# Rhode Island's Salt Pond Region: A Special Area Management Plan

**(Maschaug to Point Judith Ponds)**

for the salt pond watersheds in the
Towns of Westerly, Charlestown, South Kingstown and Narragansett
April 12, 1999

**Prepared for the**
**Rhode Island Coastal Resources Management Council**




**This document was prepared for the Coastal Resources Management Council by:**
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Coastal Resources Management Council

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**FORWARD**

The revisions to the Salt Pond Region Special Area Management Plan (SAMP) reflect the concept of partnership and community participation which began with the development and use of special area management planning in Rhode Island during the early 1980s. The Rhode Island Coastal Resources Management Council (CRMC) is fortunate to have the scientific and management expertise available at Rhode Island Sea Grant, the University of Rhode Island's (URI) Coastal Resources Center, Department of Geology, Department of Natural Resources Science, Graduate School of Oceanography, Environmental Data Center, and Cooperative Extension, the Rhode Island Department of Environmental Management (RIDEM) Division of Fish and Wildlife and Water Resources, the Rhode Island Historical Preservation Commission, and the federal resources agencies: Fish and Wildlife Service, National Marine Fisheries Service, Environmental Protection Agency and the Natural Resources Conservation Service.

CRMC partners throughout the revision process included the four municipalities Westerly, Charlestown, South Kingstown and Narragansett, the Narragansett Indian Tribe, the Salt Ponds Coalition, URI Watershed Watch, the URI Cooperative Extension, the URI On-Site Wastewater Training Program, the RIDEM Septic System Maintenance Policy Forum, the Rhode Island Mmarine Trades Associationindustry, the Rhode Island Builder's Association, The Nature Conservancy and many others. The input of these partners was valuable and has enabled CRMC to present more complete and pertinent data, and better management measures and policies.

The revisions to the SAMP are the result of the Rhode Island Coastal Resources Management Council's Strategy for enhancing the Rhode Island Coastal Resources Management Program in accordance with the requirements of Section 309 of the 1972 Coastal Zone Management Act (16 U.S.C. §1451 et seq.) as amended by the 1990 Coastal Zone Act Reauthorization Amendments.

The purpose of the revisions to the Salt Pond Region SAMP are to reassess the issues addressed in the original document.s In so doing, policies, standards and recommendations to municipalities and federal and state agencies have been revised and updated. CRMC also modified the SAMP boundary to reflect the surface watershed boundaries of the salt ponds.

The focus of these revisions is primarily on density controls and other regulatory requirements thato better manage nonpoint source pollution and cumulative and secondary impacts which can result in habitat loss, erosion and sediment control problems, stormwater impacts and groundwater contamination from septic systems. The revisions also address other important issues such as wetlands protection, breachway modifications, dredging, recreational boating, storm hazards, and public access.

The revisions to the SAMP are the result of implementing the CRMC's Strategy for enhancing the Rhode Island Coastal Resources Management Program in accordance with the requirements of Section 309 of the 1972 Coastal Zone Management Act (16 U.S.C. §1451 et seq.) as amended by the 1990 Coastal Zone Act Reauthorization Amendments.

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## ACKNOWLEDGMENTS

Special thanks are due to the many people who had a hand in the revisions to the Salt Pond Region Special Area Management Plan (SAMP). Members of the Planning and Procedures Subcommittee of the Rhode Island Coastal Resources Management Council (CRMC), including George DiMuro, Chairman, Turner C. Scott, Vice Chairman, Michael M. Tikoian, Lloyd Sherman, Eileen Naughton, Peter Troy, Robert Ellis Smith, Pam Pogue, Augustinho Nunes and Andrew McLeod, attended meetings, providing their expertise in dealing with coastal resources management issues. The CRMC staff members, Jim Boyd and Donna Lynne Doyle and Jim Boyd, who began to work on the SAMP revisions in 1994, set the foundation. Dave Reis, Ken Anderson, Jeff Willis and Laura Miguel all made important contributions to Chapter 1, Objectives, Chapter 2, Framework of Management and Chapter 9, Regulations. The entire permitting staff at CRMC (Tom Medeiros, Tim Motte, Rich Lucia and Mike Deveau) were excellent at identifying problem areas in the 1984 SAMP. Special thanks to Joanne Moore, Lisa Mattscheck and Gerry Higgins for assisting in compilation, Kevin Cute for formatting and Brian Kavanagh for production.

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The Council also extends its sincere thanks to:
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the nonprofit groups: Dave Monk from the Salt Ponds Coalition and the Salt Pond Watchers, Sue Nardone, the data manager from the Salt Pond Watchers, Eugenia Marks from The Audubon Society,, and Allison Walsh from Save the Bay; and Dave Monk from the Salt Ponds Coalition

the Charlestown Planning Commission, for their extensive interest and input;

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and the concerned residents who attended the many public meetings.

To all of you who gave of your time and effort in this revision, and in the initial formidable task of writing this plan in the first place, the Salt Ponds and the CRMC staff thank you.

**DEDICATION**

This plan is dedicated to the memory of John "Skinny" Sposato. His work and love of the coastal environment continue to be a valuable contribution to the effectiveness of this program.

**Salt Pond Region Special Area Management Plan**

## Table of Contents

**Chapter 1**
**Objectives of the Special Area Management Plan**

## 100. Introduction

### A. The Purpose of the Salt Pond Region Special Area Management Plan Revisions

1. The strategy behind the development of the Special Area Management Plan (SAMP) is to recognize how water quality, land-use, habitat, storm hazards and geology all interact on an ecosystem level to impact the health of the salt ponds. The SAMP is part of the Rhode Island Coastal Resources Management Council's (CRMC), ongoing responsibility under both the Rhode Island General Laws 46-23 and the Coastal Zone Management Act (CZMA) (16 U.S.C. §1451). The CRMC has been empowered by Rhode Island state statute 46-23 to develop management programs for the protection and enhancement of the states coastal resources. It has also been given authority to implement the federal Coastal Zone Management Program under 46-23-15. Specifically, G.L.R.I. 46-23-15 gives the CRMC authority to administer land and water use regulations as necessary to fulfill their responsibilities under the federal CZMA. The revisions to the Salt Pond Region SAMP address four priority areas for enhancing the Rhode Island Coastal Resources Management Program (CRMP); Special Area Management Planning, cumulative and secondary impacts, wetlands, and public access. The revisions to the SAMP also implement recommendations of the Narragansett Bay Project by developing the following: statewide critical resource protection policies, including objective criteria for designating critical resources; a geographic information systems (GIS) based inventory of identified resources; regulatory and non-regulatory controls to protect identified resources; and an assessment of cumulative impacts through the CRMP. Finally, the revisions will facilitate the implementation of Rhode Island's Coastal Nonpoint Pollution Control Program (CNPCP). Beyond fulfilling program requirements and recommendations, the revisions to the SAMP address the challenge of a growing population and the need for innovative land-use controls to address the impacts of existing and proposed development on the salt ponds.

### B. The Challenge

1. The salt ponds are coastal lagoons; shallow, productive marine embayments separated from the ocean by barrier spits. Although the physical characteristics shown in Table 1-1 vary between salt ponds, they all provide important ecosystem and habitat functions. These functions include prime habitat for commercial and recreational fin and shellfish; resting and feeding stops for water fowl migrating along the Atlantic flyway; and their protected waters support a variety of human uses ranging from a commercial fishing port and the Block Island ferry terminal to favorite sites for recreational uses such as wind surfing, boating, fishing, water skiing, and nature photography. The salt ponds are

an important factor in the quality of life for local residents and a prime recreational attraction for tourists in the region.

**Table 1-1** Physical Characteristics of Rhode Island's Salt Ponds (Lee 1980, RIGIS 1996, Grace and Kelley 1981).

| | Pt. Judith | Potter | Cards | Trustom | Green Hill | Ninigret | Quonochontaug | Winnapaug | Maschaug |
|---|---|---|---|---|---|---|---|---|---|
| Area (acres) | 1530 | 329 | 43 | 160 | 431 | 1711 | 732 | 446 | 49 |
| Avg. Depth (ft) | 6 | 2 | 1.5 | 1.5 | 2.5 | 4 | 6 | 5 | 7 |
| Avg. Salinity (ppt) | 29 | 27 | 4 | 5 | 19 | 24 | 29 | 28 | 7 |
| Watershed Area (acres) | 3536 | 3311 | 1820 | 794 | 3039 | 6025 | 2307 | 2294 | 347 |
| Groundwater Vol. ($m^3$/yr) | $2.5 \times 10^7$ | $5.0 \times 10^6$ | $2.2 \times 10^6$ | $1.1 \times 10^6$ | $6.8 \times 10^6$ | $1.5 \times 10^7$ | * | * | 0 |

The Salt Pond Region extends from the barriers that separate the salt ponds from the ocean to the inland boundary of the surface watersheds of the individual ponds. For regulatory purposes, the region is defined as shown in Figure 1-1 and includes 45 square miles. This region includes the towns of Narragansett, South Kingstown, Charlestown and Westerly. Land-use in the region is shown in Figure 1-2 for 1988. The population of the Salt Pond Region increased 69 percent between 1981 and 1992, exceeding the national trend of 60 percent estimated for other coastal regions (Culliton et al. 1990, Lee and Ernst 1996). The Rhode Island Division of Planning projects an average 20 percent growth rate for Rhode Island's suburban and rural communities between 1985 and 2010, compared to a 2.6 percent growth rate in the state's cities, and a statewide growth rate of 9.5 percent. Human population and development is continuing to grow within the watersheds of the salt ponds, and it is estimated there will be almost 20,000 housing structures at full development in the watersheds given 1995 zoning regulations. Although the initial SAMP regulations and changes in municipal zoning reduced the potential extent of development and pollutant sources in the watersheds, the cumulative impact of nonpoint sources of bacteria and nitrogen continue to result in closed shellfish beds and eutrophic conditions in the salt ponds.

2. Evidence of some of the cumulative impacts of development include:

(a) Symptoms of eutrophication include increases in marine macroalgae abundance and increased organic material in bottom sediments, during the summer months in poorly flushed waters surrounded by dense residential development (Lee and Olsen 1985).

(b) All of Green Hill Pond has been permanently closed to shellfishing by the RIDEM since 1994. In 1996, RIDEM extended the permanent shellfish closure into the eastern portions of Ninigret Pond where it connects to Green Hill Pond. Point Judith Pond is closed to shellfishing around the marinas, at the Port of Galilee in the lower pond, and in the upper pond (RIDEM 1996).

(c) The concentration of total nitrogen beneath densely developed areas is elevated 100 times above the background levels found in areas unaffected by anthropogenic changes (Olsen and Lee 1984, Lee and Ernst 1996).

(d) Sedimentation from nonpoint sources of pollution and the breachways have covered settling substrate for shellfish and lobsters (Ganz 1997).

(e) Between 1960 and 1992, Ninigret Pond lost 2.1 $km^2$ of its eelgrass (*Zostera marina*), representing 30.4 percent of the pond area (Short et al. 1996).

3. A burgeoning population and increasing competition among activities threatens to overwhelm the capacity of the salt ponds to absorb wastes, provide shelter for boats and vessels, attract residents and tourists and underpin premium real estate values. Large areas of the salt ponds are poorly flushed, which makes them valuable as fish and shellfish nurseries but, also particularly susceptible to eutrophication and bacterial contamination. The salt ponds' ecology can be drastically changed by such alterations as stabilizing the inlets that connect them to the ocean, dredging channels, and altering the quality and quantity of freshwater flow through sewering or public water withdrawal.

4. Recent studies and surveys by the Environmental Protection Agency (EPA) and by State water quality agencies indicate that the majority of the water quality impairments in our nation's rivers, streams, lakes, estuaries, coastal waters, and wetlands result from nonpoint source pollution (EPA 1993). In the salt pond region, failing and substandard Individual Sewage Disposal Systems (ISDS) are the single most important nonpoint source of bacterial and nutrient contamination to the region's coastal waters (Chapter 3). Water quality problems associated with ISDS are related to the existence of a large number of sub-standard systems installed prior to the adoption of the current RIDEM ISDS regulatory program. Problems are also exacerbated by the fact that in many areas, ISDS were installed at densities greater than those necessary to ensure the proper treatment of sewage and prevention of surface and groundwater contamination.

5. The original Salt Pond Region SAMP focused on managing the potential development of the salt pond watersheds, and the repair and/or maintenance of existing ISDS. Amendments to the SAMP in 1993 required new denitrification technology for all new structures and structures undergoing significant alterations located in the areas adjacent to Green Hill Pond and the eastern part of Ninigret Pond. In the new revisions to the SAMP, CRMC focuses on utilizing new nitrogen reducing technologies, buffer systems, sediment and erosion controls and storm water management to address the cumulative impacts of development in the region.

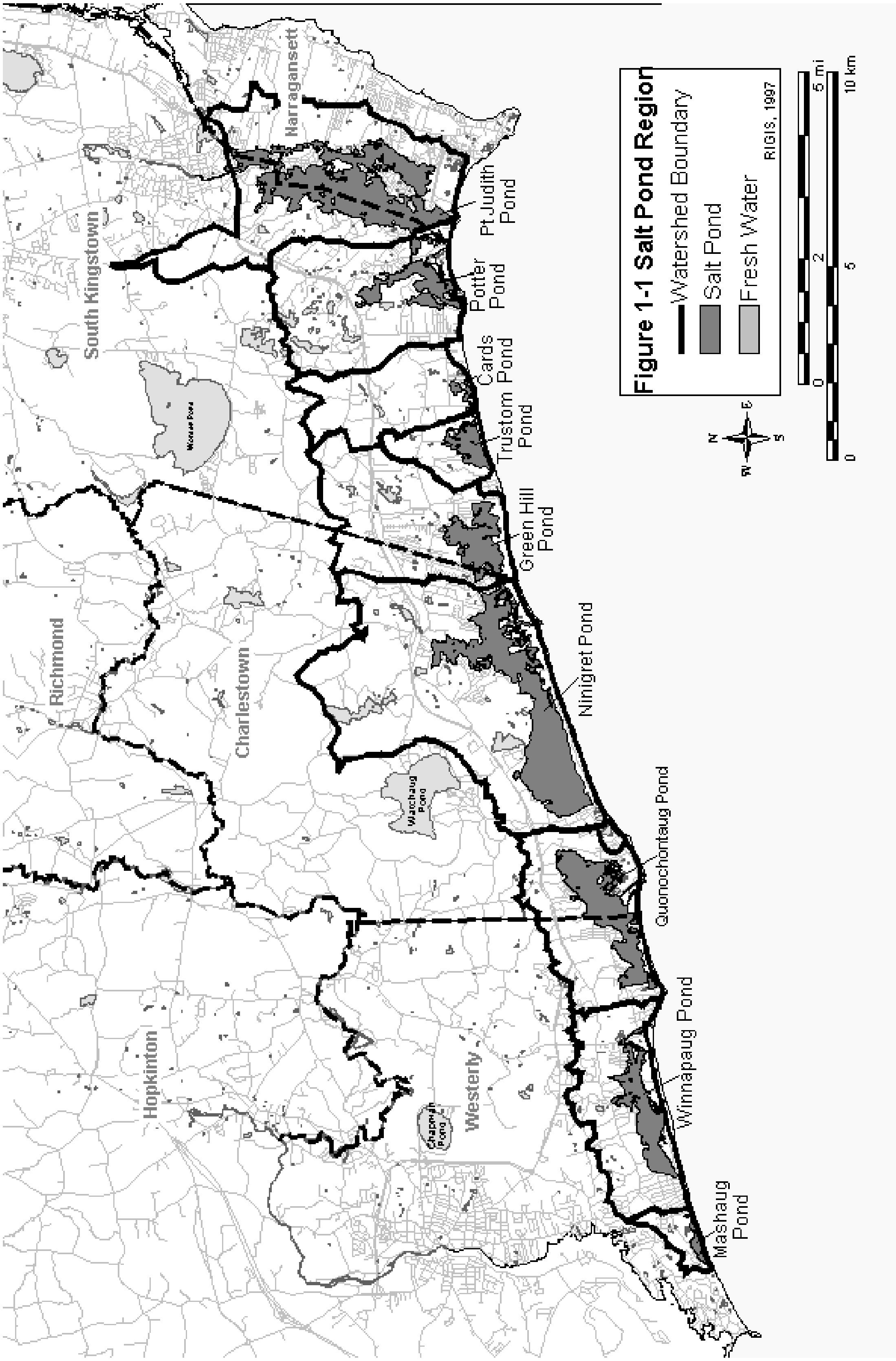


Figure 1-1 Salt Pond Region
Watershed Boundary
Salt Pond
Fresh Water
RIGIS, 1997
0 2 5 mi
0 5 10 km
N
E
S
W
Narragansett
South Kingstown
Pt Judith Pond
Potter Pond
Cards Pond
Trustom Pond
Green Hill Pond
Ninigret Pond
Quonochontaug Pond
Winnapaug Pond
Mashaug Pond
Richmond
Charlestown
Hopkinton
Westerly

**Figure 1-2 Land Use in the Salt Pond Region (RIGIS 1988).**

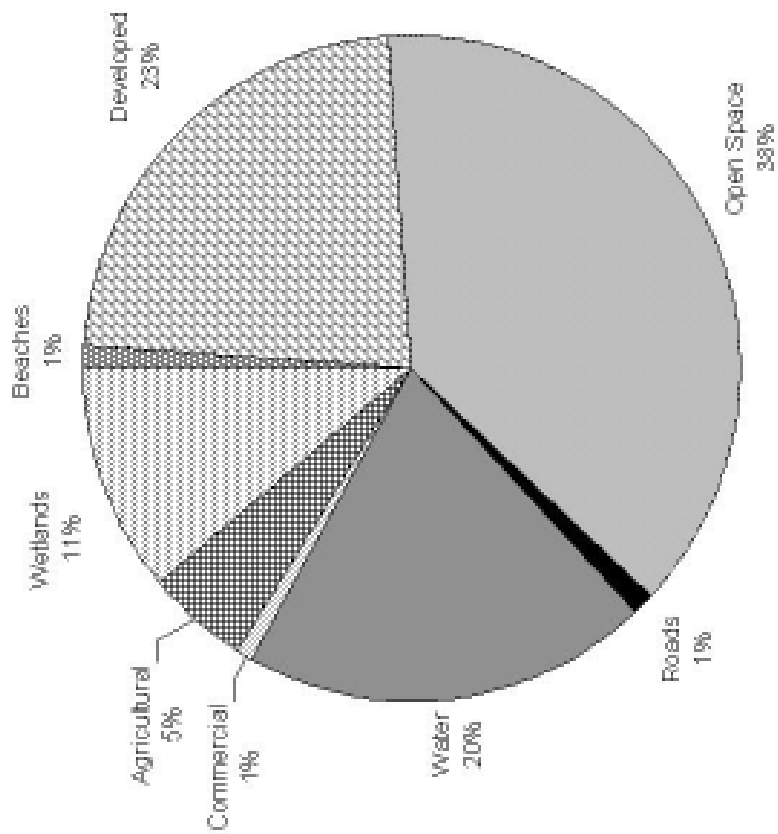
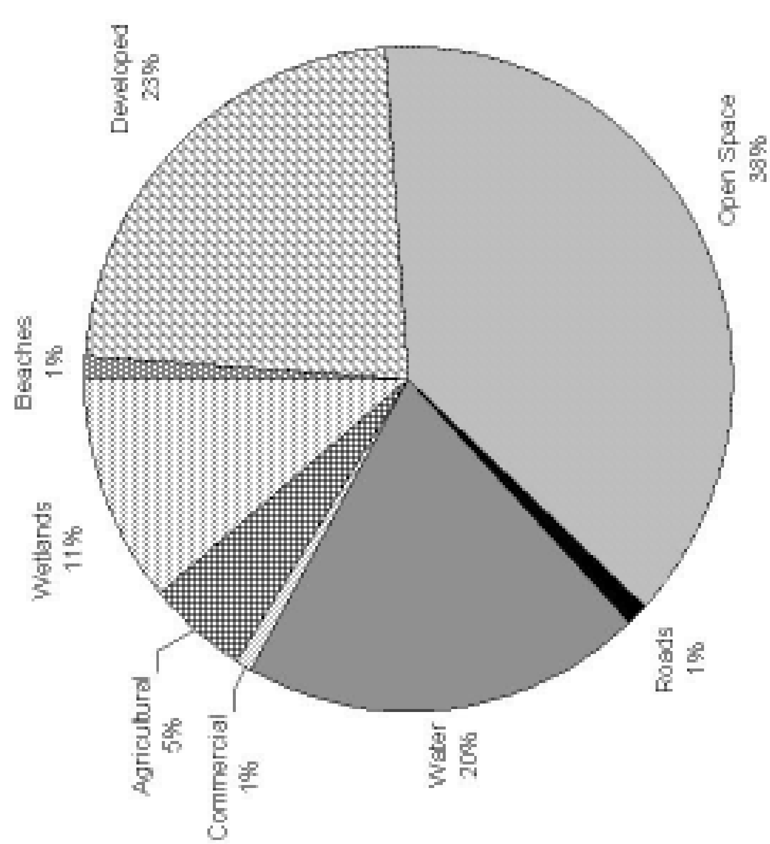


**Figure 1-2 Land Use in the Salt Pond Region (RIGIS 1988).**



## 110. Objectives

### A. The Objectives

- Evaluate the cumulative and secondary impacts of pollutant loadings;
- Develop revised boundaries, regulatory requirements, policies and recommendations for the SAMP;
- Develop revised regulatory requirements for the CRMP;
- Develop additional management measures for Rhode Island's CNPCP; and
- Simplify the format of the SAMP by placing all regulatory requirements and standards in one chapter on land-use management.

## 120. Origins of the SAMP

### A. Public Involvement

1. In 1977, in response to growing concern over the apparent degradation of water quality in the salt ponds, the CRMC held a public workshop at the Quonochontaug Grange to discuss ideas for state policies and regulations to protect and manage coastal areas and their uses. Local residents and officials expressed concern and offered ideas to avoid further degradation of the salt ponds. This was the first time that residents and local officials were able to voice their concerns for the salt ponds and their ideas for steps that should be taken to avoid their further degradation. The public interest provided the impetus for a pilot project to identify the interrelationships among the major management issues and resulted in the publication of an ecological history of the salt ponds entitled "An Elusive Compromise: Rhode Island Coastal Ponds and their People," by Virginia Lee. The principal issues at the time were:

- Formerly abundant fish and shellfish stocks were virtually disappearing while others were declining.
- Human-stabilized inlets were causing rapid sedimentation within the salt ponds. Many, therefore could not provide safe access to the ocean, and subsequent delta formation was altering water circulation and causing further sedimentation of large areas.
- Water pollution threatened to become more widespread; bacterial contamination was a threat to larger shellfishing areas; eutrophic conditions were degrading fish and shellfish habitats and the scenic quality of the salt ponds.
- Residential development threatened to overwhelm the ecosystem's capacity to absorb waste and provide potable drinking water. Farmlands and woodlands that provided the character and beauty of the area were being

sacrificed for new residential development.

- C Hurricanes remained a recurring problem for the south shore, with residents and developers ill-prepared.
- C Competition among aquaculture, commercial and recreational fisheries, recreational boating, and other commercial interests required management.

The pilot project led to a major four-year interdisciplinary research project funded primarily through the URI Sea Grant Program and the Rhode Island Coastal Resources Management Council, with additional funding from the Statewide Planning Program and the Towns of South Kingstown and Narragansett. The research undertaken during 1978-1982 was designed to evaluate the issues raised in 1977, to document the present condition of the salt ponds and describe major trends. Results from this original study were the foundation for the Salt Pond Region SAMP. Specific issues addressed in the study included a framework for management, water quality, land use, fish and fisheries, breachways, channelization and sedimentation, storm hazards and intensified use.

## 130. The Salt Pond Region Special Area Management Plan

### A. An Ecosystem-Based Management Strategy

1. The SAMP is designed to address a diversity of issues on a watershed scale and is rooted in the CRMC's legislative mandate that states:

> "...the coastal resources of Rhode Island, a rich variety of natural, commercial, industrial, recreational, and aesthetic assets, are of immediate and potential value to the present and future development of this state; that unplanned or poorly planned development of this basic natural environment has already damaged or destroyed, or has the potential of damaging or destroying, the states coastal resources, and has restricted the most efficient and beneficial utilization of these resources; that it shall be the policy of this state to preserve, protect, develop, and, where possible restore the coastal resources of the state for this and succeeding generations through comprehensive and coordinated long range planning and management designed to produce the maximum benefit for society from these coastal resources; and that preservation and restoration of ecological systems shall be the primary guiding principle upon which environmental alteration of coastal resources will be measured, judged, and regulated (G.L.R.I. 46-23-1)."

Central to the SAMP's management strategy is recognition that there is a complex interrelationship among the many elements of the ecosystem and often far-reaching and unexpected consequences resulting from a change to one element of the ecosystem.

**B. The Development of the Special Area Management Plan**

1. The development of the Salt Pond SAMP incorporated a diversity of management issues into a strategy anchored in CRMC's mandate "to preserve, protect, develop, and where possible, restore the coastal resources of the state." The geographic focus of the plan was the groundwatershed of the individual ponds (including the barrier beaches that separate the salt ponds from the ocean) (G.L.R.I. 46-23-1).

2. A central purpose of the SAMP was to coordinate a management strategy to which all previously independent regulatory programs would contribute.

3. The primary focus of the initial SAMP was water quality. The major water pollution problems in the region were directly related to the density and distribution of development within the watersheds of the salt ponds. Because nitrogen from many ISDS and sub-standard removal systems like cesspools was recognized to be the major pollutant, CRMC proposed specific land-use classifications for watershed protection:

> (a) Self-Sustaining Lands - lands which were undeveloped or developed at a density of not more than 1 residential unit per 2 acres. In these areas, nutrients released to groundwater by ISDS, fertilizers and other sources associated with residential activities were expected to be sufficiently diluted to maintain potable drinking water.
>
> (b) Lands of Critical Concern - lands which were undeveloped or developed at a density of not more than 1 residential unit per 2 acres and (a) abut sensitive salt pond areas that are particularly susceptible to eutrophication and bacterial contamination and/or (b) overlie aquifer recharge areas for existing or potential water supply wells.
>
> (c) Lands Developed Beyond Carrying Capacity - lands which were developed at densities above carrying capacity, frequently at one residential or commercial unit per 1/8 to ½ acre. Such intense development was the major source of contamination to groundwater and the salt ponds. High nutrient loadings and contaminated runoff waters were resulting in a high incidence of polluted wells and increasing evidence of eutrophic conditions and bacterial contamination in adjoining salt pond waters. Most of the individual sewage disposal systems in these areas predated state-enforced siting and design standards and were approaching their expected life span.

4. The SAMP also addressed the high pressure to develop lots with wetlands, 10 percent slopes or greater, poor drainage, and high flood zones. Re-zoning recommendations were made to the towns based on a build-out analysis which showed that under existing zoning, more intense development than the watershed could support could be allowed. Additional local and state ordinances and regulations such as: local soil erosion and sediment control ordinances; FEMA construction setbacks and standards; CRMC setbacks, prohibitions, and assent stipulations regarding structure placement; wetland restrictions,

and drainage requirements also addressed the impact of poorly sited and designed development.

5. Key to the development and implementation of this plan is a continued recognition of the interdependence of the ponds' numerous resources and the vulnerability of these resources to the pressures of development with the region. In the original SAMP, the CRMC identified eight goals which formed, and continue in these revisions to form, the foundation of the regulatory standards and policies.

**C. The Goals of the Plan:**

- to maintain the exceptional scenic qualities of the salt ponds and diversity in the mix and intensity of the activities they support.
- to manage expansion near areas of the salt ponds that are threatened by harmful bacteria or eutrophic conditions.
- to ensure that groundwater will be unpolluted.
- to preserve and enhance the diversity and abundance of fish, shellfish, and waterfowl.
- to restore barrier beaches, salt marshes, and fish and wildlife habitats damaged by past construction or present use and to prevent further degradation of the natural system by over development.
- to encourage preparation for storms, and both pre-and post-storm response.
- to maintain Point Judith Harbor as a commercial fishing port.
- to create a decision-making process appropriate to the management of the region as an ecosystem.

**D. Special Area Management Plan Effectiveness as a Management Tool**

1. The SAMP is an effective land-use management tool because the local communities complied with the recommended 2 acre minimum housing lot (Charlestown, South Kingstown and Narragansett). As a result, potential building density in the salt pond watersheds was reduced dramatically. The local municipalities also agreed to uphold CRMC policies and standards regarding land-use, stormwater, ISDS, construction and other resource management issues, for projects that are not subject to CRMC authority within the watersheds of the salt ponds. The CRMC addressed pollution issues by requiring denitrification units in areas around Green Hill and Ninigret Ponds, participating in a design/training initiative with URI on alternative sewage disposal systems, requiring buffer zones, and applying soil erosion and stormwater management standards. CRMC initiated the Harbor Management Planning process to help municipalities organize mooring fields. Other mechanisms in the state which make the SAMP an effective tool are the Rhode Island Comprehensive Planning and Land Use Regulation Act which requires towns to complete comprehensive plans, and the Land Development and

Subdivision Review Enabling Act of 1992 (G.L.R.I. 45-22-2). These land use management tools are implemented by the Rhode Island Department of Administration and together are viewed as a single, integrated approach to state oversight over local land and water uses. The Land Development and Subdivision Review Enabling Act (G.L.R.I. 45-23) provides for a joint pre-application review of major land development or subdivision applications.

**140. Salt Pond Region Special Area Management Plan Revisions**

1. The salt ponds continue to be threatened by water quality concerns related to development within the watersheds. These revisions identify pollution sources, wildlife habitat and prudent development strategies to effectuate restoration and preservation of the salt pond resources. The recommended management strategies, based on the existing conditions and new research and data focus on the following areas:

(a) Identification of pollutant sources, such as failed ISDS or improperly constructed and designed systems, nonpoint sources of pollution, and priority areas for sewering;

(b) Stormwater runoff control and soil erosion and sediment control;

(c) Identification of unplatted areas with conflicting zoning and high density development potential;

(d) Identification and understanding of land-uses and appropriate mitigative measures;

(e) Better utilization of buffer zones, and other land management practices such as conservation easements, critical habitat overlay districts in zoning, and acquisition priorities;

(f) Public education on unique resources within the watershed; and

(g) Protection of flood abatement areas such as wetlands.

The regulations contained in Chapter 9 of the revised SAMP are additional to the regulations of the RICRMP. The CRMP will be cited where applicable, but should always be consulted in addition to the SAMP for complete regulatory information. All metadata for the maps created with the Rhode Island Geographic Information Systems (RIGIS) are in Appendix B.

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# Chapter 2
# Framework of Management

## 210. Findings of Fact

### 210.1 Management Authorities

### A. State and Federal Mandate for Special Area Management Planning

1. The CRMC has direct authority over the salt ponds, their shoreline, the oceanfront shoreline, and associated coastal resources. The SAMP is part of CRMCs ongoing responsibility under the CZMA (16 U.S.C. 1451). CRMC in partnership with RIDEM is also responsible for developing and implementing the Rhode Island Coastal Nonpoint Pollution Control Program under Section 6217 of the Coastal Zone Reauthorization Amendments (CZARA) of 1990. The CRMC has been empowered by Rhode Island state statute 46-23-15 to administer land and water use regulations as necessary to fulfill their responsibilities under the Federal CZMA, as amended. The state legislative mandate for ecosystem-based planning describes the resource management process as follows:

(a) Identify all of the state's coastal resources: water, submerged lands, air space, finfish, shellfish, minerals, physiographic features, and so forth.

(b) Evaluate these resources in terms of their quantity, quality, capability for use, and other key characteristics.

(c) Determine the current and potential uses of each resource.

(d) Determine the current and potential problems of each resource.

(e) Formulate plans and programs for the management of each resource, identify permitted uses, locations, protection measures, and so forth.

(f) Carry out these resource management programs through implementing authority and coordination of state, federal, local, and private activities.

(g) Formulation of standards where these do not exist, and reevaluation of existing standards.

An initial series of resource management activities shall be initiated through this basic process, then each phase shall continuously be recycled and used to modify the Council's resource management programs and keep them current (G.L.R.I. 46-23-1).

2. The SAMP is based on an ecosystem-based examination of the resources, their use and impacts from use, the problems, and the existing institutions of the watershed. Its policies and regulations are designed specifically to insure the preservation of the vital elements of the ecosystem, to guide future development within the limitations of the land, and to resolve existing problems. CRMC has the authority to require that allocations of land use consider impacts on surface and groundwater resources, wetlands, coastal features, and other sensitive and fragile natural resources.

**B. Federal Mandate for Special Area Management Planning**

1. The federal mandate for ecosystem-based planning and management of coastal resources, which encourages Special Area Management Planning is the Coastal Zone Management Act (16 U.S.C. §1452) under Section 303(K)(3). In creating this mandate, the United States Congress declared that it is the nation's policy:

> "to encourage the preparation of special area management plans which provide for increased specificity in protecting significant natural resources, reasonable coastal-dependent economic growth, improved protection of life and property in hazardous areas, including those areas likely to be affected by land subsidence, sea level rise, or fluctuating water levels of the Great Lakes, and improved predictability in governmental decision making (16 U.S.C. §1452)."

