MANDAHL BAY
AREA OF PARTICULAR CONCERN
(APC)

AND

AREA FOR PRESERVATION AND RESTORATION
(APR)

A COMPREHENSIVE ANALYTIC STUDY

V.I. DEPARTMENT OF PLANNING AND NATURAL RESOURCES
Coastal Zone Management Program

September 21, 1993

Draft Prepared By:
Island Resources Foundation
under Contract PC PNR-330-92

With assistance From:
The University of the
Virgin Islands

This publication is financed in part through a federal grant from the Office of Coastal Zone Management, NOAA under the provision of Section 305 of the Coastal Zone Management Act of 1972 (Public Law 92-583).

Copies of this document may be obtained from the Department of Planning and Natural Resources, (Coastal Zone Management Program), Nisky Center, Charlotte Amalie, St. Thomas, United States Virgin Islands 00802.

MANDAHL BAY
APC/APR *COMPREHENSIVE ANALYTIC STUDY*
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
Coastal Zone Management Program	CZMP
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 Comprehensive and Coastal Zone Planning	CCZP
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
Water and Power Authority	WAPA

LIST OF FIGURES

LIST OF KEY ACRONYMS

Area of Particular Concern	APC
Base Flood Elevation	BFE
Coastal Barriers Resource System	CBRS
Coastal Zone Management Act	CZMA
Coastal Zone Management Program	CZMP
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 Comprehensive and Coastal Zone Planning	CCZP
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
Water and Power Authority	WAPA

LIST OF FIGURES

1. INTRODUCTION

1.1 General

The Mandahl Bay area is one of 18 Areas of Particular Concern (APC) designated by the Planning Office in 1979 after public nominations and comment had been received (Figure 1). The APC is located on the Great North Side of St. Thomas between Lovenlund and Tutu Bays, and includes the drainage basin of Mandahl Bay, the publicly owned Mandahl Salt Pond and Mandahl Beach, and offshore waters to the shelf edge (Figure 2). Several endangered species are found in the area, which has great potential for recreational and educational opportunities.

On July 26, 1991, the CZM Commission adopted the 18 APC's recommended in the Final Environmental Impact Statement (USDOC, 1979), which accompanies the Virgin Islands CZM Act. The Final Environmental Impact Statement notes "the importance of the entire coastal zone", but declares that "certain areas are of yet greater significance." It also establishes the criteria for the designation of Areas of Particular Concern which are as follows:

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

In September of 1991, the Coastal Zone Management (CZM) Commission met and held public hearings on all three islands on the boundaries for all 18 APC's. The Commission met again on October 1, 1991 and, based upon public input and staff recommendations, approved the boundaries of the APC's.

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 Comprehensive Analytic Study and proposed 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 Comprehensive Analytic Study and proposed management plan was prepared under the authority of the Coastal Zone Management Commission. The Study and proposed 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 contained 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 (DPNR), the Port Authority, the Water and Power Authority (WAPA), the Department of Public Works (DPW), the National Park Service (NPS), the U.S. Fish and Wildlife Service (USFWS), the U.S. Army Corps of Engineers (USACOE), the U.S. Environmental Protection Agency (USEPA), and the Department of Property and Procurement. This Study and proposed plan will serve as a guide for future decisions concerning the area. Future development activity should be consistent with the Study and proposed management plan.

The intent of this Study and proposal for a 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 Study and proposed plan does not eliminate the authority of those agencies, but increases 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 Study and proposed plan.

The issues surrounding any proposed use or activity within the coastal environment are complex. A proposed use immediately outside the boundary of the APC planning area may result in significant adverse impacts on the APC and impair the goals of the APC management framework described herein. This Plan contains several different forms of guidance all of which should be considered in evaluating impact on and APC. Both the individual property owner who is considering a specific proposal and the decision-maker who is evaluating the proposal should follow the guidance of this Plan.

1.3 Historical Perspective and Overview

Mandahl Bay (and associated salt pond) is an APC 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, which was approved by the V.I. Legislature, was for the purpose of developing a marina-condominium complex to operate in conjunction with a resort development on Hans Lollik Island.

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.

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). The Federal Coastal Barrier Improvement Act of 1990 established areas in the USVI as part of the CBRS. The purpose of the system is threefold (Island Resources Foundation, 1986):

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

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).

Floodplain

The entire shoreline of the APC, the salt pond, and adjacent upland areas are situated within a designated 100-year floodplain (section 2.3.3) [Figure 5].

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 (Figure 2):

> 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 Lollik and Little Hans Lollik 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.

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 (plot No. 33) are presently

leased by Tamarind Resort Associates from the V.I. Government as part of a 99-year lease between Government and the Hans Lollik Corporation (1964).

On the west side of the Salt Pond, the Mandahl Management Corporation owns approximately 15.5 acres comprised of parcels 34, 34a, 34b, 34b-1, 34b-2, and 34c Estate Mandahl. This property is known as "The Inn at Mandahl", the site of an existing eight-unit hotel (formerly the Bali Hai Hotel) and restaurant complex that was established in the early 1960's, but which was severely damaged during Hurricane Hugo in 1989.

Plot No. 37 which comprises approximately 52 acres on the ridge east of the Salt Pond heading out to Mandahl Point is owned by a private corporation.

2.3 Physical Environment

2.3.1 Climate

Rainfall in the Virgin Islands generally increases with increasing elevation and exhibits a trend on each island of a dry-to-wet cline from east to west. January 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.

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. 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.

Historical Seismicity in the USVI

As a result of convergence between the Caribbean and North American tectonic plates, the Virgin Islands are located in one of the most earthquake prone regions of the world. During the past 450 years, damage has occurred from earthquakes and associated tsunamis. Strong seismic shocks were recorded for the Virgin Islands in 1777, 1843, 1867, and 1918. Destructive tsunamis occurred in the U.S. Virgin Islands in 1867 and in 1918; the latter resulted in 116 deaths and economic losses estimated at $4 million (in 1918 dollars) [USGS, 1984]. The 1867 tsunami was reported to have a wave height of 27-feet above sea level (Geoscience Associates, 1984b).

Potential human and economic losses for a similar event occurring today would be several orders of magnitude higher. Scientists report high seismic potential for a major fault rupture in the Puerto Rico Trench north of Puerto Rico and the Virgin Islands (USGS, 1984). The Virgin Islands are classified as "Zone 4" for earthquake vulnerability, the highest damage zone and the same classification given to many parts of California (Brower and Beatley, 1988).

Studies prepared in 1984 estimated that an earthquake of MMVIII intensity (Modified Mercalli Scale) has a recurrence period of between 110 and 200 years for the St. Thomas/St. John area. The probability of such an earthquake occurring in the next twenty years is between 50 and 70 percent, and between 60 and 80 percent during the next 50 years (Geoscience Associates, 1984a and 1984b).

2.3.3 Hydrological Setting

The overall land and salt pond area of the APC, 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.

A-Zone floodplains exist with the APC (Figure 5). A-Zones are, in general, comprised of 100-year riverine floodplains, for which Base Flood Elevations have been determined for some areas and not for others. As shown in (Figure 5), BFEs of six (6) feet are identified for land adjacent to the salt pond.

The U.S. Geological Survey has identified two unused wells (10-1 and 10-2) within the Mandahl Bay watershed. 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

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 Biological Environment

2.4.1 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).

