U.S. VIRGIN ISLANDS

ST.THOMAS

# MANDAHL BAY

## AREA OF PARTICULAR CONCERN (APC)

and

## AREA FOR PRESERVATION AND RESTORATION (APR)

*DRAFT MANAGEMENT PLAN*

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PREPARED FOR:

**VIRGIN ISLANDS DEPARTMENT OF PLANNING AND NATURAL RESOURCES**
**DIVISION OF COASTAL ZONE MANAGEMENT**

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PREPARED BY:

**ISLAND RESOURCES FOUNDATION**

With Cooperative Assistance From
**THE UNIVERSITY OF THE VIRGIN ISLANDS**
**Eastern Caribbean Center**

# MANDAHL BAY
# APC/APR DRAFT MANAGEMENT PLAN

## TABLE OF CONTENTS

## LIST OF KEY ACRONYMS

| | |
|---|---|
| Area of Particular Concern | APC |
| Base Flood Elevation | BFE |
| Coastal Barriers Resource System | CBRS |
| Coastal Zone Management Act | CZMA |
| Department of Housing, Parks, and Recreation | DHPR |
| Department of Planning and Natural Resources | DPNR |
| Department of Public Works | DPW |
| Division of Archeology and Historic Preservation | DAHP |
| Division of Coastal Zone Management | DCZM |
| Division of Environmental Enforcement | DEE |
| Division of Environmental Protection | DEP |
| Division of Fish and Wildlife | DFW |
| Federal Emergency Management Agency | FEMA |
| Mean High Water | MHW |
| Mean Low Water | MLW |
| Million Gallons Per Day | MGD |
| National Flood Insurance Program | NFIP |
| Significant Natural Area | SNA |
| Territorial Pollutant Discharge Elimination System | TPDES |
| U.S. Army Corps of Engineers | USACOE |
| U.S. Coast Guard | USCG |
| U.S. Department of Agriculture | USDA |
| U.S. Environmental Protection Agency | USEPA |
| U.S. Fish and Wildlife Service | USFWS |
| U.S. Geological Survey | USGS |

## LIST OF FIGURES

# 1. INTRODUCTION

## 1.1 General

The Mandahl Bay (see NOTE 1) and salt pond, located on the Great North Side of St. Thomas between Lovenlund and Tutu Bays (Figures 1 and 2), was nominated as an Area of Particular Concern (APC) and Area for Preservation and Restoration (APR) by the Virgin Islands Government in 1979. This action was taken in accordance with the national Coastal Zone Management Act (CZMA) which notes that while all coastal areas are important, certain areas are of greater significance than others and so have special management needs. These more significant areas are classified as Areas of Particular Concern (APCs) and/or Areas for Preservation and Restoration (APRs), and may include one or more of the following:

- Significant Natural Areas
- Culturally Important Areas
- Recreation Areas
- Prime Industrial and Commercial Areas
- Developed Areas
- Hazard Areas
- Mineral Resources

APC management requires knowledge of an area's historical development and traditional uses, and an action-oriented plan for the area's future utilization. This management plan is intended to serve as the overall planning and management framework within which the various regulatory entities carry out their respective decision-making authorities.

The APC planning effort recognizes that permit decision-making is most often reactive; that is, the decision to approve or disapprove a proposed development is made in response to a permit request, not in advance of it. The general goal of developing an APC management framework is to be able to make *a priori* decisions about the allowable extent of modification of an entire landscape unit. In other words, to raise the level of decision-making from the site-specific to that of natural landscape units and the maintenance of a wide array of interactive resource uses.

## 1.2 Relationship to Other Plans and Regulations

The Mandahl Bay APC Management Plan was prepared under the authority of the Coastal Zone Management Commission. The Management Plan is intended to serve as the overall planning and management framework within which the various planning and regulatory entities carry out their respective authorities. It is intended that the policy framework proposed herein will be incorporated into the policies and review criteria of those entities, including, but not limited to, the Department of Planning and Natural Resources, the Port Authority, the Water and Power Authority, the Department of Public Works, the Department of Housing, Parks,

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*NOTE 1: The Department of Planning and Natural Resources' Coastal Zone Management Program maps indicating the boundaries of the Mandahl APC/APR follow previous U.S. Geological Survey maps' spelling of "Mandal", rather than the traditional "Mandahl". Mandal is the legal name, approved by the official geographic place names review board (McGuire, 1925). In "The Virgin Islands Coastal Management Program and Final Environmental Impact Statement" (1979) the more traditional spelling of MANDAHL is used. This report uses the more commonly accepted "Mandahl" version (except where base maps use the alternative spelling) and recognizes that the use of either version is acceptable.*

and Recreation, the Department of Property and Procurement, and the Governor's Office. In essence, therefore, the intent of this Management Plan is for all participating territorial and federal agencies to utilize the broad policy framework to guide planning and permit decisions with respect to their own authorities. For those agencies that issue permits or review and comment on permit applications, the Management Plan does not eliminate or modify the authority of those agencies, but does increase the predictability and timeliness of the permitting process since many of the issues that must be addressed in a specific permit application are already addressed in the Plan.

It should be understood that this Plan does not answer all questions on what can or cannot be done with a specific piece of land. As explained above, the Plan does not usurp the authority of existing regulations, nor does it remove any decision-making responsibility of a local, territorial, or federal agency. The Plan is designed to provide **guidance** to the decision-making process.

The issues surrounding any proposed use or activity within the coastal environment are complex. The decision on such a proposal is therefore rarely based on a simple "right or wrong", or "good or bad" evaluation. Because of this, it is not possible to simply turn to page 16, for example, to find "the right answer" to the question of a specific allowable use. Moreover, a proposed use immediately outside the boundary of the APC planning area may result in significant adverse impacts on the APC, and impair the ability of society to achieve the goals of the APC management framework described herein. It is therefore an error to think that the boundaries of the APC, as described herein, are "absolute" limits to guide decision-making. This Plan contains several different forms of guidance **which all must be considered** to determine what is "right". Both the individual property owner who is considering a specific proposal and the decision-maker who is evaluating the proposal must use all of the guidance of this Plan to achieve balance and sustainable solutions in making final judgement.

### 1.3 Historical Perspective and Overview

Mandahl Bay (and the associated salt pond) is an APC/APR because it contains "significant natural resources," and potential "recreation areas." The area requires special management consideration to halt degradation, and to restore or preserve it in accordance with section 906 of the Virgin Islands CZMA and with the Coastal Land and Water Use Plan (CLWUP).

This particular area has been of special interest since 1964 when a 99-year lease was signed between the Government of the Virgin Islands and the Hans Lollik Development Corporation for the approximately 24-acre plot, #33 Mandahl. The lease agreement was for the Mandahl area's development into a marina-condominium complex to operate in conjunction with a resort development, authorized by the V.I. Legislature, on Hans Lollik.

Major alterations were made to the area, including dredging and filling of the salt pond (from its original 15 acres to its present size of about 7 acres), the construction of two large stone jetties seaward from the northeastern portion of the beach at Mandahl, and the dredging of a meandering channel from the sea (between the two jetties) through the berm to the salt pond. Aerial photographs reveal that the final connection of the Bay and salt pond was made sometime between 1974 and 1978. After this work was completed, the project was abandoned.

New development schemes for the Mandahl Bay and salt pond were presented in 1980 and 1991 (linked with a resort at Hans Lollik), but no further development has yet been approved at Plot 33 Mandahl. In 1991 an applicant was denied a permit to proceed with plans to use Red Hook as a departure marina and staging area to accommodate proposed development at Hans Lollik.

### 1.4 Other Classifications

**Coastal Barrier Resources System**

Mandahl Bay and salt pond are collectively included in the Federal Coastal Barrier Resources System (CBRS) as VI-30 (Figure 3). Because CBRS is extended to a portion of the APC, development projects within the designated CBRS portion cannot receive federal assistance of any kind.

The Federal Coastal Barrier Improvement Act of 1990 established areas in the USVI as part of the Coastal Barrier Resources System. The purpose of the system is threefold:

1. to halt development in low-lying areas subject to natural disasters (i.e., flooding, hurricanes, etc.);
2. to stop wasteful federal expenditures in these areas; and
3. to protect valuable natural resources from being destroyed by unwise economic development.

By law, any kind of federal expenditures (e.g., grants or loans), including federal flood insurance, is prohibited for any development projects within a designated CBRS site. The law does not, however, prevent projects from going forward with private backing. Certain exemptions are included for park lands, recreational areas, public recreation infrastructure, and land acquisition. Federal funds can be used under certain circumstances with U.S. Fish and Wildlife Service approval.

**Territorial Park System**

The 1991 Territorial Park System Planning Project, commissioned by the Virgin Islands Department of Planning and Natural Resources (DPNR), found Mandahl Bay and salt pond suitable and desirable as a potential park site in the Virgin Islands Territorial Park System (VITPS). The area was identified as site T-11 during the project (IRF, 1991). No subsequent action has been taken by the Virgin Islands Government to establish the Territorial Park System.

## 2. DESCRIPTION OF THE SITE

### 2.1 APC Boundary

The APC boundary established by the Coastal Zone Management Commission in October, 1991, is described as follows:

> *Beginning at Mandahl Point, the boundary follows the ridgeline in a southerly and then westerly direction to the shoreline on the west side of Mandahl Bay, enclosing the drainage basin of Mandahl Bay; from the shoreline the boundary extends north, passing east of Hans Lollick and Little Hans Lollick Islands to a point on the shelf edge or the three mile limit, (whichever is closer); east along the south edge or three mile limit to a point directly north of Mandahl Point, and then south to Mandahl Point, the point of origin.*

Including the entire drainage area for the Mandahl basin within the APC provides the maximum potential effectiveness for the management plan.

## 2.2 Ownership Summary

**The majority of land within the APC is privately owned, with individual residences predominating. Mandahl Salt Pond and the entire beach front below Mean High Water Line are V.I. Government owned. Approximately 24 acres of land on the east side of the salt pond are presently leased by the V.I. Government to Tamarind Resort Associates, as part of a 99-year lease the Government signed with the Hans Lollik Corporation in 1964.**

## 2.3 Physical Environment

### 2.3.1 Climate

The Mandahl Bay area of St. Thomas receives an average of 35-45 inches of rainfall per year (Figure 4). February and March are normally the driest months, September and October the wettest, with most rainfall coming in brief showers. Heavy rainfall sometimes occurs during the passage of an easterly flowing tropical wave. Occasionally, these waves intensify into tropical depressions, tropical storms, or hurricanes.

The Virgin Islands experience the easterly flow of the trade winds. At this latitude (about 18 degrees N), the temperatures range from the mid to high 70s at night to the mid 80s in the heat of the day. Summer months are somewhat warmer due to cessation of the tradewinds.

During the summer, the wind tends to be from a more southeasterly direction, and from a more northeasterly direction during the winter. The prevailing wind direction during the winter months can cause heavy northerly sea swells to strike unprotected portions of the north shore of St. Thomas. At Mandahl Bay, the heavier northerly swells increase the surf at the beach to the extent that boat operation from the Bay into the salt pond through the channel can be unsafe.

### 2.3.2 Geological setting

The Mandahl Bay basin is underlain by the Tutu Formation, a thick series of wackes estimated to be of early Cretaceous Age (about 98 to 110 million years ago) (Donnelly and Whetten, 1967). The shape of the Bay and salt pond complex is primarily influenced by a northwest-southeast trending dextral fault system which runs through the basin.

**Soils and Sand**

Several main soil types are found within the Mandahl Bay APC/APR (Figure 5). Jaucas Beach Sand (JuB), a well-drained and highly permeable carbonate sand of marine origin, is found around the back beach area at Mandahl Bay. The beach area where this sand is found is flanked by headlands of exposed volcanic rock of the Tutu Formation (Vr) and much of the intertidal zone of the beach proper is underlain by beachrock. The floodplain surrounding the salt pond is comprised of San Anton soils (SaC). These are well-drained, rocky clay loam soils typical of alluvial floodplain deposits in the Virgin Islands. Soils of the watershed are predominantly of the Cramer series (CrF and CrE) consisting of gravelly clay loam overlying bedrock. These soils are characteristic of moderate to steeply sloped areas and are highly susceptible to erosion if the plant cover is removed and the soil exposed to the elements.