The federal government encourages the preparation of SAMPs because they are a management framework which protects natural resources, improves protection of life and property (especially in hazardous areas), and improves the predictability of government decision-making.

**C. Local Authorities and Programs**

1. The CRMC has direct and comprehensive authority over the salt ponds, its shoreline, and associated coastal resources. It also has comprehensive authority over the entire watershed through the federal consistency process. Through the SAMP, the CRMC has attempted to network with the other inland regulatory authorities, including state and municipal authorities, to take a comprehensive and more effective unified approach to our management of the watersheds. The challenge is for the regulators to work in unison, cooperating to make decisions that compliment one another and work towards a common goal as laid out in the following pages.

Other regulatory bodies with authority within the Salt Pond Region include but are not limited to: The RIDEM, the Marine Fisheries Council, and the Towns of Westerly, Charlestown, South Kingstown, and Narragansett. This plan was formulated from direct interest and participation by citizens of the watershed, involved municipalities, and state and federal agencies. The success of this type of management plan depends upon each player, including the developers, to uphold their responsibility to act in accordance with the priorities and framework outlined within the plan.

2. A recent statewide effort which addresses cumulative and secondary impacts is the municipal comprehensive planning program, as provided for in the Rhode Island Comprehensive Planning and Land Use Act of 1988 (Land Use Act) (G.L.R.I. 45-22-2) and the State of Rhode Island Land Development and Subdivision Review Enabling Act of 1992 (Development Review Act) (G.L.R.I. 45-23). The comprehensive planning program is implemented by the Rhode Island Department of Administration, Division of Planning, and combined with Development Review Act and Land Use Act, is a single integrated approach to state oversight of local land use planning. As a minimum, under the Land Use Act, the towns must consider the allocation of land for residence, business, industry, municipal facilities, public and private recreation, major institutional facilities, mixed uses, open space and natural and fragile areas. Optimum intensities and standards of development must be established for each use classification and location, based upon: current development; natural land characteristics; and projected municipal, regional and state services and facilities. Allocations of land use must consider impacts on surface and groundwater resources, wetlands, coastal features, and other sensitive and fragile natural resources. Under the Development Review Act, the framework for review of development applications will provide for more up-front review input by state agencies to be afforded to the towns before they make their series of reviews. This significantly improves the coordination of the numerous regulatory agencies involved, and mimics the joint cooperative review envisioned under the initial SAMP.

3. The framework for review as required by the Development Review Act revolves around the town designating an Administrative Officer to administer the Act and coordinate all joint reviews of development applications. The towns have three levels of review: master plan, preliminary plan, and final plan. This new municipal review process will enable applicants or municipalities to request a preliminary application meeting with all applicable boards, commissions, and where appropriate, state agencies, for information on standards, regulatory process, etc. At the master plan level, the town will bring local, state, and federal agency comments together, and provide a general public informational forum prior to any planning board action. Before the preliminary plan level, all state approvals required prior to construction must be in place (including CRMC, RIDEM Wetlands, ISDS, etc.), and a formal public hearing must be held. The town will then move on to the final plan approval, where local regulatory requirements and any mitigation through public improvements are made final.

4. In addition to local zoning ordinances, the municipalities can implement other land use management controls and request technical assistance under the following programs and legislation:

- 1990 R.I. Erosion and Sediment Control Act (G.L.R.I. 45-46) - enables municipalities to adopt erosion and sediment control ordinances.

- R.I. Septic System Maintenance Act of 1987 (G.L.R.I. 45-24.5) - enables municipalities to adopt waste water management districts.

- Farm, Forest and Open Space Act (G.L.R.I. 44-27) - enables municipal tax assessors to assess lands according to current use rather than highest and best use. Landowners apply for the reduced assessment. Farmland must be designated by the RIDEM, Division of Agriculture and forest land must be designated by RIDEM, Division of Forest Environment. Requirements include a minimum of five acres and application for a conservation plan for farmland, and 10 acres and a management plan for forest land.

- Conservation Districts - provide technical assistance to municipal officials and land owners. For example, the three conservation districts in Rhode Island have expended great effort in getting municipalities to develop and implement soil erosion and sediment control ordinances.

- Cooperative Extension (URI) - this program concentrates on providing technical assistance to land owners and municipal officials on various nonpoint pollution control issues.

- Sea Grant (URI) - this program concentrates on providing technical assistance to land owners and municipal officials on various nonpoint pollution control issues.

- US Geological Survey Water Quality Initiative and Natural Resources Conservation Service combined efforts - these programs cooperate to address nonpoint sources of pollution as in the Pawcatuck River Hydrologic Unit Area and the Narragansett Bay Project.

- R.I. Sustainable Agriculture Committee - this committee formed in 1990 to provide information about practices that are being used or researched in RI that reduce pollution, conserve natural resources, and sustain productivity.

**D. Federal Consistency**

1. The CRMC also has authority over the entire watershed for various federal and federally licensed or supported activities through the federal consistency process. This process is executed according to the provisions set forth in the RICRMP, Section 400, and the most recent version of the CRMC's Federal Consistency Manual.

## 210.2 Incentives for Growth Management and Water Quality Protection

### A. Manage growth and existing pollutant problems

1. As of 1995 38% of the Salt Pond Region was undeveloped or preserved in open space. The manner in which open lands are developed or preserved will determine the future water quality in the salt ponds and health of the ecosystem throughout the watershed. These lands hold the region's fate as either a unique environment of exceptional quality, or as another densely developed suburb where such character is reduced or destroyed. The Salt Pond Region is located in one of the fastest growing areas of the state and has experienced steady growth over the past forty years. Development pressures continue to place powerful economic incentives on the conversion of open space to residential use.

2. Today, the manner in which remaining open lands are developed or preserved is not the only principal determinant of future salt pond water quality. Although growth management controls are still necessary for subdivisions and the few remaining large lots, water quality protection requires a holistic look at existing sources of pollution and innovative technologies to control inputs. There are many existing sources of pollutants which are currently impacting water quality and habitat in the salt ponds including bacteria from substandard ISDS, nutrients from high density development adjacent to the salt ponds, sediment from roads and runoff, heavy metals, and fuel oil.

3. Public health concerns regarding water quality are always at the forefront of salt pond issues. High nitrogen levels which cause eutrophication and subsequent biohazards for fish, submerged aquatic vegetation and benthic organisms effect not only the vitality of the ecosystem, but the enjoyment of use and the aesthetics of the ponds as well. Fecal coliform contamination of groundwater supplies and surface water is a major health hazard concern associated with development, due to the limited capacity this region has to assimilate sewage via septic systems. Out-of-date sewage disposal systems and a high groundwater table create a major public health hazard with contamination of private wells, and is exacerbated by poor drainage in many areas.

4. Additional development also poses a human health risk due to increased storm and flooding hazards. As more structures are placed closer to the water and closer to each other in federal Emergency Management Agency-declared high hazard flood or V-zones, more people are placing themselves in direct storm-surge risk, as well as contributing to the debris that will travel and increase property damage during and immediately following a storm. In addition to the health and monetary risks of the people, are the ripple effect risks to the coastal resources which are jeopardized by damage from initial improper construction and placement, and furthered by improper post-storm recovery methods. Increased requests to alter the natural environment through structural shoreline protection are prompted by the misconception that there is an inherent weakness in the coastal

feature, rather than an understanding that the coastal feature, if left alone, functions as it should by dissipating storm energy and re-establishing a stable profile.

5. There is also a need to manage development around critical habitat in and around the salt ponds. Estuarine and brackish systems provide a sheltered link between fresh and salt water that for so many organisms is crucial to their viability as a species. The fish and shellfish resources are substantially impacted by the development of the salt pond watershed. Loss of open beach/dune habitat impacts a variety of upland bird and animal species as well. Both plants and animals from the rare and endangered species list are among those affected by development and loss of habitat.

## 210.3 The Watershed Based Approach to Management of a Critical Area

### A. Continuing the Process

1. The original 1984 SAMP provided a management framework which resulted in an increased understanding of the steps that are necessary to protect the watershed, and a more unified approach by regulators with regard to decision-making within the watershed.

2. Subsequent to the adoption of the original 1984 plan, continued interest in the Salt Pond Region was demonstrated by the University and the towns as evidenced by additional studies, reports, and evaluations.

3. The revisions to the SAMP are intended to provide a watershed management program for the changes in land-use, development and ecology of the salt ponds. New information includes updated water quality analysis, an updated calculation for all the potential development in the watersheds according to 1995 zoning practices, and revised technical information on habitat and geological processes. Important to this revision is the placement of all standards, policies and recommendations into one chapter, and the change in the framework of management to reflect the coordinated review process mandated by the Development Review Act (G.L.R.I. 45-23).

4. CRMC accomplishes early input to the coordinated review process through the Preliminary Determination process which is a determination of jurisdiction and applicable sections of the RICRMP. There is an application form available at the CRMC offices which explains in detail the information required.

### 210.4 Management Objectives

**A. Primary objectives**

1 . Provide guidance to applicants.

2. Provide guidance on CRMC regulations to other municipal and state authorities.

3. Improve coordination of the regulatory permitting process.

4. Organize and prioritize future action agendas for the region.

5. This shall be accomplished through the following:

(a) A Preliminary Determination process at CRMC for applicants who desire initial regulatory information before filing a full application with detailed activity or construction plans to towns and to CRMC.

(b) CRMC participation in the preliminary review process when initiated by the municipalities under the Development Review Act, or any other state agency.

(c) A list of recommendations and future research initiatives for municipalities and state agencies in each subsequent chapter of this plan.

(d) Maps and policies that integrate concerns and simplify the process.

**Literature Cited**

Coastal Zone Management Act. 1972. 16 U.S.C. §1451 et seq.

Rhode Island Farm Forest and Open Space Act. G.L.R.I. 44-27

Rhode Island's Coastal Nonpoint Pollution Control Program. 1995. Rhode Island Coastal Resources Management Council, Rhode Island Department of Environmental Management and Rhode Island Department of Administration, Providence, RI.

Rhode Island Comprehensive Planning and Land Use Act. 1988. G.L.R.I. 45-22-2.

Rhode Island Land Development and Subdivision Review Enabling Act. 1992. G.L.R.I. 45-23.

Rhode Island Erosion and Sediment Control Act. 1990. G.L.R.I. 45-46.

Rhode Island Septic System Maintenance Act. 1987. G.L.R.I. 45-24.5.

# Chapter 3
# Water Quality

## Water Quality of the Salt Ponds

### Introduction

1. A primary goal of the SAMP is to protect and restore salt pond water quality. Water quality of both groundwater and surface water continues to be degraded as a result of residential and commercial development within the region. The SAMP establishes regulatory standards to protect and improve the salt pond water quality. Because the watershed is the major source of freshwater to the coastal ponds, management of the watershed will enable the salt pond ecosystem to sustain fish, shellfish and other wildlife, as well as provide recreational and commercial opportunities for the benefit of residents and visitors to the Salt Pond Region.

2. Increasing uses of the salt ponds and their respective watersheds are causing pollutant loadings that threaten water quality, the quality of life for local residents, and ultimately, the economy of the region (Anderson and Edwards 1986, Edwards 1984 and 1986, Olsen and Lee 1991). The population of the Salt Pond Region increased 69% between 1981 and 1992, exceeding the national trend of 60% estimated for other coastal regions (Culliton et al. 1990, Lee and Ernst 1996). Figure 3-1 is a graph of development trends around the salt ponds from 1850-1992 south of Route 1.

3. Nutrient loading and bacterial contamination that result from increases in residential and commercial development are the primary water quality problems in the salt ponds (Lee and Olsen 1985, Olsen and Lee 1984, Nixon et al. 1982, Salt Pond Watchers 1997 in prep.). These are also the principal water quality problems of other estuaries all along our nation's coasts. More square miles of estuarine waters are polluted by nutrients and bacteria than any other type of contaminant (EPA 1995).

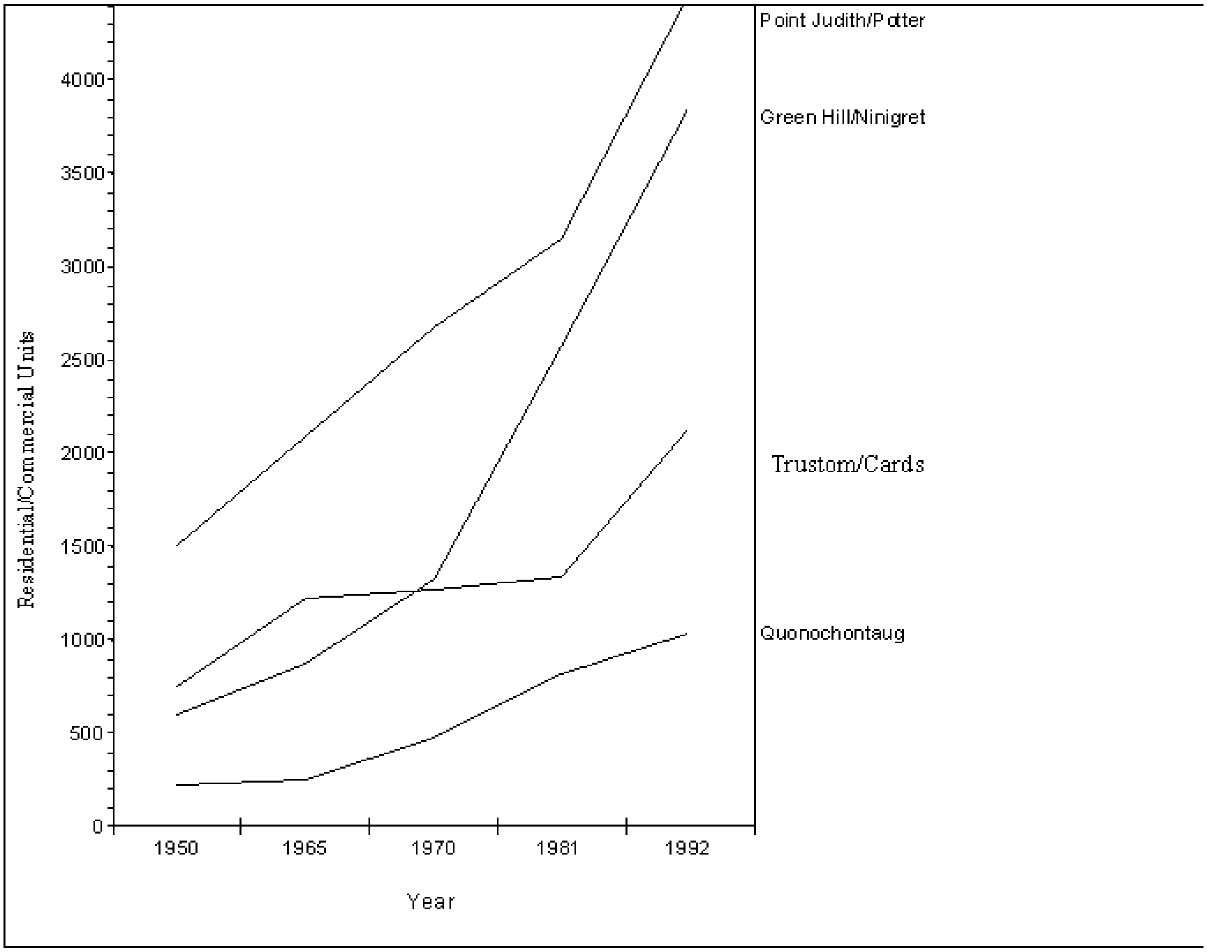



Figure 3-1 Number of Residential/Commercial Units from 1950-1992 for the Salt Pond Region.

## B. Sources of Contamination of Salt Pond Water Quality

1. Sewage disposed through septic systems is a major documented source of nitrogen and bacteria loading for many coastal environments. This is the case in the Salt Pond Region (Nixon et al. 1982, Olsen and Lee 1984, Lee and Olsen 1985, Olsen and Lee 1982), as well as Cape Cod (Eichner and Cambareri 1992, Eichner 1993, Valiela and Costa 1988, Persky 1986, Costa et al. 1992), the Chesapeake Bay (Chesapeake Bay Program 1995, Kemp et al. 1983), the Delaware Inland Bays (State of Delaware 1995), Long Island Bays (Koppleman 1978, Wolfe et al. 1991), and Tampa Bay (Johansson and Lewis 1992).

In densely developed areas where septic systems are the primary form of sewage disposal, nitrogen and bacteria contaminate groundwater, the source of private and public drinking water supplies. The cumulative effect of many septic systems discharging to groundwater can then degrade coastal water quality, impacting aquatic vegetation, fish and shellfish habitat, and the marine food chain.

2. Stormwater runoff carries sediment, nutrients, oxygen-demanding substances, road salts, heavy metals, petroleum hydrocarbons and pathogenic bacteria and viruses to coastal waters (EPA 1995). As paved or impervious surfaces increase over a watershed, runoff increases, groundwater recharge is reduced, and more pollutants are carried into coastal waters and tributaries (Turner et al. 1977, Ikuse et al. 1975, Okuda 1975, Yoshino 1975, Hollis 1975, Gregory and Walling 1973, Lindh 1972, Holland 1969, Leopold 1968).

3. Agricultural, commercial and residential fertilizer applications are also sources of water quality contamination (EPA 1992, EPA 1995). Recent studies in the Chesapeake Bay indicate that agricultural practices of crop fertilization and disposal of animal waste are less than 1/3 of the total human induced nitrogen loading (Jordan et al. 1997). In the Salt Pond Region, although the amount of land used for agriculture has diminished over the last fifteen years, there are still several working farms.

4. Petroleum hydrocarbons are occasionally serious contaminants of the salt ponds. Field studies indicate that, in shallow-water environments, petroleum disappears rapidly from the water column but the portion that reaches the sediments may be expected to persist for many years (Butler and Levy 1978, Mann and Clark 1978, Sanders et al. 1980). Petroleum hydrocarbons may enter the salt ponds from runoff, from recreational boating and from occasional oil spills. On January 19, 1996, 828,000 gallons of heating oil spilled along the South County shoreline. The *North Cape* spill caused the death of thousands of pounds of lobsters, shellfish and hundreds of seabirds in a 250 square mile area from Ninigret Pond to the eastern coastal border of Rhode Island, and south to Block Island (Salt Pond Watchers 1996).

Many commercial and residential structures in the salt pond watersheds have underground fuel tanks storing heating oil. Underground storage tanks (USTs) for fuel oil have leaked into groundwater in the region and may eventually pollute the salt ponds. Nationally, of the 1.2 million federally regulated USTs, 139,000 have leaked and impacted groundwater quality (EPA 1995). In Rhode Island, of 255 active USTs, 75% involve motor fuel leaks at gasoline service stations (EPA 1995).

5. The permanent alteration of the breachways and associated dredging have changed the ecology, chemistry and biology of the ponds, altering the flushing characteristics of the ponds (Lee 1980). The stabilization of the Charlestown breachway in 1962 radically changed the ecology in Ninigret Pond depleting the formerly productive estuarine fisheries (Olsen and Lee 1982). Although it is a popular belief that greater water exchange between the lagoons and the ocean will enhance water quality, changes to the breachways to increase flushing can have many undesirable affects on the ecology and use of the ponds (Olsen and Lee 1982).

6. The scientific literature indicates that there are both benefits and impacts to coastal habitats from aquaculture. The critical factor appears to be the method of aquaculture and the siting and design of the facility. Because the health and success of wild organisms and aquaculture species depend on good water quality, studies have illustrated aquaculture can contribute to improvements in water quality (Ulanowicz and Tuttle 1992), and the importance of water quality to aquaculture (Volk 1998). The filtering capacity of mollusks may eliminate unwanted nutrients and contaminants from the water column (Ulanowicz and Tuttle 1992). Culturing mollusks at an appropriate density in coastal areas may contribute to improving water quality, lessening eutrophication, and enriching habitat conditions for natural stocks.

Research has also shown that the development of aquaculture facilities, either land- or water-based, may directly remove or change the physical and biological properties of habitat (Rosenthal 1994; deFur and Rader 1995; Thompson 1995). High densities of shellfish or finfish may remove a large quantity of indigenous organisms (Ulanowicz and Tuttle 1992) and essential nutrients from the environment (Kelly 1992). Large assemblages of filter feeders (i.e. mollusks) and larval fish in cages or pens may feed on unusually high amounts of plankton. The removal of plankton from an ecosystem may have cascading effect on the trophic structure. Increasing mollusk concentrations may decrease phytoplankton productivity as well as pelagic populations of microbes and particulate organic carbon (Ulanowicz and Tuttle 1992). Filtering unusual amounts of nutrients from the water column and benthos may alter the nutrient cycle.

There are active aquaculture leases for Point Judith Pond and Winnapaug Pond, inactive leases for upper Potter Pond and Fort Neck Cove in Ninigret Pond, and growing pressure for more.

7. Marinas and boats may introduce petroleum hydrocarbons, solvents, antifreeze, antifouling paints, heavy metals, acids/alkalis, surfactants present in most detergents and other cleaning agents, nutrients, bacteria, floatables/plastics, and creosote from pilings (Olsen and Lee 1985, Milliken and Lee 1990). New guidance for pollution prevention adopted by the Rhode Island Marine Trades Association, RIDEM and CRMC in 1996, make this source less of a concern (Amaral et al. 1996).

## 310.1 Bacterial Contamination

### A. Definition of the Problem

1. In accordance with the national guidelines established by the EPA, fecal coliform bacteria are used as the primary indicator of sewage contamination, and hence indicate the potential for human pathogenic disease transmission as a result of water contact or consumption of raw shellfish. The U.S. Food and Drug Administration National Shellfish Sanitation Program established fecal coliform bacteria concentration limits for determining the safety of salt water areas for the harvesting and consumption of shellfish. The Rhode Island Department of Environmental Management (RIDEM) closes areas for the harvesting of shellfish in accordance with the National Shellfish Sanitation Program criteria listed in Table 3-1.

Table 3-1. State of Rhode Island Water Quality Standards for Dissolved Oxygen (mg/l) and Fecal Coliform (MPN – most probable number per 100 milliliters)(1996).

| Salt Water<br>Class – Use | Dissolved Oxygen | Fecal Coliform<br>(MPN per 100 milliliters) |
|---|---|---|
| Class SA - Shellfish harvesting for direct human consumption; bathing and primary contact recreation; fish and wildlife habitat | Not less than 6 mg/l at any place or time | Geometric mean not to exceed 14 nor shall 10% exceed 49 |
| Class SB - Shellfish harvesting for human consumption after depuration; bathing and primary contact recreation; fish and wildlife habitat | Not less than 5 mg/l at any place or time | Geometric mean not to exceed 50 nor shall 10% exceed 500 |
| Class SC - Boating and other secondary contact recreation; fish and wildlife habitat; industrial cooling; good aesthetic value | Not less than 5 mg/l at any place or time | None that impair use |
| Fresh Water<br>Class – Use | Dissolved Oxygen | Fecal Coliform<br>(MPN per 100 milliliters) |
| Class A - Drinking Water Supply | 75% saturation, 16 hrs/day; no concentration less than 5 mg/l at any place or time | Geometric mean not to exceed 20 nor shall 10% exceed 200 |
| Class B - Public water supply with appropriate treatment; agricultural uses, bathing; other primary contact recreational activities; fish and wildlife habitat | Minimum of 5 mg/l any place or time, except as naturally occurs | Geometric mean not to exceed 200 nor shall 20% exceed 500 |
| Class C - Boating and other secondary contact; recreational activities; fish and wildlife habitat; industrial processes and cooling | Minimum of 5 mg/l any place or time, except as naturally occurs | Not applicable |

## B. Findings - Sources of Bacterial Contamination

1. Failing and sub-standard individual sewage disposal systems (ISDS) and resultant contaminated runoff are the principal sources of bacterial contamination to the salt ponds. Sources of fecal coliform contamination to groundwater and surface waters include discharges of improperly treated sewage to storm sewers, fecal material from pets and livestock carried by stormwater runoff, and leaking sewers.

2. Most of the existing residential and commercial development in the watersheds of Point Judith, Potter, Trustom, Cards, Green Hill, Ninigret, Quonochontaug and Winnapaug Ponds are unsewered and therefore rely upon ISDS for the disposal of sewage. Municipal sewers extend to only a small portion of Winnapaug Pond, part of the eastern shore of Point Judith Pond in Narragansett (but not to Great Island or Harbor Island) and much of the town of Wakefield along the Saugatucket River that flows into the northern end of Point Judith Pond.

3. Many of the ISDS in the Salt Pond Region were installed prior to the adoption of state construction standards promulgated in 1969. Other systems pre-date the implementation of more rigorous standards of the early 1980s. Before the adoption of state regulations and standards, commercial and domestic wastewater was discharged through a variety of methods ranging from improvised systems to dry wells and cesspools. These older systems are frequently sited on undersized lots without adequately sized leach fields, are in direct contact with the groundwater table, or are used at levels which exceed the original design capacity. As a result, these systems do not adequately treat sewage nor meet current state standards. In some of these cases, new innovative and alternative technologies may be necessary for the adequate treatment of wastewater.

4. Many of the houses around the salt ponds which were originally constructed as summer cottages have since been converted to year-round residences, yet the ISDS have not been replaced to meet existing building codes. Of those residences used seasonally, many have ISDS which are overloaded and must be frequently pumped out due to continuous and heavy use during the summer months.

5. In the early 1980s, construction standards and field inspections became more rigorous to protect public health and the environment. The RIDEM Division of Groundwater and ISDS issues permits for ISDS to ensure that minimum standards are upheld in the siting, design and construction of such systems. RIDEM has specific standards for the siting and design of large systems designed to treat more than 2,000 gallons per day and subdivisions in critical resources areas which include the salt ponds. In accordance with state regulations, an ISDS installed in the Salt Pond Region must meet special siting standards listed below.

(a) Large Systems (>2,000 gallons)

(i) Depth to groundwater must be less than 5 feet of the original ground surface;

(ii) Large systems are not permitted in high permeable soils (perc rate faster than 3 minutes per inch) unless it can be shown that groundwater and surface water will be protected.

(iii) Horizontal separation distances from large systems to wells and surface waters must be three times that given for ISDS less than 2,000 gallons (25-200 feet).

(b) Subdivisions

(i) Where combined flow from each system within a subdivision is 2,700 gallons per day or greater an assessment of the impact of the estimated pollutant loadings to ground and surface waters including ability of wetlands to support indigenous animal and plant life will be required.

In addition, for all components of an ISDS there is a 150 foot setback from critical resources areas (including the salt ponds), and a 200 foot setback from surface drinking water supply or tributary stream or drain (RIDEM 1992).

6. The CRMC manages for the potential impacts of ISDS on the coastal environment by requiring a 200' setback from the coastal ponds.

7. Properly constructed and maintained ISDS are preferable to sewers in most areas because the ISDS percolate recharges the underlying groundwater. Maintenance of the quality and quantity of groundwater is essential for sustainable development of the Salt Pond Region. Groundwater is the sole source of drinking water for all commercial and residential development in the region. Private wells and wells that serve the public water supply of South Kingstown's south shore system, the Wakefield water company or the Westerly water system all rely on an ample groundwater source that is clean enough to drink safely.

The continued flow of clean groundwater into the salt ponds is also critical to maintain the ecology of the salt ponds. As the major source of freshwater to the ponds, groundwater flow sets the salt balance and flushing characteristics of these productive estuarine habitats.

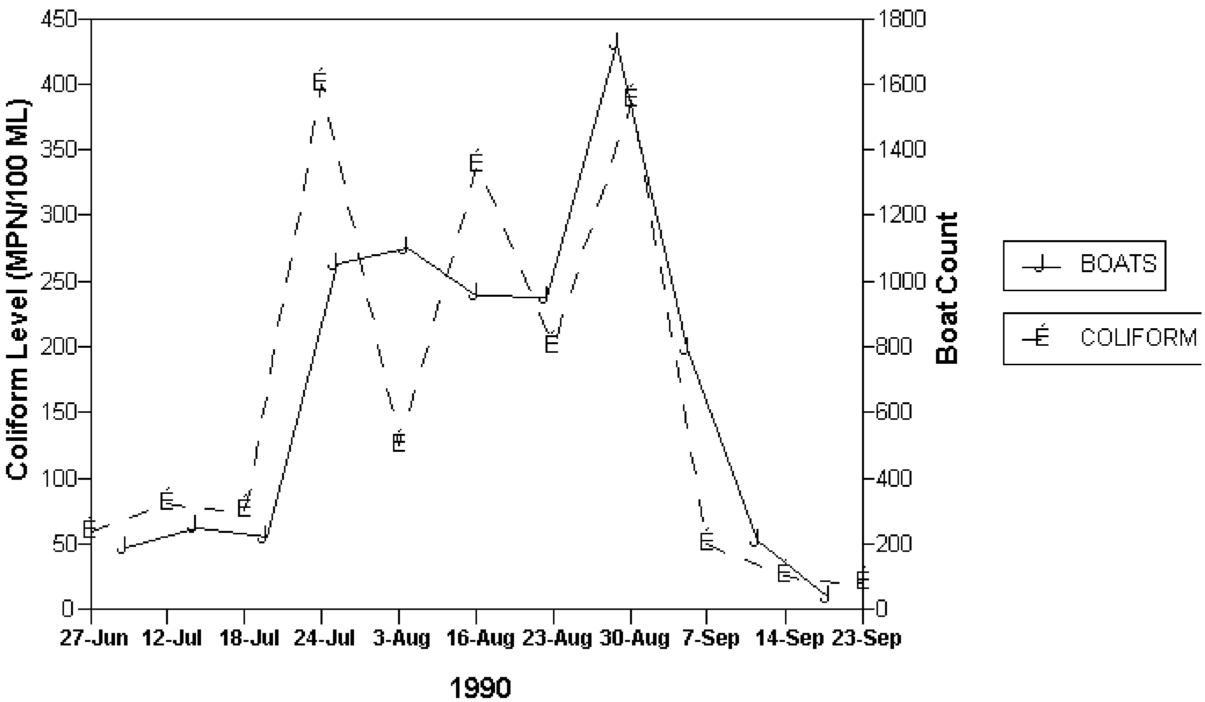
8. Stormwater runoff is a significant source of bacterial contamination to the salt ponds, as is evident from the high concentrations of coliform in the streams flowing into the ponds and areas of the ponds adjacent to dense residential development after heavy rainstorms (Lee et al. 1992, Salt Pond Watchers 1996). Pathogens carried in runoff are flushed into the salt ponds during storm events and are responsible for shellfish harvesting closures (RIDEM 1997, Salt Pond Watchers 1997).

9. Illegal discharge of marine sanitation devices (MSD) from boats in anchorages or at marinas can also be a seasonal source of bacterial contamination to Point Judith Pond. At present, day boats too small to have MSD are used in the other salt ponds.

Vessel discharge of sewage has been correlated with unsafe increases in fecal coliform bacteria during high boat-use times in Martha's Vineyard, Massachusetts (Gaines and Solow 1990), and Block Island, Rhode Island (Amaral et al. 1996). Figure 3-2 shows 1990 bacteria data and boat counts from the Great Salt Pond on Block Island, R.I. and a strong correlation with the number of boats and elevated counts of bacteria. The current trend in Rhode Island and across the country, is to move towards federally approved no-discharge areas where it is illegal to allow sanitary waste, treated or untreated, to be discharged into the water (Amaral et al. 1996). To date, all of Narragansett Bay and the Great Salt Pond on Block Island have been formally designated by the Environmental Protection Agency as a no discharge zone.

Besides being a source of pollution for gas spills and sewage discharge, boat props and jet skis can damage habitat. Submerged aquatic vegetation in the salt ponds are particularly susceptible to prop damage because SAV grow in shallow areas and boaters are often unaware of any impacts.

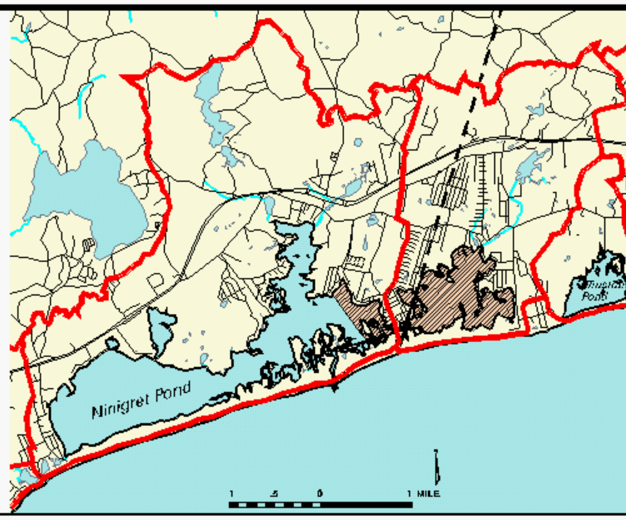
Figure 3-2. Boats v. Coliform, Great Salt Pond, Block Island 1990.