The salt ponds in this APC and throughout the Virgin Islands differ appreciably depending upon the amount of fresh water and seawater flowing into the pond. In general, salt ponds have a complex and dynamic ecology. Common animals are fiddler crabs and the large land crabs (Cardicoma guanhumi). Several kinds of insects which prefer saline environments live or breed there, including flies and several kinds of midges. Mosquitoes may breed in salt ponds during brief periods when heavy rains sufficiently lower salinity levels. Several kinds of microscopic algae float in the water, sometimes giving it a green, pink, orange, brown, or red color. Other micro-algae grow as mats on the shallow margins.

A number of wading birds (stilts, sandpipers, etc.) feed along the edges of the ponds on crabs, insect larvae, and other small animals. Salt ponds frequently contain large numbers of brine shrimp which are in great demand throughout the world as food for aquarium fish (sennet, small barracuda, mullet, tarpon, snook, etc.) and marine crabs. These are fed upon by kingfishers, herons, and ospreys. Kingbirds, martins and swallows frequently feed on flying insects over the water.

The local animals and plants associated with salt ponds are not well known, and the complex ecology of the ponds can only be inferred in simple outline. They have never been studied properly. It is known that salinity changes over a very wide range. It may be concentrated to more than three times that of sea water (over 100 parts per thousand) or be depressed by heavy flooding to almost freshwater (depending on the volume of flood water, the size of the pond and the permeability of the pond-bay barrier). Periodic changes of even one-third of this magnitude will cause significant changes in the types and numbers of organisms inhabiting the pond. Slow changes, as by evaporation concentrating the salt, promote a gradual die off of some forms of animal life and gradual invasion and development of others. There is a constant, slow modification of the natural community in response to this change.

Sudden changes in salinity, caused by flood water, for example, result in catastrophic changes to the biota. Masses of halophilic (salt-loving) forms are killed while other types, suited to the new, less saline environment, quickly invade the pond and become established. Following heavy flooding, many ponds contain large amounts of dead halophilic algae, insects, etc. These often account for the occasionally bad odor found in a pond.

Other environmental characteristics of salt ponds include high concentrations of hydrogen sulfide, especially in the sediments (from the decay of dead organic matter), high temperature (from isolation with lack of shade), low dissolved oxygen (from high temperature, salinity and BOD), and high turbidity (from large concentrations of land and pond-derived solids).

The natural ecosystem function of salt ponds is as buffer zones and sumps. Located between the bay and its upland watershed, they receive and trap most of the runoff from the land, thus protecting the bay.

Sediment coring in several local points has revealed thick layers of terrigenous (land-derived mud and silt) interbedded with layers of organic muck, algal mats, and occasional sand lenses. The latter may have been deposited when the pond was open to the sea, or when a hurricaneor other violent storm breached the pond or washed waves over the berm bringing sea sand into the pond.

Most of the upper layers of pond sediment are largely organic and have been anaerobically decomposed. Disturbing these sediments often releases obnoxious sulfide odors; when these materials are dispersed, they use up the available oxygen rapidly. This can also kill animals and plants in the pond.

Attributes and Use Options for Salt Ponds

1. Act as natural catchment and settling basins to protect marine resources.
2. Provide feeding places for wading birds, including birds feeding on insects, crustaceans and fish.
3. Low in dissolved oxygen, frequently less than 4 parts per thousand.
4. Biota limited to relatively few organisms which are tolerant of high and changeable salinity.

Use Limitations

1. Sediments unstable for foundations.
2. Sediments - fine, toxic, and with high oxygen demand - can be dangerous to adjacent marine biota if released.
3. Modification may adversely alter drainage and runoff patterns and result in sedimentation of adjacent marine waters.
4. If filled, the weight of overburden may, depending on the nature of pond sediments, extrude these sediments at certain points. Overburden may be plastic.
5. Nature of sediments may limit use of deep-rooted vegetation on overfill.
6. Modification will alter or destroy habitat for associated birds, crabs, etc.

A mangrove lagoon-type environment has developed around the salt pond's edge (Figure 9). 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 1960's and early 1970's). 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 "nursery" habitat for young marine organisms, and in their effective action as a sediment trap, make this a very significant development for the Mandahl Salt Pond.

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, *Eluthérodactylus*, may also inhabit the area. Mammals that live in or frequent the Mandahl Bay area include mongoose, rats, and bats.

2.4.2 Marine

Leeward of the southern jetty (Figure 8) 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 Engineering (1979). 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 are 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 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.*

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).

2.4.3 Endangered Species

The U.S. Endangered Species Act defines "endangered species" to mean a species or subspecies that is in imminent danger of extinction throughout all or a significant portion of its range. "Threatened species" are those likely to become endangered in the foreseeable future unless current trends are reversed. Such species are protected by Federal law which states that neither the whole animal nor

any products from it may be taken, sold, or possessed. Alteration of the habitat in which any of these species occur may be prohibited or constrained.

There is also Virgin Islands endangered species legislation. The Indigenous and Endangered Species Act of 1990 authorizes the Commissioner of DPNR to promulgate a list of endangered and threatened species in the Virgin Islands. The V.I. Government, Department of Planning and Natural Resources, Division of Fish and Wildlife maintains a list of locally endangered or threatened species.

The following species, found within the APC, are either endangered (E) or threatened (T), and appear on either the Federal (F) or Virgin Islands (V) list:

Humpback whale (*Megaptera novaengliae*)	E F
Green Sea Turtle (*Chelonia mydas*)	T F
Hawksbill Sea Turtle (*Eretmochelys imbricata*)	E F
Brown Pelican (*Pelecanus occidentalis*)	E F
Roseate Tern (*Sterna dougallii*)	T F
Great Blue Heron (Ardea herodius)	E V
Great (common) Egret (*Casmerodius albus*)	E V
Fisherman Bat (*Noctilio Leporinus*)	E V
V.I. Tree Boa (*Epicrates monensis granti*)	E F*
Bahama Duck (*Anas bahamensis*)	E V
White-tailed Tropicbird (*Phaethon lepturus*)	E V
Least Tern (*Sterna antillarum*)	E V
White-crowned Pigeon (*Columba leucocephala*)	T V

* It is not confirmed that the V.I. Tree Boa occurs within the APC, however, the animal is known to exist on the east end of St. Thomas and it is thus possible that the snake may be found in the area.

2.5 Cultural Resources

2.5.1 Prehistoric

There are no known prehistoric resources within the APC. Reconnaissance surveys have been carried out on separate occasions by qualified archaeologists, but to date no prehistoric artifacts or evidence of human settlement have been found (McComb Engineering, 1980; Green and Associates, 1990).

2.5.2 Historic

Similarly, there are no known historic resources within the APC. All evidence suggests that human use of the area is limited to recent decades, primarily for residential and recreational purposes.

2.6 Built Environment

2.6.1 Roads and Ports

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 salt pond is presently utilized as a mooring site for a about ten (10) small, shallow-draft boats. It is used as a hurricane shelter for many small vessels when necessary. Development of the harbor into a full marina has been conceptually proposed (section 3.1)

2.6.2 Water Systems

Rain water is collected and stored in cisterns in association with the various dwelling units within the APC. There is no public supply of water to the APC.

2.6.3 Wastewater Systems

Wastewater is disposed of by means of individual septic tank systems and leach fields. There is no "community-type" septic system or sewage treatment system within the APC.

2.6.4 Energy Systems

Electrical energy is supplied to areas within the APC by the V.I. Water and Power Authority.

2.6.5 Solid Waste Disposal Systems

As throughout the Territory, residents are required to dispose of solid waste at the public roadside dumpsters provided by the Department of Public Works. Businesses are required to provide for their own solid waste removal.

