SANDY - MUD	3.0	3.0	3.0	1.0	3.0	FRESH
	3.0	4.0	5.0	3.0	3.0	BRACKISH
	3.0	6.0	1.0	▬	▬	MARINE
MUD <0.0625 mm	3.0	3.0	3.0	1.0	3.0	FRESH
	3.0	4.0	5.0	3.0	3.0	BRACKISH
	3.0	6.0	1.0	▬	▬	MARINE

1/ RELATIVE VALUES ARE BASED ON NATURAL BIOLOGICAL PRODUCTIVITY AND SPECIES DIVERSITY OF SPECIFIC HABITAT TYPES. A "▬" MEANS THE HABITAT TYPE PROBABLY DOES NOT EXIST.

2/ FRESH WATER SALINITY RANGE IS 0 ‰ TO 0.5 ‰. BRACKISH WATER SALINITY RANGE IS 0.5 ‰ TO 25 ‰. MARINE WATER SALINITY RANGE IS 20 ‰ TO 35 ‰.

nationwide. On the one hand, it provides an objective, quantitative means of assessing mitigation requirements which is straightforward and easily grasped by field personnel, while on the other hand it allows for considerable flexibility in designing the type of mitigation which would best benefit the affected system.

RECOMMENDED MITIGATION POLICY

The objective of any recommended mitigation policy for the Tampa Bay Region should be to maintain as much of the existing estuarine wetland habitats as is feasible, while avoiding or minimizing costly man-assisted efforts through sound preliminary planning. Where impacts on estuarine habitats are unavoidable, habitat creation or restoration should be required in a systematic manner that will ultimately lead to an incremental net increase in those habitats affected. The ideal mitigation policy should include the following elements:

- The method for assessing mitigation requirements should be objective, quantitative and easily implemented by field personnel
- The policy should be flexible enough to allow a range of mitigative options to best suit the site-specific conditions, and
- The policy should contain a feedback mechanism through monitoring and evaluation to allow for fine tuning over time.

Because the State of Oregon mitigation policy essentially meets the above requirements, it is a most suitable model for the Tampa Bay Region. The recommended mitigation policy that follows is closely modeled after the Oregon scheme but has been specifically modified for use and implementation in the Tampa Bay Region.

(1) Mitigation shall be defined as the creation, restoration or enhancement of a marine or estuarine wetland habitat to offset adverse impacts resulting from dredge and/or fill activities and to maintain the functional characteristics and processes of the estuary, such as its natural biological productivity, habitats and species diversity, unique features, and water quality.

(2) No mitigation proposal may be inconsistent with an adopted comprehensive land use plan or other implementing ordinances for the area where the dredge/fill activity will occur or where the mitigative action is located.

(3) Mitigation must occur within the same estuarine system or subsystem as the proposed dredge/fill activity, except where it can be clearly demonstrated that a particular mitigative action would be more beneficial elsewhere, pursuant to section (1) above.

(4) Mitigation shall restore or enhance estuarine lands and resources in an area proportionate to the area affected by the proposed dredge or fill activity. The area affected shall include the actual area where material is removed or filled and any

surrounding intertidal or subtidal area adversely affected by the activity. At minimum, the mitigation action shall offset the adverse impacts of the intertidal or subtidal dredge/fill activity.

(5) Mitigation shall "maintain" (replace) the natural biological productivity and species diversity of the intertidal removal-fill site by creation, restoration or enhancement of an appropriate area of another estuarine habitat site. Any shallow subtidal or intertidal estuarine habitat may be used to "replace" the habitat lost to dredge/fill, but the area will be proportionate to the RELATIVE VALUE of the habitats involved. The surface area of a mitigation site may not be smaller than the surface area of the development site.

(6) Habitat types found in Florida estuaries have been evaluated and compared in terms of natural biological productivity and species diversity. The result of this evaluation is a set of RELATIVE VALUES which can be used to determine how much area of one habitat is needed to mitigate each acre of another habitat lost to dredge/fill. Figure 109 shows a matrix of habitat characteristics and RELATIVE VALUES for habitats found in Florida estuaries.