## C. Findings - Impacts of Bacterial Contamination

1. In 1981, studies conducted by the R.I. Department of Health and researchers at URI (Nixon et al. 1982) revealed that concentrations of fecal coliform bacteria exceeded the shellfishing standards in upper Point Judith, Cards, Trustom and Green Hill Ponds. Today, high concentrations of fecal coliform bacteria, indicative of sewage pollution, have led to the permanent closure of several areas within the salt ponds for shellfish harvesting. Green Hill Pond has been permanently closed for shellfishing by the RIDEM since 1994. In 1996, the RIDEM extended the permanent shellfish closure into the eastern portions of Ninigret Pond where it connects to Green Hill Pond (Figure 3-3) (RIDEM 1996). Point Judith Pond is closed to shellfishing around the marinas, the Port of Galilee in the lower pond, and in the upper pond from Buttonwood Point to the northwest of Betty Hull Point, including Congdon Cove, the Narrows, Long Cove, Upper Pond, Silver Spring Cove, Stone Water Fence Cove, and the tidal portion of the Saugatucket River (Figure 3-4) (RIDEM 1996).

Figure 3-3




**Areas Closed to Shellfishing, 1996**

Shellfish Closure, RIDEM

RIGIS 1995

Figure 3-4

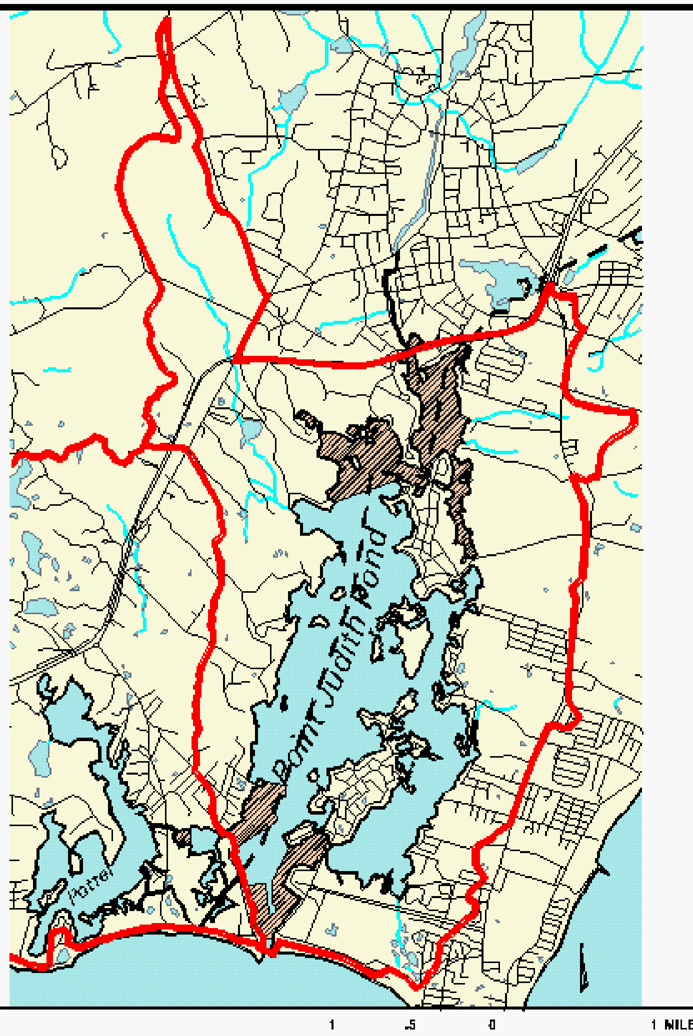



**Figure 3-4 Areas Closed to Shellfishing, 1996**

Shellfish Closure, RIDEM

RIGIS, 1995

2. Bacteria is also contaminating groundwater near the older, more densely developed communities within the watersheds. The high density of development and incidence of polluted wells in areas of Matunuck and Green Hill made it necessary for South Kingstown to build the South Shore Water Supply System in the 1970s. Water quality monitoring of well water in the communities near Green Hill and Ninigret Ponds indicates that bacterial contamination of drinking water may also be an increasing problem. According to a Rhode Island Department of Health survey of 163 wells in this area between 1966 and 1972, 30 percent were judged not safe as potable water supplies due to unacceptable bacterial contamination (Rhode Island Department of Health 1972). By 1980, a survey in the same area by the Rhode Island Programs for the Environment found that 50 percent of the 19 randomly selected wells were contaminated with fecal coliform bacteria (RI Programs for the Environment 1982).

3. Streams that flow into the salt ponds are polluted with high levels of fecal coliform bacteria which exceed class A or B standards for freshwater. Teal Brook and Factory Brook, which flow into the northern end of Green Hill Pond (Figure 3-5), exceeded the median of 20 Most Probable Number (MPN) in Class A waters for safe drinking water in almost all samples between 1994 and 1996 (Figure 3-6); and most sampled in 1994 exceeded safe levels for swimming and wildlife. The Saugatucket River, which flows into the northern end of Point Judith Pond, exceeded the median of 20 MPN in Class A waters for safe drinking water and the median of 200 in Class B waters for safe swimming, agricultural uses and fish and wildlife habitat almost consistently between 1994 and 1996, at three sample stations located at the outlet to Point Judith Pond. The brook flowing into Quonochontaug Pond has two branches, both of which have elevated levels of fecal bacteria; however, the discharge from the brook appears to be diluted to levels which are safe for shellfishing.

Figure 3-5. Teal Brook and Factory Brook at the Northern end of Green Hill Pond.

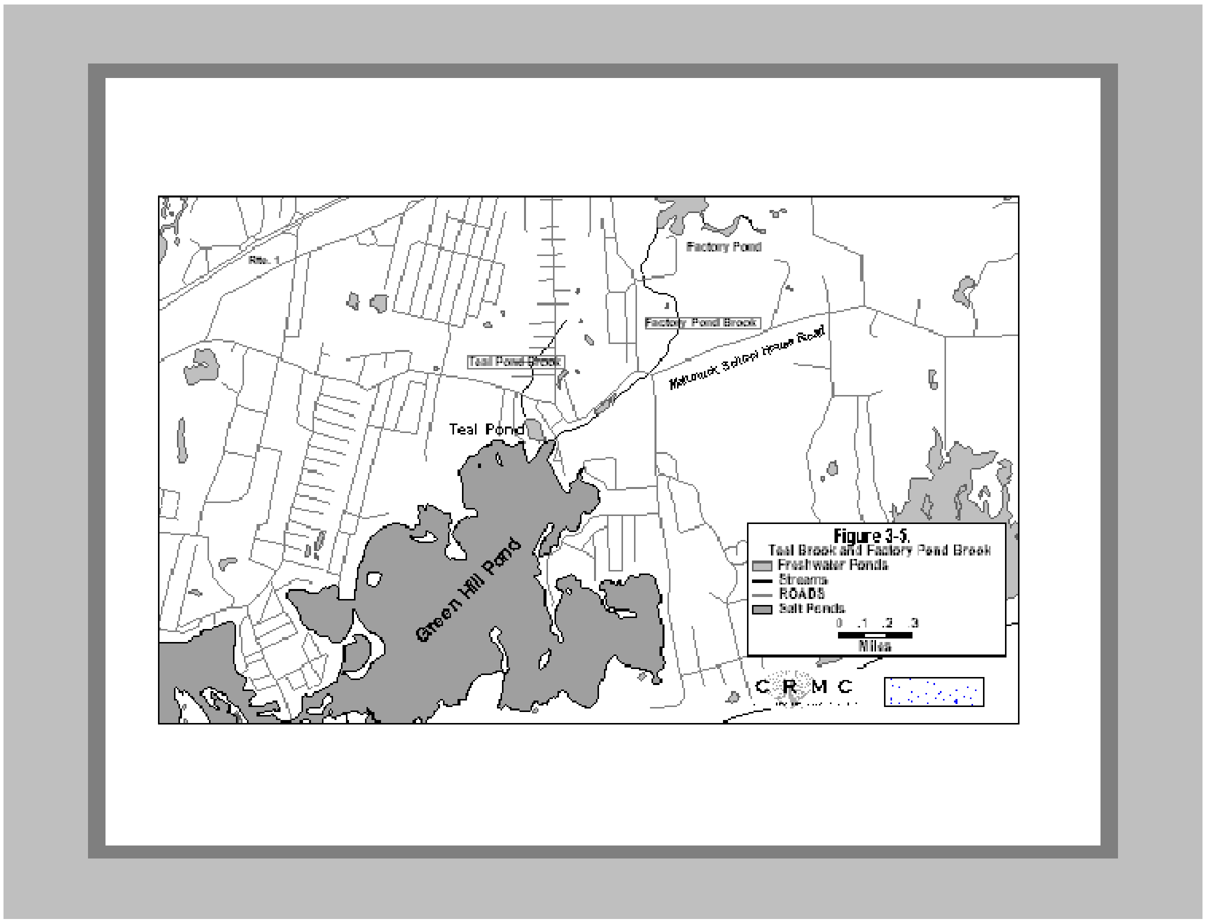
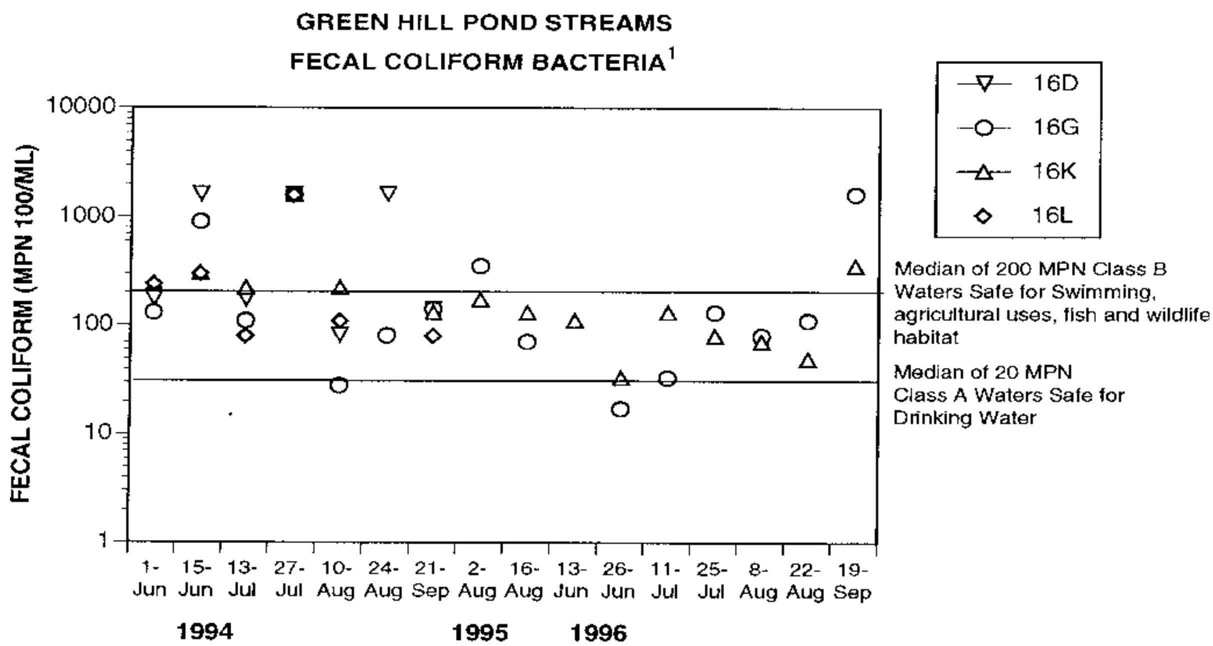


Figure 3-6. Teal Brook and Factory Brook samples between 1994-1996.




[1] Rhode Island Salt Pond Watchers Data

310.2 Nutrient Loading and Eutrophication

A. Definition of the problem

1. Eutrophication is a process where there is an increase in the rate of supply of organic matter to an ecosystem (Nixon 1995). Eutrophication resulting from excessive nutrient loading of coastal waters has been identified as one of the major emerging problems for the coastal environment in the twenty-first century (Goldberg 1995, GESAMP 1990, Nixon 1995). In the 1994 National Water Quality Inventory, the EPA reported that more square miles of estuarine water were polluted by nutrients and bacteria than any other pollutant or process (EPA 1995). In marine ecosystems nitrogen is the essential nutrient which stimulates plant growth, while in freshwater ecosystems phosphorus plays the controlling role. (Ryther and Dunstan 1971, Nixon and Pilson 1983, Smith 1984, Taylor et al. 1995a). Studies of nutrient impacts on ecosystems similar to the salt ponds in the northeast include Moriches and Great South Bays on Long Island, New York (Ryther 1989), Mumford Cove in Connecticut (French et al. 1989) and Waquoit and Buttermilk Bays in Massachusetts (Valiela and Costa 1988).

2. Nutrients act as powerful biostimulants causing an increase of primary production of organic matter and consequent symptoms of eutrophication in coastal waters. (Nixon 1993 and 1995). Symptoms of coastal eutrophication include:

C Reduced biodiversity
C Increased seaweed biomass
C Shift from large to small phytoplankton
C Shift in species composition of phytoplankton from diatoms to flagellates (which are less desirable as a food source for shellfish and other filter feeders)
C Loss of eelgrass habitat
C Shift from filter feeding to deposit feeding benthos
C Bottom sediments become increasingly organic
C Increased disease in fish, crabs and lobsters
C Increase in aerial extent and frequency of low oxygen events resulting in the depletion of fish and shellfish populations
C Occurrence of toxic phytoplankton blooms
C Loss of aesthetic quality and recreational use

Many of these symptoms of eutrophication have been reported for our local salt ponds.

3. As nutrient loading increases in enclosed bays like the salt ponds, massive growth of algae occurs and the dissolved oxygen necessary for aquatic life is depleted. During extreme low oxygen events, hypoxia (less than 3 mg oxygen per liter) or anoxia (all the dissolved oxygen is consumed) occurs with consequent fish kills, reduced biodiversity of fish and shellfish populations, mass mortality of benthic animals, bacterial slimes, foul smelling odors and in extreme cases, generation of toxic levels of hydrogen sulfide (Nixon 1995, Goldberg 1995). Eventually, fish and shellfish populations decline, waters become weed-choked and murky, the bottom accumulates organic sediments, and anoxic events that are toxic to aquatic life occur.

B. Findings - Sources of Nitrogen Pollution to the Salt Ponds

1. Groundwater. Research in the last decade indicates that groundwater flow and transport of nutrients into shallow coastal waters is far more significant and widespread than had been previously realized (Johannes 1980, Bokuniewicz 1980, Capone and Bautista 1985, Lewis 1987, Lee and Olsen 1985, Valiela et al. 1990). Groundwater flow is especially important where

underlying coastal sediments are coarse, unconsolidated sands of glacial or marine origin which is typical of much of the Salt Pond Region (Valiela et al. 1990). Nitrate concentrations in groundwater vary widely and seasonally depending on hydrology and land-use. Extensive sampling of the groundwater in the Salt Pond Region in both 1980 and 1994 revealed that the concentration of total nitrogen beneath densely developed areas is elevated 100 times above the background levels found in areas at the head of the watershed, unaffected by anthropogenic impacts (Olsen and Lee 1984, Lee and Ernst 1996).

2. Nitrogen was measured in groundwater, streams, rainfall and the ocean by the University of Rhode Island Graduate School of Oceanography and the Coastal Resources Center in 1980-81 and again in 1994-95 (Nixon et al. 1982, Ernst et al. in prep.). Quantification of the principal sources of total inorganic nitrogen to each of the salt ponds demonstrates that groundwater is the dominant pathway by which nitrogen enters the salt ponds. Storm runoff, streams, atmospheric deposition and the ocean also transmit nitrogen to the salt ponds to varying degrees as shown in Table 3.2.

Table 3-2. Preliminary Estimates of Dissolved Inorganic Nitrogen Inputs to the Salt Ponds (kg/N/yr for 1995). (From filed measurements from Nixon et al. 1982, Ernst and Lee 1995).

| Source | Point Judith Pond | Potter Pond | Cards Pond | Trustom Pond | Green Hill Pond | Ninigret Pond | Quonochontaug Pond | Winnapaug Pond | Maschaug Pond |
|---|---|---|---|---|---|---|---|---|---|
| **Groundwater** | 28333 | 16999 | 10415 | 3600 | 25635 | 29595 | * | * | * |
| **Precipitation on pond** | 7758 | 1877 | 205 | 922 | 2106 | 8238 | 3743 | 2385 | 232 |
| **Storm runoff** | 367 | 64 | 68 | 32 | 104 | 227 | * | * | * |
| **Streams** | 27322 | 0 | * | 0 | 3345 | 1149 | * | 0 | 0 |
| **Block Island Sound** | * | * | 0 | 0 | 1361 | 2722 | * | * | 0 |
| **TOTAL** | 63780 | 18880 | 10688 | 4554 | 32551 | 41931 | 3743 | 2385 | 232 |

3. Nitrogen in the groundwater of the Salt Pond Region is predominantly in the form of nitrate. The average concentration of nitrate in groundwater ranged from 1.44 mg/N/l to 3.71 mg/N/l in 1994 (Table 3-3). Nitrate levels beneath densely developed portions of these watersheds are much higher than the average concentrations. For instance, areas to the east of Green Hill Pond have concentrations in the 5.00 - 6.99 mg/l $NO^3$-N (Figure 3-7). The nitrogen loading to the salt ponds calculated from values in the scientific literature for ISDS, residential fertilizers and other sources, and a detailed analysis of land use in 1988 from RIGIS yields estimated groundwater nitrate concentrations (Table 3-4) which are in good agreement with the field measurements of nitrate levels in wells sampled throughout the region.

Table 3-3. Average nitrate well water concentrations (mg/l) for 1994, based on 156 wells sampled in the salt pond watersheds (Ernst 1996).

| Watershed | Mean $NO_3$ 1994 |
|---|---|
| Point Judith | 2.29 |
| Potter | 2.07 |
| Cards | 3.71 |
| Trustom | 1.57 |
| Green Hill | 2.75 |
| Ninigret | 1.44 |

4. Other studies in New England have also found higher concentrations of groundwater nitrogen in densely developed areas that rely on ISDS for sewage disposal. Persky (1986) found a positive correlation between nitrate concentration and housing density on Cape Cod (Figure 3-8). In the Waquoit Bay watershed, groundwater nitrogen concentrations are higher beneath the more developed subwatershed of the Childs River than in groundwater beneath the rural Quashnet River and Sage Lot Pond watersheds (Valiela et al. 1992).

Figure 3-7.

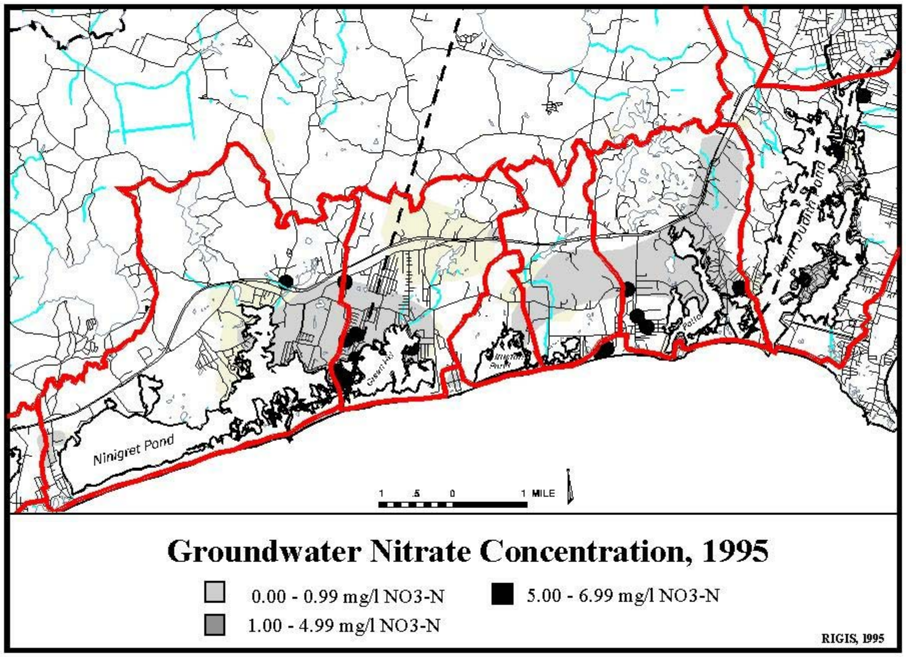



**Table 3-4.** Calculated Nitrogen Loading to the Groundwater of the Salt Pond Watersheds (kg/N/yr).

| Source | Point Judith Pond | Potter Pond | Cards Pond | Trustom Pond | Green Hill Pond | Ninigret Pond | Quonochontaug Pond | Winnapaug Pond | Maschaug Pond |
|---|---|---|---|---|---|---|---|---|---|
| Septic[1] | 23773 | 13078 | 4514 | 1264 | 22467 | 17606 | 10613 | 15139 | 3127 |
| Lawns[2] | 1342 | 600 | 207 | 58 | 1031 | 647 | 449 | 773 | 156 |
| Pets[3] | 1743 | 776 | 268 | 75 | 1334 | 1045 | 630 | 919 | 186 |
| Agriculture[4] | 223 | 1620 | 4860 | 2025 | 0 | 8637 | 961 | 2853 | 0 |
| Open Space[5] | 1089 | 884 | 566 | 178 | 733 | 1593 | 613 | 532 | 56 |
| Golf Fields[6] | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 598 | 399 |
| Playing Fields[7] | 163 | 41 | 0 | 0 | 0 | 67 | 134 | 7 | 0 |
| **Total** | **2833** | **16999** | **10415** | **3600** | **25535** | **29595** | **13400** | **20821** | **3924** |
| | | | | | | | | | |

Land Use is based on 1988 RIGIS database

1 3.2 kg/yr/capita loading (Gold et al. 1990), occupancy based on Town Comprehensive Plans for Narragansett, South Kingstown, Charlestown, and Westerly, septics from 1992 RI Statewide Planning from 1992 RI Statewide Planning aerial photographs.

2 3.8 kg/acre (Gold et al. 1990).

3 .19 kg/person/yr (Koppleman 1978).

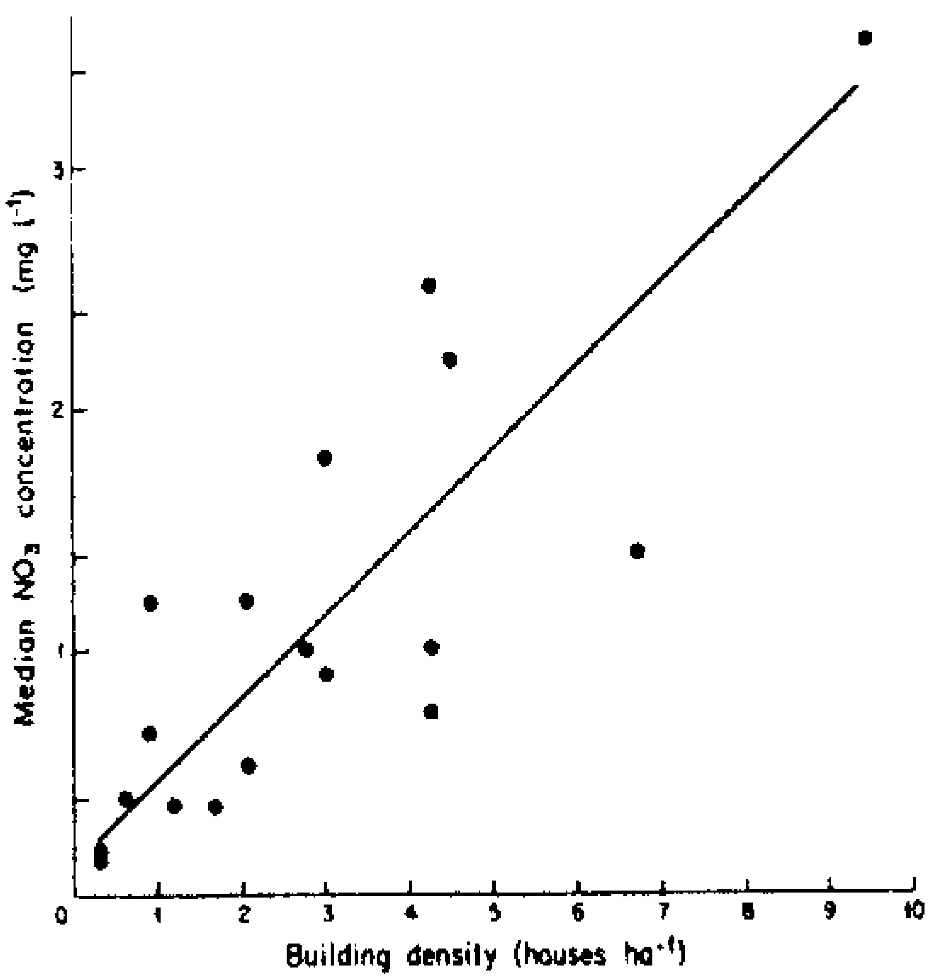
4 40.5 kg/acre (Gold et al. 190).

5 10% loss from DIN in ppt (Gold et al. 1990).

6 Misquamicut Club 30.0 acres, 1773.7 kg/N/acre, 23% loss (Brown et al. 1982).

7 Town of South Kingstown and Narragansett fertilizer application rates and areas for playing fields and nitrate-N loading based on Gold et al. 1990).

Figure 3-8. Median nitrate ($NO_3$) concentrations in groundwater beneath areas of Cape Cod with different building densities (Persky 1986).

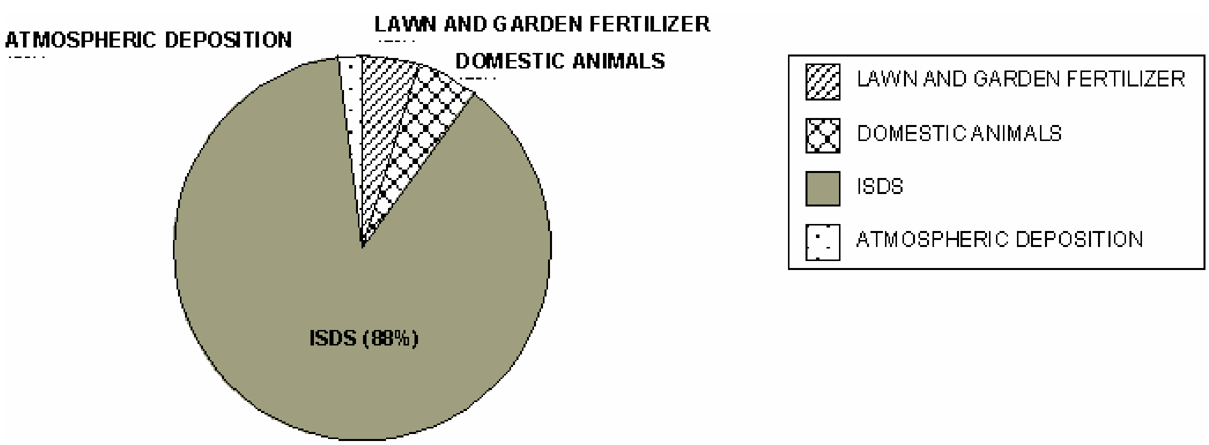


5. The slow rate at which groundwater moves toward the salt ponds suggests that the impact of recent development in the watersheds is not yet being realized as increased annual loadings of nitrate to the salt ponds. On Cape Cod, Sham et al. (1995) showed that nitrogen loading to Waquoit Bay lags behind the rate of development by almost a decade due to the time of travel of groundwater, about 0.3 - 1 meter $yr^{-1}$.

6. Individual sewage disposal systems ISDS are the largest contributor of nitrate-nitrogen to groundwater in the salt pond watersheds, according to an analysis of land use practices in the Salt Pond Region from the Rhode Island Geographic Information System (RIGIS 1988), and calculated nutrient loading estimates taken from the scientific literature. In fact ISDS contribute almost ten times the amount as any of the other sources of nitrogen (Table 3-4).[1] In a single family residence in Charlestown, for instance, ISDS are the largest contributor of nitrate-nitrogen to groundwater (Figure 3-9).

Household water use can have implications for the transmission of nitrogen through the ISDS. Use of water control devices will not only conserve water, but will also reduce nitrogen loading to sensitive areas in the salt ponds. Differences in water use do contribute to the amount of nitrogen retained in the leachfield (Figure 3-10) (Valiela et al. 1997). As the volume of water that is used by a household increases, effluent moves more quickly through the septic system and less nitrogen is retained.

**Figure 3-9.** Estimated sources of nitrate-nitrogen to groundwater from a household with 2.3 people (1990 U.S. Census Bureau data for Charlestown) on a 1394$m^2$ lot (1/3) acre with 464.7$m^2$ of lawn and garden with 1.19m of rainfall and 1.04 mg/$NO_3$-N/l (Cape Cod Commission 1992, Gold et al. 1990, Koppleman 1978, Fraher 1991, URI Rainfall 1994-95).




[1] Except for the Saugatucket River.

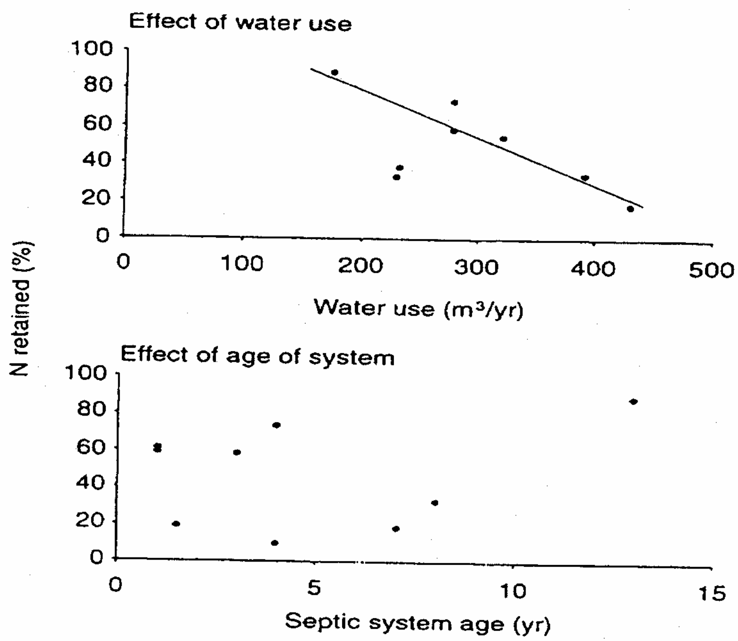



**Figure 3-10.** Nitrogen percentage retained in relation to household water use and to septic system age (Valiela et al. 1997).

Nitrogen losses to groundwater occur as the effluent plume moves away from an ISDS. Analyses of nitrogen loss in plumes indicates that concentrations of dissolved inorganic nitrogen decrease with distance away from leaching fields (Valiela et al. 1997). Valiela et al. estimate that 200 m is a possible length of plumes from ISDS and that 35% of the nitrogen entering an ISDS plume will be lost during the first 200m. Consequently, ISDS closer than 200 m to shore are likely to make significantly greater contributions to nitrogen loading of estuaries than septic systems located farther away.

7. Agriculture. Water that percolates through well drained soils in corn fields fertilized with manure (fertilizer and crop most common on Salt Pond Region farms), can have levels as high as 10 mg/l in mid-summer and continue to be elevated throughout the fall (Gold et al. 1990). However, farmland is so sparse in most of the salt pond watersheds that agriculture is not a significant source of nitrogen here. Even in areas around other estuaries where agriculture is a dominant land use, nitrogen loading to groundwater are less than one third of the total human loading (Jordan et al. 1997).

8. Golf Greens. Sandy rooting media used in golf greens has rapid infiltration rates and provides the potential for as much as 9 to 22 percent $NO_3$ loading to groundwater following application of $NH_4NO_3$ in fertilizer (Brown 1982). Golf courses occur only in Maschaug and Winnapaug Pond watersheds.

9. Lawns and Gardens. Higher rates of microbial processes in lawns and the perennial nature of home lawns contribute to lower leaching of nitrogen to groundwater than reported for many agricultural crops (Gold et al. 1990). Consequently, fertilized home lawns are not a major contributor of nitrate to groundwater in the Salt Pond Region.

10. Domestic pets. Domestic pets contribute nitrogen directly to the groundwater and through storm runoff.

11. Streams. The main sources of nitrogen to streams in the Salt Pond Region are the same as for groundwater: ISDS, storm runoff, fertilizer and atmospheric deposition. Measurement of nitrogen concentrations and stream flow for 1994-95 were made in Cross Mills Stream, Factory Pond Brook, Teal Pond Brook and the Saugatucket River (Ernst 1996). Concentrations and flow indicate that streams are the second major source of nitrogen for Green Hill Pond and Point Judith Pond from the Saugatucket River. A comparison of flux and flow in each of the streams for 1980-81 and again in 1994-95 indicates nitrogen flux is consistently higher with increased flow. Nitrogen flux, or discharge from the rivers and streams to the salt ponds increase as flow increases (Figure 3-11).