3. RESOURCE USE, USE CONFLICTS, AND ADVERSE IMPACTS

3.1 Resource Use

Recreational use of Mandahl Beach has been significantly curtailed in recent years, as much of the beach sands have disappeared since construction of the jetty. Recreational facilities at the beach has been limited to the placement of picnic benches at several sites around the beach. Access to Mandahl Beach is possible either by boat or overland via a single, unimproved (steep) dirt road from the west (section 2.6.1).

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" lagoon habitat of the altered salt pond.

3.2 Use Conflicts

There are no significant use conflicts presently known for the APC. As mentioned below (section 4), certain types of future development might be in conflict with the goal of establishing the area as part of the Territorial Park System (Figure 6).

3.3 Adverse Impacts

3.3.1 Water Quality

Water quality is measured through a variety of parameters, including dissolved oxygen (the amount of dissolved oxygen in the water); turbidity; salinity; temperature; and the amounts and kinds of nutrients and other pollutants found in the water. At the Mandahl Bay salt pond, water quality is affected primarily by inputs from stormwater runoff (i.e., surface runoff containing nutrients, suspended sediments, and other pollutants such as agrochemicals), and temperature fluctuations that can lead to algal blooms.

Surface runoff is a form of nonpoint source pollution, and it is generally a periodically recurring phenomenon associated with heavy rain within the Mandahl Bay watershed. 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.

Historical water quality monitoring records (circa 1980) show isolated occurrences of fecal coliform bacteria in the Mandahl salt pond, the source of which is most likely residential septic tank effluent that reaches the pond via surface runoff.

Sediment and other 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 overall water quality of the salt pond decreases drastically with sudden, large influxes of stormwater runoff, the pond and adjacent vegetated lowlands buffer 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. Despite this amelioration effect, turbid nearshore waters are occasionally observed (Island Resources Foundation, 1991).

3.3.2 Air Quality

There are no known adverse impacts on air quality within the APC.

3.3.3 Noise Pollution

Except for heicopter noise, on occasion, there are no known adverse impacts resulting from excessive noise levels within the APC.

3.3.4 Impacts on Biological Resources

Prior to the major alterations that took place in the bay and salt pond in the late 1960's and early 1970's (Sections 1.1 and 2.3), the Mandahl salt pond consisted 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. At that time, the salt pond was a shallow, saline enclosure influenced primarily by runoff from upland areas, precipitation, and evaporation. It is now a brackish lagoon up to 10 feet in depth under tidal influence, in addition to the fresh water inputs from terrestrial runoff and precipitation.

The opening of the salt pond to the sea has only minimally impaired the 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. The salt pond's faunal community consists of both permanent and transient species (Section 2.3). 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.

As mentioned in section 2.5, there are no known prehistoric or historic cultural resources found within the APC.

4. MANAGEMENT RECOMMENDATIONS

4.1 Policy Framework

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 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.

From the various designations that have placed special importance on the Mandahl Bay and its associated salt pond as areas worthy of conservation, the area should be preserved for its natural, recreational, and scenic attributes.

The salt pond should not be further developed as a marina. The pond has low flushing capacity and thus a marina, especially one that would permit boat repairs and/or refueling operations, would likely result in contaminated sediments and degraded water quality. Such conditions would not be in concert with the designation given the area as an Area of Preservation and Restoration (APR).

4.2 Planning and Permitting

The Mandahl Bay APC is currently comprised of two zoning designations (Figure 4). The salt pond and adjacent lowlands is designated W-1 (waterfront pleasure), and all other surrounding areas within the APC are designated as R-1 (residential low density). Most of the R-1 area has been subdivided into single-family lots of approximately 1/3 acre. Permitted uses for these zones can be found in the V.I. Code, Title 29, Chapter 3, Section 228.

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 goal of the Comprehensive Plans is to ensure that the quality of life for island residents is maximized.

Flooding

The Mandahl Salt Pond and its adjacent lowlands are prone to flooding during periods of heavy rainfall and would be inundated during a storm-generated surge (Figure 5). Local residents have reported that standing water can remain on the lower road for more than a week following heavy rains. 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.

Solid Waste

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. More frequent waste removal is required.

Hazardous Waste

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 used portable generators to provide their homes with electricity, 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. 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.

Sediment Control

Due to the potential for adverse impacts to marine resources in the event of sediment runoff, all permitted development should be required to strictly follow Best Management Practices (BMPs) for nonpoint source pollution control. It is recognized that soil erosion and downslope sediment deposition (from unpaved roadways and devegetated building lots) in the marine environment poses a serious threat to biological resources and nearshore water quality (Teytaud, 1981).

Although the islands have no perennial streams or rivers, episodic events of intense rainfall deliver pulses of fresh water laden with sediments, nutrients, organic matter, and potentially toxic chemicals to nearshore receiving waters. Specifically, development requiring excavation should not be permitted on slopes greater than 40 percent (22 degrees), or in areas deemed otherwise inappropriate (e.g., critical habitats or known natural hazard areas). Permitted development should be required to maintain an adequate distance from critical landscape features such as guts, salt ponds, beaches, etc.). The setback distance (or buffer zone) should be determined through consideration of slope, aspect, vegetative cover, and other relevant factors.

Another significant (potential) sediment source is 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.) A green-space setback rule, where feasible and legally permissable, 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.

Water Quality

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.

Air Quality

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.

Noise pollution

Presently, noise pollution does not greatly affect the Mandahl Bay APC/APR. To reduce noise disturbances:

Broadcasting of loud amplified music should not be allowed within the APC.

Construction activities within the APC should be limited to certain, daytime hours.

Transportation

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); roadside gutters should be built parallel to and at a slightly lower elevation than the road surface. These should 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.

Commercial Development

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.

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 type of development. Environmental considerations, community interest, traditional usage, and the educational opportunities the site offers should be emphasized.

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.

Wetlands

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 Study. Every effort should be made to ensure compatibility of all resource management plans that affect the same area.

4.3 Legislative Change

Legislation is required to establish the Territorial Park System, including the necessary funding allocations and, where appropriate, provisions for creative, cooperative management with groups and agencies outside of the V.I. Government. If possible, the Mandahl Hill subdivision (Plot 37) should

be considered for acquisition, through either fee simple or other terms, for inclusion in the Territorial Park System.

4.4 Institutional Development

Successful management of the Mandahl Bay APC will come about more quickly and with more lasting results if the local community, including the landowners in the area, is drawn into the planning process. The various environmental and cultural organizations, and other commercial and philanthropic organizations should be encouraged and invited to work together and in conjunction with DPNR to address certain specific components of the overall management framework, and even to finance certain elements (including fundraising for land acquisition) that will have obvious payback benefits to the entire community.

5. CONCLUSION

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. Management of the Mandahl Bay APC will require some sort of routine monitoring and enforcement program, and Government should explore the viability of a partnership arrangement with local residents to provide management services.

The Study outlines Best Management Practices that should be used to guide new developments, including the use of excavation and/or grading plans, and the use of structural and vegetative soil stabilization techniques to 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 to minimize potential sedimentation and other pollutant impacts to the pond's water quality.

REFERENCES CITED

Adams, A. Jr., and Associates, 1991. Environmental assessment report, Hans Lollik Resort, phase 1: Landing, infrastructure, hotel, and services, Volumes I, II and III. Prepared for Tamarind Resort Associates.

BC&E/CH_2M Hill, 1979. A sediment reduction program. Prepared for the Government of the U.S. Virgin Islands. Gainesville, FL.

Brower, D.J. and T. Beatley, 1988. Natural hazard mitigation plan for the U.S. Virgin Islands. Prepared for the Virgin Islands Territorial Emergency Management Agency (VITEMA). St. Thomas, USVI.