Inshore sediments in the vicinity of Mandahl Bay are carbonate sand. The channel is overlain by coarse, clean carbonate sand, while the salt pond bottom is predominantly clay-silt derived from eroded upland soil.

### 2.3.3 Hydrological setting

The overall land and salt pond area of the APC/APR, excluding any sea area, is over 150 acres. Of that amount, approximately 105 acres is "upland" area, 40 acres is fill, floodplain, and beach, and about 7 acres is the modified (reduced from 15 acres) salt pond itself.

The U.S. Geological Survey has identified two unused wells (10-1 and 10-2) within the Mandahl Bay watershed (Figure 6). Well 10-2, located on the floodplain at the eastern edge of the salt pond, was the only well tested for water quality. Test results proved the water quality to be poor, with high saline content.

### 2.3.4 Coastal Environment and Benthic Communities

Leeward of the southern jetty (Figure 11) the bottom is strewn with boulders of less than two feet in diameter. The boulder zone extends at least 300 feet from the small jetty and contains remnants from the first two attempts to build permanent jetties to protect the harbor. The first jetties were built with stone that was much too small to withstand the force of storm waves that affect the area; the structures were destroyed by natural forces.

In the southwestern part of Mandahl Bay at depths of 10 to 15 feet, the bottom consists primarily of carbonate pavement overlain with some turf algae and a loose layer of sand. The sea bottom at this end of the Bay is devoid of hard and soft corals and most other sessile organisms. The scarcity of sessile organisms may be caused by the lack of exposed hard substrate for larval attachment. The sand, although shallow in depth, may prevent juvenile-stage settlement. This part of the Bay is directly exposed to heavy winter ground swells from the north which may also contribute to the low recruitment of benthic organisms in the area.

In contrast to the western portion of the Bay, the carbonate platform in the northeastern part of the Bay contains a rich and diverse community similar to that described in McCrain (1982) and McComb (1980). This region of the Bay contains soft coral, patch reefs, and an abundance of reef-associated marine life.

The large (northern) jetty, made of rocks of more than 1 meter in diameter (10 and 20 ton rocks), provides numerous sheltered crevices for reclusive fish species like grunts, snappers, puffer fish, moray eels, surgeon fish, parrot fish, and goatfish.

The jetty rocks provide substrate for a diverse benthic community of corals, zooanthids, anemones, and algae. Colonies of *Acropora palmata* are located on the exposed northern side of the large jetty and extend landward along the inner part of the jetty about 50 feet. Other species of hard coral, including *Millepora alcicornis, Diploria clivosa*, and *Siderastrea radians*, extend further landward along the inner portion of the large jetty.

The benthic community of the small jetty is not as diverse as that on the northern side. No hard or soft corals are present. The rocks are primarily covered with turf algae. Anemones were common, including *Stichodactyla helianthus* and *Actinoporus elegans*. Barnacles inhabit a narrow intertidal zone on rocks throughout the channel and schools of juvenile surgeon fish, parrot fish, and goatfish are present near the jetty.

The surface substrate of the outer, middle, and inner channel passage is clean carbonate sand. The bottom is mostly covered with filamentous algae and is punctuated by numerous mounds from burrowing organisms. The sand becomes progressively finer as one moves easterly towards the entrance channel of the salt pond, with increasing amounts of decomposing material beneath the surface sand layer. On an August 3, 1992, site visit, the water in the

outer channel was clear but became increasingly turbid landward, with horizontal visibility of less than 5 feet in the middle- and inner-channels.

The lagoon-like pond, a much modified remnant of the original (pre-1974) salt pond, was dredged to a depth of 10 feet as part of the initial salt pond development scheme. This removed the natural benthic community structure. Dissolved oxygen readings in the salt pond show little variation on a yearly average, but are likely to fluctuate significantly during any one day based on tide, wind, current, and climatic influences (McCrain, 1982).

High levels of turbidity from suspended sediment and algal growth limit light penetration in the salt pond. In 1982, only the spermatophyte *Halophila baillonis* and the filamentous algae *Asparagoperis sp.* were found growing on the mud bottom (McCrain, 1982). During the most recent site visit of August 3, 1992, water clarity at the seaward end of the salt pond was less than 2 feet, decreasing to less than 0.5 feet near the bottom. At a depth of about 10 feet, the bottom was composed of gray mud and there was no evidence of any algae or *Halophila*.

The diurnal and semi-diurnal tidal ranges in the Virgin Islands are small, with a mean range of about 0.8 feet (IRF, 1977). Mandahl Bay experiences a semi-diurnal tide with a range of about 0.9 feet. This tidal range combined with the fairly open configuration of the Bay results in its high flushing capability (Nichols, *et al.*, 1979). The salt pond, however, has a narrow entrance which reduces the tidal flushing and results in periodic problems with algal blooms and turbidity, which can be 3 to 5 times higher in the salt pond than in the Bay.

### 2.4 Terrestrial and Marine Resources

**Terrestrial**

The vegetation around Mandahl Bay is comprised mostly of dry brush, cacti, and small trees. A cactus-woodland forest dominates the upland slopes. The lower floodplains are covered by mostly secondary-growth plants which establish themselves in disturbed areas (McCrain, 1982).

A mangrove lagoon-type environment has developed around the salt pond's edge (Figure 12). Buttonwood (*Conocarpus erecta*), white mangrove (*Laguncularia racemosa*), and red mangrove (*Rhizophora mangle*) have all established themselves in the area. The lack of a black mangrove (*Aviccenia germinans*) population could be due to the relatively young nature of the mangrove zone (established since the salt pond's dredge and fill in the late 1960s and early 1970s). The majority of the trees (75 percent) are young with a diameter at breast height (dbh) of less than 10 cm, substantiating the theory that this mangrove lagoon is in an early or developmental stage. The important roles mangrove lagoons play in providing a "nursery" for young marine organisms, and in their effective action as a sediment trap, make this a very significant development for the Mandahl Salt Pond.

**Birds, Amphibians, Reptiles, and Mammals**

The Mandahl Bay and salt pond are host to a number of bird species for feeding and nesting. Resident species include the Brown Booby (*Sula melanogaster*) and Brown Pelican (*Pelecanus occidentalis*). Little Blue Heron (*Florida caerulea*), Yellow-crowned Night Heron (*Nyctanassa violacea*), and Ground Dove (*Zenaida auritia*), as well as terns, thrashers, and bananaquit all feed or nest in the Mandahl Bay APC (Adams, 1991)

*Iguana iguana* is common at Mandahl Bay, as are other varieties of lizards (i.e., *Anolis spp.* and *Sphaerodactylus macrolepus*). The small frog, *Eluthero dactylus*, may also inhabit the area.

Feral mammals that live in or frequent the Mandahl Bay area include mongoose, rats, and bats.

**Marine**

Benthic communities in Mandahl Bay, the former salt pond and the channel have been described by McComb Engineering (1980).

Living marine resources of the open Bay are abundant. Numerous fish species have been identified in the bay waters, including pelagics like bonito (Euthynnus alleteratus) and other schooling fish. Tidal pools in the intertidal beachrock host small fish and numerous invertebrates including the short-spined sea urchin *Echinometra lucunter*, chitons, limpets, mussels, hermit crabs, and gastropods. Seaward of the beachrock is a region of cemented "pavement" with various species of algae and isolated coral colonies including gorgonians and scleractinian corals like Acropora palmata and several species of mound coral (*Diploria spp.*, *Porites spp.*, and others).

Adams (1991) reports that Hawksbill sea turtles occasionally nest on Mandahl Bay beach. This claim is supported by local residents (personal interviews with residents, August 1992). It is likely that the waters in and around Mandahl Bay also provide refuge for young Green sea turtles (Adams, 1991).

The salt pond provides ideal habitat for juvenile fish and adult schooling fish. Blue and white fry, false prichards, and some species of peacock flounder, gobies, and mullet reside in the "lagoon." These bait fish attract some transient species, such as tarpon, jacks, barracuda, rays, and sharks, that enter the salt pond to feed (Adams, 1991).

## 3. RESOURCE AVAILABILITY and USER CONFLICTS

### 3.0 General Land Use in the APC/APR

The Mandahl Bay area is zoned R-1, low density residential. Most of the area has been subdivided into single-family lots of approximately 1/3 acre, with the exception of Parcel 33. This lot is zoned W-1, waterfront-pleasure (Figure 7).

### 3.1 Principles and Policy Guidelines

As stated in the preliminary Comprehensive Land and Water Use Plan for St. Thomas, the north side of the island is planned mostly as a District No. 2, (low intensity). This reflects the existing character of the area -- scattered lower density residential development and the lack of public facilities and services either existing or planned in the area. In addition, the steep topography and winding roads in the area will make more intensive development very difficult to manage (Strategic Planning Group, 1991).

Mandahl Bay and the associated salt pond and mangrove community have been designated an Area for Preservation and Restoration. Under Section 906 of The Environmental Laws and Regulations of the Virgin Islands, environmental policy for the first tier is to conserve significant natural areas for their contribution to marine productivity and value as habitat for endangered species and other wildlife.

The area is also included in the Coastal Barrier Resources System (Figure 3), approved by the U.S. Congress in legislation which went into effect on November 16, 1990 (Section 1.4). The

Coastal Barrier Resources Act, passed by Congress in 1982 and amended in 1990, recognizes that coastal barriers provide:

1. (A) habitats for migratory birds and other wildlife; and (B) habitats which are essential spawning, nursery, nesting, and feeding areas for commercially and recreationally important species of finfish and shellfish as well as other aquatic organisms such as sea turtles.

The act further states that:

2. coastal barriers contain resources of extraordinary importance which are being irretrievably damaged and lost due to development on, among, and adjacent to, such barriers;

3. coastal barriers serve as natural storm protective buffers and are generally unsuitable for development;

4. certain actions and programs of the Federal Government have subsidized and permitted development on coastal barriers and the result has been the loss of barrier resources, threats to human life, health, and property, and the expenditure of millions of tax dollars each year; and

5. a program of coordinated action by Federal, State, and local governments is critical to the more appropriate use and conservation of coastal barriers.

Mandahl Bay and salt pond have potential for increased public recreational use, especially for residents of St. Thomas' north side. Recent recommendations for a Territorial Park System include Mandahl Bay and salt pond (Section 1.4).

## 3.2 Pollution

### 3.2.1 Water pollution

Water quality is measured through a variety of parameters, including biological oxygen demand (BOD) or the amount of dissolved oxygen in the water; turbidity; phytoplankton primary production; and the amounts and kinds of nutrients and pollutants found in the water. At the Mandahl Bay salt pond, water quality is affected primarily by inputs from stormwater runoff (freshwater with nutrients, sediments from roadbeds, and associated pollutants), and temperature fluctuations that can lead to algal blooms.

Nonpoint source water pollution is generally a temporary phenomenon within the Mandahl Bay watershed. Nonpoint source pollution takes place primarily during times of heavy rain, and occurs due to sediment laden runoff from roadway and construction sites.

Previous water quality monitoring records (circa 1980) show isolated occurrences of fecal coliform bacteria in the salt pond, which most likely came from residential septic tank effluent discharge. Under certain conditions (such as the intense downpours that occur amidst dry periods in the Virgin Islands) the Cramer series soil type becomes quickly saturated, resulting in heavy runoff.

Sediment and contaminants picked up from road surfaces are also carried by storm runoff. The salt pond and surrounding areas (flatlands behind the berm) serve as a sediment trap for accumulated runoff (residents observations, reported August, 1992). While the turbidity and overall water quality of the salt pond decreases drastically with sudden, large influxes of

stormwater runoff, the area buffers the adjoining Bay from the negative impacts of receiving direct runoff. Measurements of turbidity in the Bay reveal very low amounts of sediment (Adams, 1991) supporting the conclusion that the salt pond is serving as an effective settling pond for the removal of these nonpoint source pollutants.