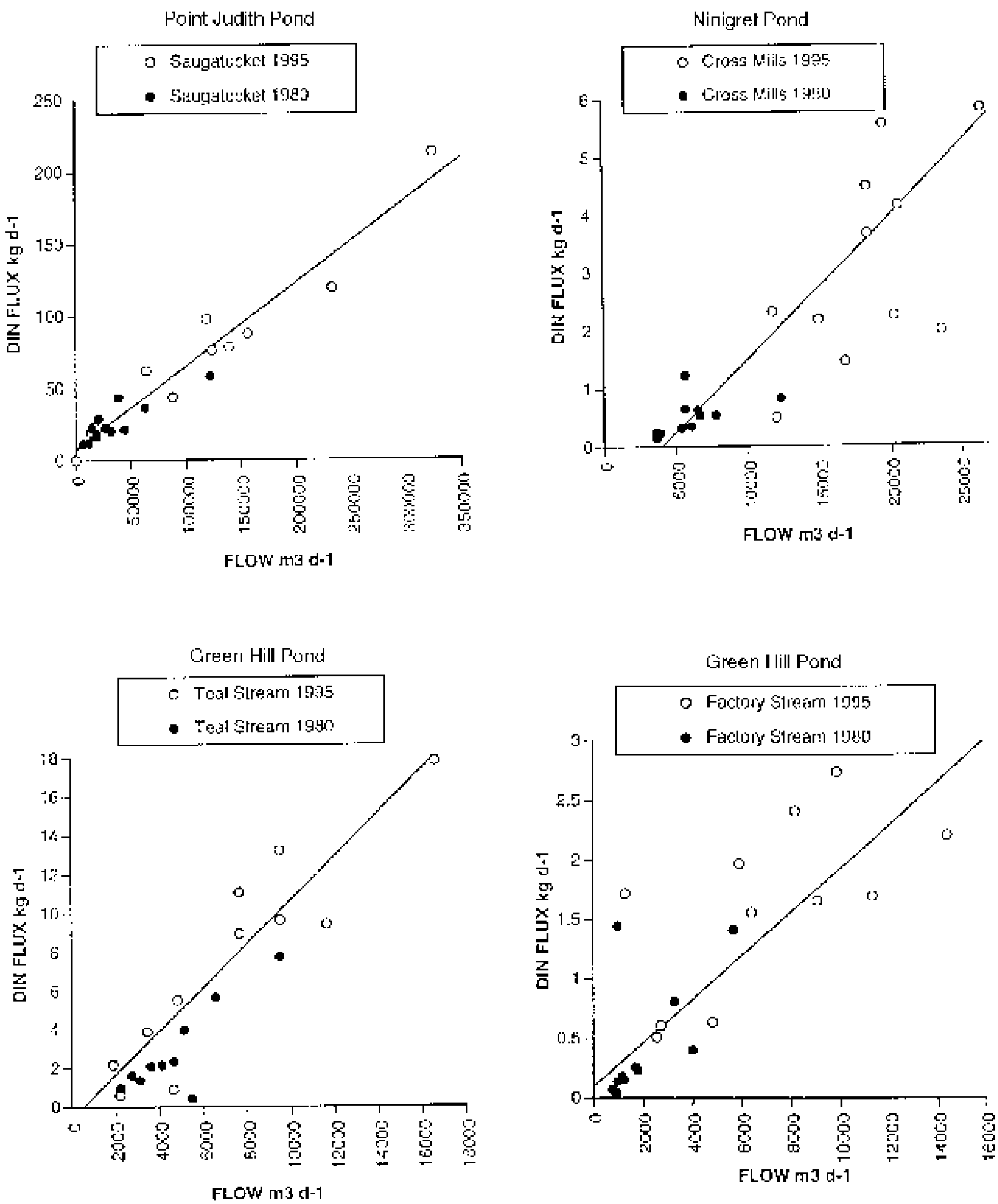
12. Atmospheric Deposition Atmospheric deposition directly to the salt ponds is the second major source of nitrogen loading to Maschaug, Winnapaug, Quonochontaug, and Ninigret Ponds. Overall, atmospheric deposition accounts for between 2 - 21% of the nitrogen loading budget in the salt ponds (Ernst 1996). Estimates of nitrogen deposition directly to the salt ponds is based on wet and dry deposition from Fraher (1991) who considered both wet deposition and direct dry deposition from nitric acid vapor using samples collected from Prudence Island, R.I. Nitrogen in the atmosphere is increasing due to by-products of combustion by industry, power plants and automobiles (East Coast Atmospheric Resource Alliance 1995).

## C. Findings - Impacts of Nitrogen Pollution on Salt Pond Ecosystem Health

1. Experimental Lagoon Ecosystems. Experimental tanks were set up to mimic the coastal ponds

at the URI Graduate School of Oceanography Lagoon Mesocosm Facility. Research has been funded by RI Sea Grant since 1991 to quantify the impact of nutrient enrichment to shallow coastal lagoons like the salt ponds. The Facility consists of ten mesocosms with average depths (1.1m) equivalent to that of the salt ponds. The bottom of the tanks are filled with sandy-silt sediments (0.3m) and planted with young eelgrass shoots from the salt ponds. Macroalgae (seaweeds), juvenile fish and shellfish are all collected from the field and added to the tanks. The mesocosms are flushed with water from Narragansett Bay at a rate of 5% per day which is typical of many of the salt ponds and other coastal lagoons (Taylor et al. 1995b).

Figure 3-11. Nitrogen flux versus flow in rivers and streams to the salt ponds (Ernst 1996).



(a) Loadings of nitrogen and phosphorus are added to the tanks to assess the response of the ecosystem to low, medium, and high levels of nutrients. The loadings are comparable to loadings in lagoon systems in the Northeast. The ecosystem responses are assessed by measuring impacts to the sediment, eelgrass, macroalgae, fish and shellfish present in the tanks. A control tank, where no nutrients are added is also maintained and assessed.

(b) The total nitrate-nitrogen input to the control tanks (.654 mmoles $m^3$/d dissolved inorganic nitrogen) compare to the loadings we are seeing in the salt ponds. In the low enriched tanks (2.47 mmoles $m^3$/d) enrichment causes increased growth of eelgrass, epiphytes and drift macroalgae; in the medium enriched tanks (4.29 mmoles $m^3$/d) there are dense phytoplankton blooms and moderate declines of eelgrass and benthic macroalgae; in the high enriched tanks (7.93 mmole $m^3$/d) there are even greater phytoplankton blooms and moderate declines of benthic plant components.

2. Nutrient Enrichment. The mesocosms confirm that shallow estuaries such as the salt ponds are much more sensitive than deep embayments like Narragansett Bay to nutrient enrichment. Equally low inputs of nitrogen stimulated much larger phytoplankton blooms in the shallow mesocosm tanks as compared to the deeper MERL tank systems (Taylor 1995a).

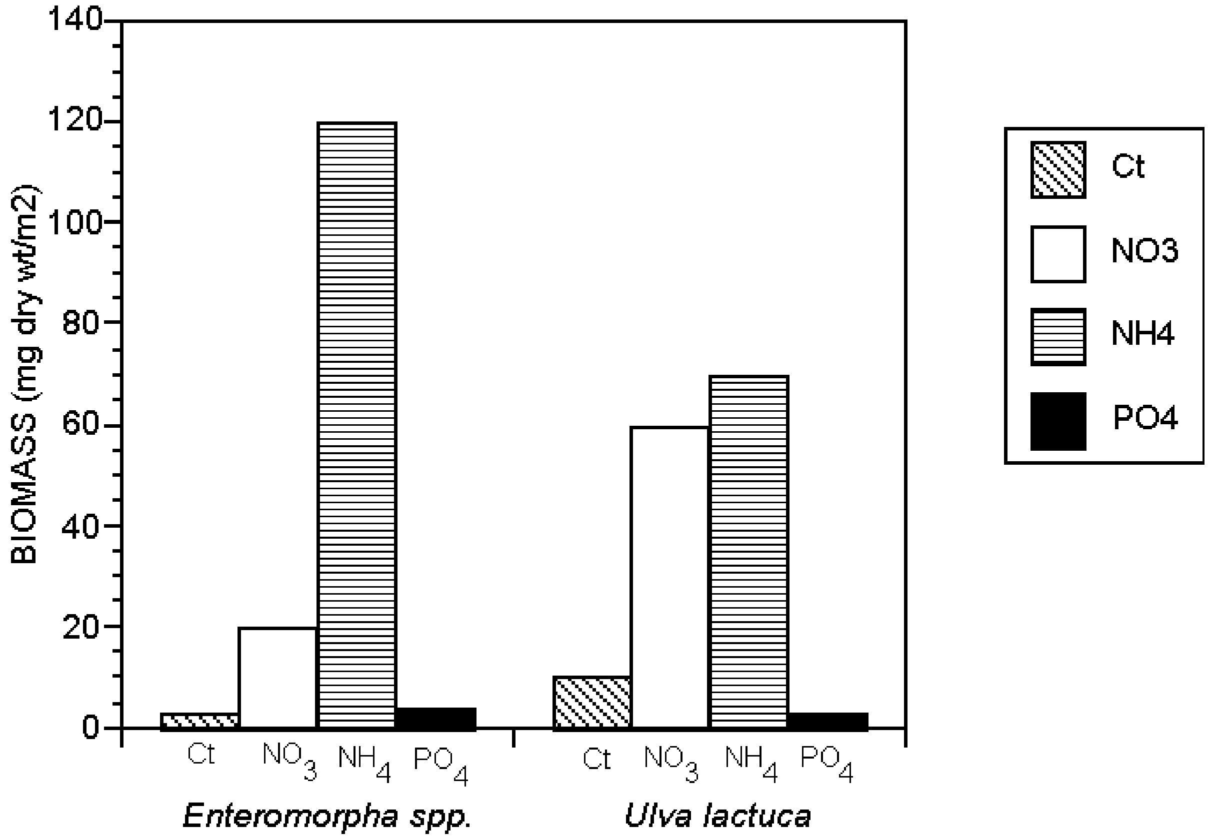
3. Phytoplankton Response to Nitrogen Loading. Fertilization experiments in the mesocosms confirmed that aquatic plant growth responds dramatically to nitrogen additions or to nitrogen when combined with phosphorus but not to phosphorus alone (Taylor et al. 1995c, Taylor et al. 1995d).

4. Seaweed Abundance. Macroalgae or seaweed is stimulated by nitrogen and phosphorus loading. Fertilization experiments in Ninigret Pond confirmed that sustained additions of inorganic nitrogen cause growth of *Ulva* and *Enteromorpha* (Figure 3-12). Masses of unattached drift macroalgae of red, green and brown forms, are increasingly abundant in the salt ponds (Harlin 1995). Large rafts of algae entangle the grass beds in Ninigret Pond, portions of Point Judith Pond, Seaweed and Segar Coves of Potter Pond, Winnapaug and Quonochontaug Ponds. Dense growth of the green algae *Enteromorpha* occurs around the edges of the ponds. Thick growths of the red algae *Gracilaria* cover parts of the bottom of Ninigret and Point Judith Ponds. During the summer, Cards Pond is choked with extensive beds of *Potomogeton* while the low salinity water of Trustom Pond is murky as a result of elevated concentrations of phytoplankton (Thorne-Miller et al. 1983). In some cases the macro algae is so dense, that it covers the bottom and forms an anoxic zone beneath it (Thorne-Miller et al. 1983).

If extensive, algae growth will render important bottom habitat unsuitable for scallops, clams, crabs and important fin fish, and ruin the aesthetic appeal of the ponds for recreation, thereby rendering areas undesirable for swimming and boating. Abundant growth of nuisance algae stimulated by nitrogen loading is a documented problem in Waquoit Bay and Buttermilk Bay, Massachusetts, and similar shallow estuaries around Buzzards Bay and the Connecticut estuaries (Valiela and Costa 1988, Harlin 1995, Lajtha et al. 1995). In the Massachusetts bays, abundant algae has been associated with anoxic events and a reduction in benthic animals.

5. Increasing Anoxia. As water temperatures rise in late summer and the algae decays, the decomposition process depletes dissolved oxygen levels creating localized hypoxic or anoxic conditions (D'Avanzo and Kremer 1994). As dead plant material decomposes on the bottom it impairs the suitability of the habitat for fin and shellfish (Lee and Olsen 1985).

Figure 3-12. Response of green algae in Ninigret Pond to nutrient enrichment during the summer of 1980. Note the dramatic growth response to nitrogen additions compared to phosphorus. Data from Harlin and Thorne-Miller 1981.




6. Eelgrass Habitat. Eelgrass (*Zostera marina*) habitat is disappearing as a result of increased phytoplankton and macroalgae growth from excessive nutrient loading (Harlin and Thorne-Miller 1981). For example, over the last 32 years the aerial extent of eelgrass beds in Ninigret Pond has declined by 41 percent (Short et al. 1996). This decline in eelgrass habitat is strongly correlated to the increases in the density of residential development in the salt pond watershed. Eelgrass is important habitat for bay scallops, winter flounder, and several crab species and the loss of eelgrass beds will negatively impact these valuable fin and shellfish. Loss of aquatic grass beds due to nutrient loading is a major issue in the Chesapeake Bay where the striped bass fishery declined with the loss of this critical habitat (Kemp et al. 1983).

7. Bottom Habitat. Bottom habitat is degraded as phytoplankton and macroalgae die and decay. What were once clean gravels and sands which supported good settling surfaces for shellfish, become covered with black organic mud. Friedrick (1982) reported that the sediments of the upper coves of Point Judith and Potter Ponds already exceeded 8 percent organic content, a level typical of eutrophic water bodies. As bottom sediments become more organic, the benthic organism composition will shift from desirable to less desirable food species, with a consequent impact on the fish and crabs that rely on those species for sustenance (Bagge 1969, Pearson and Rosenberg 1978, Sarda 1995). As organic matter increases in the bottom sediments, nutrient flux from the sediments will increase, adding more nitrogen to the overlying waters which will stimulate more aquatic plant growth and exacerbate the already problematic nutrient loading situation (Lee and Olsen 1985, Nowicki and Nixon 1985).

8. Well Water Contamination and Public Health Problems. In addition to the problems resulting from nutrient loading to the salt ponds, there is a very serious public health problem associated

with nitrogen contamination of groundwater in the region. As the groundwater flows toward the salt ponds it accumulates nitrogen from fertilizers, sewage effluent discharges from ISDS and animal waste so that the concentration of nitrogen in densely developed residential areas near the salt ponds is elevated 100 times above the background levels found in the upper reaches of the watershed (Olsen and Lee 1984 and Lee and Ernst 1996).

Nitrogen in the groundwater of the Salt Pond Region is predominantly in the form of nitrate ($NO_3$), which is a very stable anion, and thus is relatively unaffected in the subsurface environment. A high level of nitrate in the groundwater is a public health problem, since groundwater is the sole source of drinking water for public water supplies and private wells in the region. The federal health limit for nitrate concentration in the drinking water is 10 parts per million by weight (10 ppm). Higher concentrations are considered a public health hazard and can cause infant cyanosis (methemoglobinemia), a condition where nitrogen rather than oxygen is transported by the blood and the child suffers oxygen starvation which, in severe cases, can lead to brain damage or death. Communities on Cape Cod have established 5 mg nitrate-N per liter as the limit not to be exceeded in order to protect groundwater for drinking supplies (Cape Cod Commission 1992). In some areas around the salt ponds, nitrate levels in the groundwater approach, and in a few cases exceed 5 mg nitrate-N per liter.

9. Managing the watershed to maintain groundwater nitrogen concentrations that meet potable drinking water standards (<10 mg/L $NO_3$-N), in order to protect human health, is not sufficient to protect the salt pond ecosystems. The health of the salt pond ecosystem is impacted by much lower concentrations of nitrogen (100 times lower) than the limit for human health. To dramatize this problem, the URI mesocosm experiment results are demonstrating a loss of eelgrass habitat and nuisance blooms of algae and phytoplankton at 1.5 to 5 micro moles (Fm) of dissolved inorganic nitrogen (DIN). This is equivalent to approximately 0.02 to 0.07 mg/l of DIN. Unfortunately, these levels are already being exceeded within the salt ponds (Salt Pond Watchers 1996). The salt pond water quality, habitat quality and aesthetic quality are all being degraded at the present loading rates of nitrogen from existing land use development. To restore and manage these qualities, it is necessary to limit additional nutrient loadings from future development and, where possible, reduce loadings from existing residential and commercial development.

10. Nitrogen loading to surface area ratio between the salt ponds and Waquoit Bay are compared in Table 3-5. Waquoit Bay has a loading rate of .003 kg-$NO_3$/$m^2$/day. Comparing this to the loading rates in the salt ponds, Green Hill Pond exceeds the rate by .017 kg-$NO_3$/$m^2$/day. Since Waquoit Bay has lost almost all of its eelgrass habitat in recent years, exceeding this nitrogen loading rate indicates the potential for further habitat declines in Green Hill Pond. Other symptoms of decline exhibited in Waquoit Bay include greatly increased macroalgal growth in areas previously dominated by eelgrass meadows, anoxic conditions in bottom waters which kill invertebrates and fish, and decreased harvests of shellfish due to habitat loss from macroalgae covering bottom areas and absence of eelgrass. Although making a direct comparison between distinct waterbodies is not possible because of different flushing rates, nutrient cycling dynamics in the sediments and other factors, the symptoms of eutrophication in Waquoit Bay are potential issues the South Count communities will be dealing with in the future.

Table 3-5. Comparison of nitrate-nitrogen loading to surface area ratio for salt ponds and Waquoit Bay, MA.

| Water Body | Nitrate-Nitrogen Loading | Nitrate-Nitrogen Loading |
|---|---|---|
| Point Judith Pond | .01 | 63780 |
| Potter Pond | .01 | 18880 |
| Cards Pond | .06 | 10688 |
| Trustom Pond | .007 | 4554 |
| Green Hill Pond | .02 | 32551 |
| Ninigret Pond | .006 | 41931 |
| Quonochontaug Pond | .001 | 3743 |
| Winnapaug Pond | .001 | 2385 |
| Maschaug Pond | .001 | 232 |
| Waquoit Bay, MA | .003 | 23130* |

*Valiela et al. 1997 estimates of nitrogen loading from atmosphere, fertilizer, and wastewater to the lower subwatersheds.

## 310.3 Future Trends

### A. Additional Development in the Region

1. Further development throughout the region is inevitable, as most land within the watershed is held in private ownership and is yet undeveloped. Estimates for saturation development (total build-out), based on 1995 municipal zoning for each town, suggest that the number of residential units within the Salt Pond Region could almost double under current zoning.

2. The towns in the Salt Pond Region have some of the fastest growing populations in the state, along with the highest number of building permits issued annually (Culliton et al. 1992). In addition to an increasing residential population, more businesses are locating within the region and seasonal tourism is on the rise. If unmitigated, an increase in the local resident population within these towns is expected to increase pollutant loadings to the ponds. In densely developed areas such as neighborhoods around Ninigret east basin, Tockwotton Cove and East Beach, the levels of nitrate-nitrogen in drinking water are already high and are projected to reach unsafe concentrations which will make it necessary to construct public water supply systems. Of major concern are undeveloped aquifer recharge areas which are adjacent to poorly flushed portions of the salt ponds that are particularly susceptible to pollution and areas adjacent to critical fish and wildlife habitats.

3. In-fill (vacant lot) construction will occur within areas that are already developed at densities well beyond what the landscape can support (Lands Developed Beyond Carrying Capacity, Chapter 9). It is important to act now to purchase land and build facilities for innovative and alternative community wastewater treatment systems, and implement best management practices for existing and future development, so that the quality of the potable water supply and the salt ponds will be restored in these communities near the ponds.

4. Based on the nutrient loading analysis conducted by URI in the early 1980s, a minimum lot size of two acres was recommended for sustainable development of lands within the watershed. If the entire watershed is developed at an average density of two acres, given the coarse soils of the

region and the groundwater resources, then each lot should be able to use an ISDS for waste disposal and sustain potable well water on site. However, this would be expected to raise groundwater concentrations of nitrate-nitrogen to 5 ppm or higher and drastically increase nutrient loadings to the salt ponds. Furthermore, this two-acre base-density for self-sustaining lands has already been exceeded in many areas close to the ponds where houses are crowded together on 1/8 to 1/4 acre lots. In these areas nitrate-nitrogen concentrations in the underlying groundwater are high, many wells are polluted with bacteria, and adjacent salt pond waters frequently show the greatest evidence of nutrient pollution (Figure 3-13) (Lee and Olsen 1985). Every effort must be made to reduce the sources of pollution in these areas. Aquifers that are capable of providing a potable water supply to these communities must be protected. Lands located up-gradient of densely developed areas should be developed at as low a density as possible so as to minimize the nitrate-nitrogen concentration in groundwater before it reaches those highly stressed areas.

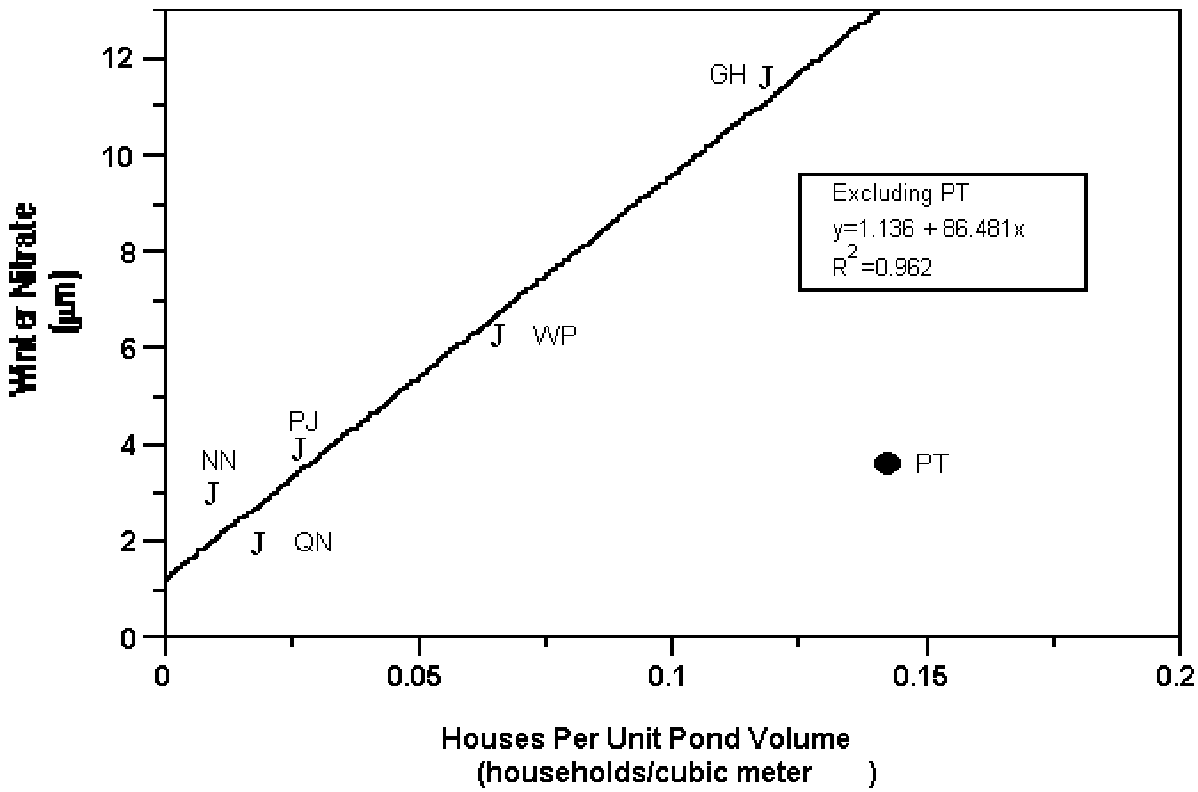



Figure 3-13. Winter nitrate (Fm) levels compared to housing per unit pond volume (houses/$m^3$).

5. The Towns of Charlestown, South Kingstown and Narragansett have amended their zoning plans to be consistent with the SAMP and to protect existing groundwater supplies, other critical areas of the watershed and the salt ponds. Because the region supports a high quality of life for residents and visitors alike, it is under extreme development pressure. Towns are being pressured by applicants and developers to reduce their existing large lot zoning and grant variances for more intense development. Because large parts of the watershed are already developed at high densities that exceed sustainable water quality for both groundwater and the salt ponds, it is critical to immediately preserve existing areas of very low density in the watershed. A combination of actions such as large lot zoning, open space acquisition, open space development, local wastewater management programs and the application of new technologies to reduce nonpoint sources of land-based pollution is essential to protect the salt pond ecosystem for future generations. Local

and state government and private groups like land trusts and the R.I. Builders Association will need to work together for sustainable development of the Salt Pond Region.

6. Innovative and alternative technologies for small-scale wastewater treatment are being used successfully by communities throughout the country and within Rhode Island, particularly in the Salt Pond Region. When these systems are properly maintained they provide important alternatives for wastewater treatment problems to reduce nutrient loading and pathogens in discharged wastewater. A variety of treatment types are available, ranging from sand filter and trickling filter technologies to extended aeration and composting toilets. Many of these technologies are featured at the On-site Wastewater Training Center (OWTC) facility located at the University of Rhode Island. The DEM Division of Groundwater and ISDS has amended the ISDS regulations to facilitate the installation of these new technologies for experimental testing in Rhode Island. DEM established a Technical Review Committee to assess the data provided by companies designing alternative systems, some of which have the capacity to reduce nitrogen loading to groundwater.

7. On-site nitrogen removal systems are effective at removing some amount of nitrogen from reaching groundwater through denitrification. Denitrification is an anaerobic biological process which results in the transformation (reduction) of $NO_3$-N and $NO_2$-N to gaseous forms of nitrogen, mainly nitrogen gas ($N_2$). Several types of bacteria are capable of participating in the denitrification process whereby they use $O_2$, $NO_3$-N or $NO_2$-N for growth. Oxygen, if present is preferred by the bacteria and under anaerobic conditions (without oxygen) $NO_3$-N and $NO_2$-N are substituted for $O_2$. In addition to denitrifying bacteria, there must be anaerobic conditions; a carbon source; and suitable temperature, pH and alkalinity levels (excerpted from "On-site Wastewater Training Series, On –Site Nitrogen Removal Systems," by George W. Loomis and David Dow).

8. In response to the need for regular maintenance and, where necessary, repair and replacement of ISDS in the Salt Pond Region, the DEM, the CRMC and the local town governments are presently working together on: (1) the delegation of authority to local governments for wastewater management programs and identification of failed or substandard systems; (2) faster response by state agencies to reported failures; (3) the establishment of standards for rehabilitation of substandard systems; (4) options for community-based sewage disposal systems; and (5) public education programs and identification of sources of funding for ISDS repairs. The Rhode Island On-site Wastewater Training Center at URI provides municipal and homeowner training regarding the proper inspection and maintenance of onsite wastewater disposal systems.

9. Based on non-proprietary systems which have been designed and installed by Dr. George Loomis and David Dow through the URI OWTC as part of an EPA Aquafund grant, nitrogen removal systems like recirculating sand filters can range in total cost for design and installation between $9,000 and $13,000 (David Dow, Personal Communication). The cost of maintenance for these systems is approximately $100 -$150 a year. Although this cost may be higher than installing a basic septic system without site constraints, nitrogen removal systems generally have much better effluent quality reducing the possibility of drainage field failures and if maintained properly should function indefinitely.

10. The local communities in the Salt Pond Region are concerned about existing sources of nitrogen and bacteria which are impacting water quality in the salt ponds. In order to encourage and assist homeowners to replace these systems, the Rhode Island Clean Water Finance Agency (RICSFA), in collaboration with RIDEM is establishing the Community Septic System Loan Program (CSSLP). Approximately 1 million dollars will be available to communities with RIDEM approved wastewater management programs. The CSSLP program will be offered to the local communities as a line of credit. Residents who need to repair or replace their septic systems will

access their community's line of credit. The money is loaned to the homeowner at an interest rate of 4% with a repayment period of up to ten years. Replacement of conventional ISDS with alternative technologies to reduce pathogens and nitrogen concentrations is allowed under the program and CRMC will be working closely with local communities to identify nutrient sensitive areas within the salt ponds that will be priorities for ISDS replacement.

## B. Public Sewer and Water Systems

1. A common response to the pollution of surface water bodies and groundwater from dense development is to build municipal sewer systems. However, sewers are too expensive to be a realistic solution for much of the region, particularly because most of the problem communities are located so far from existing municipal sewage treatment facilities. In addition, municipal sewer systems raise another set of issues. Once an area is sewered, many of the constraints that presently limit development disappear. For example, sites with soils which do not meet percolation standards or minimum depth to groundwater requirements may support new development provided they have sewers available. The experience of many communities nationwide demonstrates that sewer systems encourage high density development and increase runoff contamination of adjacent water bodies (Pye et al. 1983, RIDEM 1980). Sewers are an appropriate solution for urbanized areas where other alternatives are no longer available, but not for areas alternative such as the Salt Pond Region where less dense development is a feasible and desirable. In areas where zoning or development is at densities greater than 2 acres, sewering will be essential and should be part of any planning and cost projections for infrastructure on the south shore.

2. As private wells become increasingly polluted, there will be demands to construct public water systems. Water supply systems encourage development, and are expensive to build and maintain. Moreover, increasing the level of development further pollutes the region's groundwater which is the sole source for both public water systems and private wells. Once contaminated, groundwater aquifers in the region would require hundreds of years to recharge and cleanse pollutants. There are no significant alternative sources of drinking water within the Salt Pond Region. When groundwater supplies on Long Island became contaminated with high nitrate levels from dense suburban development in the 1970s, municipalities drilled through clay layers to a deeper uncontaminated aquifer (Koppleman 1978). There is no such option in the Salt Pond Region, where the glacial aquifer extends down to bedrock.

3. Providing public water systems for expanding development has the additional problem of altering the groundwater hydrology. A public water supply system that draws from the watershed of one salt pond and exports it to the watershed of another, alters the flow of freshwater to both salt ponds. This can have potentially profound impacts on their ecology by altering salinity levels, aquatic habitat and species diversity. For example, the wells near Factory Pond that supply South Kingstown's South Shore Water System withdraw 6 percent of the freshwater flow from Factory Brook and the Green Hill Pond watershed to the watersheds of Trustom and Potter Ponds. This water source supplies houses in Matunuck, Blackberry Hill and Snug Harbor where private wells became contaminated decades ago (Lee and Olsen 1985). If all the houses that can legally request tie-ins to the existing municipal water supply mains do so, the annual freshwater flow in Factory Brook Pond will be reduced by 17 percent. A 10 to 20 percent reduction in stream flow will have a significant environmental impact on the stream and on Green Hill Pond.

4. Groundwater recharges streams and other surface waterbodies, maintaining streamflow during periods of low flow or drought conditions (EPA 1995). Modifications to the quantity or quality of

groundwater discharged into surface water ecosystems can impact recreation, public health, fisheries, and tourism economies in the region (EPA 1995). Groundwater is the principal source of freshwater to the salt ponds and is responsible for defining the basic ecology of these estuaries (Lee and Olsen 1985). Groundwater either directly flows into the ponds up through the bottom sediment, through springs along the edges of the ponds, or discharges into streams which then flow into the ponds (Grace and Kelley 1981). Groundwater is the only source of public drinking water for Ninigret, Green Hill, Trustom, Cards and Potter Pond watersheds. In the coastal ponds, flushing and salinity gradients are largely dependent on stream flow and groundwater input (Deason 1982). A reduction in freshwater recharge would increase salinity levels in the ponds which could affect fish and shellfish distributions. Most importantly, flushing would be reduced, accentuating the pollution problems which already exist (Deason 1982).

## D. Buffer Zones

1. Undisturbed zones along the perimeter of salt ponds, their tributaries and associated wetlands play an important role in preserving the qualities of the coastal environment. These benefits are summarized in Section 150 of the Rhode Island Coastal Resource Management Program and the Coastal Resources Center (1994) publication entitled *Vegetated Buffers in the Coastal Zone* (Desbonnet et al. 1994). The benefits of vegetated buffers include erosion control, checking the flow of pollutants, protection of flora, fauna, and the preservation and enhancement of scenic qualities. Wide buffer zones are particularly important in areas designated as Lands of Critical Concern (Chapter 10). These as yet undeveloped or sparsely developed tracts abut poorly flushed portions of the salt ponds, which are therefore particularly susceptible to pollution. Their undisturbed shorelines are valuable natural habitats with high scenic values. Wide buffer zones in these areas also minimize flood damage, and have the additional benefit of protecting the numerous archeological sites that are clustered along the pond shorelines. According to surveys conducted by the Rhode Island Historic Preservation & Heritage Commission, two-thirds of the important archeological sites around Potter Pond are within 650 feet of the shoreline and 80 percent of the artifacts are within 300 feet of the shoreline (RIHPC 1984).