Dobin, J. and Associates, Inc., 1990. Hans Lollik and Mandahl Bay environmental program for sustainable resort development. Preliminary draft report. Prepared for Tamarind Resort Associates.

Donaldson, D.K., Consultants Inc., 1990, Hans Lollik/Mandahl Project, report on environmental analysis, D.K. Donaldson Consultants Inc. Ottawa, Ontario, Canada.

Donnelly, T. and J. Whetten, 1967. Field guide to the geology of the Virgin Islands. Fifth Caribbean geological conference.

Federal Emergency Management Agency, 1992. Flood Insurance Rate Map, U.S. Virgin Islands, Island of St. Thomas. National Flood Insurance Program. Community Panel No. 780000 0015 E; revised August 3, 1992.

Geoscience Associates, 1984a. Phase 1 report; Vulnerability analysis, earthquake hazards of the U.S. Virgin Islands. Prepared for the USVI Government, Office of the Governor, Disaster Programs Office. St. Thomas, USVI.

Geoscience Associates, 1984b. Phase 2 report; Vulnerability analysis, earthquake hazards of the U.S. Virgin Islands. Prepared for the USVI Government, Office of the Governor, Disaster Programs Office. St. Thomas, USVI.

Great Hans Lollik Island Company (The), 1980 Environmental assessment report for resort, residential, and marina development at Mandahl Bay, St. Thomas and Great Hans Lollik Island, USVI.

Green and Associates, 1990. Mandahl Bay Villas environmental assessment report. Prepared for Mandahl Management Corporation.

Island Resources Foundation, 1977. Marine environments of the Virgin Islands, Technical supplement No.1. USVI Government, Planning Office, Coastal Zone Management Program. St. Thomas, USVI.

Island Resources Foundation, 1986. Puerto Rico and Virgin Islands coastal barriers summary report. Prepared for the Department of the Interior, U.S. Fish and Wildlife Service. St. Thomas, USVI.

Island Resources Foundation, 1991. Virgin Islands territorial park system planning project and hurricane Hugo coastal resources damage and recovery assessment, St. Thomas, USVI.

McCrain, J., 1982. Mandahl Bay area of particular concern (APC): Planning guidelines and management recommendations. USVI Government, Department of Conservation and Cultural Affairs, Division of Coastal Zone Management. St. Thomas, USVI.

McGuire, J.W., 1925. Geographic dictionary of the Virgin Islands of the United States. U.S. Department of Commerce, Washington D.C.

McComb Engineering, 1979. Environmental assessment report for resort, residential, and marina development at Mandahl Bay, St. Thomas and Great Hans Lollik Island. EAR for Great Hans Lollik Island Company. CZM permit application.

Nichols, M., A. Kuo, C. Cerco, and P. Peebles, 1979. Virgin Islands bays: modeling of water quality and pollution susceptibility. Island Resources Foundation, under contract to the USVI Government, Department of Conservation and Cultural Affairs. St. Thomas, USVI.

Real Estate Data, Inc., 1987. Real estate atlas of the Virgin Islands. Miami, FL.

Smith, Commissioner, 1991. Letter from Commissioner Smith to Mr. A. James Casner, III, regarding concerns about the proposed Mandahl Hill Subdivision project. Dated 29 January 1991.

Teytaud, A., 1981. A Virgin Islands land use/land cover classification system. USVI Government, Department of Conservation and Cultural Affairs, Division of Coastal Zone Management.

U.S. Department of Commerce, 1979. The Virgin Islands coastal management program and final environmental impact statement. National Oceanic and Atmospheric Administration, Office of Ocean and Coastal Resource Management. Washington, D.C.

U.S. Department of the Interior, 1960. Park and recreation plan for the U.S. Virgin Islands.

U.S. Environmental Protection Agency, 1990. EPA Region II Caribbean distinctive habitats module.

U.S. Fish and Wildlife Service, 1990. Coastal Barrier Resources System Map. October 24, 1990.

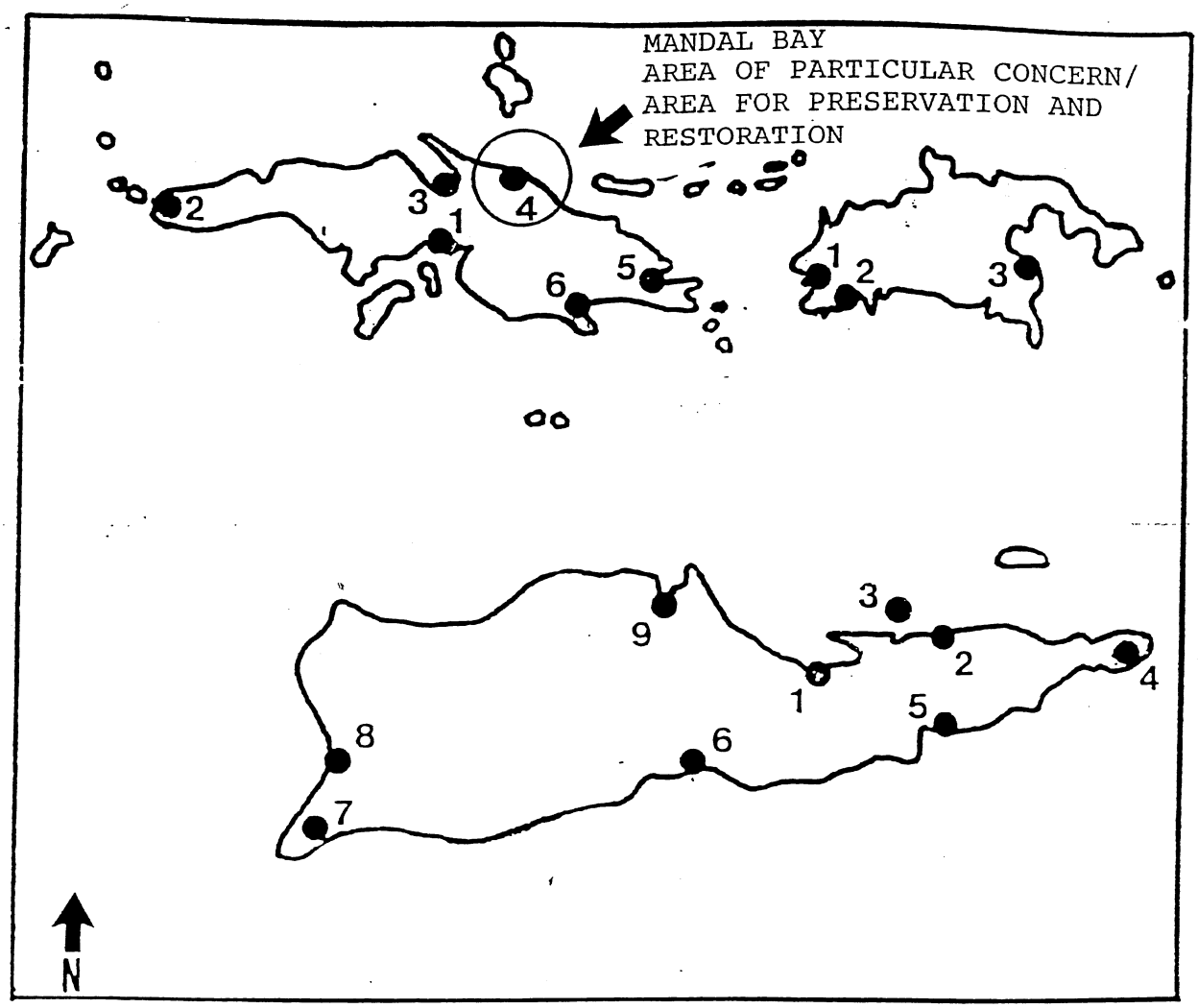
U.S. Geological Survey, 1984. A workshop on earthquake hazards in the Virgin Islands region. Open-file report 84-762. U.S. Department of the Interior, USGS. Reston, VA.