(a) The base RELATIVE VALUES for estuarine habitats shall range from 1.0 to 5.0.

(b) The RELATIVE VALUE of any habitat type may be adjusted if site conditions and characteristics such as very low or exceptionally high resource values warrant such adjustment. Such adjustment may not exceed 25 percent of the base RELATIVE VALUE in either direction.

(7) The equation for determining how much intertidal area is required for mitigation shall be:

AM = 2.0 (RVD/RVm) (AD) where:

AM = Area of mitigation site
RVd = Adjusted RELATIVE VALUES of the development site
RVm = Adjusted RELATIVE VALUE of the mitigation site
AD = Area of development site

(8) The equation for determining how much shallow subtidal area is required for mitigation shall be:

AM = 3.0 (RVd/RVm) (AD)

Figure 109

ESTUARINE HABITAT CLASSIFICATION SYSTEM				SYSTEM DESCRIPTOR	EXAMPLE SPECIES	RELATIVE VALUE
ESTUARINE	SUBTIDAL	HARDBOTTOM	BEDROCK	Live Bottoms	_Leptogorgia, Cliona_	5.0
			RUBBLE	Artificial Reefs	_Archosargus_	2.0
			MOLLUSK	Oyster Bars	_Crassostrea_	3.0
		UNCONSOLIDATED BOTTOM	SAND	Course Sediments	_Mercenaria_	1.5
			MUD	Fine Sediments	_Nereis_	1.0
		AQUATIC BED	ALGAL	Algal Beds	_Caulerpa, Cladophora_	2.5
			ROOTED VASCULAR	Seagrass Beds	_Thalassia, Syringodium_	5.0
	INTERTIDAL	HARD SHORE	BEDROCK	Rocky Shore	_Enteromorpha_	1.0
			RUBBLE	Rip-Rap	_Chthalamus_	2.0
		UNCONSOLIDATED SHORE	SAND	Sand Beaches	_Uca_	3.0
			MUD	Mud Flats	_Capitella_	3.5
		EMERGENT WETLAND	LOW MARSH	Salt Marsh	_Juncus, Spartina_	4.5
			HIGH MARSH	Salt Barrens	_Salicornia, Sesuvium_	4.0
		FORESTED WETLAND	FRINGE FOREST	Mangrove Fringe	_Avicennia, Laguncularia_	4.5
			OVERWASH FOREST	Mangrove Islands	_Rhizophora_	5.0

NOTE: If shallow subtidal habitats are offered as mitigation, the required surface area is larger than the size of the surface area required if an intertidal area of equal RELATIVE VALUE is offered. The surface area of the mitigation site (AM) may not be smaller than the surface area of the development site (AD). Figure 110 shows the relationship between the adjusted RELATIVE VALUES of the development and mitigation sites and the ratio of the Mitigation Area to the Development Area (AM/AD) when the habitat replacement occurs pursuant to section (7) and (8) above.

(9) The MITIGATION CREDITS attributable to any restored or enhanced habitat may be obtained as follows:

(a) Obtain the base RELATIVE VALUE of the existing habitat from Figure 109 and adjust appropriately, based upon the degree of degradation or dysfunction

(b) Estimate or otherwise determine what the adjusted RELATIVE VALUE of the affected habitat will be after mitigation occurs

(c) Subtract (a) from (b) to obtain enhancement RELATIVE VALUE, and

(d) Multiply the enhancement RELATIVE VALUE (c) times the number of acres restored or enhanced.