2. Research on the effectiveness of naturally vegetated shoreline buffers to remove nutrients makes buffers one of the single most cost-effective management activities for the coastal ponds. Many states require or recommend buffer zones of widths ranging from 150 to 1,000 feet to protect water bodies from pollution. Buffers 100 to 300 feet wide are recommended to protect surface water bodies from sedimentation and 300 to 1,000 feet are recommended for 50 percent to 90 percent nutrient removal from runoff waters (Desbonnet et al. 1994).

3. Wetlands, sites of denitrification due to anaerobic soil conditions and an adequate carbon source (organic matter), can play an important role in reducing the amount of nitrogen transported into the salt ponds. Research on riparian forests in Rhode Island emphasizes the importance of preserving forested wetlands along tributary streams as well as emergent wetlands along the shore in reducing nitrogen loading to the salt ponds (Simmons et al. 1992, Groffman et al. 1992, Hanson et al. 1994, Nelson et al. 1995).

## E. Conclusion

1. If management steps are not implemented to address present nitrogen loading problems, we can expect further declines in water quality. Because of the slow rate at which groundwater moves through glacial deposits toward the salt ponds, the impact of recent residential development in the upper reaches of the watershed will be delayed. Therefore, the extent of damage to the salt pond habitat as a result of eutrophication is likely to become more severe with time.

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# Chapter 4
## Geologic Processes

### 410. Findings of Fact

### 410.1 Introduction

### A. Rhode Island Barrier and Headland System

1. This section discusses how the Rhode Island barrier and headland system formed, how it has evolved, and how the present system is maintained. It will focus on the mechanisms and patterns of erosion and deposition that shape this dynamic environment, and hopefully provide an understanding of the system necessary to interpret the data presented in the following discussion.

(a) Barrier/Headland Origins. The Rhode Island southern shoreline (Figure 4-1) is in many ways typical of other coastal areas along the east coast of the U.S., and the processes that formed other east coast shorelines are at work in Rhode Island. Yet the south shore of Rhode Island is unique in some ways, beginning with the origin of the present land forms. Approximately 25-30,000 years ago, glacier ice of the Laurentide Ice Sheet extended from the Hudson's Bay area of Canada south to Nantucket Island, Block Island, and southern Long Island, covering southern New England with a thick sheet of ice. This ice mass moved large volumes of sediment, ranging in size from silt grains to large boulders, by entrainment within the ice, leaving some sediment (glacial till) smeared onto the underlying bedrock. About 21,000 years ago the global climate began to warm up and the ice wasted away from Rhode Island. More of the entrained sediment was directly released from the melting ice to be deposited as glacial till. Meltwater rivers flowing beneath the melting ice sheet and emanating from the ice margin incorporated additional sediment that was deposited on glacial river flood plains and in glacial lakes. The headlands at Point Judith and Green Hill are composed of glacial till, a mixture of particle sizes from silt grains to boulders deposited directly by the ice. The more widely distributed deposits, those left by meltwater flowing from the retreating ice sheet, are glacial river sand and gravel, such as that exposed along the eroding Matunuck headland (Figure 4-1).

About 14,000 years ago the global climate warmed up very rapidly and added much additional glacial meltwater to the ocean, causing the sea to rise rapidly across Block Island and Rhode Island Sounds to arrive in the vicinity of the present shoreline by 4,000 years ago. Ocean waves eroded the glacial deposits, carrying sediment in wind-driven currents alongshore and depositing it as barrier spits in the adjacent low-lying areas between the topographically higher headlands. As the spits developed and grew alongshore from the headlands, the low-lying areas behind the spits were almost entirely sealed off from the ocean, forming coastal lagoons (coastal ponds) connected to the sea through narrow inlets. The inlets are the conduits for the exchange of water and sediment in and out of the lagoons, and before they were fixed in place by jetties, they were maintained by tidal forces and by surges from storms. From the time of this early spit formation to the present, the glacial river deposits and glacial till have continued to erode, and the barrier spits and coastal lagoons have moved landward and upward, all by the force of storm waves and storm surges controlled by the level of the sea at the time of the storm. The present arrangement of barriers and headlands is controlled by the topography of the glacial till and glacial river sediment. The areas of glacial deposits with higher relief are exposed at the surface and form the present headlands, while those areas below mean low water are now topped by barrier spits or submerged by coastal lagoons.

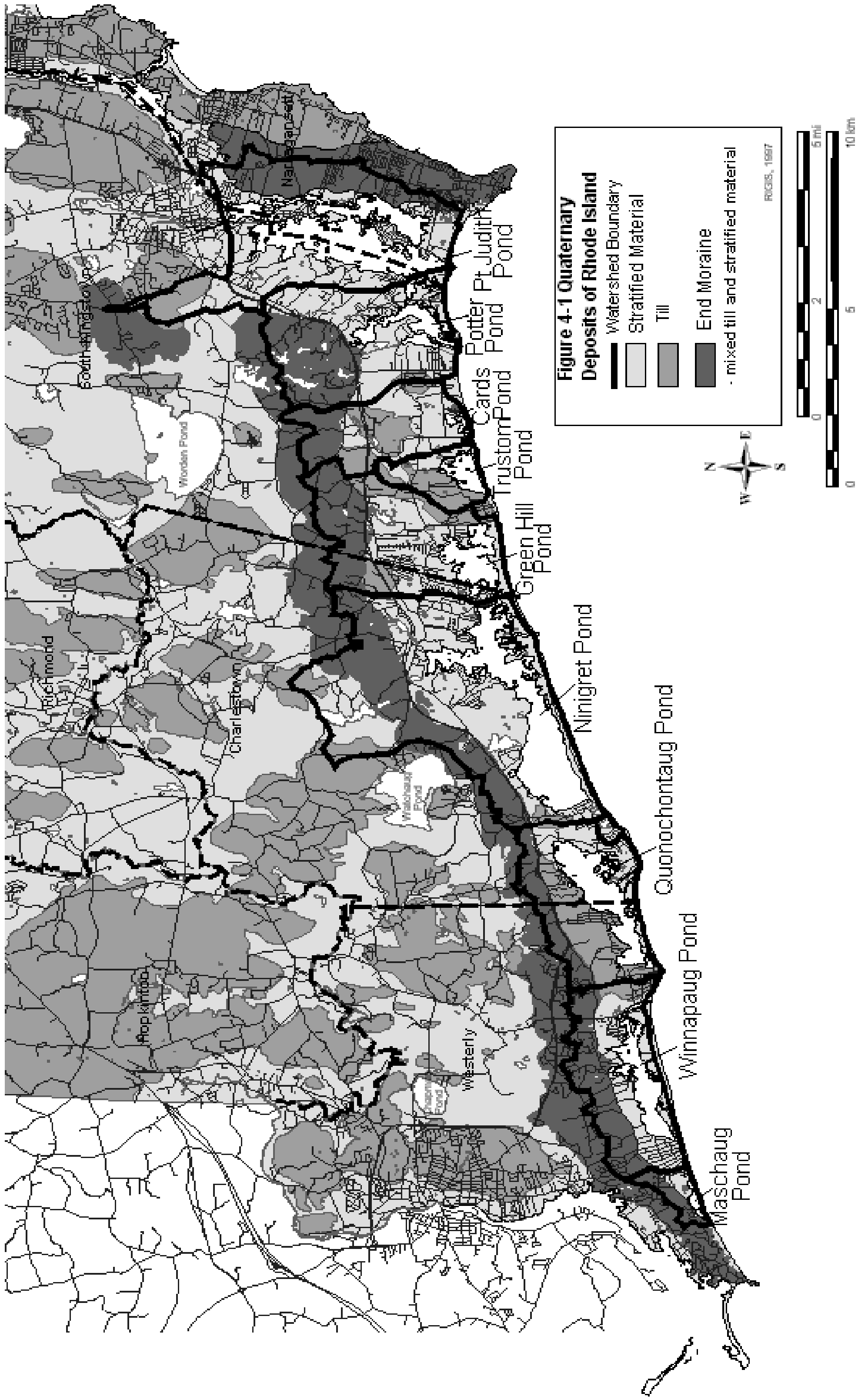


**Figure 4-1 Quaternary Deposits of Rhode Island**

(c) Barrier/Headland components. Barrier spits are land forms composed of sand and gravel that lie parallel to the coastline, are attached to the mainland, and enclose a coastal lagoon or salt water wetland. The map in Figure 4-2 illustrates the name and location of the Rhode Island barrier spits. The boundary is defined by the interface between the glacial till or glacial river/lake deposits forming the headland, and the wave and surge deposited sand and gravel forming the barrier. These boundaries were drawn in most cases by extending a shore-perpendicular line from the mean high waterline (MHW) to the lateral edge of the backing coastal lagoon. This barrier/headland delineation does not work for all barrier boundaries, for example the east end of the Misquamicut barrier is defined by the Weekapaug inlet. It should be noted that the barrier/headland interface can not always be delineated by a straight line on a map, and in that sense it is a generalization. The exact boundary can only be determined by an on-site assessment of the underlying geology.

Headlands along the Rhode Island south shore are land forms composed primarily of glacial till or glacial river sand and gravel (Figure 4-2). The Weekapaug and Quonochontaug headlands contain small bedrock outcrops. The headlands are fronted by beaches just as barriers are, but they are not backed by a marine environment such as a coastal lagoon.

Figure 4-2 depicts two vertical cross-sections, one showing the internal components of the Charlestown/Green Hill barrier spit, the other the internal components of the Matunuck headland near the South Kingstown town beach. These cross-sections serve as representative examples of headland and barrier environments. As described above, the barrier spits sit atop low-lying glacial topography across which they have migrated in response to storms and rising sea level. The whole barrier and lagoon system is moving landward over the glacial sediment. The glacial surface at many locations contains large kettle holes, steep-sided depressions in the glacial river sediment left unfilled during accumulation of the surrounding sediment because the space was occupied by blocks of ice. On top of the glacial river deposits and filling the kettle holes, is a layer of silt-sized organic material deposited within lagoon basins and then covered by landward migration of the barrier. One of the ways to determine that a barrier is migrating landward is to look for the presence of this organic layer low on the eroded beach face after storms. This indicates the previous site of the lagoon. On top of the silty organic material is a 1- to 3-meter thick layer of sand deposited by storm-surge overwash during severe storms. Above the storm-surge sand is the barrier core. The internal components of the barrier are simplified in Figure 4-2, the internal components and means of deposition of the barrier core will be discussed in more detail later. The surface features or depositional environments of the barrier system are the shore face, the beach, the foredune zone, the back barrier flat and the storm-surge platform. Notice the location of the mean sea level waterline relative to the barrier features.

The internal components of the Matunuck headland are illustrated in Figure 4-2. This headland is primarily glacial river sand and gravel deposited by meltwater rivers emanating from the retreating glacier. The postglacial eolian mantle is a thin layer of silt deposited by the wind after the glacial river sediment was deposited. The small wedge-shaped washover fan and eolian dune at this site is sand eroded from the berm and deposited by a combination of wind and storm-surge overwash along the margin of the eroding headland bluff. The berm is wave-deposited sand.

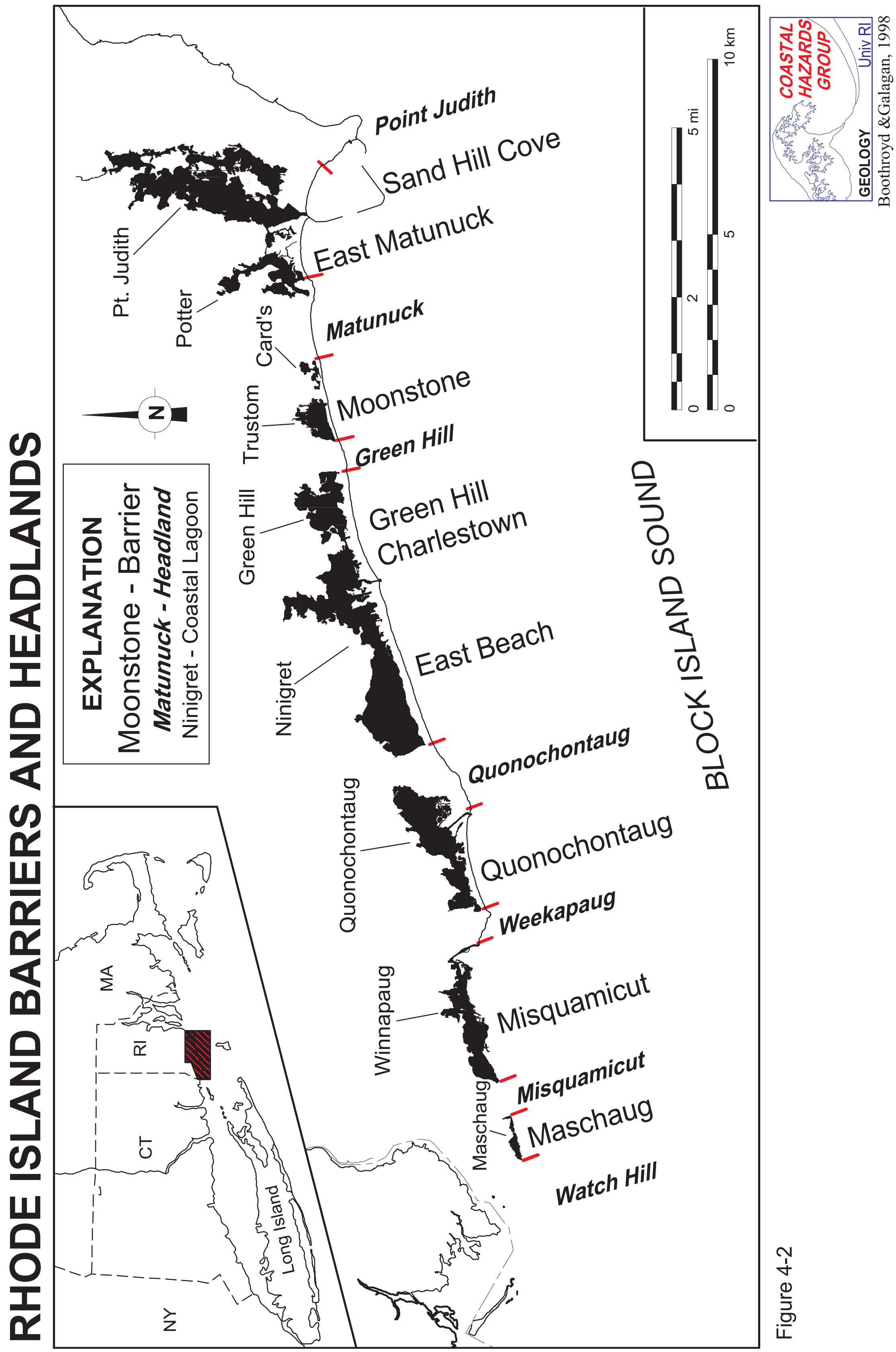
RHODE ISLAND BARRIERS AND HEADLANDS
EXPLANATION
Moonstone - Barrier
Matunuck - Headland
Ninigret - Coastal Lagoon
N
Point Judith
Sand Hill Cove
East Matunuck
Matunuck
Moonstone
Green Hill
Green Hill
Charlestown
East Beach
Quonochontaug
Quonochontaug
Weekapaug
Misquamicut
Misquamicut
Maschaug
Watch Hill
Pt. Judith
Potter
Card's
Trustom
Green Hill
Ninigret
Quonochontaug
Winnapaug
Maschaug
BLOCK ISLAND SOUND
MA
RI
CT
NY
Long Island
0
2
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Figure 4-2

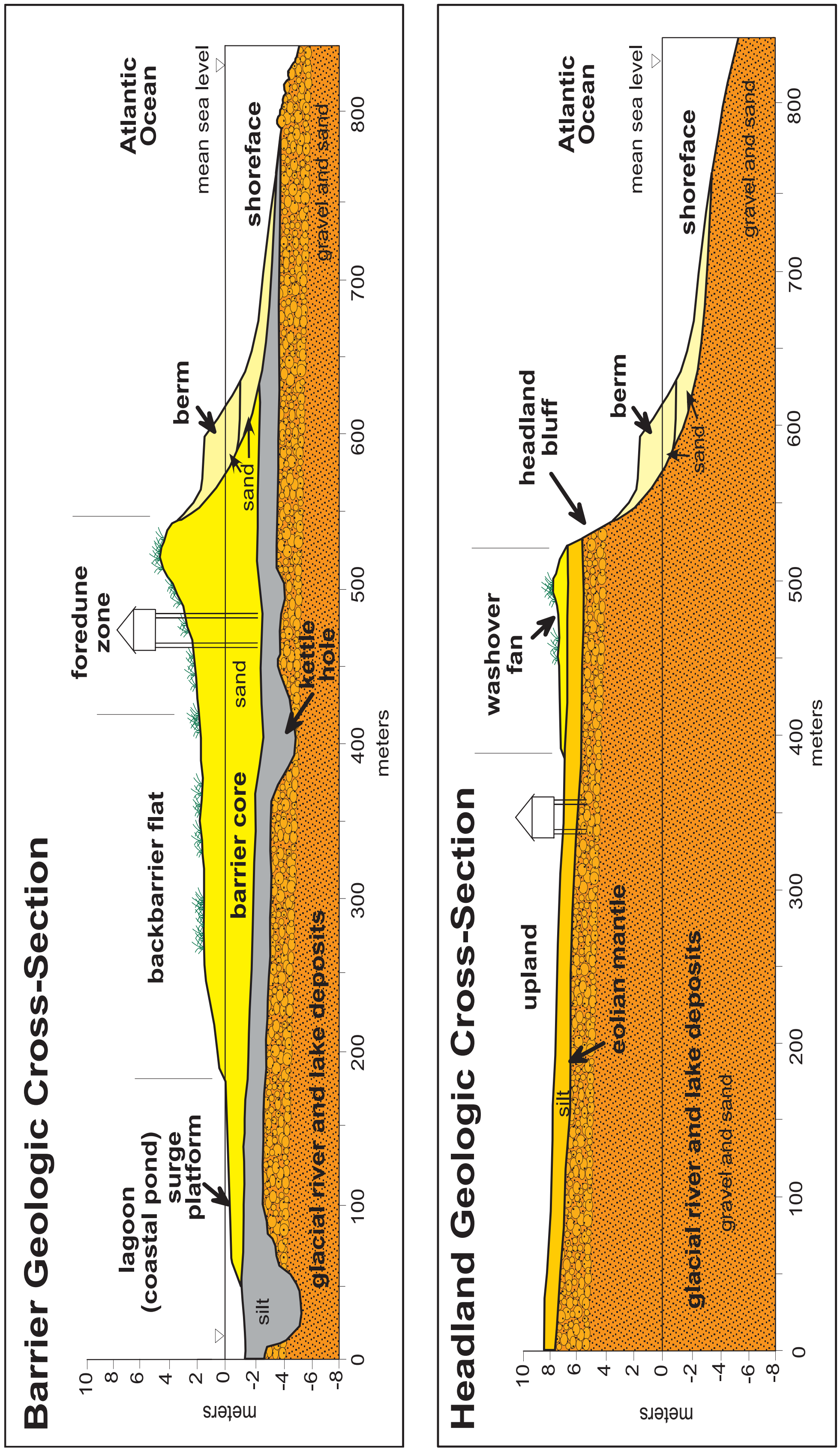


Figure 4-3

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## 410.2 - Geologic Processes - The Energy Budget

### A. Introduction

1. Understanding sediment movement within a closed system such as the Rhode Island south shore requires knowledge of the amount and sources of available material - the sediment budget - as well as knowledge of the amount of energy coming into the system - the energy budget. It is useful to think of a barrier shoreline in these terms because it expresses the dynamic nature of the system. Energy is constantly input and work is constantly being done, reshaping the land forms on a human time scale.

2. Wave energy. Energy reaching the shoreline arrives in the form of wind, waves and currents. Waves generated at great distances by storms in the open ocean, arrive as swell, that is, long wave length, low-amplitude waves about 1-2 meters high with a period of greater than 10 seconds. Locally generated waves (Block Island and Rhode Island Sounds) are created by local wind systems, and are typically less than 1 meter in height with a period of 3 to 5 seconds. A third type of wave, generated by storms south of Rhode Island, but not in Block Island Sound, can have waves of up to 6 meters in height and periods of about 6 seconds. The energy contained within a wave is a function of the wave height multiplied by a given distance along the wave crest. The delivery of this energy to the surf zone by waves erodes, transports, and deposits sediment on the shore face (the subtidal part) and on the berm (the intertidal part) of the barrier and headland system.

Longshore currents, generated by waves striking the shoreline at an angle, are one of three primary means of wave-generated sediment transport along the south shore (see Figure 4-4a). The energy, or wave power, available for sediment transport within the longshore current is a function of the height of the breaking wave, the forward speed of the breaking wave, and the angle between the advancing wave crest and the shoreline at the break point of the wave. Higher, faster traveling waves breaking in the surf zone at high angles to the shoreline generate longshore currents of greater velocity, and result in larger sediment volumes transported.

The second means of wave-generated sediment transport is by swash uprush and backwash on the beach face of the berm. The water from waves breaking at the shoreline is propelled up the beach face at an angle as swash uprush, and moved down the beach face by gravity in the backwash, transporting sediment along the beach face in a zig-zag pattern (see Figure 4-4a). Sediment in the active berm is deposited by swash processes.

The third wave-generated sediment transport mechanism is rip currents, the means by which sediment and water piled up against the shoreline by breaking waves (called wave setup) are returned offshore. Rip currents develop in the surf zone where incoming waves have slightly less height, and thus wave setup is less. These areas of lower setup

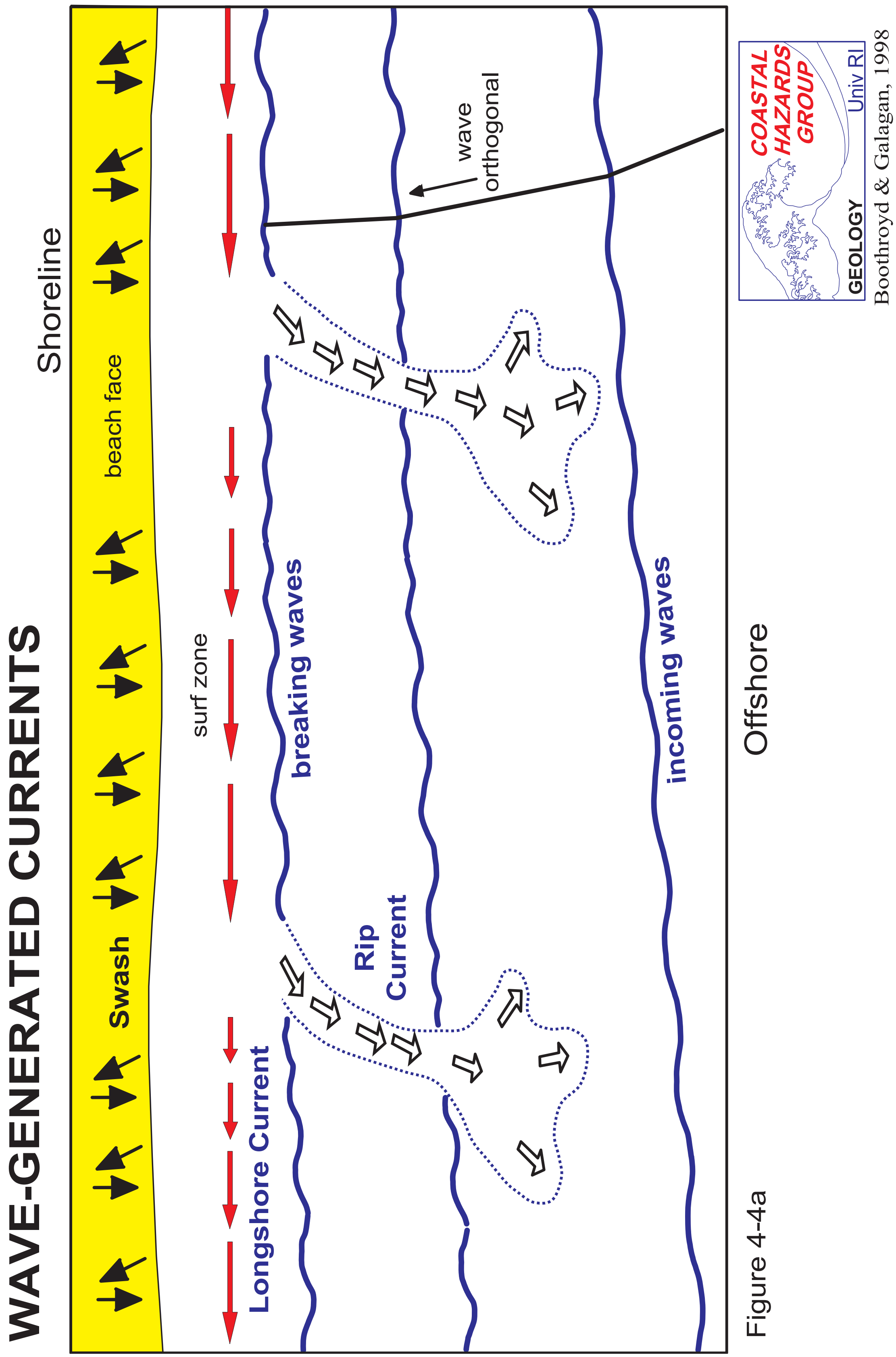
WAVE-GENERATED CURRENTS
Shoreline
beach face
Swash
surf zone
Longshore Current
breaking waves
Rip
Current
wave
orthogonal
incoming waves
Offshore
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Figure 4-4a

become areas of convergence for the water in adjacent areas of higher setup (in a sense water runs down hill). The converging water turns and flows seaward within narrow areas of the surf zone and transports sediment offshore (Figure 4-4a).

3. Tidal energy. Tides in Rhode Island are semi-diurnal, meaning two high tides and two low tides occur every 24 hours and 12 minutes. The mean tidal range at the Newport tide gauge (maintained by NOAA) is 1.1 meters (3.6 ft) with a spring range of 1.6 meters (5.2 ft). The tidal range along the south shore varies somewhat but it is useful to use the Newport data when considering tidal range.

Spring tides occur twice monthly at the time of a new moon (earth, sun and moon aligned with the moon in the middle) and at full moon (earth, sun and moon aligned with the earth in the middle). Block Island Sound is unique in that tidal currents generated by water exchange in and out of Long Island Sound flow parallel to the southern shoreline offshore of the beaches. Flood-tidal currents flow from east to west, and ebb currents from west to east, at speeds typically between 20 and 60 centimeters per second (0.7 and 2.0 ft per second). Tidal range in all the lagoons except Point Judith Pond is 7 to 10 centimeters (mean) (0.2 to 0.3 ft) and 16 centimeters (spring) (0.5 ft) due to the constriction of tidal-current flow through the inlets (breachways). Point Judith Pond is open to the sea through a relatively wider and deeper inlet than the others, and has a similar tidal range to that of the open ocean.

During a flooding tide, the water level of the open ocean increases, causing water to flow through the inlets into the coastal lagoons (Figure 4-4b). The tidal flow carries sediment, delivered by the longshore current system described above, through the inlets, depositing it as flood tidal deltas in the open lagoon. The deposition of sediment within the tidal deltas is one of the primary means by which the Rhode Island barrier spits migrate landward, something that will be discussed in later sections when the sediment budget is considered.

4. Storm Surge. Storm-surge is the elevation of the ocean surface above a given astronomical tide elevation resulting from the effect of a storm. It is measured as the difference between actual sea-surface elevation during a storm, and the sea-surface elevation associated with the astronomical tide at the time. Storm surges result from several factors, but are primarily a function of the high winds blowing across the ocean surface and reduced atmospheric pressure associated with extratropical and tropical storms. The onshore-directed winds of a severe storm or hurricane interact with the ocean surface and actually pushes the ocean water mass toward the shoreline. This onshore flow of water piles up (or sets up) against the coast; while reduced atmospheric pressure (called the inverse barometer effect) causes an additional rise by reducing the pressure on the ocean surface. While set up and the inverse barometer effect are the primary forces causing elevated water levels during storms, probably the most important factor in the peak elevation attained during any individual surge event is the phase of the

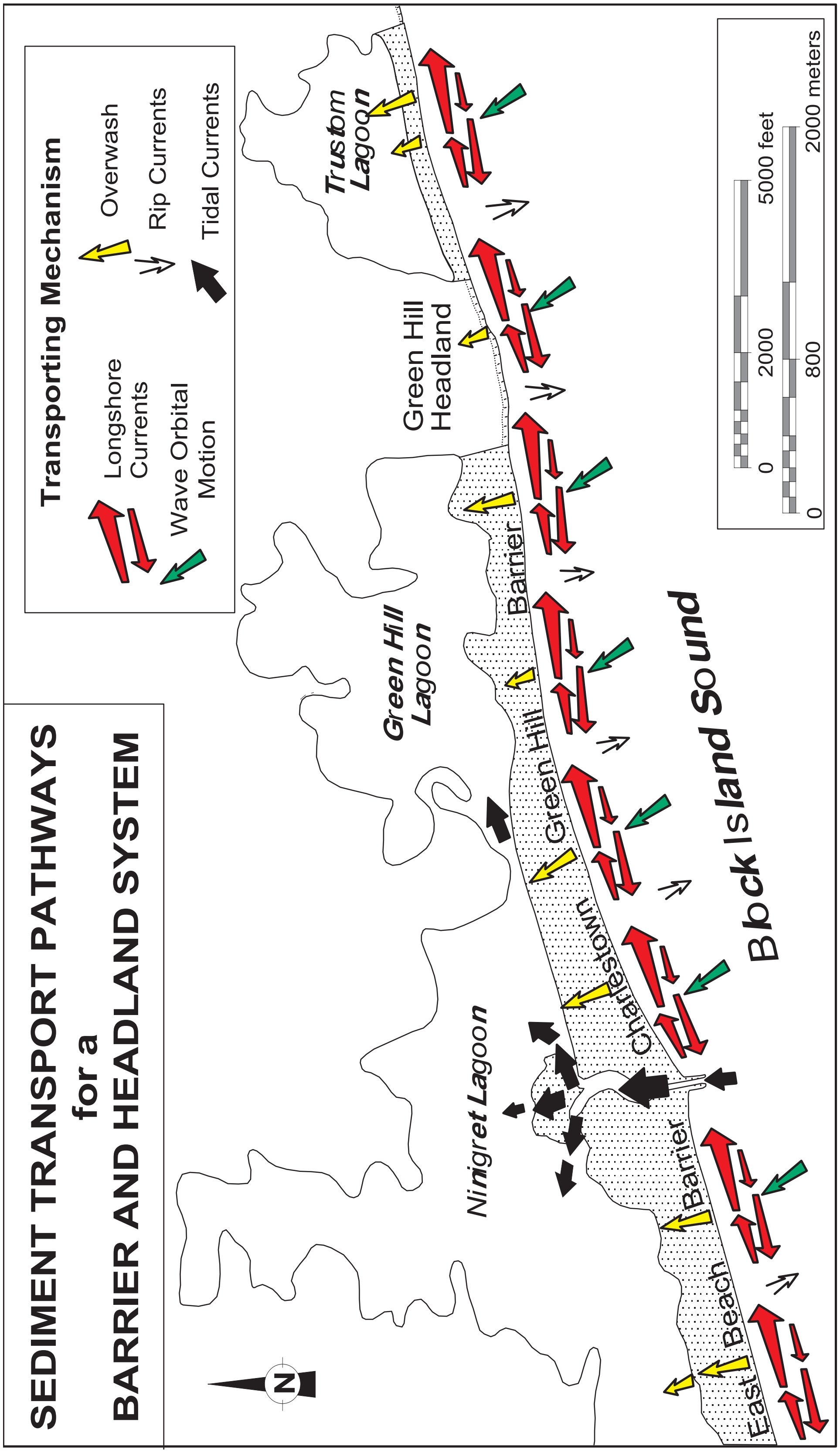


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Figure 4-4b

tide relative to the time of storm passage.

5. Overwash. During severe storm surge, water moves rapidly over the low barrier spits in a process called overwash (Figure 4-4b). Driven by the wind, waves and swash of the storm, overwash water delivers sediment eroded from the front of the barrier onto the back barrier flat and into the lagoon. The overwash process results in deposition of washover fans on the back of the barrier and the formation of storm-surge platforms in the lagoons. During overwash, temporary storm-surge channels are eroded through the barriers providing a conduit for sediment and water into the lagoon. The resulting storm-surge deposits, discussed in a later section, form extensive storm-surge platforms within the coastal lagoons.

6. Storms: Energy Producers. During fair weather, the wave energy imparted to the barrier and headland system results in relatively little change when compared with the changes caused by storms. The width of the berm at any given location may grow slowly or remain essentially the same during the fair weather of the summer months, yet one storm in the Fall may erode half of the volume of the berm and deposit the sand offshore on the shore face. The storms with the most effect on the south shore are extratropical Nor'easters and Sou'easters, occurring in the late fall, winter and early spring; and tropical hurricanes occurring in the late summer and early fall.