USVI Government\Department of Conservation and Cultural Affairs, 1982. A report on the environmental quality and documented physical and biological conditions of bays to be

included in the proposed coastal water use policies. Office of Natural Resources Management, St. Thomas, USVI.

USVI Government\Department of Planning and Natural Resources. U.S. Virgin Islands Comprehensive Land and Water Use Plan. Unpublished draft, 1991.

AREAS OF PARTICULAR CONCERN



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) Coral Bay (APR)

St. Croix

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

Figure 1
Regional APC Map
Adapted from: USDOC, 1979

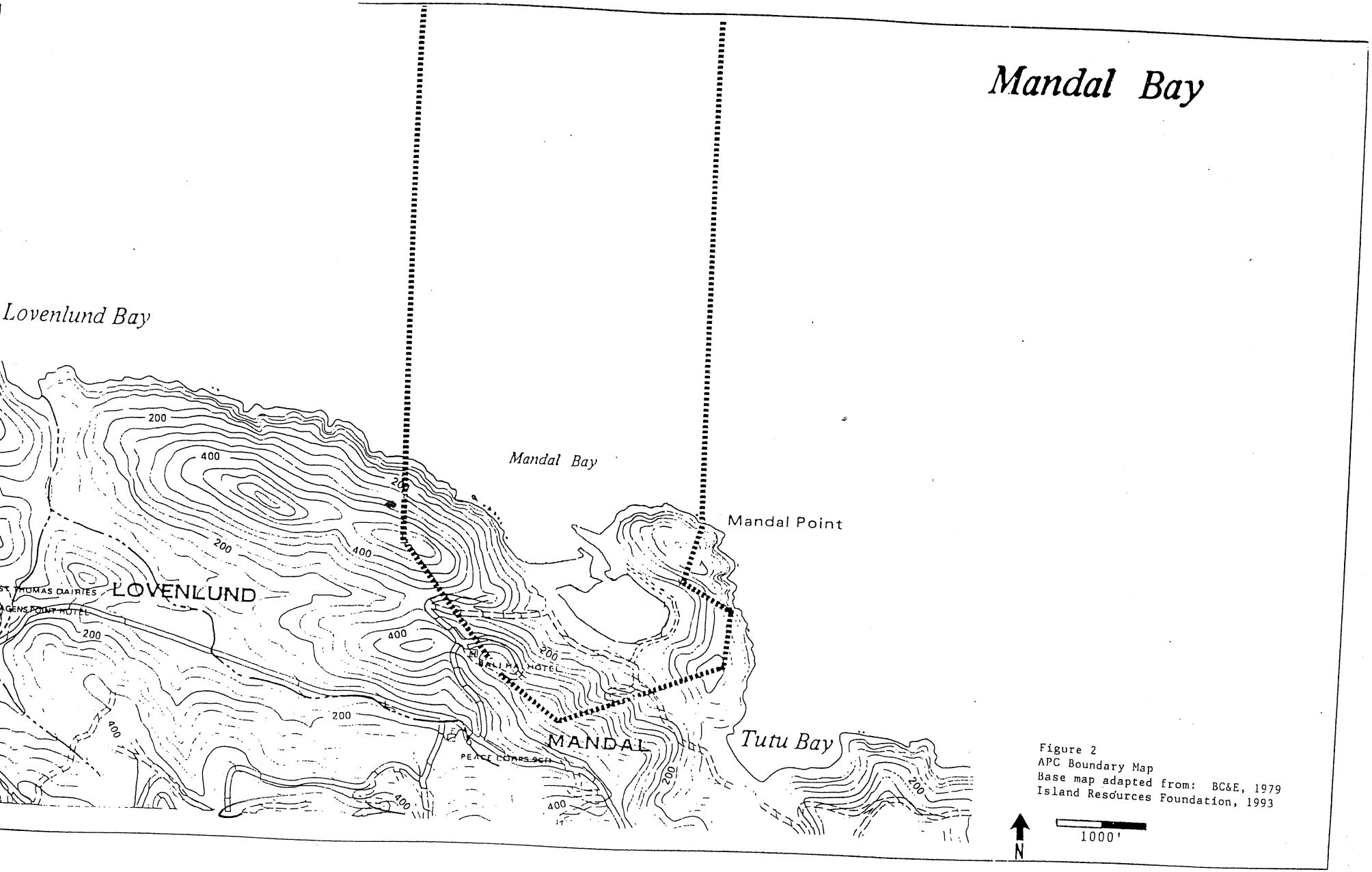


Figure 2
APC Boundary Map
Base map adapted from: BC&E, 1979
Island Resources Foundation, 1993