### 3.2.2 Groundwater pollution

The Mandahl Bay watershed is zoned R-1 at present and the dwelling density is low. Much of the groundwater contamination in the Virgin Islands results from a septic loading of the soil when the soils reach their holding capacity. In most instances, a heavy septic loading of the soils is not problematic due to the normally dry conditions and high temperatures which accelerate the evaporation rate and speed the chemical activity involved in the breakdown of the organic compounds. As discussed in Section 3.2.1.2, there is the potential for water contamination in times of heavy rains when the high septic loading of the soil can become a problem.

(See section 3.2.3.2 - Hazardous Waste - for further discussion on ground water pollution.)

### 3.2.3 Land pollution

Informal solid waste disposal, especially at the beach, continues to be a problem within the APC/APR, even though several trash barrels are provided for public use at the beach by area residents. The Department of Public Works is responsible for maintenance of the beach area, but local residents contend that cleanup crews only infrequently visit the area (communication with local residents, 1992).

Mounds of trash and overturned trash barrels are evident around the beach area. Rusted hulks of abandoned cars are scattered in the brush around the salt pond and along the road at the bottom of the basin. A blatant incident of trash dumping on one of the salt pond access roads occurred Friday, July 31, 1992, and was highlighted in a local newspaper article (*Daily News*, August 1, 1992). The relative remoteness and low use of the beach and salt pond area precludes a citizen's community watch group from effectively stopping this type of indiscriminate dumping. The area residents should be commended on their conscientious care of the neighborhood, and this type of community pride should be encouraged. More frequent waste removal assistance needs to come from the government agency responsible for maintaining cleanliness of the site.

Hazardous waste is not normally a problem within the APC. Following the passage of Hurricane Hugo in September of 1989, however, many individuals within the APC/APR used portable generators to provide their homes with electricity (WAPA was unable to provide power to residences in the area until late November, 1989). The heavy use of household generators in the Virgin Islands during the period resulted in an increase in the dumping of waste oil onto the ground. The extent, if any, of petroleum contamination of the groundwater has not been quantified.

The single greatest problem in the Mandahl Bay watershed, as in any developed or partially developed watershed in the Virgin Islands, is the erosion of topsoil by storm runoff waters. It is commonly recognized that soil erosion and downslope sediment deposition from the unpaved roadways and devegetated building lots into the marine environment (both the salt pond and Mandahl Bay) poses a serious threat to coral reefs, grass beds, and coastal waters (Teytaud, 1981).

**Erosion and runoff from roads**

Most of the runoff threat is from the erosion of the steep, unpaved access roads to the beach at Mandahl Bay. These roads are poorly maintained, and erode rapidly during heavy rains. The roads channel runoff from the surrounding hillsides down to the flat valley floor. Aerial photos taken immediately following Hurricane Hugo show a heavily sediment-laden pond and a large sediment plume extending out from it into Mandahl Bay. Much of the sediment in the plume was undoubtedly from such land-based erosion.

**Erosion and runoff from building sites**

The danger of heavy sediment loss from building lots in the Mandahl area is highest during the construction phase due to devegetation, the amount of earth that has to be moved and the steepness of the slopes (average of 35 - 40 degrees in the residential zoned areas (Adams, 1991)). The practice of clear-cutting building lots is a major contributing factor in the area's soil erosion and runoff problems and therefore in any potential, related water pollution in the Bay and salt pond.

### 3.2.4 Air pollution

In the absence of energy intensive industry, large buildings and major roads, air pollution is not a major threat in the Mandahl Bay APC/APR.

### 3.2.5 Noise pollution

Because Mandahl Beach is not heavily used as a public recreation beach, there is little of the noise pollution problem associated with powerful sound systems, such as those commonly used at Vessup Beach, Smith Bay, and Magens Bay beach parties. Jet skis and other noisy power boats are not reported to be a problem in the salt pond or the Bay.

At one time, helicopter noise was a source of contention for the residents of North Side, including within this APC. However, following residents' protests, the helicopters now operate at higher altitudes than before, thereby reducing the noise pollution problem.

## 3.3 Transportation

Land access to Mandahl Bay is via two steep, poorly maintained roads which lead from the paved residential development roads of the Mandahl area. These development roads lead from the Mahogany Run/Mandahl Road (Route 42) in the Mahogany Run valley. A third road runs eastward along the eastern gut that connects Mandahl with Tutu Bay. This is also a source of sediment into Mandahl Salt Pond.

The harbor serves as the mooring site for about ten boats, and is used as a hurricane shelter for many small vessels when necessary. As discussed earlier, plans for further development of the harbor into a full marina have been proposed, but no further action toward that end has taken place.

## 3.4 Development Activities and Trends

### 3.4.0 Ongoing and expected development activity

Although proposals have been submitted for the development of the harbor into a marina and dockominium site on several occasions, except for the initial salt pond dredging and breakwater construction project, and the building of the Bali Hai Hotel (now Mandahl Inn) in

the early 1960s, development activity in the Mandahl Bay watershed has been limited to the construction of residential, single-family homes within the R-1 zoning designation (Figure 10).

A proposal to build a condominium development in the vicinity of the Mandahl Inn was recently submitted to DPNR. (Green and Associates, 1990). The plans were rejected due to technical insufficiencies.

The lease held by the latest team proposing development of a resort on Hans Lollik Island, does present the possibility of expanded marine facilities in the salt pond at some future date.

### 3.4.1 Residential development

The APC, with the exception of Parcel 33, is zoned R-1. There has been a continuous, but not intensive, home building trend in the Mandahl area. The Atlantic Drive subdivision was partitioned into 1/3 acre lots, rather than the traditional 1/2 acre lots that are normal to areas zoned R-1. Apartments are prohibited in this area; the reduced lot size limits all homes within the Atlantic Drive subdivision to single-family only.

Even with the ongoing residential building, the Mandahl Bay APC/APR has a fairly large amount of open space available, mostly all is in private hands, zoned for residential development. Imminent threat to the remaining natural resources would seem remote, if not for the fact that the entire Mandahl Hill section (Parcel 37, comprising some 52 acres) has been purchased and subdivided (Figure 9). A permit application (No. CZT-29-90L) was received by DPNR in October 1992: a proposal to develop a 58-lot subdivision comprised of 0.5-1.6 acre parcels. The application indicates a 5.5 acre parcel at the southeast corner of the pond to be set aside for an unspecified future use. Major concerns with the proposed development stem from the area's steep slopes and soil types not well-suited for septic tank drain field, plus the need to maintain an adequate buffer zone (setback) between the pond and any development to minimize impact on terrestrial and marine resources (Smith, 1991). A 150 foot buffer zone of undisturbed vegetation is recommended to ensure that the pond's sediment filtering capability is not diminished.

Much of the area that is, or may soon be, undergoing residential development is steeply sloped (average slope is 35-40 degrees). Builders in the Mandahl area watershed should make use of proper erosion control practices at building sites with steep slopes in order to minimize soil loss to runoff waters.

### 3.4.2 Commercial development

The Mandahl Bay APC/APR had seen minimal tourism development prior to the mid 1960s. The Inn at Mandahl, originally called the Bali Hai Hotel, was established on the western hill overlooking the Bay and salt pond in the early 1960s. The owner's intent was to provide a quaint, island setting for visitors. It has remained a small, "secluded" inn through several changes in ownership. The present owners have almost completed restoration of the structure, following extensive damage by Hurricane Hugo in September, 1989; as of October 1992, no re-opening date has been set.

Prior to the major alterations that took place at the Bay and salt pond in the late 1960s and early 1970s (these changes are detailed in Sections 1.1 and 2.3)., Mandahl had an integral salt pond of about 15 acres separated from the sea by an approximately 200 foot wide berm with little obvious alteration of the shoreline by any human activities. Remnants of a coconut plantation are visible in back of the berm.

A development proposal in January, 1980, called for the re-dredging of the already restructured pond to allow the construction of a 70-slip marina, and the building of a resort complex, including 340 living units comprised of 120 resort hotel units, 50 resort villas, 90 vacation villas and 70 custom villas, plus staff accommodations for ten persons. The project was presented as part of a joint development proposal that included the development of Hans Lollik Island. The plans were not approved.

On January 5, 1990, an environmental assessment report (EAR) was submitted for Mandahl Bay Villas, a proposed 52-unit, upper-income, residential condominium development. The Villas were proposed to be built below and to the west of the existing "Inn at Mandahl" on 6 parcels, collectively about 15.5 acres. The density was within the R1 zoning allowance of two dwelling-units per half acre, but technicalities involving the merging of lots for the project halted it.

A development proposal was presented in 1990 (Dobin and Associates, 1990) which initially investigated the co-development of Hans Lollik and Mandahl Bay. An updated, more detailed version of the development proposal was presented in July, 1991, which replaced Mandahl Bay with Red Hook as a staging area.

### 3.4.3 Non-commercial recreation development

Non-commercial recreation development at the beach has been limited to the placement of picnic benches at several sites around the beach. Trash cans are also in place at the beach, despite some confusion as to who is responsible for emptying them.

The jetty/breakwater is commonly used as a line-fishing spot. When the seas are relatively calm, the waters around the jetty provide for excellent snorkeling. Some spear fishing and SCUBA diving also occur in the Bay. The few boats moored in the salt pond are essentially the only recreational boaters that frequent these waters.

### 3.4.4 Infrastructure development

In the Mandahl Bay APC/APR, the infrastructure development consists of rugged, infrequently maintained gravel roads, a cemented private development road (Atlantic Drive), and electrical power and telephone distribution to the homes there.

## 3.5 Educational Use and Potential

The Mandahl Bay and salt pond are recognized and used for natural resource education by some area teachers and students (high schools and the University). The area offers a diversity of natural habitats ranging from scattered coral heads in the Bay, beach rock tidal pools at the shore, and the "natural" lagoonal habitat of the altered salt pond.

## 3.6 Natural Hazards

The salt pond area and low lands surrounding it are prone to flooding during periods of heavy rainfall and would be inundated during a storm-generated surge. (Figure 8.) Area residents reported that standing water can remain on the lower road area for more than a week following heavy rains.

## 3.7 Wetlands

Mandahl Salt Pond used to be a shallow saline enclosure influenced predominantly by runoff from neighboring upland areas, precipitation, and evaporation. It is now a

brackish lagoon up to 10 feet in depth under tidal influence, as well as the fresh water inputs from terrestrial runoff and precipitation.

The opening of the salt pond to the sea has only minimally impaired the salt pond's function as a sediment trap, failing in extreme rain and runoff conditions like those created by Hurricane Hugo in 1989.

The original salt pond bottom consisted primarily of silt and clay. Dredging removed or disturbed much of that bottom around the floodplain, some of which gets washed back into the salt pond and Mandahl Bay during rainy periods. The changes in the salt pond's depth, flushing action by tidal influences, and varying nutrient levels within the salt pond waters have altered the floral, faunal, and benthic communities that exist there.

Despite the disruption, Mandahl Salt Pond has a prolific wildlife community and appears to be healthy. Of noteworthy mention, however, was the siting of three dead brown pelicans near the salt pond during a July 9, 1992, reconnaissance trip to the area. (The cause of death could not be determined without autopsy). The salt pond's faunal community consists of both permanent and transient species (see Section 2.3 for a more detailed discussion of wetland flora and fauna).

The ecosystem is undergoing a transition after being artificially altered from a pond to a lagoon (from a relatively low-energy, closed system to a higher-energy open system). This is evidenced by the introduction of red mangrove (which does not normally occur at salt ponds within the Virgin Islands), white mangrove, and buttonwood. In addition to opening and dredging the salt pond, the jetties have also affected the area's wetlands and shoreline. Their construction has made net sand migration to/from the beach negative, so that presently, except for a small portion just west of the jetties, the wading areas and shoreline are devoid of sand. The shoreline consists of beachrock and coral rubble, and presents a far less attractive and less useful recreational beach than residents remember from a decade ago.