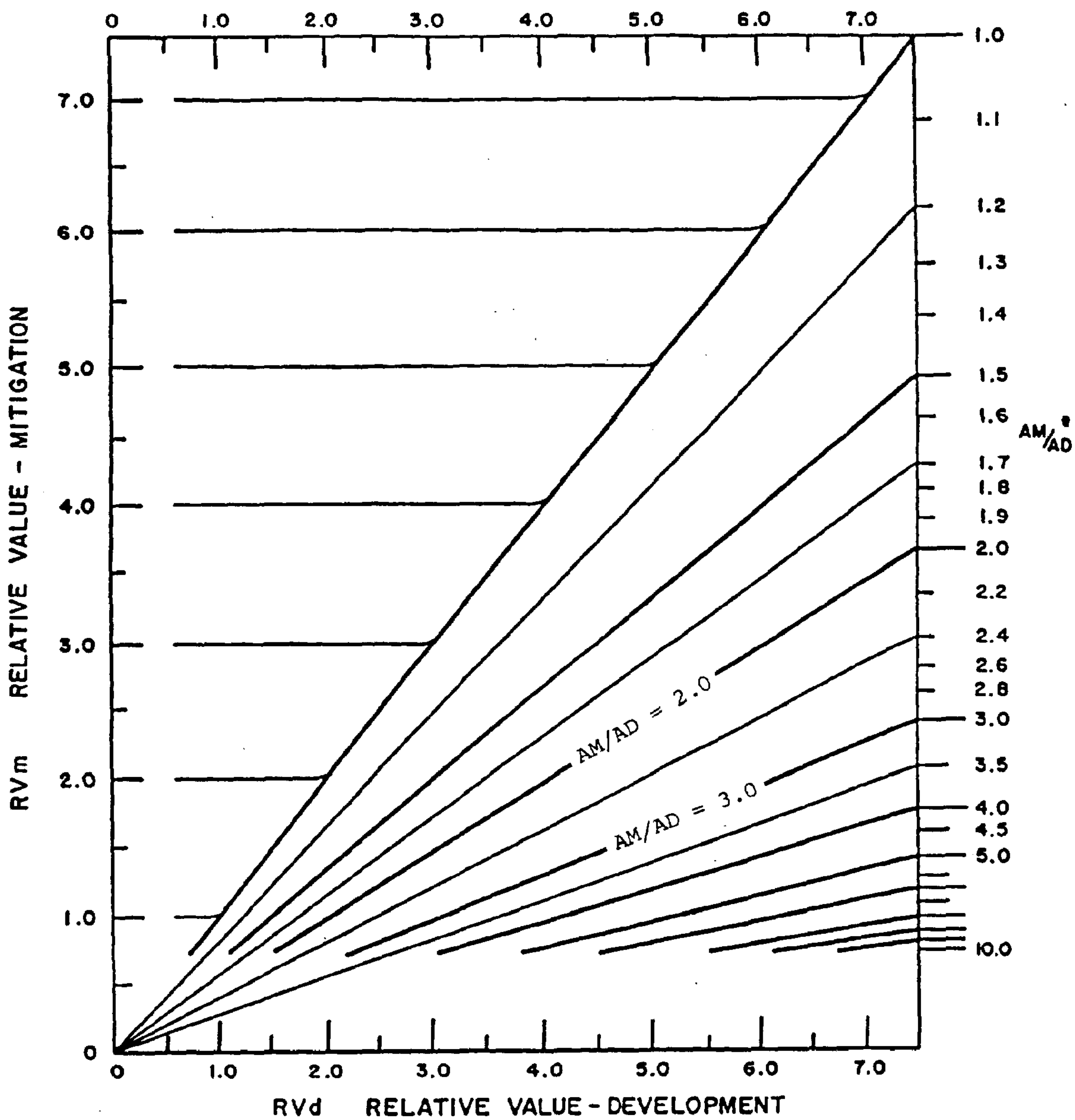
(10) In-kind habitat creation or restoration shall be encouraged wherever possible except where it can be clearly demonstrated that an alternative habitat type, or a variety of habitat types, would be more beneficial pursuant to section (1) above.

(11) Estuarine habitat creation or restoration projects contiguous with existing habitat stands shall be encouraged wherever possible in lieu of projects which result in isolated stands.