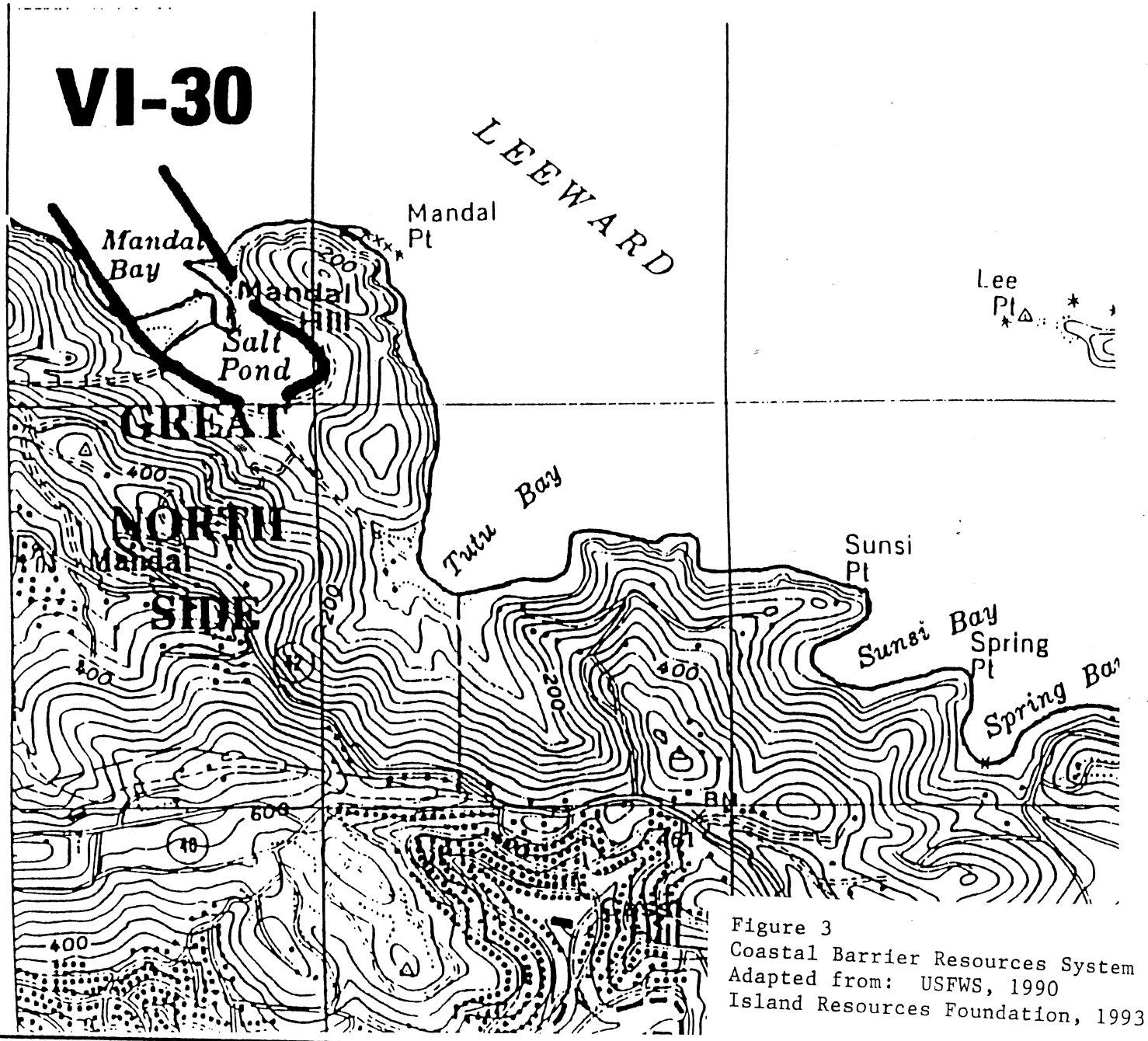
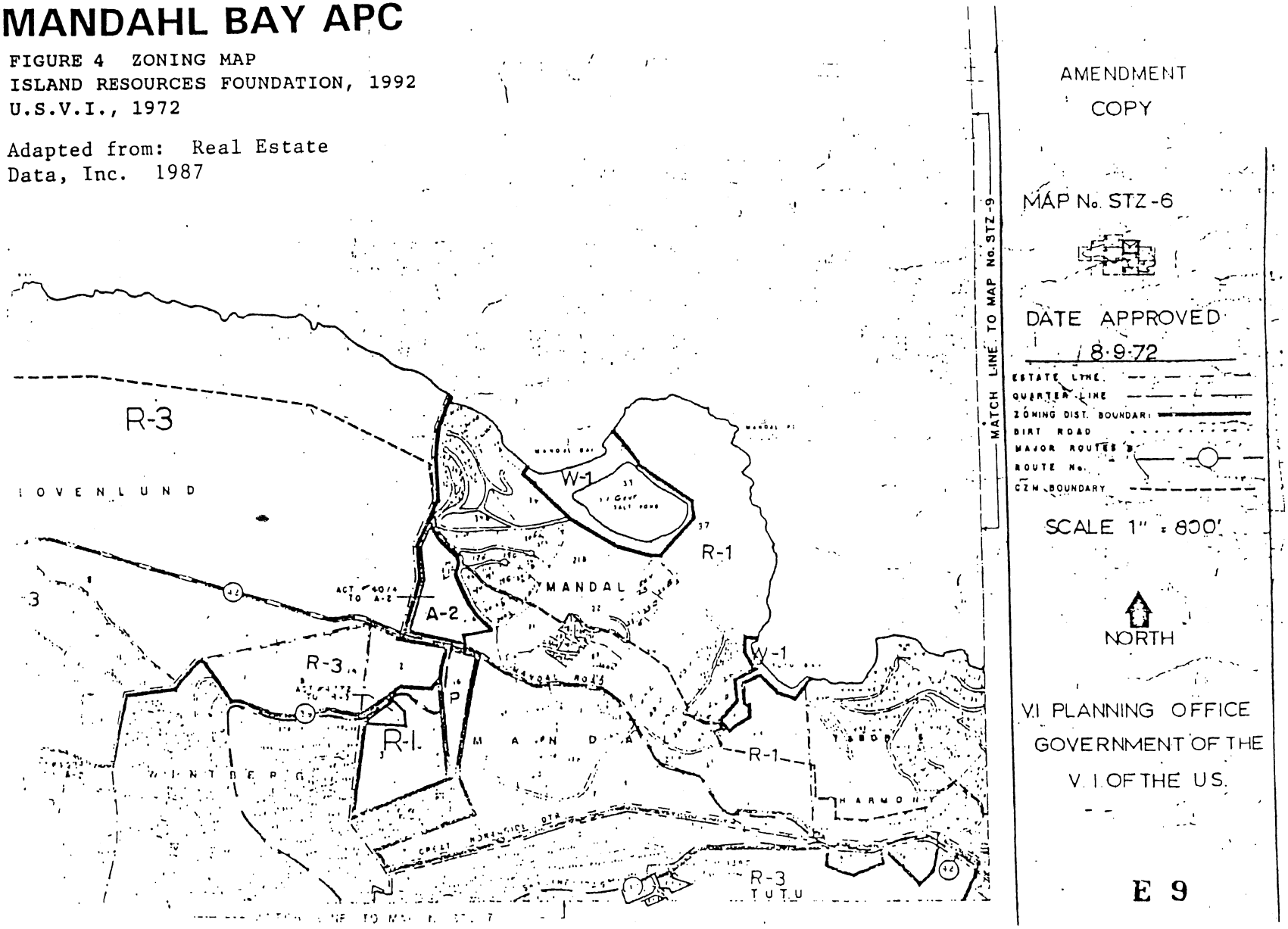


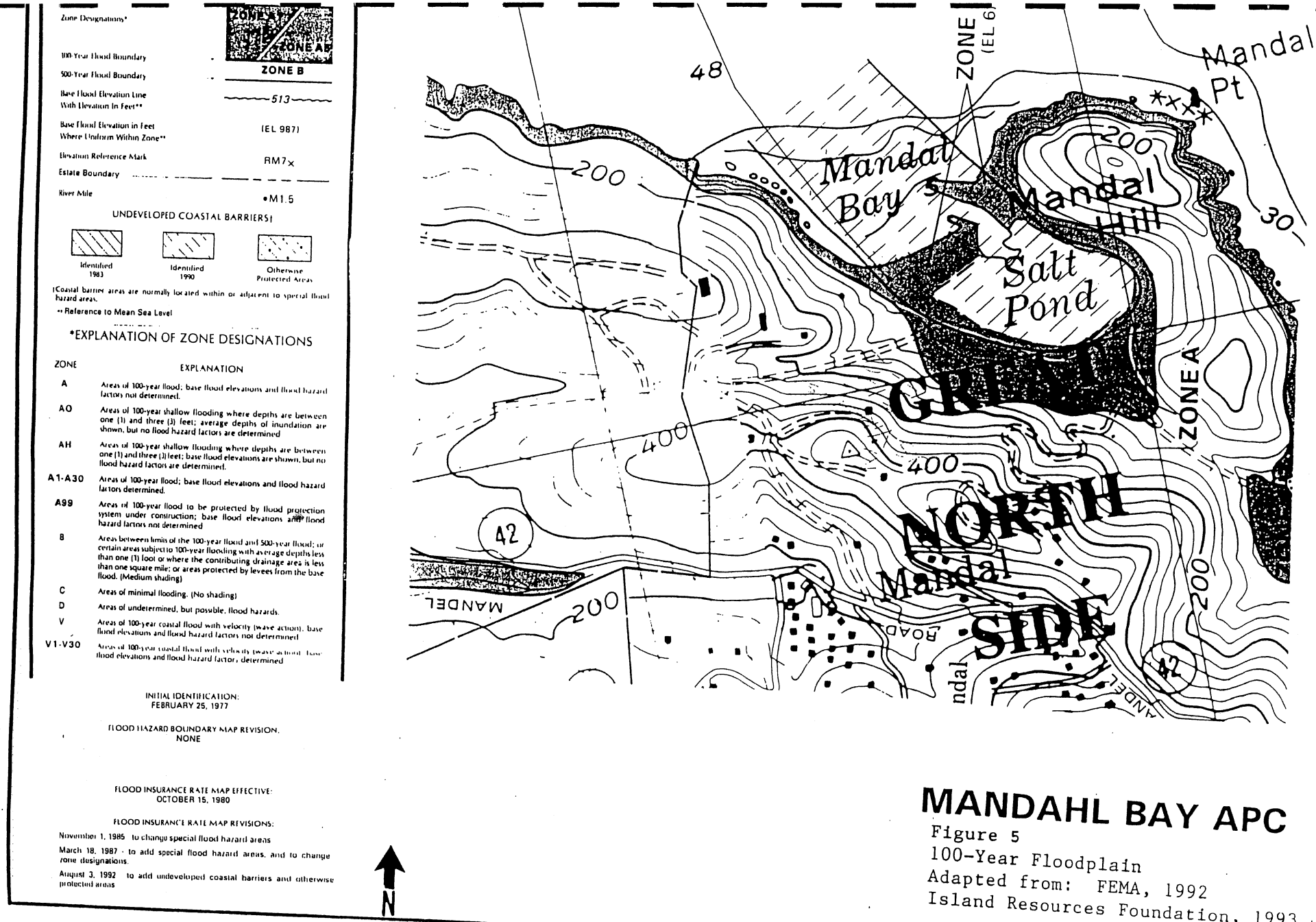
Figure 3
Coastal Barrier Resources System Boundary
Adapted from: USFWS, 1990
Island Resources Foundation, 1993