The alterations to the coastal system were done as part of a marina development plan. The plan has temporarily been halted. Still, there is the threat to the wetlands from residential development. Development is likely to increase the sediment input to the salt pond as a result of erosion on the steep slopes. The relatively thin soils of the uplands allow for little absorption of rain water that carries nutrients and pollutants from surrounding areas into the salt pond.

# 4. MANAGEMENT RECOMMENDATIONS

## 4.1 Pollution

### 4.1.1 Water Pollution

DPNR water quality monitoring data indicate that, infrequently, water quality within the salt pond deteriorates. This usually occurs during storm periods when runoff from heavy rainfall carries debris, sediment, and possibly fecal coliform from septic systems into the salt pond. Efforts should be made to minimize water pollution within the Mandahl Bay area, especially as residential building density increases:

*Inspections should be made of the septic tank and leach pit systems used by the homeowners, with the possible outcome that as the housing density increases in the watershed, the homeowners will have to use technologically better solid waste/waste water disposal systems.*

*Septic systems should be prohibited on slopes over 40 percent and on slopes of 20-40 percent septic-system applicants should be subject to on-site soil investigations, including percolation tests; proof of meeting territorial and federal environmental sanitation, health and water regulations; scientific or engineering documentation stating that there is sufficient area available for the system's operation; and, CZM Committee determination of the systems' acceptability (Teytaud, 1981).*

*Economic or tax incentives should be used to encourage homeowners to use alternative wastewater treatment systems, such as low-flush toilets, composting toilets or incineration systems, instead of septic systems.*

*The salt pond area should not be further developed into a marina. Occasional, low-density boat mooring within the basin is acceptable. Except its possible development as a harbor of refuge or hurricane shelter for boats more moorings should not be encouraged.*

### 4.1.2 Groundwater pollution

Although groundwater is not actively used as a resource within the APC/APR, there is potential to develop it in the future. However, contamination of the groundwater can be hazardous to residents and visitors by increasing the likelihood of tainting cistern water and, during periods of heavy rainfall, bringing the contamination to the surface and the salt pond. In order to protect and enhance the groundwater quality in the Mandahl APC/APR:

*Septic tanks from individual residences should be maintained with the tank sludge pumped periodically. The leach pit method of wastewater dispersal should be changed to the leach field or trench method of disposal. This decreases the point loading of the septic effluent. The leach field method may also be coupled with an irrigation system, or secondary wastewater treatment system. See also the recommendations in Section 4.2.1 on Water Pollution.*

### 4.1.3 Land pollution

#### 4.1.3.1 Solid waste

To effectively control the solid waste problem in the Mandahl Bay APC/APR consideration should be given to:

1. resident funded, private sector service (needs local association); or

2. formal schedule for removal by Public Works agreed to by Public Works and community.

*PWD, DPNR and the neighborhood residents who currently maintain the beach should coordinate their efforts at trash removal from the beach. The residents' efforts should be commended and similar actions encouraged in neighborhoods throughout the Territory. Responsible government agencies must remain active partners to support and encourage such local responsibility.*

*Abandoned vehicles left in the brush around the Mandahl Salt Pond should be removed from the APC/APR to an auto salvage yard. When possible, serial numbers from these vehicles should be traced and the owner either fined, or if the vehicle had been reported stolen, held responsible for removal costs.*

*The ongoing anti-litter campaign in the Virgin Islands should be continued, with proper recognition given to those community members who participate. Litter laws should be enforced and violators "recognized."*

#### 4.1.3.2 Hazardous waste

Although hazardous waste pollution is primarily limited to releases under extreme circumstances, some common hazardous substances, such as waste automotive oil, household chemicals, and waste paint products can present future pollution problems.

*The Territory needs to develop a waste oil collection network to provide an alternative to the direct ground dumping of oils as now commonly occurs. Fines should be levied against individuals who are found to deliberately dispose of waste oil on the ground.*

### 4.1.4 Air pollution

Air pollution is not of major consequence in Mandahl. Instances of air pollution may occur due to accidental or unexpected events such as fires. In which case normal practices to prevent and/or extinguish fires should be followed.

### 4.1.5 Noise pollution

Noise pollution does not greatly affect the Mandahl Bay APC/APR. Traditional or customary beach use, including family picnics and other "organized" gatherings at Mandahl do not typically include the use of loud, amplified sound systems. Instances of heavy equipment and power tool operation during construction can create temporary discomfort within the watershed because of the amphitheater-effect of the basin. To reduce these noise disturbances:

*Broadcasting of amplified music should not be allowed within the APC/APR.*

*Construction activities within the APC/APR should be limited to certain, daytime hours; for example: only between 7:00 am and 8:00 pm.*

## 4.2 Transportation

### 4.2.1 Land related

The gravel access roads, many of which are badly eroded, are major sources of runoff laden sediment to Mandahl Salt Pond and Bay. In order to control the sediment from these access roads:

*The length of roads and driveways built on slopes that are greater than 20 percent should be held to a minimum. Roads and drives should follow the contours of the land as much as possible and avoid long, straight, downslope runs that make them virtual streambeds with great erosive power during storms (Teytaud, 1981)*

*While paving the roads leading to Mandahl Bay is not essential, roadside gutters should be built parallel to and at a slightly lower elevation than the road surface. These could channel water off the roads and reduce their erosion, direct the water into heavily vegetated areas to disperse and reduce the strength of its flow and allow some filtering of sediments before the water reaches the floodplain and salt pond.*

#### 4.2.2 Marine related

*DPNR should eliminate the use of Mandahl Salt Pond as a vessel storage site. Public use moorings may be established to protect the benthic environment while encouraging continued (limited) use of the area.*

*Due to the salt pond's low flushing capability, already high-input of nutrients and pollutants in storm runoff, and developing lagoon-like habitat, any marina development permitted in the Mandahl Salt Pond should not be allowed to incorporate fuel-dispensing equipment.*

### 4.3 Development

#### 4.3.1 Residential development

The area within the Mandahl Bay APC is currently comprised of two zoning designations (Figure 7). The area surrounding the salt pond is zoned as W-1 (waterfront pleasure). Upland areas within the APC, including Mandahl Point, are zoned as R-1 (residential low density).

In the early 1980s, DPNR/DCZM prepared and adopted the Coastal Land and Water Use Plan (CLWUP), which designates all coastal areas of the Territory as one of ten (10) classifications. The CLWUP designations were, in some locations, in conflict with the existing zoning designations. For the Mandahl Bay APC, however, the CLWUP basically supported the earlier zoning designations, and provided new refinement of allowable water uses.

Since the late 1980s, DPNR/Comprehensive Planning staff have worked to prepare a Comprehensive Land and Water Use Plan that will re-designate all land and water in the Territory as one of ten (10) new designations, known as "Intensity Districts". The purpose of the proposed Comprehensive Plan is to allow the territorial Government to begin providing public services and facilities concurrent with the demand for those services and facilities; that is, to ensure that the provision of public services and facilities occurs at the proper level and at the proper timing during the course of development. The overarching goal of the proposed Comprehensive Plan is to ensure that the quality-of-life for island residents is maximized by guiding the location and type of future growth through the provision of public facilities. DPNR/Comprehensive Planning is currently working to finalize the proposed Comprehensive Plan, including preparation of final maps for public review.

The proposed Comprehensive Land and Water Use Plan classifies the upland areas surrounding the salt pond as Intensity District 1 (conservation/agriculture).

Intensity District 1 would allow the following (Strategic Planning Group, 1991):

> Intensity District 1 (conservation/agriculture) - Located in undeveloped and sparsely developed areas that are environmentally constrained, lack adequate infrastructure, and are not subdivided for residential or commercial development. Limited residential development is to be accommodated. Areas with soils well suited to agriculture are also included, and performance standards prohibit development in natural resource areas. Protective measures are provided to ensure that the natural functions of environmentally sensitive areas such as salt ponds, very steep slopes, wetlands, beaches, floodplains, mangroves and potential well-field areas are maintained.

This proposed designation makes good sense for this environmentally sensitive area. The preservation of the Territory's remaining wetland areas and salt ponds is essential. A proposed

subdivision for Mandahl Hill (Figure 9) is in conflict with the current and proposed zoning. If this subdivision is passed by the legislature, the zoning would have to be changed to accommodate development.

*If the proposed Mandahl Hill subdivision is passed by the legislature, strict building requirements should be made in the zoning guidelines. These requirements would include specific guidelines for erosion control, building practices, mooring practices and septic control measures.*

The average slope of the residentially zoned areas within the Mandahl watershed is approximately 35 - 40 degrees (Adams, 1991). Building on slopes of this steepness requires special measures; erosion control efforts must be proportionately more stringent than on areas of lesser slope.

*While residential housing construction is appropriate and legal in situations similar to Mandahl Basin, a green-space, setback rule should be established around the salt pond and floodplain as a buffer between the watershed and the sea.*

*Utilizing appropriate building practices to reduce erosion, both vegetative and structural stabilization of the soil is essential (Teytaud, 1991). Proper use of silt fencing (the base of the fence set into the ground), swales to guide runoff, and the removal of minimal vegetation are important methods of reducing and/or preventing unnecessary erosion. Clear-cutting of any lot should be prohibited and strictly enforced.*

### 4.3.2 Commercial development

There are currently a number of proposals and counter-proposals concerning the development of Hans Lollik Island with and without the association of the Mandahl Basin at various stages in the application and permitting process.

*Further commercial development projects should not be undertaken within the APC/APR until the status of the plans and proposals that already exist are resolved.*

### 4.3.3 Non-commercial recreation development

There are three options for non-commercial recreation development in the Mandahl area (beach and salt pond):

a. Leave the area in its present condition. Only increasing minimal, existing services such as trash removal. Implement control systems for runoff and erosion.

b. Proceed with a moderate development plan. Access roads should be improved (but not necessarily paved), parking areas designated, and informational and educational displays/kiosks and possibly some pavilions added.

c. Undertake large-scale recreational development in the area. This type of project would include paving the access roads, adding facilities (changing and rest rooms), and providing security and/or law enforcement. A successional approach to such an expansive recreation area could include future phases to revegetate the area with more "desirable" plants (non-commercial recreation development).

*The area is most suitable for non-commercial recreation development, as opposed to commercial ventures. Within the scope of non-commercial recreation, the area is most suitable for a moderate (option b.) type of development. Environmental considerations,*

*community interest, traditional usage, and the educational opportunities the site offers all would benefit most by a limited, but very focused development program. Concerns over beach crowding, parking, access, and pollution would be minimized by this approach.*

#### 4.3.4 Infrastructure development

The road system to the Mandahl Bay and salt pond should be upgraded, but not necessarily paved, in order to control erosion of the roadbed and driveways. For specific recommendations about this subject, see the discussion in Sections 4.3.1 and 4.4.1

### 4.4 Education

The Mandahl area has been used by some teachers as an "outdoor classroom" facility. To enhance the educational value of the site:

*A kiosk should be built near the beach area to provide interpretive displays on wildlife and sea life found along the beach, in the Bay waters, and in the salt pond.*

*Current, relevant information on natural resource management, environmental and marine ecology issues should also be included in these educational displays.*

### 4.5 Natural Hazards

The salt pond and surrounding floodplains are indicated on the FEMA FIRM maps as potentially inundated to a 5 foot depth during a 100-year storm situation.

*Building in the flood hazard zone should be restricted to open structures for educational and recreational use.*

### 4.6 Wetlands

As mentioned previously, attention to erosion control, building practices, mooring practices and septic control measures within the watershed will help to maintain and improve the integrity of the wetland area. Other means to protect the area's wetlands include:

*Proactive reforestation of highly eroded areas or devegetated building sites should be undertaken to reduce negative effects of runoff.*

*Loss of vegetation around the salt pond would have adverse effects on the wildlife now frequenting it, therefore no mangroves should be cut to accommodate the construction of buildings or for boat mooring.*

*A Territorial wetlands management plan should be developed in a cooperative and comprehensive manner with this APC/APR Management Plan. Every effort should be made to ensure compatibility of all resource management plans that affect the same area.*

## 5. CONCLUSION

Mandahl Bay beach and salt pond is a publicly-owned north shore land and water tract of approximately 30 acres. Located 2.5 miles northeast of Charlotte Amalie, the area would be ideal for development as a recreational day-use area for island residents and, to a more limited extent, visitors alike. In addition, the area could be developed for use by the Boy Scouts or other youth-oriented groups during the summer months when the kids are out of school. Its

natural and scenic amenities would provide an ideal setting within which to provide an exceptional educational experience of the natural environment.