7. Hurricanes. Figure 4-5 illustrates the paths and associated wind patterns of hurricanes that come onshore in southern New England. In the northern hemisphere, winds move in a counterclockwise direction around low pressure centers. The eye of a hurricane is a small area of low pressure that can move rapidly over the open ocean encircled by high velocity winds. When the eye passes to the west of Rhode Island, the wind blows onshore along the south shore barriers and headlands. This is the most destructive path because the wind moving across the Rhode Island coastline has the combined velocity of the wind circulating around the eye plus the velocity of the storm system as it moves onshore. During the September 1938 hurricane, which passed to the west, the onshore winds reached 150 mph due to this combined velocity effect.

When hurricanes pass to the east of Rhode Island, winds along the south shore blow offshore and at relatively slower velocity because the velocity of the storm system is subtracted from the velocity of the circulating winds. The latest hurricane to strike the Rhode Island coast, Hurricane Bob which occurred in August 1991, passed over Block Island, diagonally across Rhode Island Sound, to go ashore in the Sakonnet area. Thus the south shore of western Rhode Island was spared the full brunt of the storm, but the southeastern Massachusetts shoreline received the maximum winds, waves, and storm surge.

8. Severe winter storms. Figure 4-5 also illustrates regional wind systems associated with major pressure systems passing through the region. The movement of low-pressure

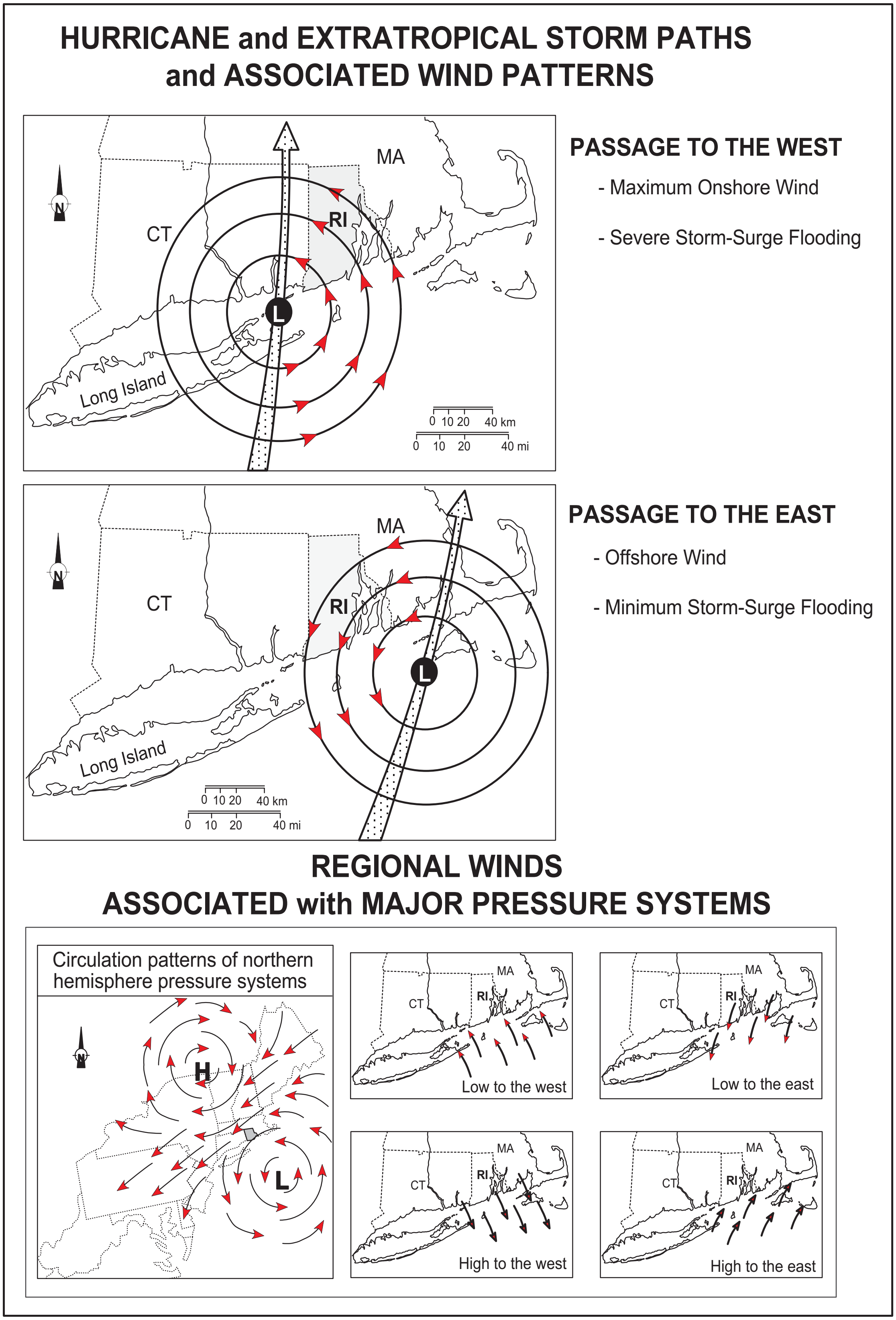


Figure 4-5 Adapted from Wright and Sullivan, 1982

centers up the east coast during the winter causes the Nor'easter, the most well known winter storms in New England. The Nor'easter is more destructive to northern and eastern facing shorelines because its northeast winds impinge more directly on shorelines of that orientation. Along the Rhode Island south shore, a Nor'easter results in an offshore wind, the least effective in imparting wave energy to the beaches and dunes. A Sou'easter, wind from the southeast, can be more destructive for the Rhode Island coast because of the exposure of the south shore to the open ocean in that direction.

9. Storm Frequency and Severity. Based on records of past storm frequency and severity, the probability of the occurrence of wave height and storm surge associated with future storms has been established for the Rhode Island south shore. It is not possible to predict when a particular storm will occur or how severe it will be, or how much erosion of headlands and barriers will take place as a result. What is known is the probability of occurrence during a given time period of a storm waves and storm surge of a given magnitude. These probabilities are expressed as storms possessing a certain return period. An example is the 100-year storm, the storm of a certain magnitude that on average occurs every 100 years, and has a 1% chance of occurring during any one year. The Great New England Hurricane of September 1938 fits the calculations of wave height and storm surge for a 100-year storm, thus it serves as the 100-year storm of record for Rhode Island. There are also a 50-year, a 10-year and a 1-year storm calculations done for the state, all based on the historical record of storm occurrence, all with different energy levels and erosion potential.

The severity of flooding in Rhode Island during the September 21, 1938 hurricane was in part because the storm came onshore at approximately spring high tide. Wind speeds of 195 to 242 kph (121 to 150 mph) accompanied by a barometric pressure drop of approximately 56 milibars at the storm center combined to create a storm surge along the south shore of 3.0 to 4.6 m (10 to 15 ft) (Nichols and Marsten 1939).

**410.3 - Sea Level Rise - The Near Geologic Future**

**A. World-Wide Trends.**

1. Based on worldwide tide gauge records dating back to the 1800s, the level of the global ocean has been rising at a rate of approximately 10 to 12 cm per century (3.0 to 4.7 in per 100 yrs) (Gornitz and Lebedeff 1987). Since continents also rise and fall from regional and global tectonic forces, the relative rate of sea level rise at a given location may be greater or lesser than the global average. Estimates of future sea level rise are based on complex climate models that contain the assumption that the atmospheric concentration of $CO_2$ (carbon dioxide) and other "greenhouse" gases will double within the next century (Charney 1979, Smagorinsky 1982). This increased concentration of greenhouse gases in the atmosphere is predicted to cause increased absorption of infrared

radiation leaving the surface of the earth, and re-radiation of this energy back to the surface, enhancing surface warming. Two results of increased surface warming would be an increase in the volume of surface ocean waters from thermal expansion, and increased melting of glacier ice. The global sea level rise estimates for the year 2100 derived from the model developed by the Environmental Protection Agency (Hoffman et al. 1983, Hoffman 1984) range from a conservative 56 cm (1.8 ft) above the 1980 level to a high projection of 345 cm (11.3 ft) (Figure 4-6). More recent work reported by the Intergovernmental Panel on Climate Change (IPCC) (Houghton et al. 1990) project a slower rise rate of 25 to 40 cm (0.8 to 1.3 ft) by the year 2050 (Figure 4-6).

2. Trends in Rhode Island. In Rhode Island the land is subsiding at a rate of approximately 15 cm per century (6 in) perhaps in response to readjustments of the underlying bedrock to release of load from the continental ice sheet (Douglas 1991). When a subsidence rate of 15 cm per century is added to a global sea level rise rate of 10 cm per century, the rate of relative sea level rise in Rhode Island is 25 cm per century (10.4 in per 100 yrs). It can be seen in Figure 4-6 that if this historic trend continues to the year 2100, sea level in Rhode Island will have risen approximately 45 cm (approximately 18 in) above NGVD (National Geodetic Vertical Datum - the zero elevation on government topographic maps). Many scientists predict a more rapid rise of sea level in the future.

3. Effect of Sea-Level Rise. The effect of any amount of future sea level rise will be an increased rate of coastal erosion as waves will break higher on bluffs and dunes along the south shore for any given storm intensity. Bathing pavilions, hotels, and other buildings now protected by coastal enginneering structures will subject to increased wave attack as the protection structures are overtopped by smaller and smaller storms. Low-lying areas adjacent to the shore front will be subject to "in-place drowning", i.e., increased flooding during storms. Water tables will rise causing failure of ISDS systems. Given the range of sea level rise estimates it is difficult to plan for a specific scenario, however it would be prudent to be aware of the impact of sea level rise. As the rate of sea-level rise estimates are refined, the responses needed can be more finely tuned.

## 410.4 Geological Deposits or Products - The Sediment Budget

### A. Sediment Sources

1. This section deals with the components of the sediment budget - the sources and sinks for sediment and the processes which erode, transport and deposit them.

(a) The primary sources of sediment on the south shore are:

- the glacial till and glacial river sand and gravel of bluffs;
- the foredune zone of the barrier spits; and

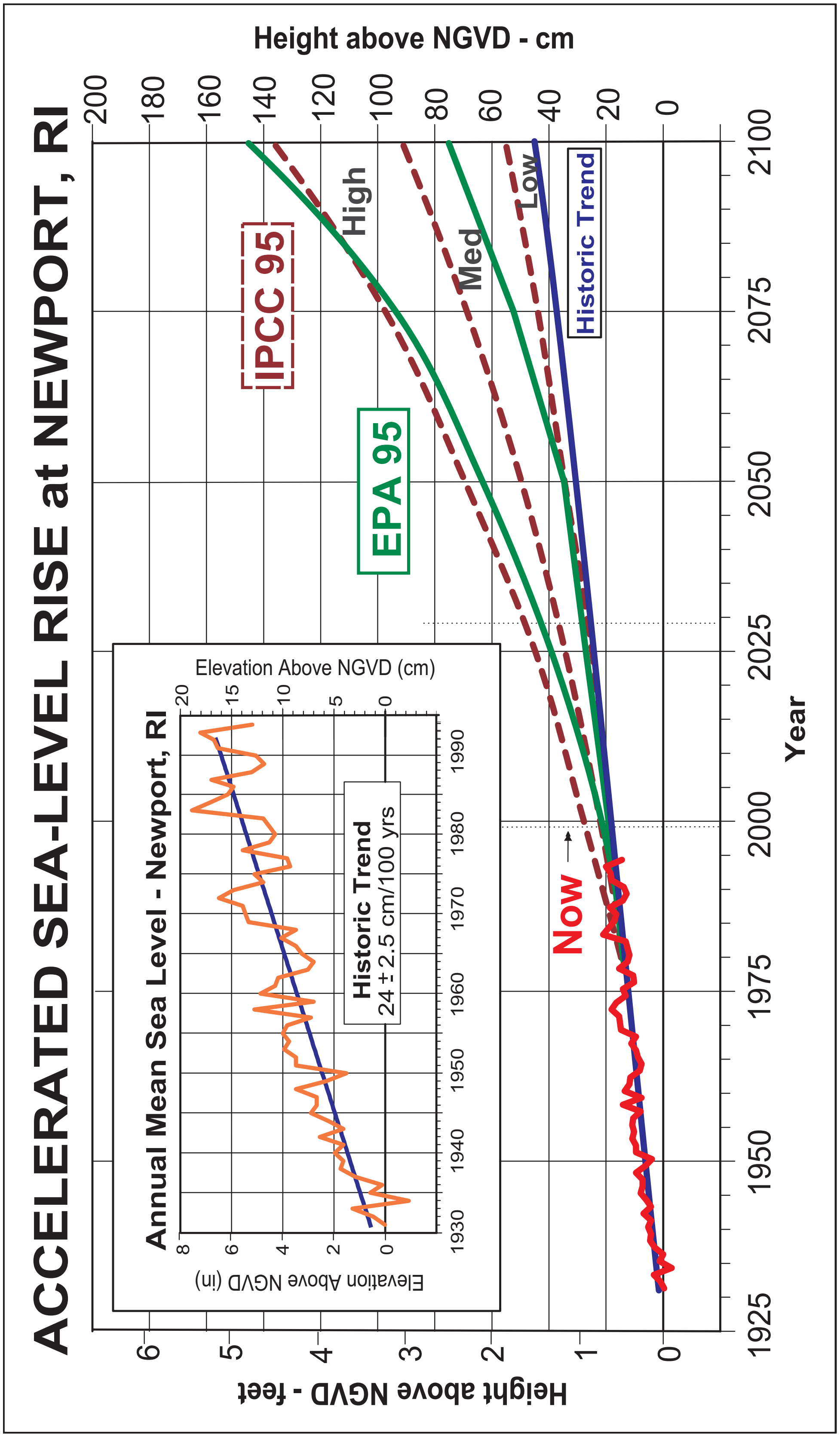


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Figure 4-6

- C the glacial deposits plus recently deposited sand on the shore face (Figure 4-3).

Headlands are eroded by direct wave attack and the eroded material is put into motion parallel to shore by longshore currents and carried offshore in rip currents. An example of eroding glacial deposits can be seen in bluffs along parts of the Matunuck headland. Glacial deposits are also exposed and eroded by wave energy on the shore face (Figure 4-3). This sediment is also eroded and transported by longshore and rip currents.

**B. Sediment Sinks: Where the Sediment Ends Up**

1. Berm. The active berm, one of the most dynamic of shoreline deposits, changes shape and size with decreases and increases of volume, in response to changes in wave conditions. The berm consists of sand and gravel that has been eroded from a nearby headland or area of the shore face and has been deposited by wave swash and backwash. Figure 4-7 depicts typical berm configurations for a south shore beach on both barriers and headlands. The berm consists of a relatively flat top, is fronted by a seaward dipping beach face, and has a well defined berm crest. Measurements of the cross-sectional area of the beach (beach profiles), such as that depicted in the low foredune barrier profile in Figure 4-7, obtained at the same site over the course of many years reveals that the berm configuration is cyclic. During non-storm periods, when wave conditions are dominated by distant swell, berms build seaward and upward attaining maximum volume. As the storm season progresses, the wave climate is dominated by regional storm systems and wave energy increases, causing erosion of berm material and deposition of this material on the shore face. With the return of fair weather, the sediment is returned from the shore face, and a wide berm with large volume is formed. The nature of this cycle will be discussed in detail in the following section.

2. Backshore Reservoir. The backshore reservoir (Figure 4-7) has a longer residence time than does the sediment of the active berm, and is more complex in origin (Graves 1990). Like the berm, it too is made up of sand and gravel, but from two separate sources and by two separate processes. Although the size and configuration of the backshore reservoir varies greatly in different areas of the south shore, the configuration depicted in Figure 4-7 serves as a good example of backshore reservoir formation. The deposit sits directly on the barrier core (discussed below), with the bulk of the sediment having been deposited by wave swash and backwash as a berm. In the example in Figure 4-7 the berm formed on an erosional surface created by the period of severe erosion culminating in the Blizzard of February 1978. Since that time, no other series of storm events has eroded the barrier at this location back to the 1978 erosional surface, and a berm has always been present. Through time, dune grass gradually spread out onto the berm top, effectively trapping wind blown sand and causing the vertical accretion of an eolian dune on the berm top. In this manner the edge of the dune and vegetation crept slowly seaward and the backshore reservoir gained volume. This seaward movement of the

dune crest and vegetation line poses an important problem for measuring setbacks for building placement. The coastal feature (fore-dune crest or vegetation line) from which the setback distance would have been measured in 1978 moved approximately 12 meters (40 feet) seaward. This seaward creep creates the impression that the shoreline at this location is a good place to build a house because of the recent depositional trend at the site. The long-term erosion rates (1939-1985), however, show that this segment of shoreline is erosional at an average annual rate of 0.9 meters per year (3.0 feet per year)(Boothroyd et al. 1988). The depositional trend of 11 years was reversed in late 1989 resulting in renewed erosion of the backshore reservoir and the consequent landward displacement of the building setback line (BoothThe backshore reservoir is not easily seen in the field and has been described and defined by examination of multiple beach profiles taken at the same sites over many years. The landward edge of the backshore reservoir is the erosional surface of the barrier core, a surface that is exposed only during periods of severe erosion. The seaward boundary changes over time as the dune crest and vegetation line move seaward, and is defined by a plane of 5 degree slope running from the base of the dune to the mean low water line.

3. Barrier Core. The barrier core is defined here by two depositional environments, the foredune zone and the back barrier flat, and illustrated with a simplified internal structure (Figures 4-3 and 4-7). Internally it consists primarily of sand deposited by eolian processes and by overwash during storms.

4. Beach Cycles. Many years of beach profile measurements along the Rhode Island south shore reveal a cyclic nature in profile shape and volume. Figure 4-8 illustrates six beach profile configurations; each will be considered in turn.

5. Long-Term Depositional profile. A high volume, highly reflective profile with a large, wide berm and backshore reservoir, this configuration occurs after years of fair weather conditions combined with few storms. Although this profile contains a large volume of sediment, it has a steeply dipping beach face providing little area over which to dissipate storm wave energy, enhancing erosion of the berm during any given storm.

6. Moderate storm erosional profile. Following a moderate storm (a fall or winter storm occurring one or two times a year) some amount of berm material is removed and the slope of the beach face is reduced as the profile adjusts to the increase in energy, making a more dissipative configuration. The backshore reservoir is not affected by this event, and the profile may experience accretion and return to the high depositional state through berm accretion if fair weather prevails. If additional storms occur and the berm continues to erode, the severe storm profile results.

7. Severe storm erosional profile. The berm has been completely removed and the backshore reservoir almost entirely eroded. Severe storms may also erode the barrier core. Much of the material has been redeposited directly offshore from the profile,

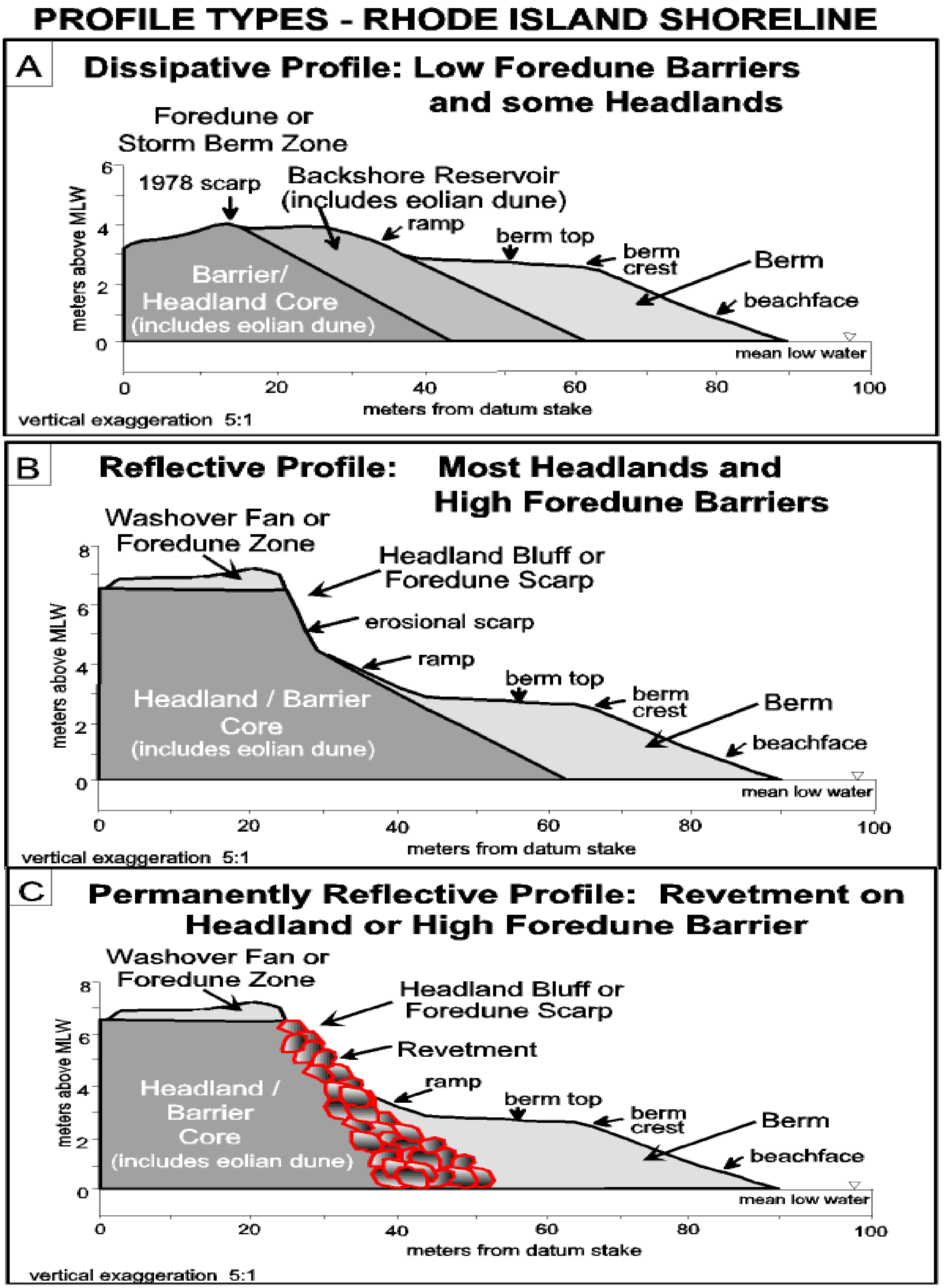


Figure 4-7

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Boothroyd & Galagan, 1998

resulting in a highly dissipative state. When compared to the high depositional profile, the same amount of wave energy applied to the highly reflective, steeply dipping beach face would now be spread out over the larger area of the dissipative, severe storm profile. Less work is done on any individual sand grain because the energy available per unit area is less. The profile has responded to the increased energy input and adjusted in shape to accommodate the change. Although the profile is in a dissipative state, the lack of a substantial berm and backshore reservoir means that the barrier core is exposed to erosion. This was the case prior to the Blizzard of February 1978 when a series of moderate storms in January depleted the berm and backshore reservoir, setting the stage for the severe erosion which occurred during the blizzard.

8. Post-storm recovery (depositional) profile. In the hours and days following the severe storm, sediment that has been deposited directly offshore begins to return onshore in the form of a low, narrow berm. This occurs by the formation and landward movement of sediment in offshore bars that weld themselves to the beach face (see Figure 4-8).

9. Neap berm and Spring berm depositional profiles. Several days to a week after the post-storm recovery, the presence of a neap berm is common if the recovery occurs during a time of neap tide. The neap berm is a relatively low-lying feature with a berm top just slightly higher than the level of a neap tide.

The formation of a spring berm occurs by the same mechanism as other berm formation, only during the time of spring tide. The result is a higher berm top that coincides with the swash limits of spring high tide. Frequently, two distinct berms can exist, one older and higher and one younger and lower which forms against the beach face of the older berm.

10. Mature berm depositional profile. The mature berm profile is the result of months of fair weather with no storms. A large volume of sediment is transported from the shore face by waves and deposited as a large, high, reflective berm. The difference between this profile and the long-term depositional profile is that wind processes have not yet modified the berm top to form small dunes and beach grass has not grown out over the berm top, thus no new back-shore reservoir is identified.

## EROSION and ACCRETION CYCLES Rhode Island Shoreline

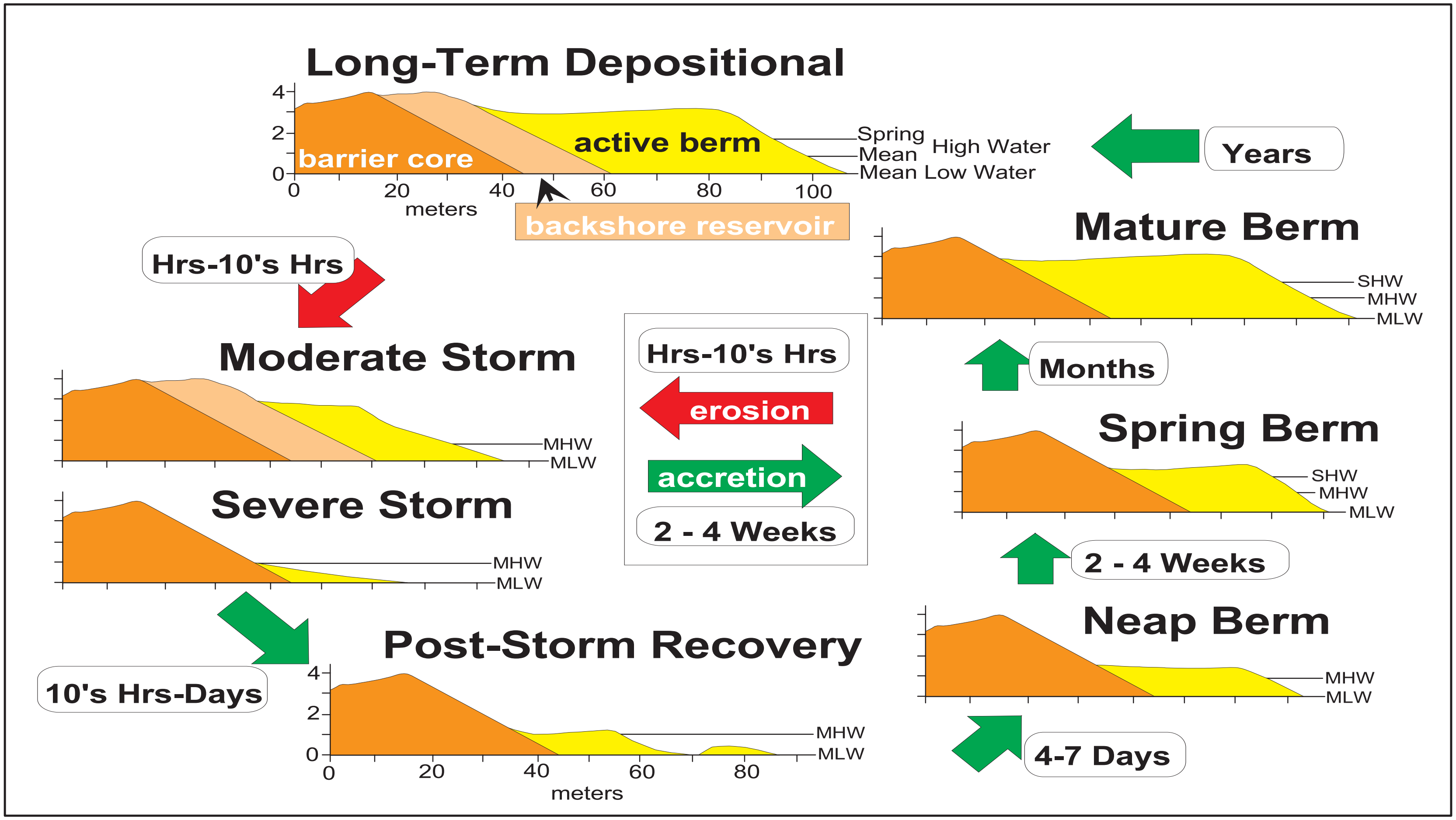


Figure 4-8

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## 410.5 Geologic Trends - Advance and Retreat of the Southern Shoreline

### A. Introduction

1. Many coastal geologic studies have been carried out on the south shore of Rhode Island , and data gathered on erosion and deposition date back many decades. The work has been accomplished primarily by University of Rhode Island faculty and students at the Graduate School of Oceanography and the Department of Geology. Two main avenues of study have been pursued:

- photogrammetric surveys measuring the change in position over time of the dune and high water lines resulting in average annual rates of change in these features; and
- beach profile measurements at selected barriers recording the beach profile volume and shape changes on a monthly to weekly interval.

2. Longest-Term changes (50 years): Photogrammetric surveys. The photographic record of the south shore spans the years 1939 to 1988, with photograph series available from the years 1939, 1951, 1963, 1972, 1975, 1981, 1985 and 1988. Figure 4-9 is a map showing the position of 98 shore-normal transects (numbered 15-113) established by Regan (1976) between which mean high water and dune line change rates for the various time intervals have been measured. Several workers have used these transects to update and expand the shoreline change data as new photo series become available. They include Regan (1976), Simpson (1977), Gautie (1977), and Boothroyd and others (1988).

Figure 4-10 shows the average annual rate of change in the MHW for the period 1939 to 1985 for segments 15 through 104 from Boothroyd and others (1988). These long-term rates are also found on the shoreline change maps in the Rhode Island Coastal Resources Management Program (RICRMP 1994). An example of a shoreline change map is included as Figure 4-11. For a discussion of the methods used in determining the different change rates see Regan (1976), Simpson (1977), and Boothroyd and others (1988).