MANDAHL BAY APC

FIGURE 4 ZONING MAP
ISLAND RESOURCES FOUNDATION, 1992
U.S.V.I., 1972

Adapted from: Real Estate Data, Inc. 1987





MANDAHL BAY APC

Figure 5
100-Year Floodplain
Adapted from: FEMA, 1992
Island Resources Foundation, 1993

MANDAHL BAY APC

1. Run-off from steeply sloped roads and residential building sites should be controlled through effective drainage system (i.e. gutters to direct water along roadways); and use of appropriate vegetative and structural erosion control methods.
2. Potential problems resulting from septic overloading of soils and subsequent contamination of run-off water. Recommend use of alternative (waterless) toilet systems in the watershed.
3. Trash disposal responsibilities on beach should be coordinated among PWD and DPNR. Abandoned vehicles must be removed from the beach and pond areas.
4. Loud or amplified music is not traditionally used at this beach and should be prohibited.
5. Future recreational development of the bay and pond should be limited to educational displays, designated parking areas and maintenance of nature trails.
6. Because of the limited flushing capability, additional moorings, increased boat traffic and marina-related facilities would cause considerable harm to the ecology of Mandal Pond and should be prohibited.
7. Potential flooding to 5' depth in a 100 year storm situation in the areas surrounding the pond. Building should be strictly limited.
8. The developing mangrove lagoon habitat around the pond must be preserved.
9. Mandahl Hill Subdivision

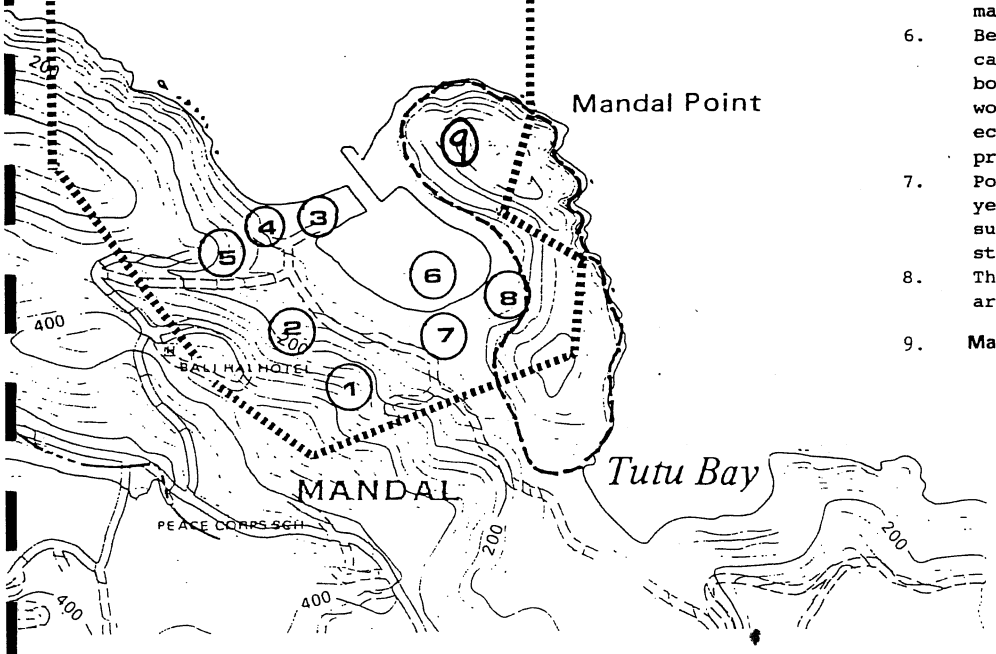


Figure 6
User Conflict Map
Base map adapted from: BC&E, 1979
Island Resources Foundation, 1993

MANDAHL BAY APC

LAND USE / LAND COVER

111	Low density residential
171	Beach (swimming)
179	Picnic Area
322	Beach Thicket
420	Mixed Woodland & Brush
423	Woodland
431	Coconut Grove
611	Mangrove
730	Exposed Rocky Shoreline

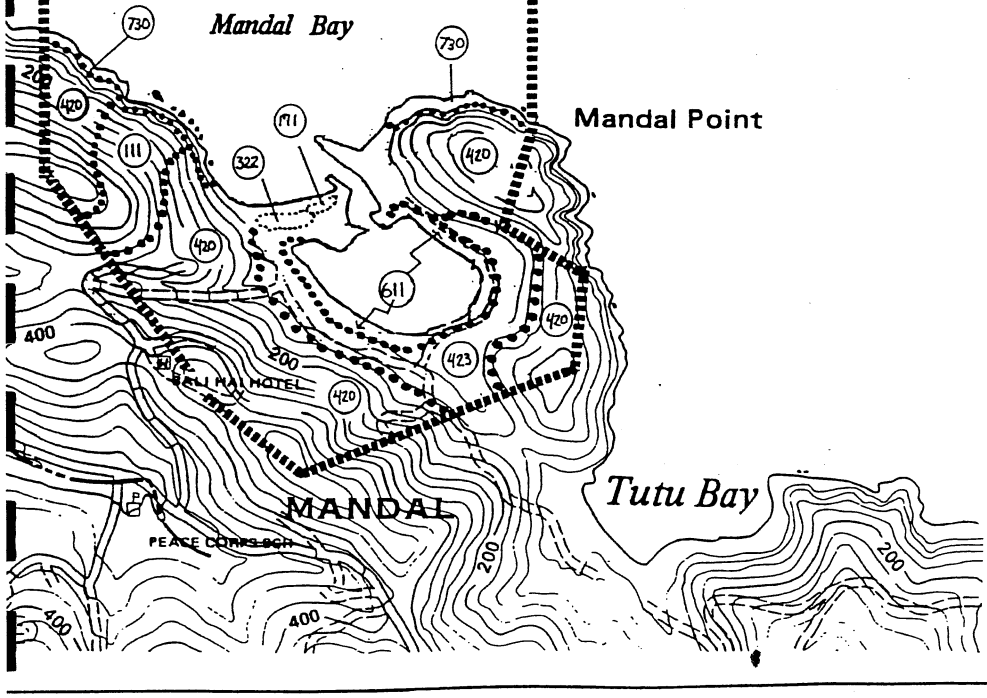


Figure 7
Land Use/Land Cover-
Base map adapted from: BC&E, 1979
Island Resources Foundation, 1993