Mandahl Hill, immediately north of the salt pond should be considered for acquisition and inclusion into a Territorial Park System. A maintained trail to the top of the hill would provide for excellent scenic views of the vicinity and the numerous cays northward. The salt pond and rocky shoreline to both the east and west provide wildlife habitat for many birds, including the endangered Brown Pelican. The pond itself could be developed for passive recreational boating activities (canoes, rowboats, kayaks, etc.) while providing a rare natural science educational and research opportunity for the island's youth. Interpretive trails could be nicely developed.

A 1960 territorial park development study made similar recommendations for the area, and called for specific improvements including: clean-up of the area; rock removal from the beach and parking areas; the development of public picnic area in the palm grove; central building with bath house, comfort facilities, etc.; and adequate water and sanitary systems. Such developments would necessitate considerable improvements (although not necessarily paving) to the steep access road leading into the area, as well as provision of adequate parking.

Now, with a proposed subdivision development of Mandahl Hill, it is perhaps too late to act on these 1960 recommendations. This Management Plan calls for the use of strict performance standards for any future construction within the watershed, especially for the steeply sloped Mandahl Hill area immediately upslope from the salt pond. Any development on such steep slopes should be subject to an environmental assessment report, including an assessment of minimal lot size, slope capability, soil type, etc., needed to safely accommodate the combined sewage seepage of such development.

Existing sewage tank and leach pit systems should be regularly inspected, with consideration given to conversion of poorly functioning systems to some form of alternative wastewater treatment technology, such as a community septic system or waterless composting toilets. Government may desire to provide futuristic guidance for new and existing homeowners, and offer incentives for conversion to more effective and environmentally safe technologies.

The salt pond should not be further developed into a marina, if the natural integrity and function of the salt pond is to be preserved. Low-intensity use by the boating community (with either a prohibition of boat repair or special attention to environmentally sound repair operations) is a feasible option to explore. But the low flushing capacity of the salt pond logically precludes further development of the area as a service marina. The oversight of Mandahl Bay APC will require some sort of routine monitoring and enforcement program, and Government may want to explore a partnership arrangement with local residents to provide management services.

The Management Plan outlines Best Management Practices that should be used to guide new developments, including the use excavation and/or grading plans, and the use of structural and vegetative soil stabilization techniques to absolutely minimize soil erosion. Vegetated buffer strips should be required along watercourses and adjacent to the salt pond, and a 150-foot vegetation buffer around the salt pond is desirable for absolutely minimize potential sedimentation and other pollutant impacts to the salt pond's water quality.

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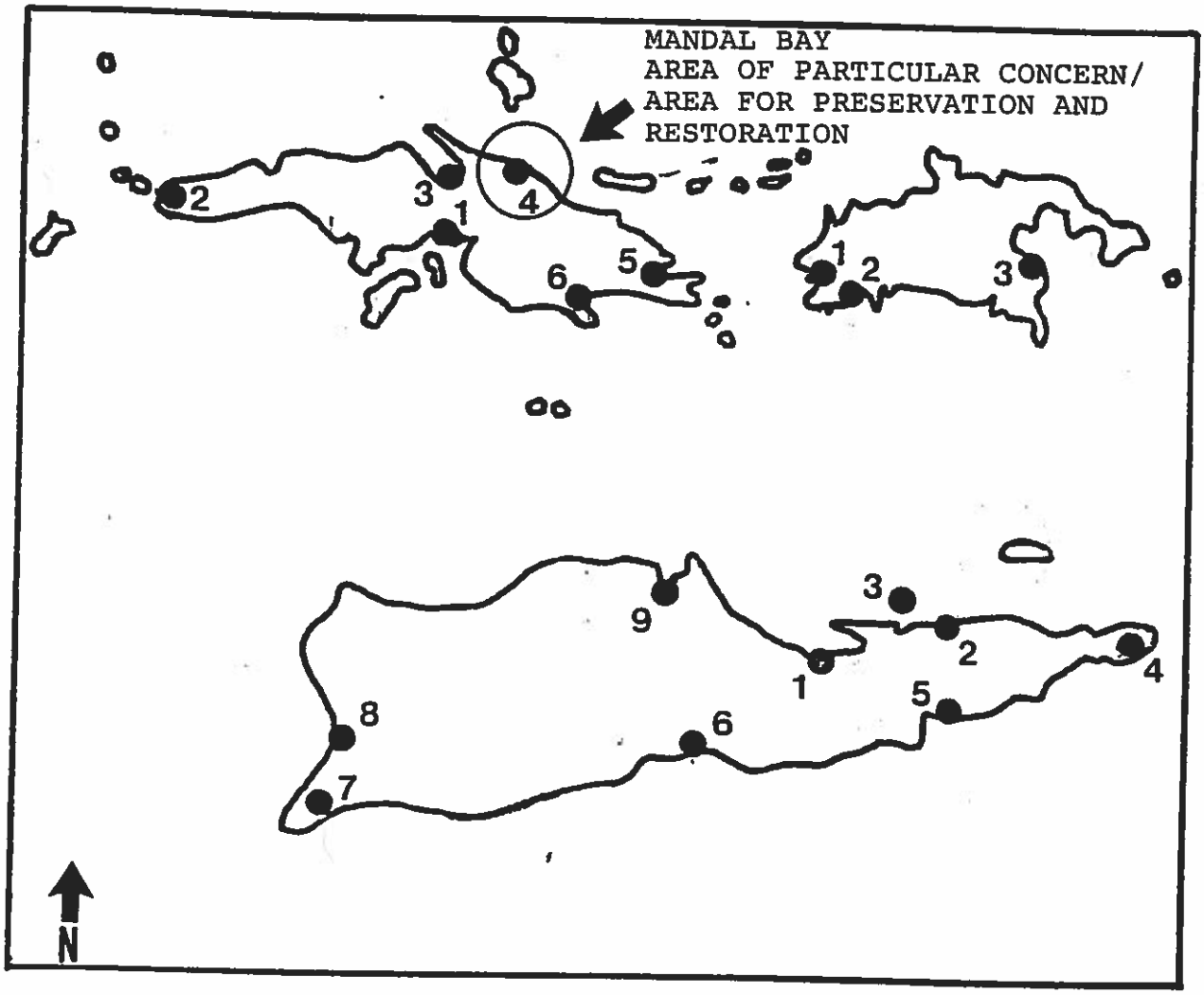
## AREAS OF PARTICULAR CONCERN




ST. THOMAS

1. St. Thomas Harbor and Waterfront
2. Botany Bay (APR)
3. Magens Bay and Watershed
4. Mandahl Bay (APR)
5. Vessup Bay - East End
6. Mangrove Lagoon - Benner Bay (APR)

ST. JOHN

1. Enighed Pond - Cruz Bay
2. Chocolate Hole - Great Cruz Bay (APR)
3. Lagoon Point - Coral Harbor (APR)

ST. CROIX

1. Christiansted Waterfront
2. Southgate Pond - Cheney Bay (APR)
3. St. Croix Coral Reef System (APR)
4. East End (APR)
5. Great Salt Pond Bay (APR)
6. Southshore Industrial Area
7. Sandy Point
8. Frederiksted Waterfront
9. Salt River - Sugar Bay (APR)

FIGURE 1
ISLAND RESOURCES FOUNDATION, 1992
ADAPTED FROM: Virgin Islands Coastal Zone Management Program and Final Environmental Impact Statement, NOAA, OCRM, 1979

# ndal Bay

## Lovenlund Bay

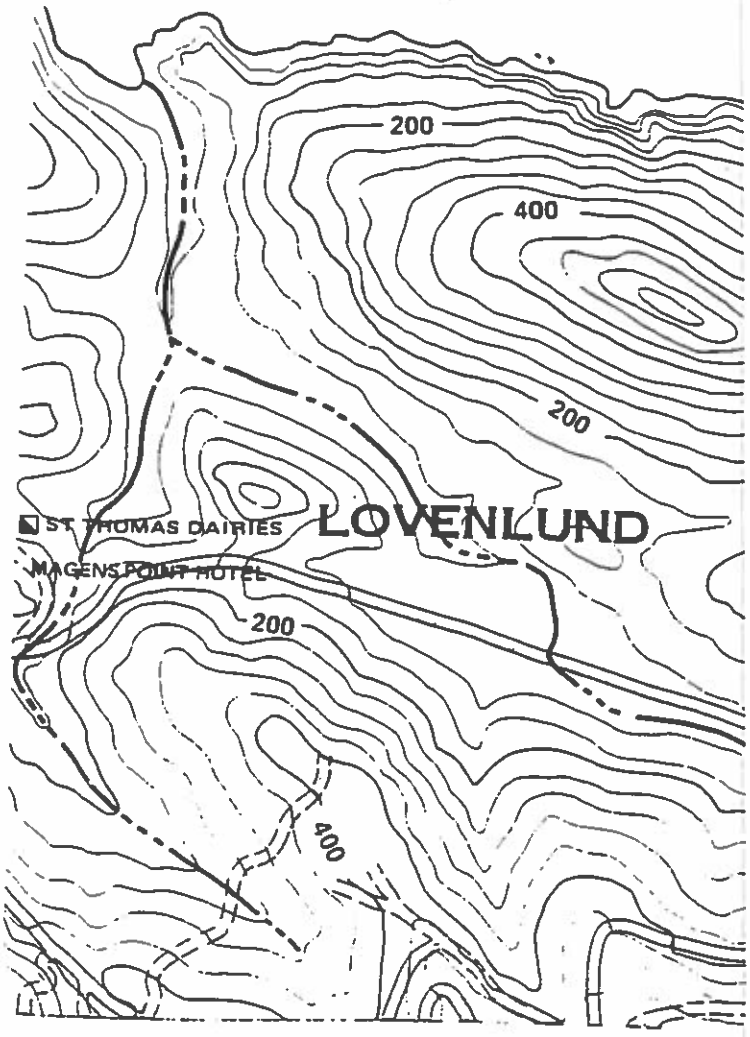



Figure 2
APC Boundary Map
Base map adapted from: BC&E, 1979
Island Resources Foundation, 1993