## BEACH PROFILE and SHORELINE TRANSECT LOCATIONS

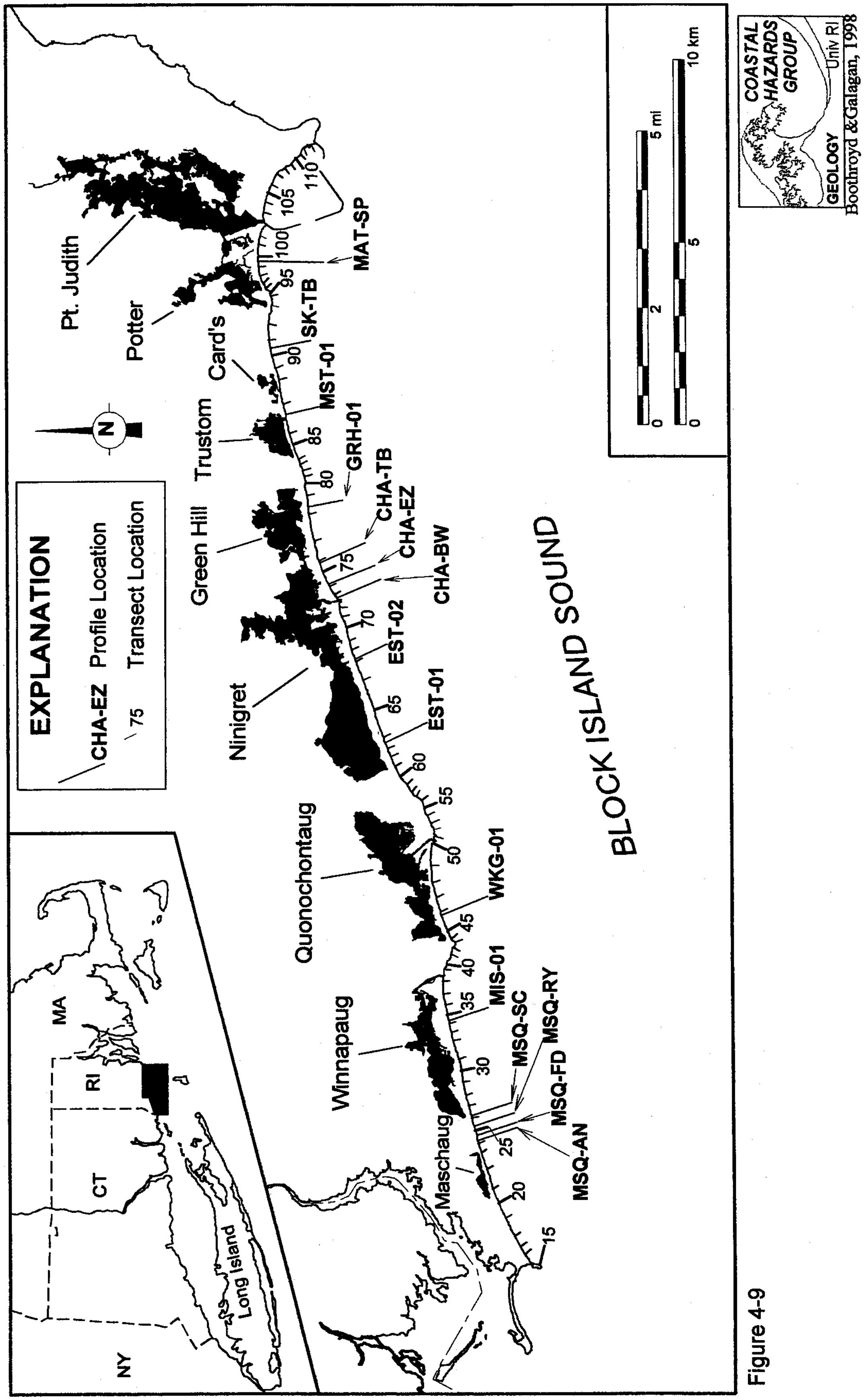


Figure 4-9

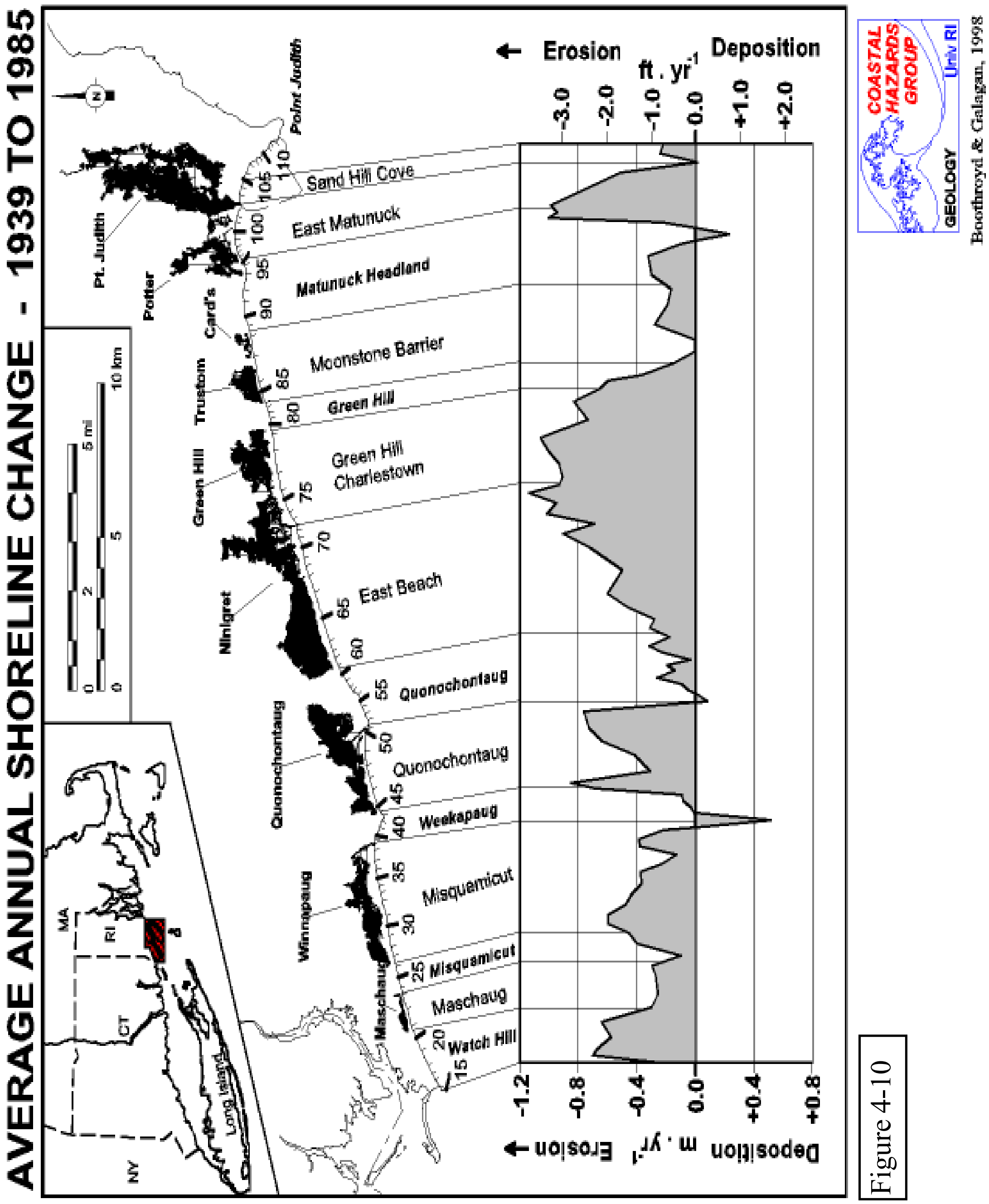
AVERAGE ANNUAL SHORELINE CHANGE - 1939 TO 1985
Erosion
Deposition
ft . yr-1
m . yr-1
Point Judith
Pt. Judith
Potter
Card's
Trustom
Green Hill
Ninigret
Quonochontaug
Winnapaug
Maschaug
Sand Hill Cove
East Matunuck
Matunuck Headland
Moonstone Barrier
Green Hill
Green Hill Charlestown
East Beach
Quonochontaug
Quonochontaug
Weekapaug
Misquamicut
Misquamicut
Maschaug
Watch Hill
MA
RI
CT
NY
Long Island
5 mi
10 km
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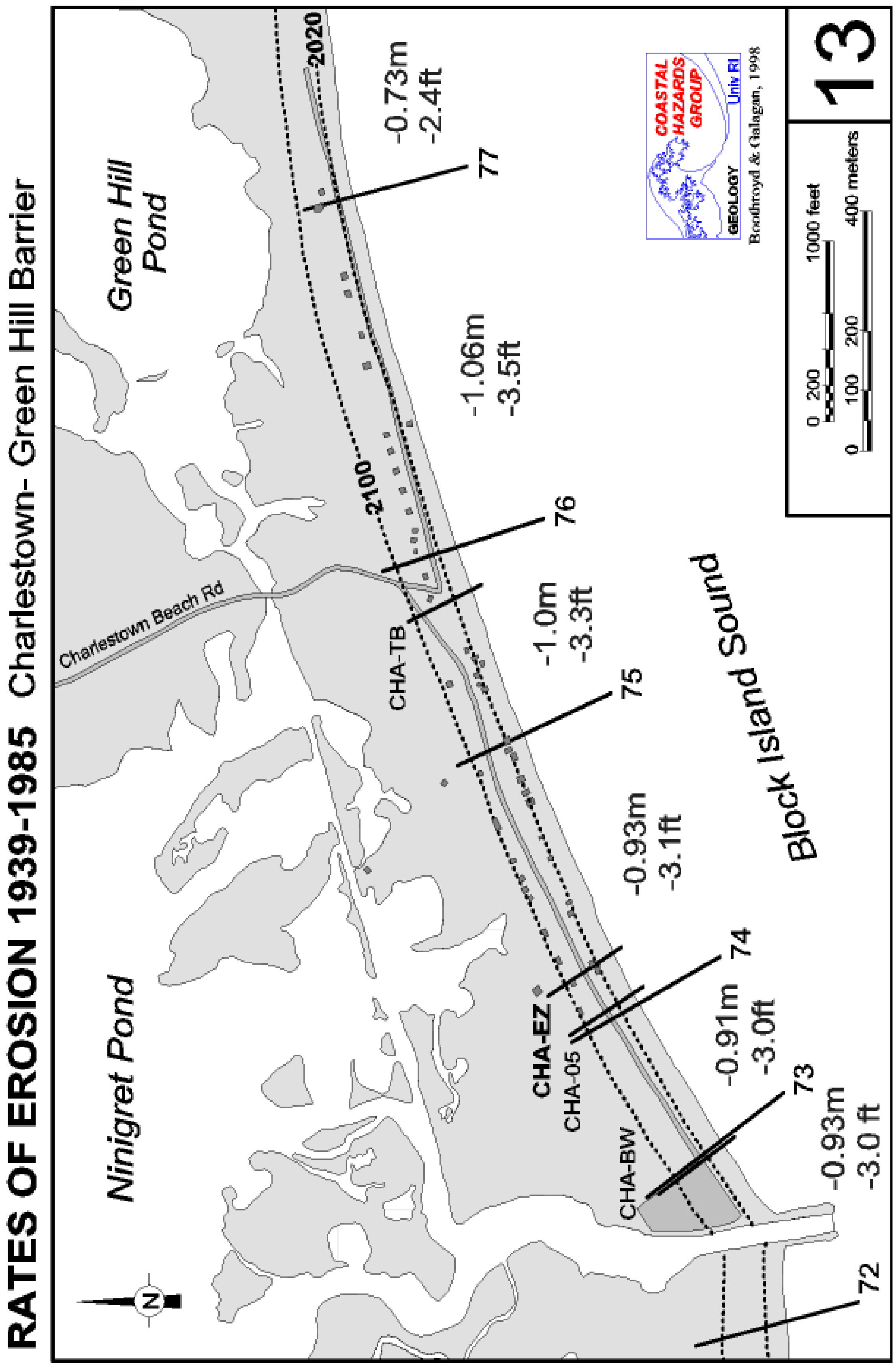
Figure 4-10


RATES OF EROSION 1939-1985 Charlestown- Green Hill Barrier
Ninigret Pond
Green Hill Pond
Charlestown Beach Rd
Block Island Sound
2020
2100
CHA-TB
CHA-EZ
CHA-05
CHA-BW
72
73
74
75
76
77
-0.73m
-2.4ft
-1.06m
-3.5ft
-1.0m
-3.3ft
-0.93m
-3.1ft
-0.91m
-3.0ft
-0.93m
-3.0 ft
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0 200
1000 feet
0 100 200
400 meters
13
N

Figure 4-11

The average annual shoreline change depicted in Figure 4-10 represents the longest photographic record available to date. The values range from a maximum erosion rate of 1.14 meters per year (3.7 ft per year) at the east end of East Beach, to maximum deposition of 0.53 meters per year (1.7 feet per year) adjacent to Weekapaug inlet. The majority of the south shore is erosional over the long-term, yet short-term measurements reveal large variability in both the rate and type of change.

Figure 4-12 is a graph of the average annual change rate for shoreline segments 58 through 81 measured for the time periods 1939-1985, 1975-1981 and 1981-1985. This graph shows varying change rates along the shoreline. Figure 4-12 also shows the average change for those segments over time. Change rates during the shorter time periods 1975-1981 and 1981-1985 are as much as 6 times greater than the long-term rates (1939-1985) and show change in both a seaward and landward direction.

2. Long-term changes (20+ years): Beach profile volume. The map in Figure 4-9 shows the location of the 10 long-term beach profiles. The first profiles were established by Robert McMaster of the Graduate School of Oceanography, University of Rhode Island, in 1962 on the Weekapaug, East Beach, Green Hill and Moonstone barriers. Profiling at the additional sites was begun between 1975 and 1981 by McMaster and Jon Boothroyd of the Department of Geology, University of Rhode Island (McMaster et al. 1961). Two important pieces of information are obtained from the profile measurements, the change in profile shape over time (see Section 410.4) and the change in profile volume over time.

The volume of sediment within a profile is defined as the area formed by the mean low water line, the back stake, and the surface expression at the site, multiplied by 1 meter in width to derive a volume amount (see Figure 4-7). A graph of the volume time series for each profile site is derived by plotting profile volume (cubic meters of sediment per meter distance along shore) versus time. Time extends over many years. Volume time series for three profiles located on the Charlestown, East Beach, and Green Hill barriers are included here because they illustrate the important concepts obtained from all the profile volume data (Figures 4-13, and 4-14).

(a) Long-term trends. Long-term trends in the total profile volume of the East Beach, Charlestown and Green Hill sites show 3 possible patterns (Figures 4-13 and 4-14). Total volume at the Charlestown site (CHA-EZ) fluctuates a great deal but shows an overall increase in volume since the low of 1978 to a high in 1987, another low in 1992 and fluctuation since that time. The total volume of the East Beach profile (EST-01) shows a slight overall decline from 1965 through 1977, but then an overall increase from 1977 through 1988, essentially returning to a 1965 volume. Note the shorter time period of the CHA-EZ time series and that the trend at the EST-01 site for the same time period (1978-1988) is similar. Green Hill (GRH-01) total profile volume has consistently decreased during its entire length, not showing the 1977-1978 volume low seen at the other sites.

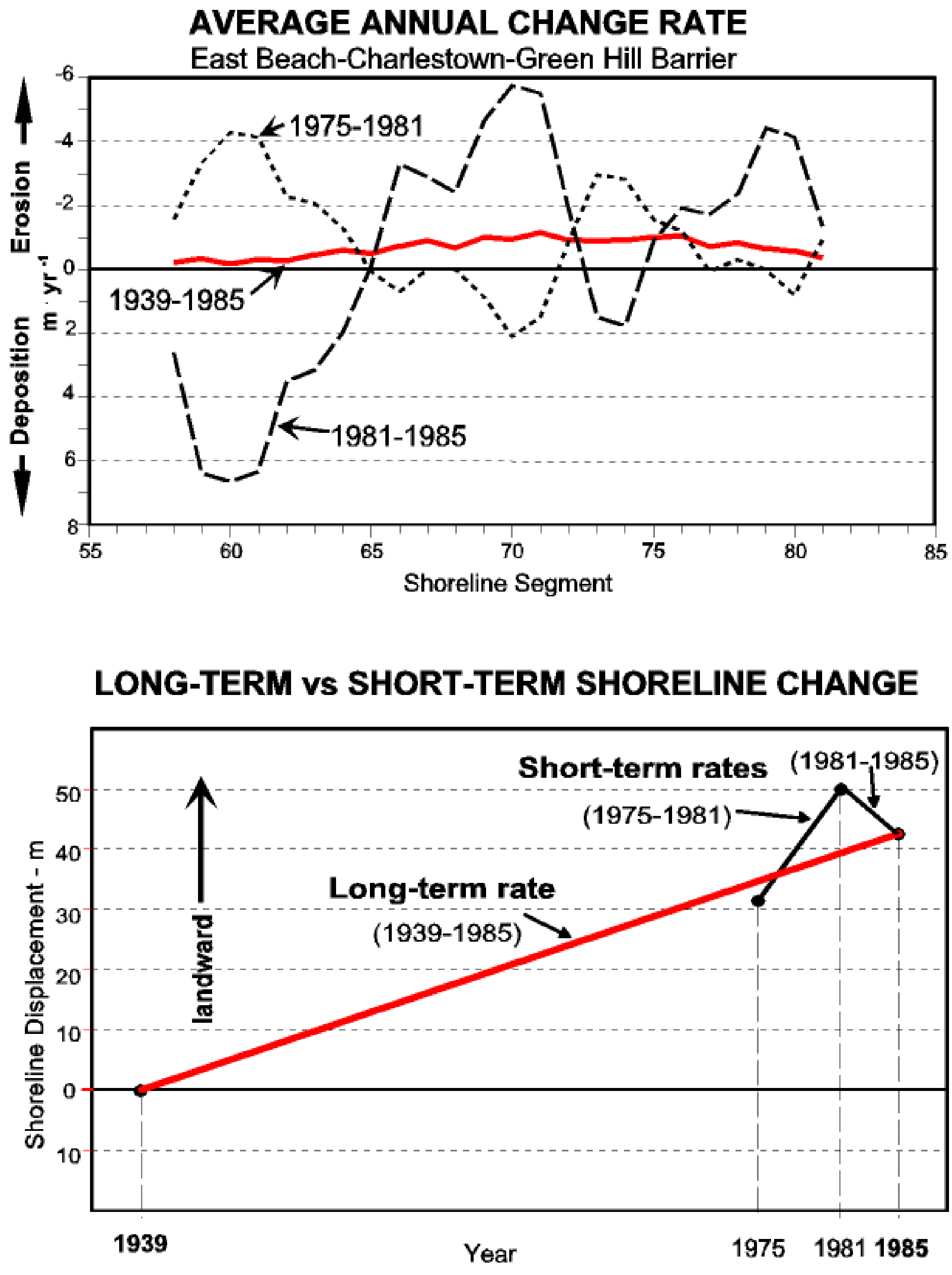


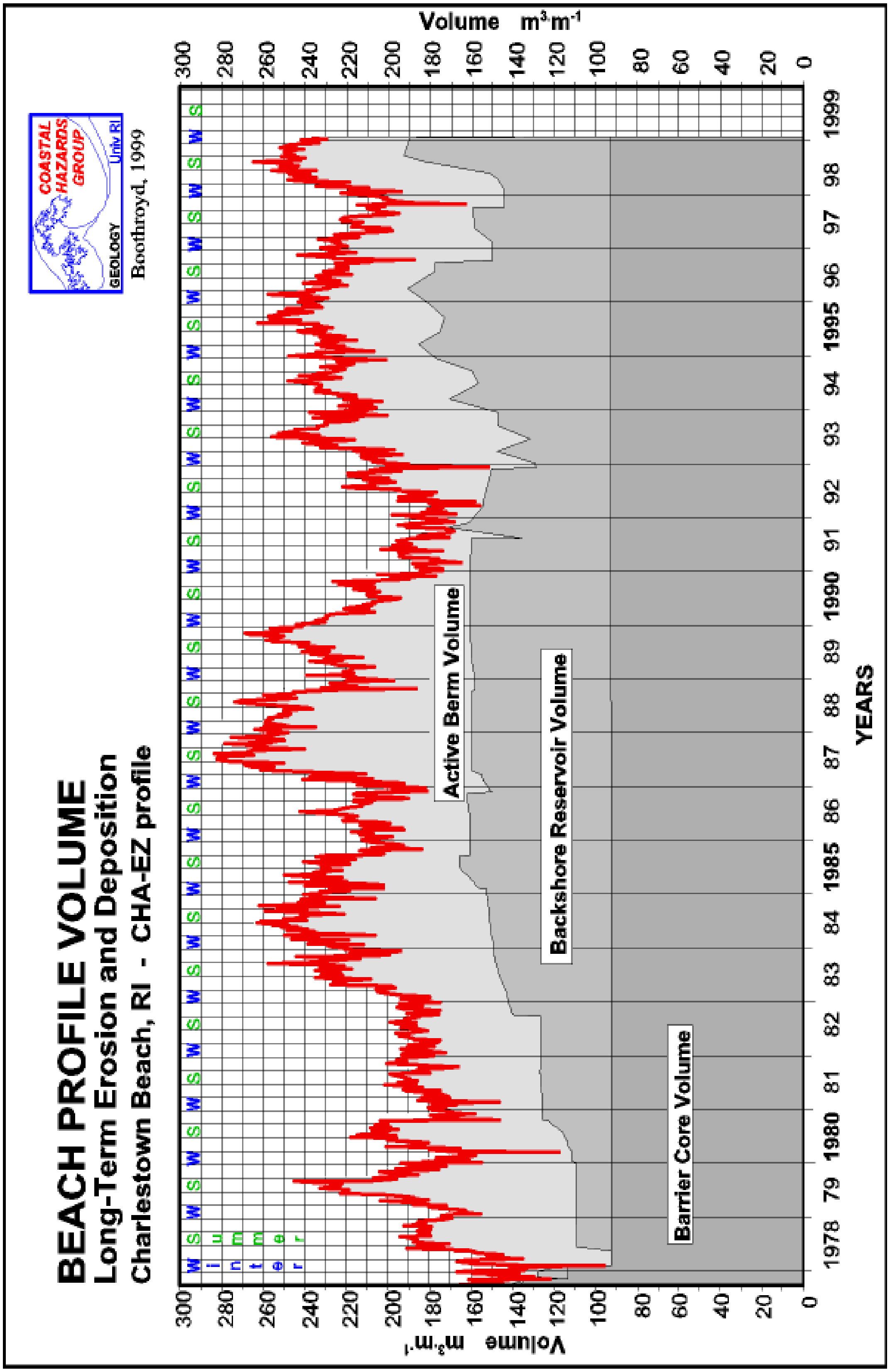

Figure 4-12

Boothroyd & Galagan, 1998

(b) Annual or seasonal variation. In Section 410.4, beach cycles were discussed in terms of the two end member beach profile configurations: high depositional/reflective and severe erosional/dissipative (Figure 4-8). During fair-weather months, a large reflective active berm exists, and total profile volume should be greater than the volume present during the months of more frequent storms (fall and winter). This seasonal signal is clearly seen in the volume fluctuations of the East Beach profile (Figure 4-14), yet it is less clear at Green Hill (Figure 4-14), and Charlestown profile sites (Figure 4-14).

(c) Active berm, backshore reservoir and barrier core volume. The active berm volume of the 3 selected profiles show short-term fluctuations of a significant amount, illustrating the short residence time of the material in the berm. A decline in barrier core and backshore reservoir volume is frequently preceded by a short period of decline in active berm volume, usually during the Fall and Winter months.

Backshore reservoir and barrier core volume of the 3 profiles show different trends over the long-term. The Charlestown Beach profile (Figure 4-13) barrier core and backshore reservoir volume increased incrementally until 1991 from the minimum reached after the Blizzard of 1978, fluctuated as the result of Hurricane Bob and the Halloween Nor'easter (1991), declined precipitously during the December 1992 storm, and has slowly recovered since. At the East Beach site (Figure 4-14) this component of the volume declined from 1965 to 1978, and has increased steadily since that time, whereas, Green Hill (Figure 4-14) barrier core and backshore reservoir volume has shown a steady decrease from about 1971 to the present.


BEACH PROFILE VOLUME
Long-Term Erosion and Deposition
Charlestown Beach, RI - CHA-EZ profile
COASTAL HAZARDS GROUP
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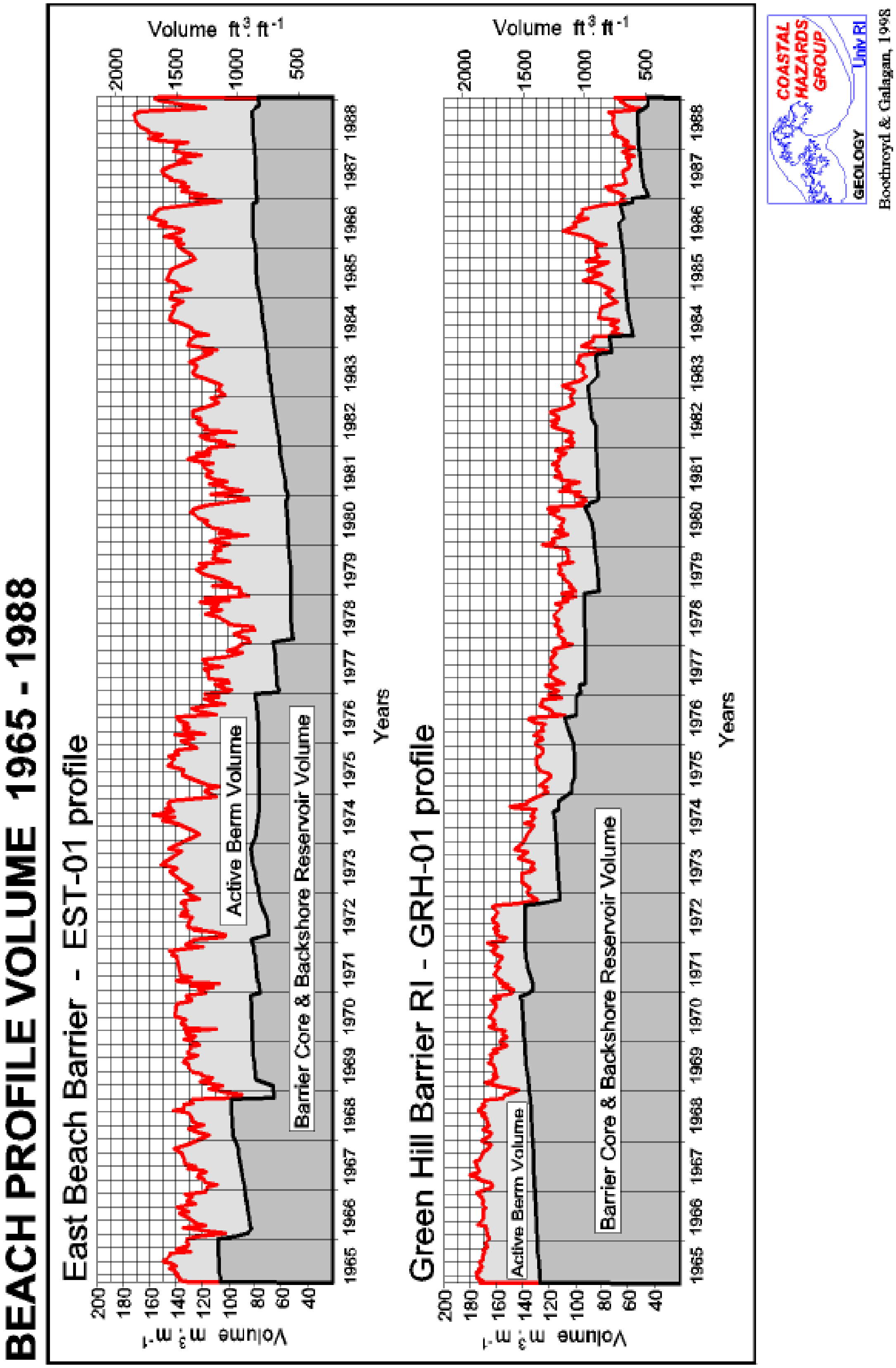
Boothroyd, 1999
Active Berm Volume
Backshore Reservoir Volume
Barrier Core Volume
Volume m3·m-1
YEARS
winter
summer

Figure 4-13



BEACH PROFILE VOLUME 1965 - 1988
East Beach Barrier - EST-01 profile
Active Berm Volume
Barrier Core & Backshore Reservoir Volume
Green Hill Barrier RI - GRH-01 profile
Active Berm Volume
Barrier Core & Backshore Reservoir Volume
Volume m³. m⁻¹
Volume ft³. ft⁻¹
Years
1965 1966 1967 1968 1969 1970 1971 1972 1973 1974 1975 1976 1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988
COASTAL HAZARDS GROUP
GEOLOGY
Univ RI
Boothroyd & Galagan, 1998

the extrapolation of historically derived average annual shoreline change rates to derive future shoreline position and configuration. This method requires site specific historic data such as vertical aerial photographs and early shoreline maps dating back many decades. For the south shore of Rhode Island the photographic record spans 49 years (1939-1988), with available annual change rates for the period 1939 to 1985 (46 years)(Boothroyd et al. 1988, 1995). The second prediction method is based on a quantitative knowledge of the wave, current, and storm-surge climate at a particular site (the energy budget), as well as the sources and sinks of sediment available for maintaining shoreline features (the sediment budget). Sediment transport based on energy input from storms can then be calculated using equations relating energy magnitude to observed shoreline changes. In order to use this method, a direct correlation between the magnitude of storm energy input and the subsequent magnitude of shoreline change must be clearly established, something that has not been done for the Rhode Island south shore. Thus this section will include a short discussion on the historic approach to shoreline prediction.

2. Long-term vs. short-term change. The majority of shoreline change along the south shore occurs during hurricanes and severe winter storms. Consequently, shoreline retreat is episodic, and a long-term shoreline change rate of 1 meter per year derived from a 30 year historic record does not mean that the waterline will be displaced a meter every year for 30 years. The long-term change rates spread the erosional effect of individual storms over many years, and most of the change in the position of the shoreline during a 30 year period will occur during discreet storm events. Because the long-term rates are averages based on the position of the waterline at the beginning and end of a specific time period, they are a measure only of the net shoreline displacement, not the overall total displacement during the period of record. Figure 4-12 is a graph of mean high waterline displacement through time for one shoreline segment on the Charlestown barrier. The long-term change rate (1939-1985) is derived by dividing the net displacement by 46 years. Yet this measurement does not accurately depict the greatest rate of displacement (1975-1981) when the waterline moved 18 meters (59 ft) landward to a position 50 meters (164 ft) from the 1939 location, the maximum point of displacement landward measured. Consequently, the long-term erosion rates reflect only an overall trend, and should be used with the understanding that the actual position of the waterline at any given time may not reflect the position calculated from the average rate.

3. Projected mean high waterlines. The long-term (1939-1985) shoreline change rates graphed in Figure 4-10 range in value from 1.14 meters per year (3.7 ft per year) maximum erosion to 0.53 meters per year (1.7 ft per year) maximum deposition. These annual rates of change were used to map projected mean high waterline position for the years 2020 and 2100 (See the maps in the RI CRMP). The method involved simply multiplying the annual change rate times 30 years (using 1990 as a base) for the 2020 line and times 110 years for the 2100 line, and moving the present waterline accordingly. The land area lost to frontal erosion by 2020 would be 50 hectares (124 acres), and by 2100 164 hectares (405 acres) (Galagan 1990). The assumptions made in drawing these lines are that the erosion rates (storm energy imparted

to the shore) remain constant for the time projected, and that sea level rises at the same rate as the past 50 years. It was also assumed that existing engineering protective structures would be maintained and that no new structures would be built. There is no reason to believe that storm frequency and severity will change significantly in the next 100 years, thus sea level rise is the variable factor affecting projected shoreline positions. The predicted increase in the rate of sea level rise would cause an increase in the erosion rate, but a sea level rise factor was not included in the projection process. The extrapolated shorelines are considered to be conservative in that they depict the least amount of erosion likely to occur.

Extrapolation of historic erosion rates defines a future barrier and headland shoreline configuration not markedly different from that of the present. Weekapaug, Quonochontaug, and the eastern portion of the Matunuck headland, currently the most prominent headlands in terms of seaward expression, will become more prominent as they continue being left behind by adjacent barriers. In contrast, the Misquamicut and Green Hill headlands will continue their present relationship to adjacent barriers, eroding at rates as high as those barriers, and allowing sediment to bypass the headlands.

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# Chapter 5
# Living Resources and Critical Habitats

## 510. Findings of Fact

### 510.1 Fisheries

### A. Introduction

1. Biologically, coastal ponds and estuaries provide nursery areas for fish which spend the remainder of their life cycles at sea or in fresh waters. These areas are also important centers of residential, recreational, commercial and industrial use. Because of the potential for heavy development in such areas, fish and fish habitat can sometimes be compromised.

There are over 100 species of finfish and shellfish which utilize the salt ponds at some stage of their life cycle (Table 5-1 and Table 5-2). A few decades ago the fisheries of the salt ponds were considered their most important feature. Today few topics excite more interest and controversy than the condition of fishery resources. With the exception of scallops, which reappeared after a 20-year absence, it is widely perceived that the stocks of the most popular species, the quahogs, oysters and flounder are all declining. How the blame for this condition should be apportioned among recreational fishers, commercial fishers and loss or degradation of habitat warrants further study. Such perceptions are difficult to prove or discount. Long-term records of annual harvests from the ponds do not exist, and the scattered data that can be found give only general indications.

A major portion of the URI Salt Pond Project was devoted to developing a better understanding of these issues and gathering the baseline information against which further changes in resources and fishing efforts may be compared (Crawford 1981, Crawford 1982). Until large scale quantitative evaluation takes place, we have only anecdotal information that the diversity and numbers have decreased.

### B. Fishery Declines

1. It is indisputable that the annual landings of certain species from individual ponds can be very large and that the sustained yields of species such as white perch and oysters were far greater in the past than they are today. The only data on catches in the past century were collected by Clark (1887) in Point Judith Pond. He reported that oyster landings had already declined significantly by the time of his one-year survey in 1879 but that 70,000 pounds of meats (10,000 bushels) had been harvested in 1870.