(12) Mitigation shall maintain "water quality" through enhancement of physical, chemical, and biological characteristics of the waters at and near the site. A mitigation proposal that produces an identifiable enhancement in estuarine water quality may be used to offset a portion of the resource losses of an intertidal removal-fill activity provided that the mitigation proposal also includes habitat replacement under sections (7) and (8) above in an amount at least equal to the area affected by the intertidal removal and fill. A mitigative proposal claiming water quality enhancement as a mitigative action shall describe the action in detail and explain why and how the project will enhance water quality. The proposal shall identify the nature and areal extent of habitats affected by the water quality enhancements. If it is determined that the water quality enhancement proposal will significantly enhance water quality, mitigation credits may be

Figure 110

MITIGATION MODEL



determined as provided in section (9) above. A water quality enhancement activity mandated by a state or federal agency to raise water quality to state or federal standards is not mitigation under this section.

(14) Mitigation sites and activities need not be fully developed biologically at the time of acceptance, but there must be a high probability of success associated with the proposed action. There shall be no penalty assessed for a mitigative action that takes time to produce the anticipated resources and habitats.

(15) Performance Bonding in an amount sufficient to cover the costs of site acquisition and any necessary physical alternations may be required. The need for bonding will be considered carefully in cases where mitigation actions will be taken after the development project, or in cases where the results of the mitigation action will not occur for several years.

NOTE: Late-maturing projects are not as acceptable as those where good results may be anticipated in one or two years.

(16) Monitoring of a mitigative action to determine performance over time may be required, especially when results are not anticipated immediately. Ordinarily, monitoring will consist of annual site inspections over a five-year period to determine whether predicted ecosystem changes have occurred as anticipated. Typically the parameters sampled will include but not be limited to: vegetation (cover, height, and biomass), animal use (diversity, numbers, age structure, and biomass), sediment characteristics and soil elevation. Comparisons of functions with adjacent natural systems should also be developed if comparable systems exist in the mitigation area.

(17) Funding for research in cases where the ramifications of a given mitigation action are uncertain may be required. Such requirement shall be set out in detail in any relevant permits.

(18) Dedication of a perpetual conservation easement shall be required for all estuarine habitat created or restored pursuant to section (1) above, which is greater than or equal to 0.1 acres in area.

(19) Activities which do not require mitigation even though they may involve intertidal removal include:

(a) Maintenance dredging--provided that the applicant can show that the site has been dredged before and is part of a regularly used project. First time dredging activities that remove intertidal or subtidal lands to obtain water depth will require mitigation.

(b) Aggregate mining--provided that the site has been used historically for aggregate removal on a periodic bases (i.e., shell pits).

(20) Examples of activities which would not be considered mitigative under this policy include:

(a) The transfer of private intertidal or subtidal estuarine lands to public ownership

(b) The dedication of intertidal or subtidal estuarine lands for conservation purposes

(c) Cash payment to a mitigation bank or trust fund

(d) Large scale piling, dolphin or rubble removal unless associated habitats would be enhanced by the removal through increased circulation

(e) Ecological research or monitoring.

(21) Examples of areas and activities considered suitable for restoration and enhancement activities include:

(a) Areas where poor water quality, or similar degradation, limits fish and shellfish production and harvest or human recreation

(b) Dredge spoil islands which could be lowered to create or restore intertidal surface area.

(c) Tidal flat or salt barren areas suitable for restoration or revegetation

(d) Areas where circulation or flushing can be restored or enhanced by breaching dikes or roadfills or removing pile groups or structures, and

(e) Deep borrow areas which could be filled to create more productive subtidal or intertidal habitat.

The above mitigation policy has been developed and proposed for use by agency personnel involved in the management of estuarine habitat in the Tampa Bay Region, and in the State of Florida.

The procedures described here are suitable for estimating the mitigation liabilities and credits of a proposed intertidal or subtidal dredge/fill project and the attendant mitigative action. In most cases, these guidelines will produce a mitigation proposal acceptable to agency personnel and interested parties. However, estuarine habitats are complex, diverse and dynamic, and the particular circumstances of any given project may require unique mitigative actions which fall outside the scope of this policy.

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