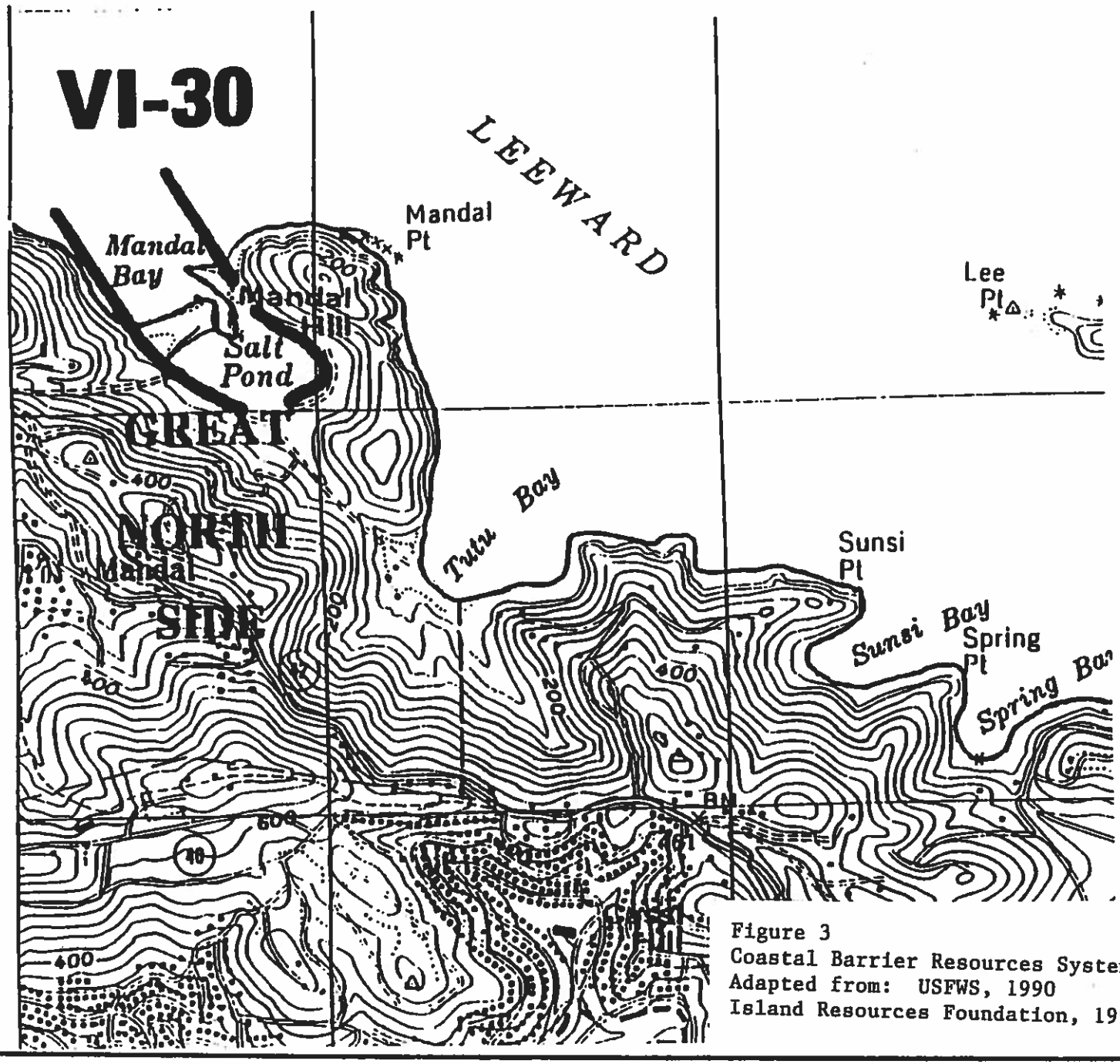



Figure 3
Coastal Barrier Resources System Boundary
Adapted from: USFWS, 1990
Island Resources Foundation, 1993

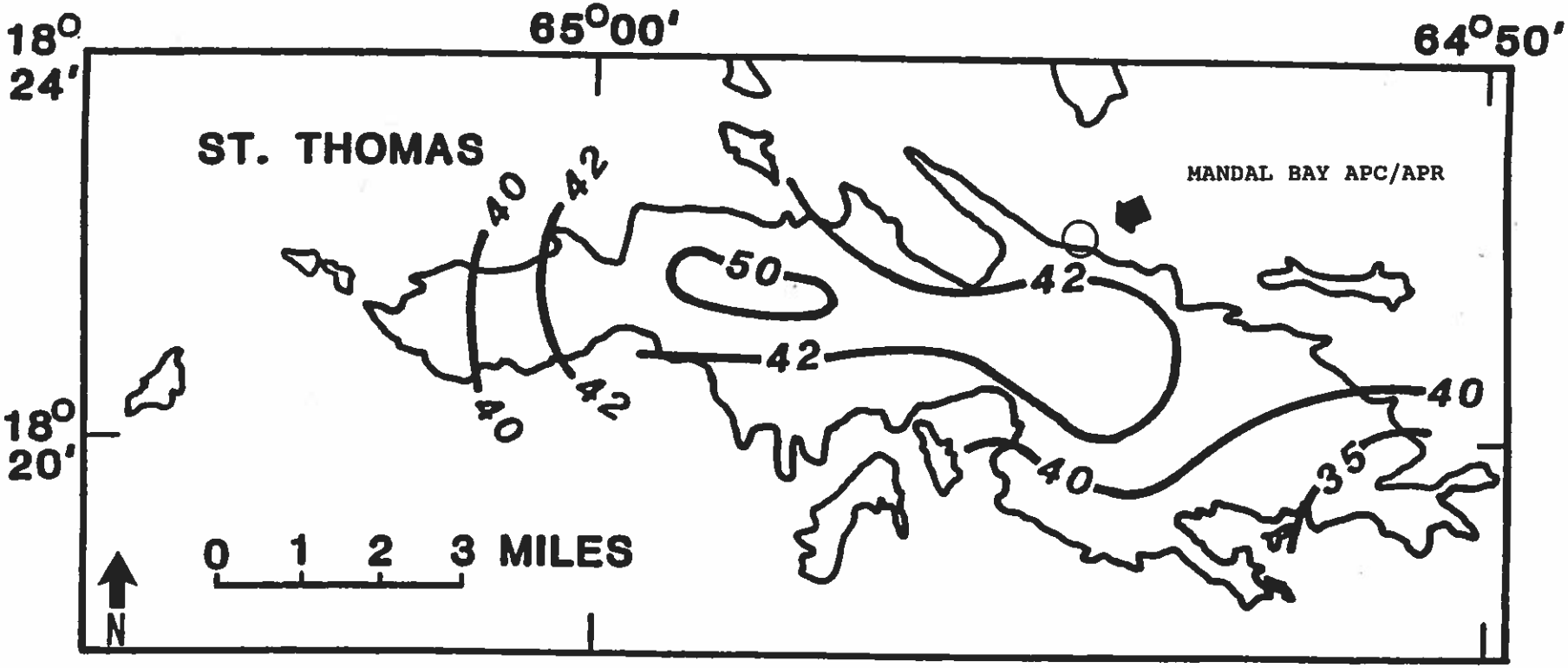



FIGURE 4 RAINFALL MAP
ISLAND RESOURCES FOUNDATION, 1992

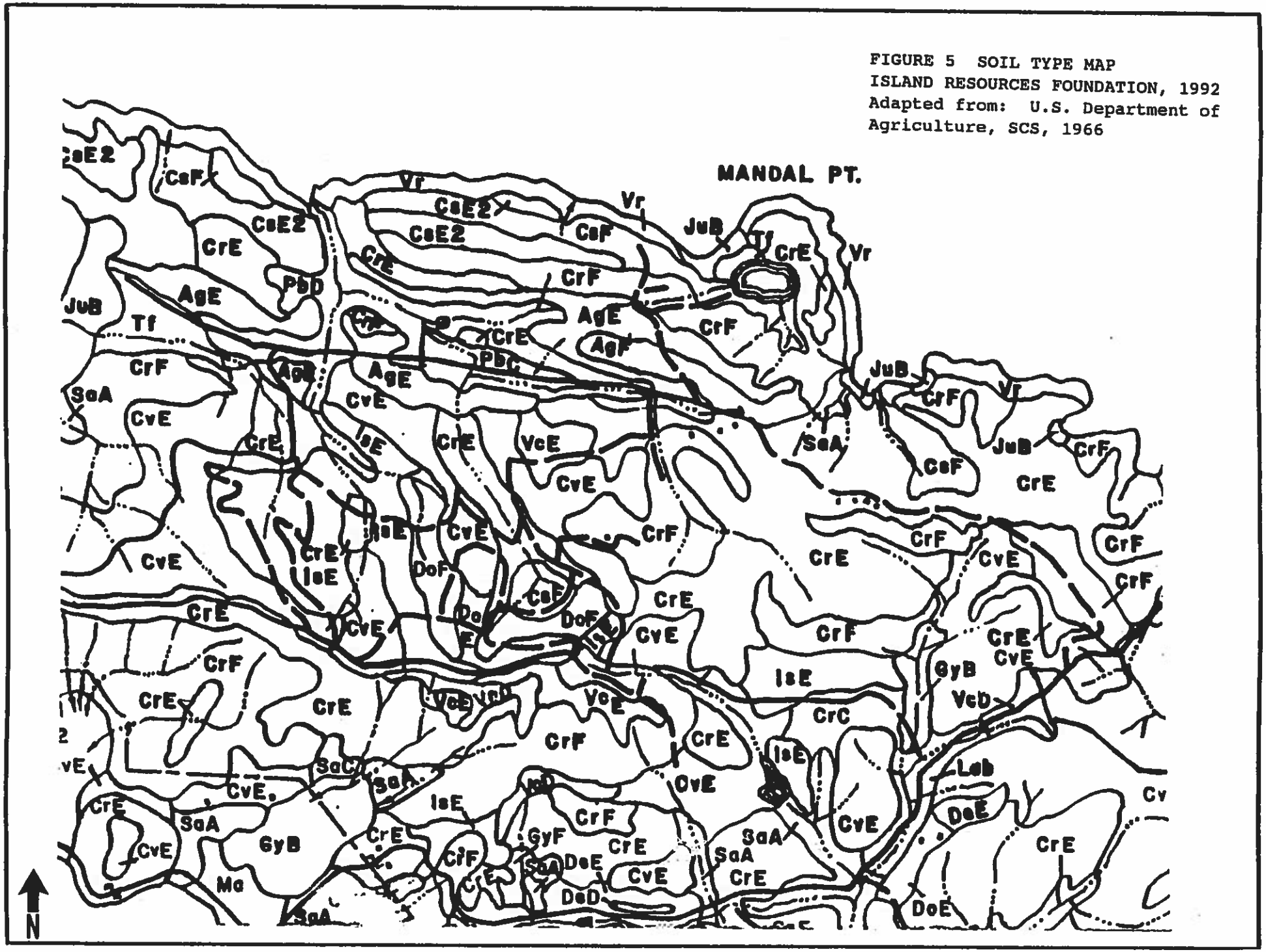
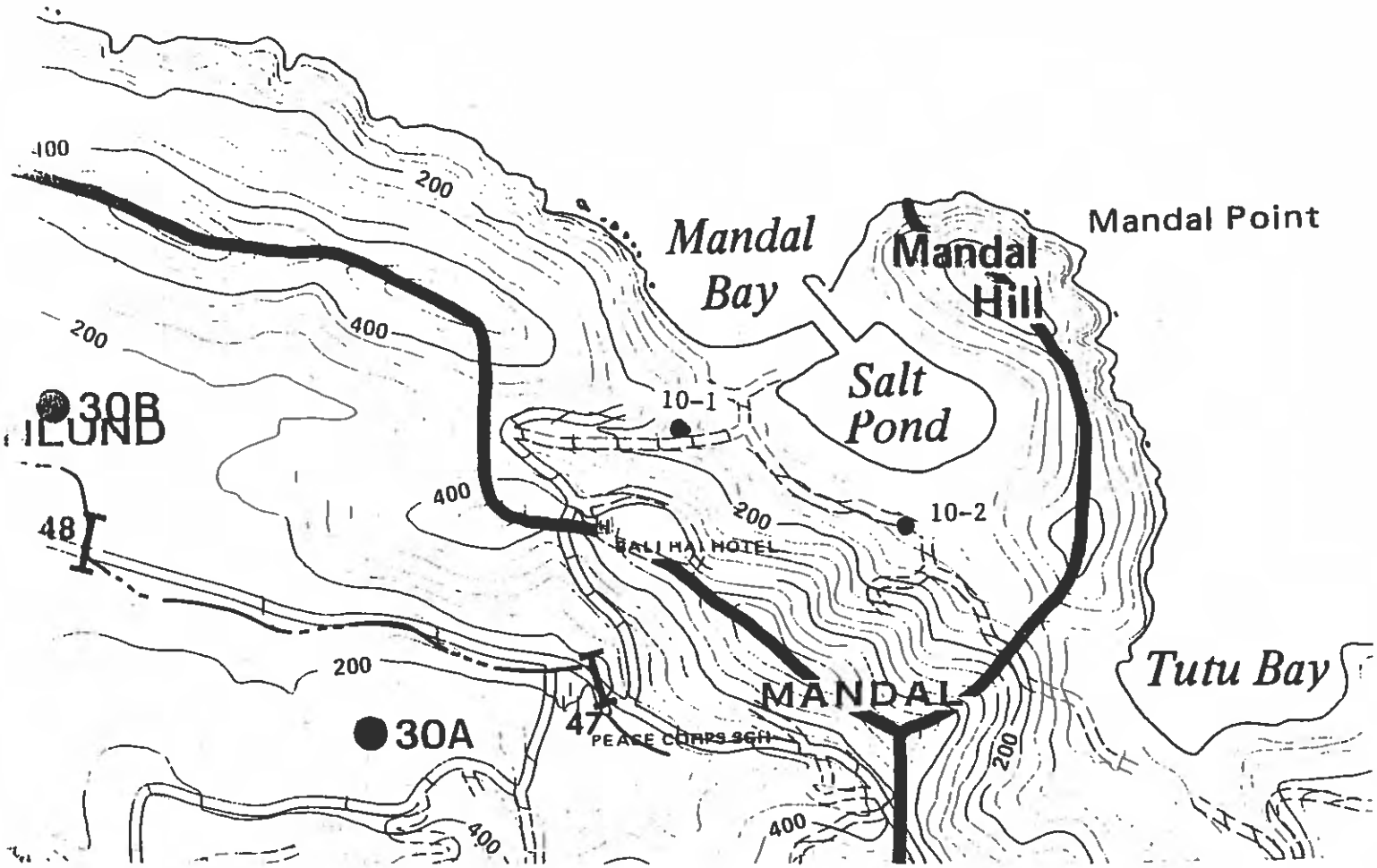