MANDAHL BAY APC

PHYSICAL FEATURES

1 Bedrock Cliffs

2 Breakwater Jetties

3 Stone Revetment

4 Beach Rock (exposed)

5 Beach Sand

6 Beach Cobble

7 Beach Rubble

8 Silt & Sand Substrate

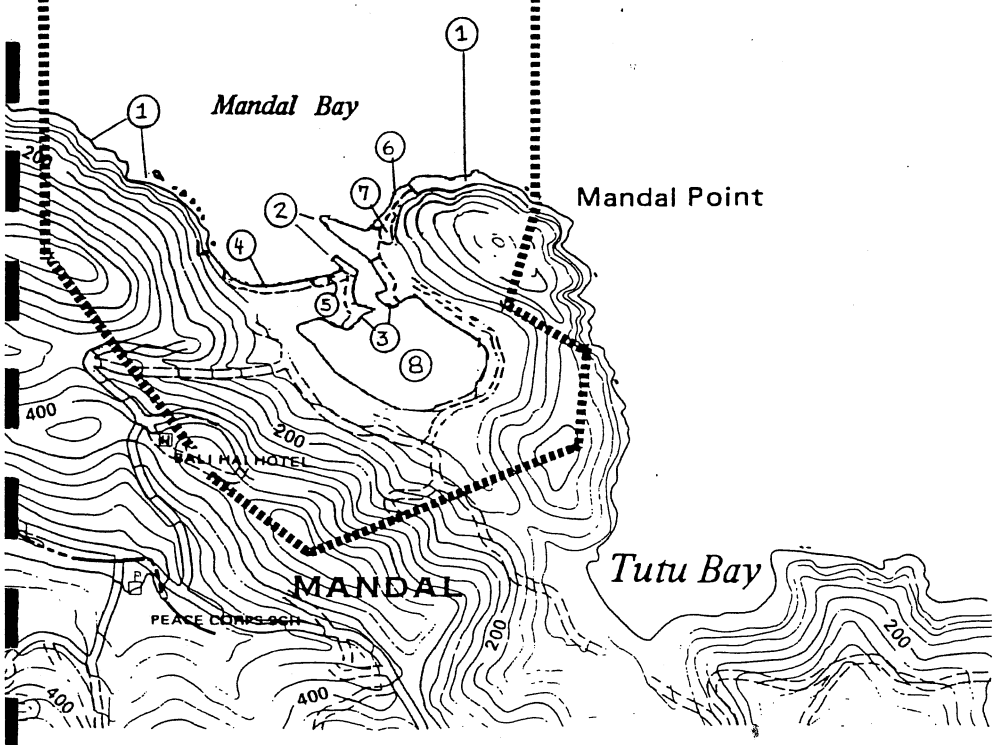
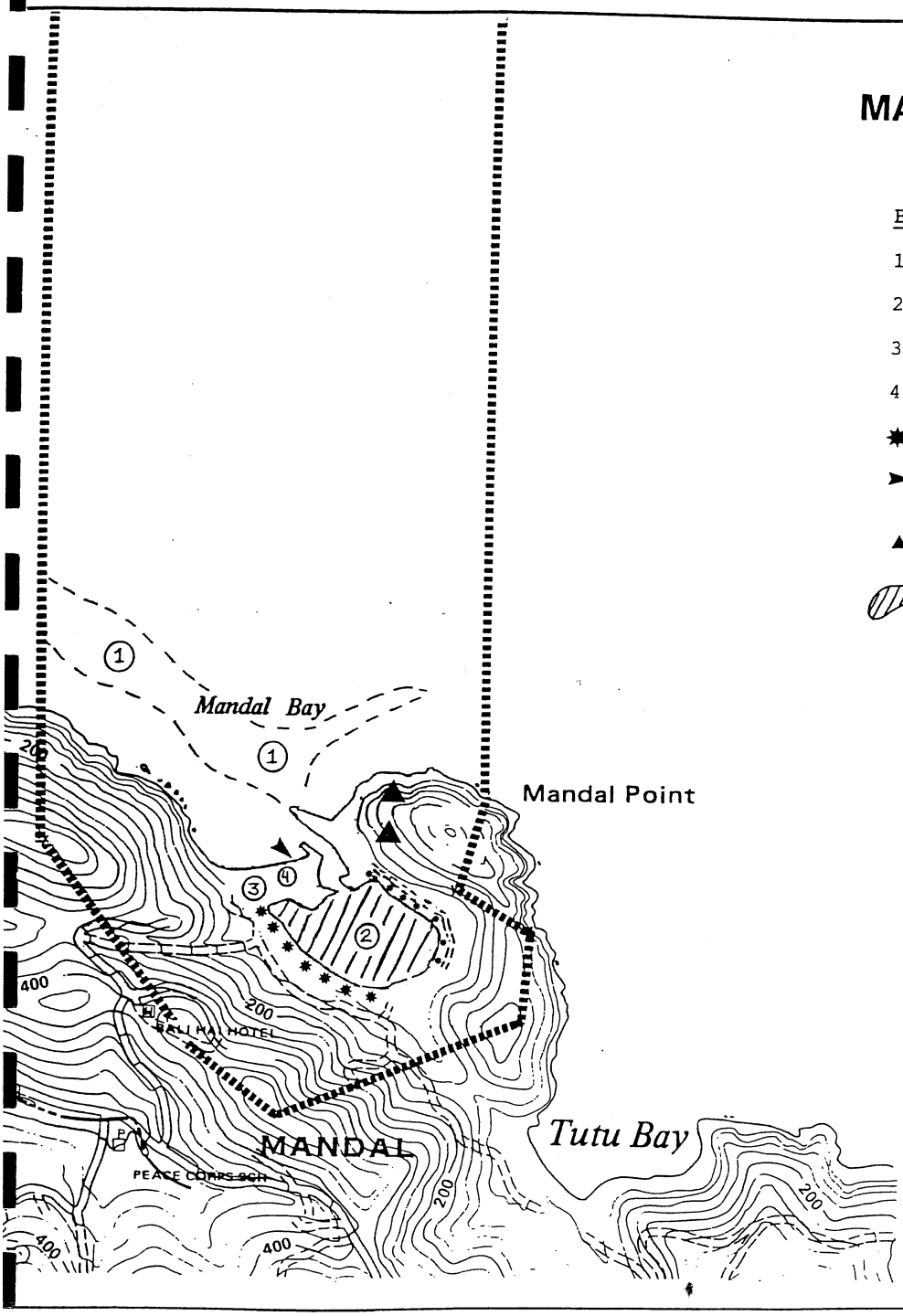


Figure 8
Physical Features
Base map adapted from: BC&E, 1979
Island Resources Foundation, 1993

1000'

N

MANDAHL BAY APC



BIOLOGICAL FEATURES

1 Patch Reef/Gorgonian Reef

2 Halophila/Algae Bottom

3 Coconut Grove

4 Coastal Thickets

✸ Mangrove

➤ Turtle Nesting Area (Hawksbill & Green Turtles)

▲ Bird Rookery (Brown Pelican)

Bird Feeding Area (Brown Pelican & Herons)

Figure 9
Biological Features -
Base map adapted from: BC&E, 1979
Island Resources Foundation, 1993

1000'

N