FIGURE 5 SOIL TYPE MAP
ISLAND RESOURCES FOUNDATION, 1992
Adapted from: U.S. Department of Agriculture, SCS, 1966

FIGURE 6 WATER RESOURCES AND WELL LOCATION MAP
ISLAND RESOURCES FOUNDATION, 1992
ADAPTED FROM: BC&E, 1979

See legend on next page



# General Legend

## CULTURAL FEATURES

- Misc. public buildings
- Fire station
- Hospital
- Marina
- Drive-in theater
- School or college, public
- School or college, private
- Apartment complex
- Hotel
- Multistory public housing
- Private buildings
- Golf course

## ROADS

- Divided four-lane highway
- Paved
- Unpaved
- Proposed

## GENERAL FEATURES

- Index contour (200-ft interval)
- Intermediate contour (40-ft interval)
- Supplementary contour (20-ft interval)
- National park boundary
- Urban limit boundary
- Coral reef
- Intermittent stream
- Marsh
- Mangrove
- Proposed development

## LETTERING STYLES

- MANDAL — Political names
- Caneel Hill — Geographic names
- *Cruz Bay* — Hydrographic names
- DOBER SCH — Misc. notes and symbol descriptions

# Water Resources Legend

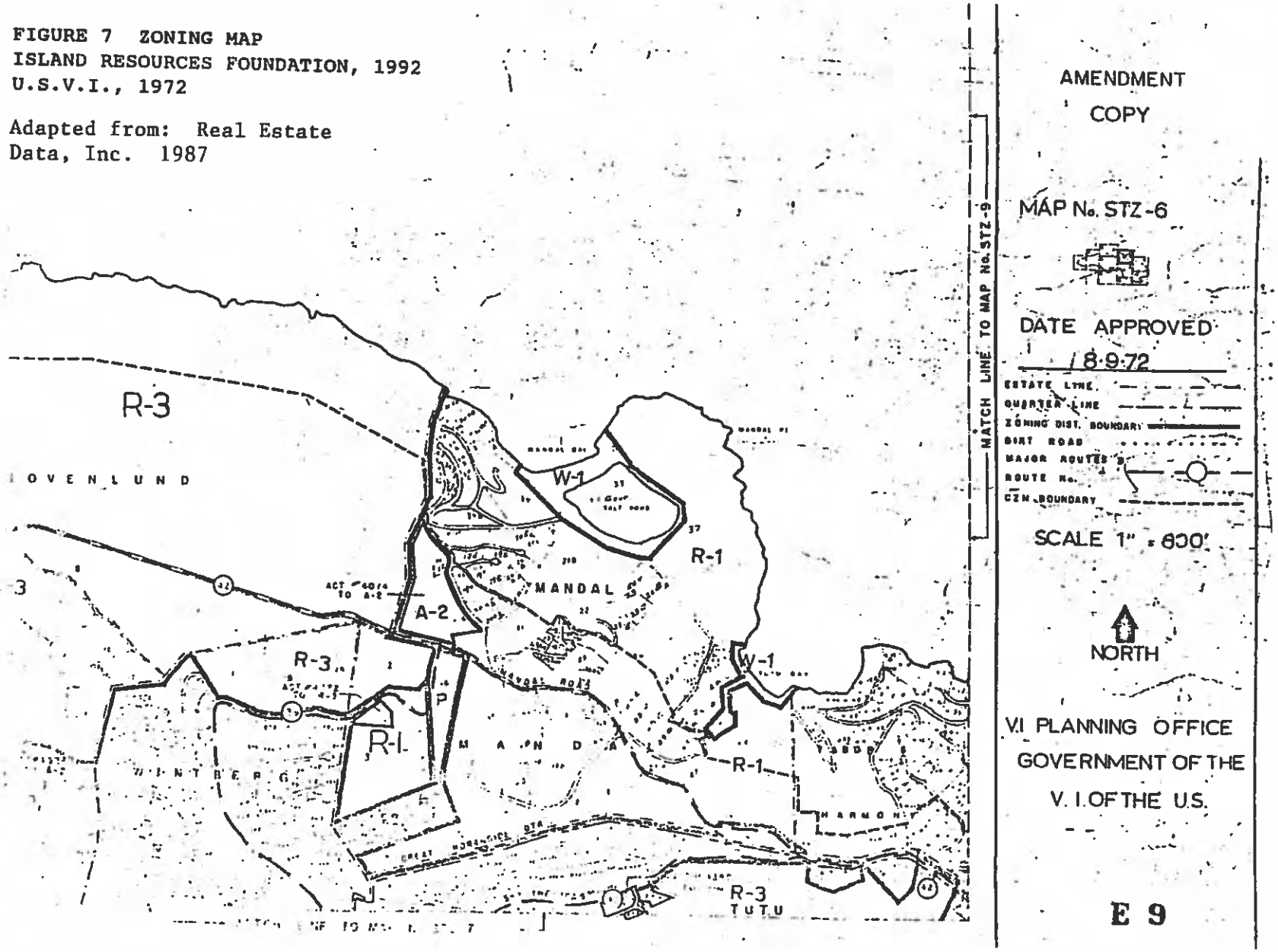
- Existing potable water line
- Proposed potable water line
- Existing saltwater line
- Existing sewer with flow direction
- Proposed sewer with flow direction
- Existing force main with flow direction
- Proposed force main with flow direction
- Boundary of area where only major water resource detail is shown
- Drainage basin boundary
- 154 — Culvert site (reference number for V.I. Dept. of CCA, Natural Resource Management Culvert Study, 1976
- 1A — Impoundment site with V.I. Dept. of Agriculture reference number
- Potential major tidal flooding area (Army Corps of Engineers study, 1975)*
- Potential major inland flooding area (U.S. Geological Survey study, 1975-76)*
- P — Potable water pumping station
- S — Saltwater pumping station
- WW — Wastewater pumping station
- W — Wastewater treatment plant

*Areas described are based on published studies. Flooding is not necessarily restricted to those areas.

LEGEND TO:
FIGURE 6 WATER RESOURCES MAP
ISLAND RESOURCES FOUNDATION, 1992
Adapted from: BC&E, 1979

FIGURE 7 ZONING MAP
ISLAND RESOURCES FOUNDATION, 1992
U.S.V.I., 1972

Adapted from: Real Estate
Data, Inc. 1987



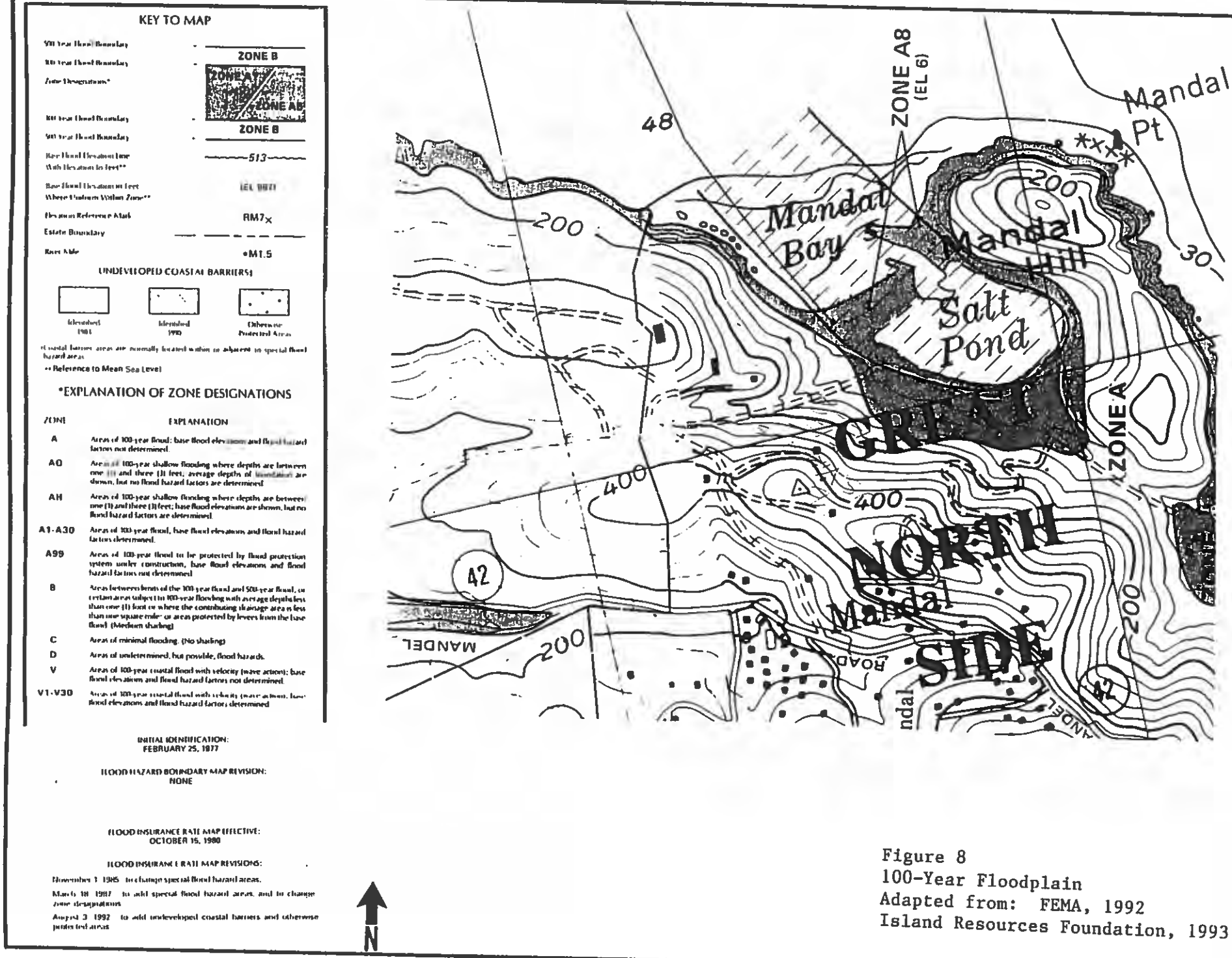


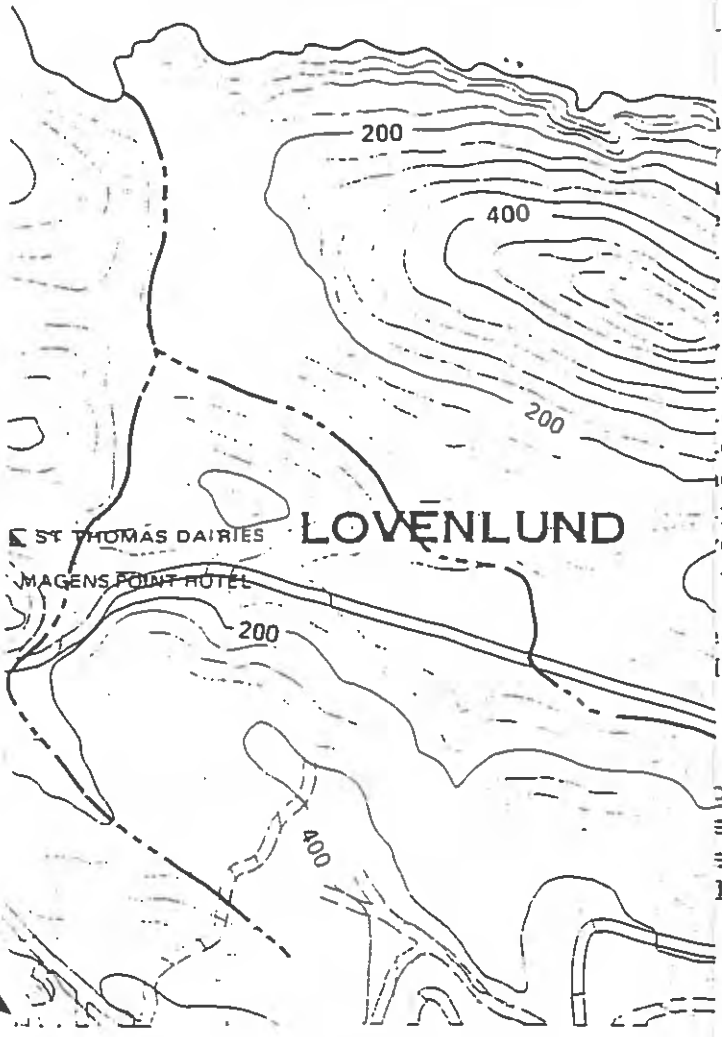

Figure 8
100-Year Floodplain
Adapted from: FEMA, 1992
Island Resources Foundation, 1993

# ndal Bay

: from steeply sloped roads and
ıtial building sites should be
ıled through effective drainage
(i.e. gutters to direct water along
/s); and use of appropriate
:ive and structural erosion control
s.
.al problems resulting from septic
ıding of soils and subsequent
.nation of run-off water. Recommend
alternative (waterless) toilet
s in the watershed.
lisposal responsibilities on
ıhould be coordinated among PWD and
Abandoned vehicles must be removed
ıe beach and pond areas.
· amplified music is not
.onally used at this beach and
be prohibited.
recreational development of the bay
ıd should be limited to educational
/s, designated parking areas and
ıance of nature trails.
of the limited flushing
.ity, additional moorings, increased
affic and marina-related facilities
:ause considerable harm to the
of Mandal Pond and should be
:ted.
.al flooding to 5' depth in a 100
.orm situation in the areas
ıding the pond. Building should be
.y limited.
:eloping mangrove lagoon habitat
the pond must be preserved.

:d by developer of proposed
lill subdivision.

*Lovenlund Bay*




gure 9
er Conflict Map
se map adapted from: BC&E, 1979
land Resources Foundation, 1993

1000'

# ...andal Bay

USE / LAND COVER

Low density residential

Beach (swimming)

Picnic Area

Beach Thicket

Mixed Woodland & Brush

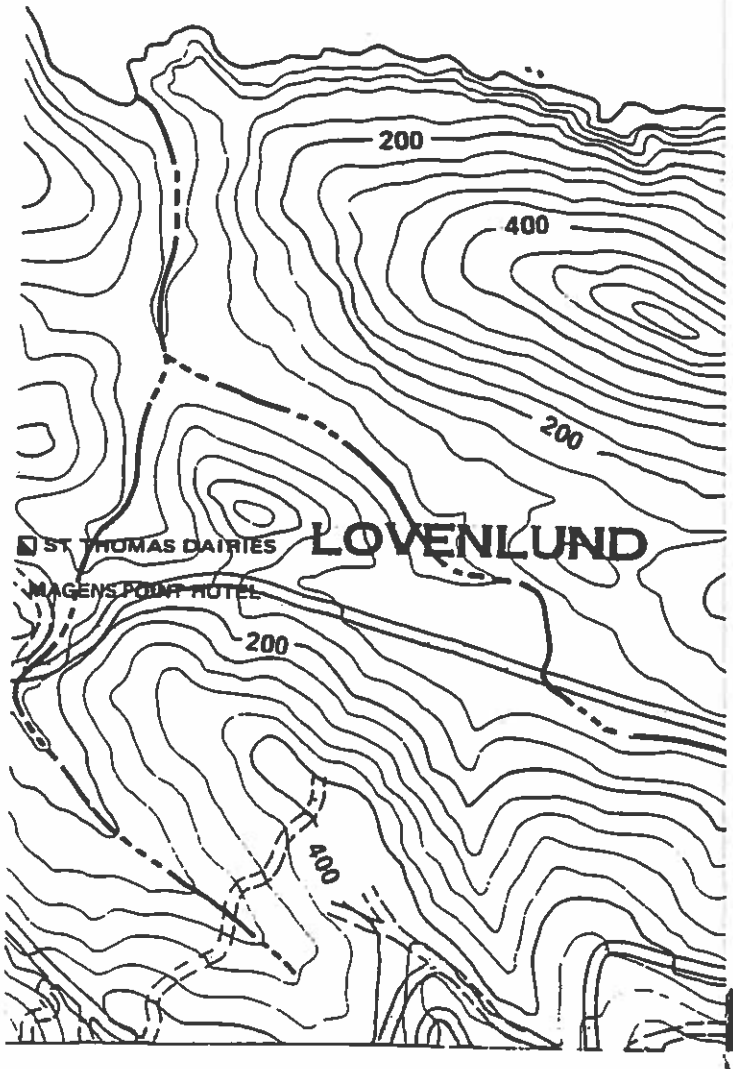
Woodland

Coconut Grove

Mangrove

Exposed Rocky Shoreline

*Lovenlund Bay*




Figue 10
Land Use/Land Cover
Base map adapted from: BC&E, 1979
Island Resources Foundation, 1993

1000'

# ...andal Bay

...ICAL FEATURES

...Bedrock Cliffs

...Breakwater Jetties

...Stone Revetment

...Beach Rock (exposed)

...Beach Sand

...Beach Cobble

...Beach Rubble

...ilt & Sand Substrate

*Lovenlund Bay*

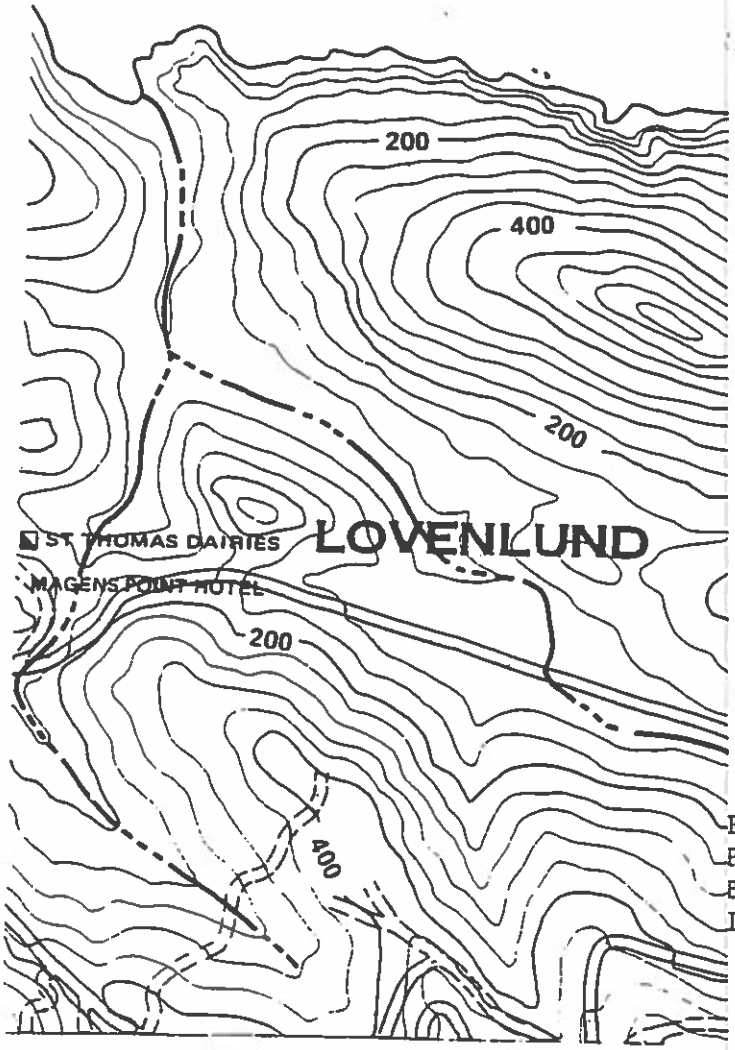



Figure 11
Physical Features
Base map adapted from: BC&E, 1979
Island Resources Foundation, 1993

1000'

N

# andal Bay

OGICAL FEATURES

Patch Reef/Gorgonian Reef

Halophila/Algae Bottom

Coconut Grove

Coastal Thickets

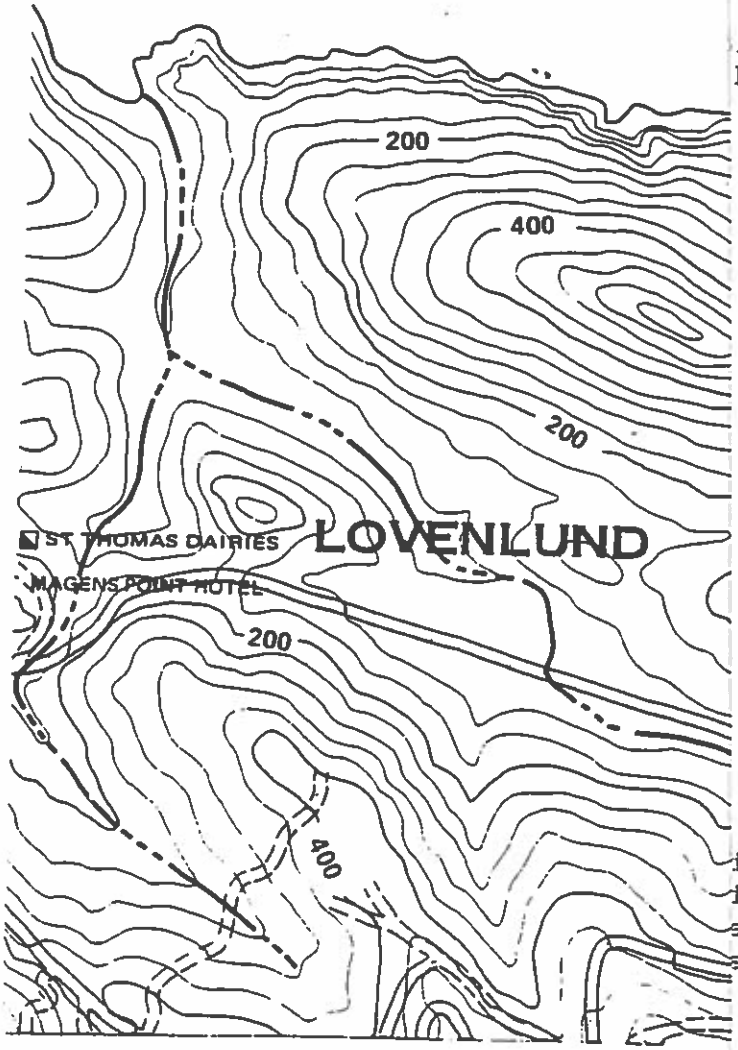
Mangrove

Turtle Nesting Area
(Hawksbill & Green Turtles)

Bird Rookery (Brown Pelican)

Bird Feeding Area
(Brown Pelican & Herons)

*Lovenlund Bay*




igure 12
iological Features
ase map adapted from: BC&E, 1979
sland Resources Foundation, 1993

1000'

N