**Table 5-1.** Finfish, Cephalopod and Crustacean Species in Rhode Island Coastal Ponds.

Sand Tiger *Odontaspis taurus*
Smooth Dogfish *Mustelus canis*
Spiny Dogfish *Squalus acanthias*
Little Skate *Raja erinacea*
Winter Skate *Raja ocellata*
American Eel *Anguilla rostrata*
Conger Eel *Conger oceanicus*
Blueback Herring *Alosa aestivalis*
Hickory Shad *Alosa mediocris*
Alewife *Alosa pseudoharengus*
American Shad *Alosa sapidissima*
Atlantic Menhaden *Brevoortia tyrannus*
Atlantic Herring *Clupea harengus*
Round Herring *Etrumeus teres*
Spanish Sardine *Sardinella aurita*
Aby Anchovy *Anchoa mitchilli*
Striped Anchovy *Anchoa hepsetus*
Brook Trout *Salvelinus fontinalis*
Rainbow Smelt *Osmerus mordax*
Inshore lizardfish *Synodus foetens*
Fourbeard Rockling *Enchelyopus cimbrius*
Silver Hake *Merluccius bilinearis*
Atlantic Tomcod *Microgadus tomcod*
Atlantic Cod *Gadus morhua*
Pollock *Pollachius virens*
Spotted Hake *Urophycis regia*
White Hake *Urophycis tenuis*
Red Hake *Urophycis chuss*
Oyster Toadfish *Opsanus tau*
Atlantic Needlefish *Strongylura marina*
Flat Needlefish *Ablennes hians*
Sheepshead Minnow *Cyprinodon variegatus*
Common Mummichog *Fundulus heteroclitus*
Striped Killifish *Fundulus majalis*
Rainwater Killifish *Lucania parva*
Silversides *Menidia sp.*
4-Spine Stickleback *Apeltes quadracus*
3-Spine Stickleback *Gasterosteus aculeatus*
Blackspotted Stickleback *Gasterosteus wheatlandi*
9- Spine Stickleback *Pungitius pungitius*
Bluespotted Cornetfish *Fistularia tabacaria*
Lined Seahorse *Hippocampus erectus*
N. Pipefish *Syngnathus fuscus*
Flying Gurnard *Dactylopterus volitans*
Northern Searobin *Prionotus carolinus*
Striped Searobin *Prionotus evolans*
Grubby *Myoxocephalus aenaeus*
Longhorn Sculpin *Myoxocephalus octodecemspinosus*
Lumpfish *Cyclopterus lumpus*
White Perch *Morone americana*
Striped Bass *Morone saxatilis*
Black Sea Bass *Centropristis striata*
Bluegill *Lepomis macrochirus*
Short Bigeye *Pristigenys alta*
Bluefish *Pomatomus saltatrix*
Cobia *Rachycentron canadum*
Blue Runner *Caranx crysos*
Crevalle Jack *Caranx hippos*
Bigeye Scad *Selar crumenophthalmus*
Look Down *Selene vomer*
Banded Rudderfish *Seriola zonata*
Permit *Trachinotus falcatus*
Rough Scad *Trachurus lathami*
Mutton Snapper *Lutjanus analis*
Gray Snapper *Lutjanus griseus*
Spotfin Mojarra *Eucinostomus argenteus*
Silver Jenny *Eucinostomus gula*
Sheepshead *Archosargus probatocephalus*
Pinfish *Lagodon rhomboides*
Scup *Stenotomus chrysops*
Silver Perch *Bairdiella chrysoura*
Weafkfish *Cynoscion regalis*
Spot Leiostomus xanthurus
Northern Kingfish *Menticirrhus saxatilis*
Dwarf Goatfish *Upeneus parvus*
Spotfih Butterflyfish *Chaetodon ocellatus*

**Table 5-1.** Finfish, Cephalopod and Crustacean Species in Rhode Island Coastal Ponds (Cont.).

| | |
|---|---|
| Striped Mullet *Mugil cephalus* | Winter Flounder *Pleuronectes americanus* |
| White Mullet *Mugil curema* | Hogchoker *Trinectes maculatus* |
| Tautog *Tautoga onitis* | Unicorn Filefish *Aluterus monoceros* |
| Cunner *Tautogolabrus adspersus* | Orange Filefish *Aluterus schoepfi* |
| Northern Sennet *Sphyraena borealis* | Fringed Filefish *Monocanthus ciliatus* |
| Radiated Shanny *Ulvaria subbifurcata* | Planehead Filefish *Monacanthus hispidus* |
| Rock Gunnel *Pholis gunnellus* | Queen Triggerfish *Balistes vetula* |
| Northern Stargazer *Astroscopus guttatus* | Scrawled Cowfish *Lactophrys quadricornis* |
| A. Sand Lance *Ammodytes americanus* | Northern Puffer *Sphoeroides maculatus* |
| Darter Goby *Gobionellus boleosoma* | Shortfin Squid *Illex illecebrosus* |
| Naked Goby *Gobiosoma bosc* | Longfin Squid *Loligo pealeii* |
| Atlantic Bonito *Sarda sarda* | American Lobster *Homarus americanus* |
| Seaboard Goby *Gobiosoma ginsburgi* | Blue Crab *Callinectes sapidus* |
| Atlantic Mackerel *Scomber scombrus* | Spider Crab *Libinia emarginata* |
| Butterfish *Peprilus triacanthus* | Lady Crab *Ovalipes ocellatus* |
| Twospot Flounder *Bothus robinsi* | Green Crab *Carcinus maenas* |
| Gulfstream Flounder *Citharichthys arctifrons* | Atlantic Rock Crab *Cancer irroratus* |
| Summer Flounder *Paralichthys dentatus* | Jonah Crab *Cancer borealis* |
| Fourspot Flounder *Paralichthys oblongus* | |
| Windowpane *Scophthalmus aquosu* | |

Data compiled from Stolgitis et. al. 1976, Satchwill and Sisson 1990, Sisson and Satchwill 1990 and 1991, Gray 1996.

**Table 5-2.** Shellfisheries of Rhode Island Coastal Lagoons.

| | |
|---|---|
| Bay quahaug | *Mercenaria mercenaria* |
| Softshell clam | *Mya arenaria* |
| Eastern oyster | *Crassostrea virginica* |
| Bay scallop | *Argopecten irradians* |
| Blue mussel | *Mytilus edulis* |

Source: Ganz (1997).

A century later fisheries for alewives, smelt and oysters disappeared from the ponds. It has been speculated by Lee (1980) that the overall effect of stabilizing the breachways resulted in the demise of the fisheries they were meant to enhance. The once abundant brackish water fisheries that yielded thousands of pounds of alewives, perch and oysters annually were ultimately lost. In many cases, they were replaced by less abundant populations of species such as quahogs, bay scallops and winter flounder that thrive in a more saline environment.

In 1979, only 250 pounds of white perch were landed, the recreational and commercial flounder harvest was estimated at 12,000 pounds and there was a flourishing eel fishery. No softshell clam catches were recorded in 1979, while quahogs totaled some 6,000 pounds, and scallops produced a harvest of 161,000 pounds (Crawford 1982). During the 1980s, shellfish dealers did not identify the areas from which the commercial catches were made, so it is hard to determine catch rates from the coastal salt ponds from this period.

## C. Variability in Fish Populations

1. The condition of salt pond fish stocks changes rapidly, resulting in large variability in catch. During the period of the URI investigations (1978-1982) a flourishing and lucrative eel fishery collapsed. In 1979 some 60,000 pounds of eels, worth some $60,000, were harvested from all south shore ponds (Point Judith through Winnapaug), but by 1982 the catch was less than 5,000 pounds (Crawford 1982). Peaks in landings occurred in 1985 and 1988, with the lowest levels recorded in 1989 and 1990 (Gray 1991). Today, approximately three harvesters are catching eels, selling them to the "eel truck" which is back in operation. Decreasing Rhode Island landings appear to be due to unreported landings (Sisson 1991). Crawford (1988) suggested that the principal cause for the decline in the American eel fishery was within the market rather than the resource. The export value decreased with increasing fishing expenses, reducing profits. This in turn resulted in many fishers dropping out of the fishery. The European market, which figured heavily in the fishery 10 years ago, remains uninterested in American eels (Crawford 1988). During the 1980 North American Eel Conference it was noted that the quality and quantity of eels being produced by fish culture operations in Europe, particularly Italy, might create problems for the North American and European commercial fisheries (Loftus 1982). This may or may not have had an effect on the declining commercial landings in Rhode Island.

2. Another example of the variability in effort is the skiff dragger fishery for winter flounder. For more than a decade, two fishers seasonally worked small areas of open bottom in Ninigret Pond, predominantly near the breachway. In 1982, the situation changed radically; a number of other fishers began dragging, and the setting of fyke nets became popular. Fyke nets are staked traps that are less affected by sea grass and algae than draggers and can therefore be operated in areas where draggers cannot work. They are a more efficient and effective means of catching flounder, since they are inexpensive to operate and, once in place, catch fish continuously. Fyke nets are less damaging to the fish and bottom habitat than dragging, and fyke nets allow the fish to be released unharmed. However, fyke nets could have the potential to expose discrete sub-populations previously unaffected by commercial fishing to increased fishing pressure (Crawford 1982). In the mid 1980s areas in Charlestown and Quonochontaug Ponds were closed to dragging. Fyke nets are prohibited in Charlestown and Quonochontaug Ponds between June 15 and September 15 annually, and fyke nets are also prohibited in the channel areas of Charlestown Pond. Fishing effort, the amount of area fished, and the number of flounder sub-populations were probably altered in some way by commercial fishing during that season. Further study is warranted to determine how this change in fishery methods and effort has affected flounder populations in the coastal ponds.

3. A third example of the variability in catch is the Point Judith Pond quahog fishery. In 1983 the area closed to shellfishing by pollution was reduced by more than half, and an abundant, formerly protected population that may have been important as a brood stock providing seed for heavily exploited beds in the southern part of the pond, became open to exploitation. Since 1983, the shellfisheries in Point Judith Pond have expanded and withdrawn due to the

changes in the pollution lines. Commercial fishers typically harvest Point Judith Pond during the periods when the major shellfishing grounds in Narragansett Bay are closed by rainfall. All of the coastal ponds, particularly Point Judith, Ninigret and Quonochontaug, Ponds have experienced an increase in commercial effort from shore-wading harvesters (short-stickers) and from divers predominantly in Point Judith Pond.

4. A huge set of soft-shelled clams in Green Hill Pond, conservatively estimated in 1978 at some 6 million individuals, had almost entirely disappeared two years later without significant fishing pressure. However, many areas in Rhode Island waters have massive sets of soft-shelled clams that never survive to harvest size. In Green Hill Pond where both oysters and soft-shelled clams were significant fisheries, shellfishing was open seasonally during the 1980s. By 1992, Green Hill Pond was permanently closed to the taking of shellfish due to pollution. The loss of Green Hill Pond placed additional fishing pressure on the other ponds, particularly on the oyster fishery in Ninigret Pond. Since 1990, both Quonochontaug and Ninigret Ponds have had heavy but localized sets of soft-shelled clams. This phenomenon occurred in the early 1970s, with one or two strong year classes occurring along with several “dry years” in between.

5. Scallop populations remain highly unstable to this day. In occasional good years Point Judith Pond has been known to produce more than 20,000 bushels. Long-term records indicate, however, that during the past century there have been 20 to 25-year cycles in abundance separated by long periods when adult scallops were practically absent (Olsen and Stevenson 1975). Ninigret Pond supported a small scallop fishery in 1992-93. In 1994 Quonochontaug Pond had the best harvest of scallops based on commercial loadings, with Point Judith and Ninigret Ponds showing respectable harvests (Art Ganz, personal communication 1997).

**D. Winter Flounder Populations**

1. The salt ponds contain seasonal populations of winter (blackback) flounder, which once supported sizable recreational and commercial fisheries. The salt ponds are believed to be the spawning grounds and nurseries for a major portion of the Block Island Sound winter flounder population, which is an important resource for trawlers working out of Point Judith and nearby Connecticut ports (Saila 1962). One of the most exciting results of the extensive research conducted through the ponds project on flounder is the strong evidence that within Ninigret, Point Judith and Potter Ponds there are distinct sub-populations, each of which feed and spawn on distinct home-grounds (Crawford 1983). In Point Judith Pond a major spawning ground is the gravel bar known as Rocky Island in the upper pond. Spawning is also known to occur near Gardner Island (Figure 5-1). Extensive sampling during 1981 in other areas of potentially suitable spawning habitat in this pond yielded no eggs. The presence of larval winter flounder in ichthyoplankton samples collected from Point Judith Pond in 1991 indicates that successful spawning of winter flounder did occur during that year (Satchwill and Sisson 1991). In Potter Pond the data collected

during 1991 seem to indicate that fewer species spawned successfully in Potter Pond than in 1971-72. However, it appears that a considerably greater diversity of adult gamefish and forage fish occupied Point Judith and Potter Ponds during 1991 than during 1971-72 (Satchwill and Sisson 1991).

2. In Point Judith Pond, a principal feeding ground is in the basin near the islands north of the sand flats. In Ninigret Pond, the basin immediately inside the breachway delta west of Fort Neck Cove appears to be an important feeding ground for flounder. Juvenile winter flounder were found to be most abundant in areas near the breachway, with abundance decreasing towards the west end of the pond (Gray 1994). Further tagging studies of adult flounder suggest that fish caught in one area do not range about the ponds but feed and spawn in a limited home area and return to it each fall, much as salmon return to the parent stream (Cindy Gray, personal communication 1997).

3. Spawning information, when coupled with what we have learned about the hydrography of the ponds (Saila 1962), suggests that slow exchange of waters between the ponds and the ocean is one of the most important reasons why the ponds provide particularly good flounder spawning and nursery habitat (Figure 5-2). For the month-long period that the larval flounder are free-floating plankton, they are in danger of being swept out into the ocean, where their chances for survival are greatly reduced. In Point Judith, the waters above Beef Island mix slowly with the lower pond waters, which are swept in and out of the pond by strong tidal currents. Slight tidal currents and conservative circulation make the upper pond particularly suitable for spawning and larval development. Areas of Potter and Ninigret Ponds are hydrodynamically similar and are equally important to the character of these ponds as nursery habitat. Therefore, alterations to the flushing rate or spawning sites within the ponds threaten the habitat value of the ponds.

### E. Overfishing

1. There are two forms of overfishing: growth overfishing and recruitment overfishing. Growth overfishing, as illustrated by the oyster and quahog fisheries of the salt ponds occurs when there is a decrease of mean size due to increased fishing pressure. With no decline in recruitment, catches may be low because fishing mortality is beyond the point of maximum yield per recruit. Recruitment overfishing is defined as the level of fishing pressure that, on the average, reduces the spawning biomass produced by a year class over its lifetime below the spawning biomass of its parents. This is characterized by a greatly reduced spawning stock, a decreasing proportion of older fish in the catch, and a generally very low recruitment year after year. Recruitment overfishing is far more difficult to detect, since it may be impossible to account for the host of environmental variables that, independent of fishing pressure, may be the cause of declining recruitment of juveniles into the stock.

2. Although there is wide variation among the various types of bottom sediments and surfaces found throughout each pond, it was typical during the years of the URI Salt Pond Project for

50 percent of the quahogs, 75 percent of the softshell clams and 90 percent of the oysters to be undersized. The high mortality of both softshell clams and oysters may be attributed to environmental conditions as much as fishing pressure, but for the nearly ubiquitous and long-lived quahogs, fishing pressure appears to be the dominant factor controlling abundance and size distribution. The greatest densities and highest proportions of legal-sized quahogs are found in areas permanently closed to fishing by bacterial contamination and in gravel or eelgrass-covered bottom, which is difficult to harvest. Fishing pressure has undoubtedly also played a major

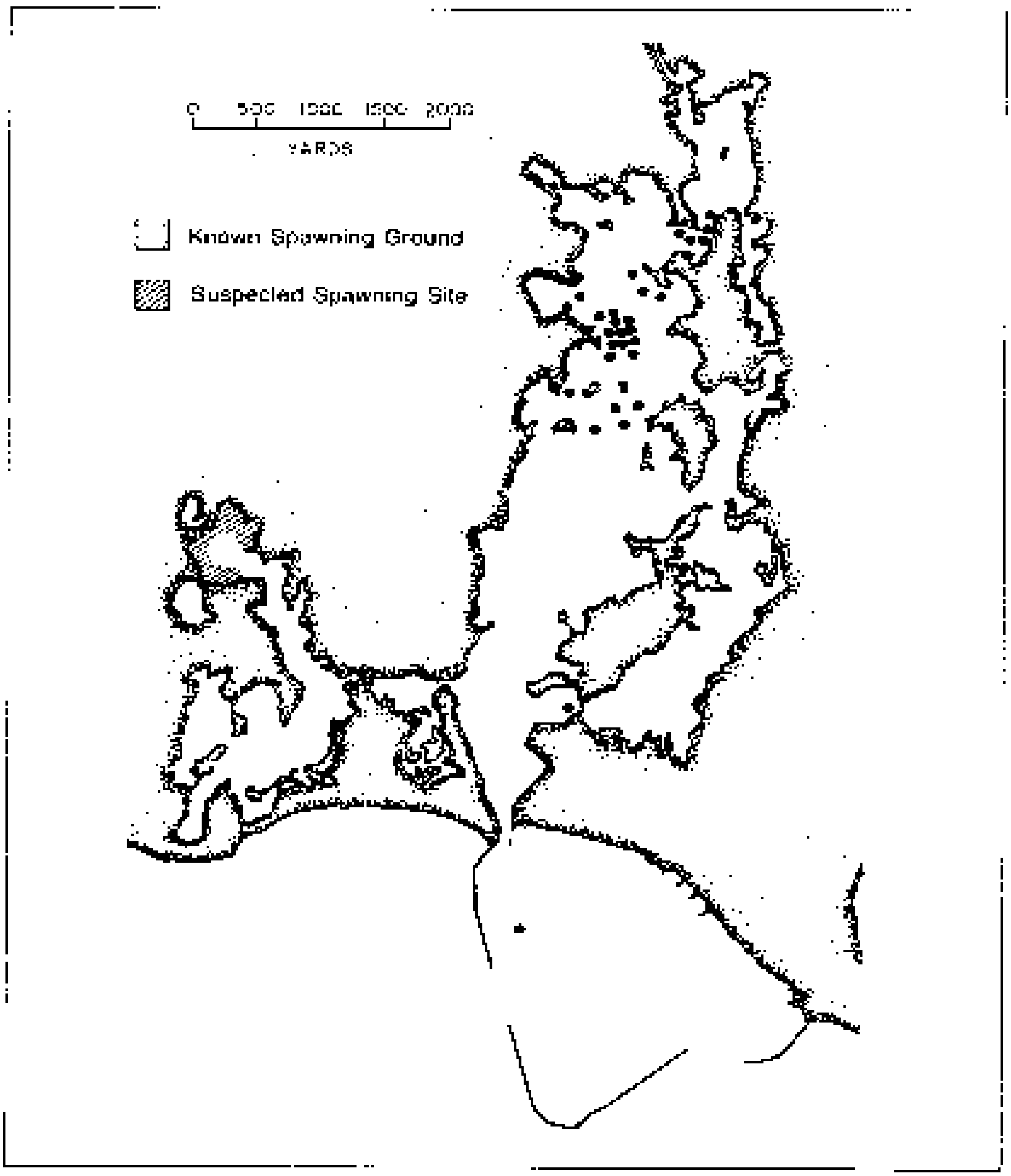


**Figure 5-1.** Winter Flounder Spawning Grounds in Point Judith and Potter Ponds.

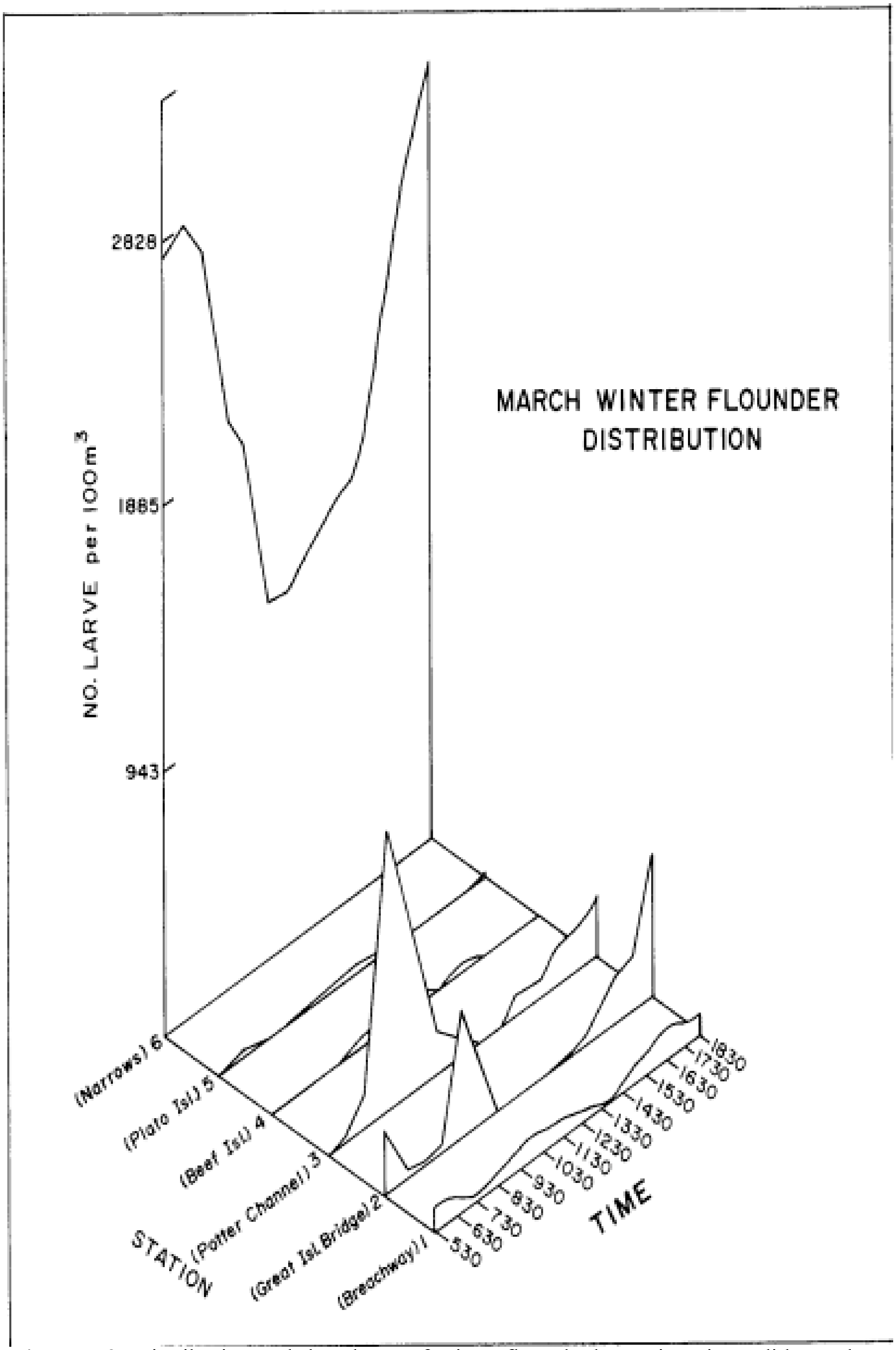


**Figure 5-2.** Distribution and abundance of Winter flounder larvae in point Judith Pond.

role in the decline of oysters, especially since the shellfish pollution closure of Green Hill pond, which has put additional pressure on Ninigret Pond oyster stocks. Because they grow on the surface of rocks and other hard substrate, they are usually visible and easy to harvest. Even if habitats were manipulated to once again favor oysters, the current abundance of eager fishers would likely keep the population at a low level.

3. While growth overfishing of popular shellfish appears to be an established problem, recruitment overfishing of the major shellfish population does not appear to be a problem at present. It is possible that protected populations of quahogs in the grass beds of Ninigret Pond and above the pollution line in Point Judith Pond contribute seed to the heavily fished beds in those ponds. Recent studies in Great South Bay, New York, suggest this may be a major reason why the open beds sustain the present rapid rate of exploitation without becoming more severely depleted (Malouf 1983). No such protected brood stock was found in either Potter or Green Hill Ponds in the 1980s, and the densities of quahogs were much lower.

4. There is no evidence prior to 1984 that the flounder in the salt ponds were overfished. However, based on monitoring of sub-populations of flounder, it was determined that populations are not as abundant as they were in the late 1970s and early 1980s (Stolgitis et al. 1976, Sisson and Satchwill 1990, Sisson and Satchwill 1991, Satchwill and Sisson 1990, and Satchwill and Sisson 1991).

5. The magnitude of the Ninigret commercial trawl fishery varied considerably from one year to another, but in peak years, such as 1977, some 20,000 pounds were caught. Commercial catches were comparable to the recreational catch in Ninigret between 1979 and 1981. Beginning in the spring of 1982, however, commercial fisheries in Ninigret changed drastically as more draggers began working, and as fyke nets became more popular in the pond.

6. Currently there is no commercial flounder dragging fishery in Point Judith Pond, but there is a small new fyke net fishery there. However, that fishery is now restricted from taking winter flounder. Fyke nets are also operated in Potter Pond. Recreational fishing in Point Judith Pond is active most of the year. The flounder fishery, before 1991, was concentrated at a few well-known sites in the spring and fall in the upper pond and was also part of a mixed-species summer fishery in the lower pond. However, during the 1980s the stocks of winter flounder had been so dramatically reduced, that a moratorium on catching winter flounder was enacted in July 1991, and was lifted in 1996. However, a Coastal Marine Life Management Area (CMLMA) was established which includes all state waters north of a line from Sakonnet Point light to Point Judith light, north of the seaward entrance to all coastal ponds, including the area north of the seaward entrances to the Harbor of Refuge for the purpose of managing winter flounder. For all legal gear types used in the Narragansett Bay area and the coastal pond area of the CMLMA, the first season will commence March 1 and shall continue until one-half of the annual quota for that area is landed.

In subsequent years the season will begin on March 1. The second season will be from October 1 through November 15 unless the entire annual quota has been reached prior to November 15. Commercially, only 300lbs and 100lbs of winter flounder can be taken from the CMLMA and the coastal ponds, respectively. During April and October of any year, only recreational fishers may take and possess not more than four (4) winter flounder in Rhode Island waters, which includes all of the coastal salt ponds.

**F. Preservation and Enhancement of Fisheries**

1. The difficulties of managing a multiple-species, free and common recreational fishery, where all state residents have an equal right to harvest a publicly owned resource, are particularly challenging in the salt ponds. The small size of the ponds, their high productivity, and their accessibility make them particularly vulnerable to misuse and over-exploitation. These difficulties are heightened by the great concern for the condition of fishery stocks by local residents and the thousands of recreationists who come regularly from all over the state, as well as Massachusetts and Connecticut, to fish and shellfish in the salt ponds (Smith and McConnell 1979).

2. The management techniques that may be used to control a free and common fishery and protect the resource from over exploitation include catch and minimum-size regulations, closed areas, gear regulations, and a variety of methods that may enhance the natural productivity or abundance of selected species. These techniques have been used for a number of years in the ponds by the Marine Fisheries Council and the RIDEM. A large proportion of the energies of the RIDEM Division of Fish and Wildlife Marine Fisheries Section are devoted to the salt ponds, particularly to the re-establishment of bay scallops and oysters, with a renewed interest in the various finfish fisheries that have been on the decline since the 1980s. Enforcement of shellfishery regulations, however, is inadequate, due to the lack of funding sources to actively pursue violators of marine laws. During the period of the URI studies, RIDEM enforcement officers were rarely seen except during the scallop season, undersized shellfish were common in recreational catches, and daily recreational catch limits for quahogs were greater than most fishers could fill. Enforcement of catch and minimum-size regulations for shellfish is made difficult by the absence of a shellfish licensing requirement for state residents. Residents are permitted larger daily catch limits than licensed non-residents, but there is no way to identify between the two on a shellfish flat. There is also no license to revoke from the violators of regulations, which would otherwise provide a simple and effective form of punishment. In the past, public sentiment against licensing residents, however, has been strong, and legislation calling for licensing has had little chance of passage in the R.I. General Assembly. However, due to the present state of the fisheries (recreational & commercial) the public may now express some sort of sentiment in favor of a marine fishing license.

3. On Cape Cod and in Maine, where similar problems have faced the managers of municipally controlled shellfish flats for many years, shellfish managers have concluded that regulations over catches, size limits and seasons are not enough. They have learned

that if growth overfishing of popular shellfish is to be curtailed, regulations must be complemented by public education and cooperation. Proponents of this approach stress that effective enforcement of regulations will be achieved only if it is based on a cooperative, educated public that actively supports and participates in management.

4. Techniques to enhance productivity, which may include seeding, predator control, special fishing restrictions and "cultivation" of the bottom, should be tested to select those that prove to be most effective in producing enhanced yields of harvest-sized shellfish.

## 510.2 Wildlife

### A. Introduction

1. The salt pond region watersheds support a variety of habitats which supply food, cover, feeding and breeding sites for a diverse animal community. Habitats are comprised of a wide range of types including upland forests and fields, freshwater wetlands, rivers and streams, salt marsh, intertidal flats, salt ponds, and barriers. In the salt pond region many of the wildlife species found elsewhere in the state are present. Also present are many species dependent upon specialized habitats, such as salt marsh or brackish wetlands. Vertebrate (with backbone) animals within the following groups will be discussed: amphibians, reptiles, birds and mammals.

### B. Amphibians

1. Amphibians (frogs, toads and salamanders) are important animals found within the watersheds. Amphibians are often found in or adjacent to freshwater wetlands and are dependent on these habitats at least for breeding. Freshwater marshes, vernal ponds, seeps and small streams within the watershed provide critical habitat for these species. Typical examples of these animals include many of the common frogs, toad and salamanders found throughout the state. Common frogs and toads include American toad, spring peeper, grey treefrog, bullfrog, green frog, wood frog and pickerel frog. Common salamanders found within the watershed include spotted, two lined and redback salamander. Amphibians generally do not occur within the tidal portion of the estuary due to the drying effects of salt water upon their highly permeable skin (Chabreck 1988).

### C. Reptiles

1. Reptiles include turtles and snakes and are common inhabitants of the salt pond area. Turtles are common in freshwater ponds and marshes which are found within the upper reaches of the watershed. Turtles found within the watershed region include the common snapping turtle, stinkpot, spotted turtle, eastern painted turtle, wood turtle and eastern

box turtle. Snapping, spotted and eastern painted turtles are found within fresh as well as brackish portions of the estuary and may range into salt marsh habitats (DeGraff and Rudis 1986). One uncommon species in Rhode Island is the wood turtle (*Clemmys insculpta)* which may occur within the upper reaches of the watershed but not in the coastal ponds. The species is susceptible to illegal collection and habitat loss (Raithel 1995). The removal from the wild, for commercial purposes, of any reptile or amphibian is prohibited by the RIDEM Division of Fish and Wildlife, except by special permit.

2. The northern diamondback terrapin (*Malaclemys terrapin)*, an estuarine turtle found in some parts of Rhode Island, has historically been found in the salt ponds. The turtle is a state threatened species which is currently limited due primarily to availability of habitat. Two historical records for this species exist from Ninigret Pond, one terrapin in 1950 and another male terrapin was caught in a fyke net and released in 1982. This species has also been documented in Winnapaug Pond when one terrapin was captured by R.I. Fish and Wildlife in a fyke net in 1989. It is theorized (Raithel 1995) that these records may represent individual turtles that wandered into the ponds and not viable populations. The nearest viable populations lie in Barrington's Hundred Acre Cove and in Connecticut in the Connecticut River Estuary, where appropriate brackish salinity levels exist. The salt ponds would appear to provide suitable habitat for the Northern diamondback terrapin, however there have been no studies to date to accurately assess the status and distribution of the species in the region. The northern diamondback terrapin along with eastern box turtle, spotted turtle and bog turtle are protected species by the RIDEM Division of Fish and Wildlife. The possession, without a permit, of these species is prohibited at all times.

3. Snakes commonly found within the watershed region include the eastern garter snake, hognose snake, northern water snake, milk snake, northern brown snake, eastern ribbon snake, and northern ringneck snake. Most of these species inhabit terrestrial sites in proximity to water; only the northern water snake inhabits primarily aquatic and semi-aquatic sites in fresh or salt water (DeGraf and Rudis 1986).

**D. Neotropical Migrants**

1. The diversity of habitats found within the watershed give rise to a variety of birds found within the region. Both year round resident and migratory species inhabit this area and consist of such diverse groups as perching birds, birds of prey and waterfowl. The Breeding Bird Atlas Project (Enser 1992) has documented the nesting status of birds in Rhode Island including the coastal lowland regions of the state. Because of habitat diversity, the list of bird species found within the entire salt pond region and watershed would include most of the common species found throughout the entire state. Many of the specialized habitats within the coastal ponds support species specific to a particular habitat type. For example birds that are known to nest exclusively in salt marshes in the state include Clapper Rail, Sharp-tailed Sparrow and Seaside Sparrow (Enser 1992). Likewise, robust emergent marshes dominated by cattails (*Typha sp)* occur in some of the coastal ponds and provide unique habitats for Least Bittern,

Virginia Rail, Sora and Marsh Wren.

2. The shorebirds are one group that depends significantly on the salt pond habitats. The great majority of shorebirds that occur in the salt pond region occur during the spring and fall migration periods, although, some breed and winter in the area. Table 5-3 lists by shorebird group the presence of shorebirds known to utilize coastal pond habitats in Rhode Island. Of the shorebirds listed in Table 5-3, Killdeer, American Oystercatcher, Willet, Spotted Sandpiper, Upland Sandpiper and Piping Plover breed in the salt pond region.

3. Habitat use by shorebirds varies between species using the coastal region and occurs relative to water depth, substrate characteristics, vegetative structure and distribution (Helmers 1992). Accordingly, during migration and wintering periods, most shorebirds require a range of habitat conditions from unvegetated mudflats to shallow vegetated water and sandy beaches. The diversity of habitats needed for this purpose are found in the salt pond region.

The Piping Plover which nests along the south shore barriers is a federally threatened species found in the salt pond region. This bird is a semicolonial nesting species that nests and feeds along the narrow beach strands of the coastal barriers. Documented nesting occurs at several sites along the south shore region, including barriers at Trustom Pond, Cards Pond, Ninigret Pond, East Matunuck Beach, Weekapaug Pond, Maschaug Pond and Napatree Point.

4. The U.S. Fish and Wildlife Service has developed lists of bird species classified as Nongame Migratory Bird Species of Management Concern in the Continental United States (1994). Species from this list which occur in the Salt Pond Region include the Seaside Sparrow, Northern Harrier, American Bittern and Black Rail. The first three species are state rare listed species and the Northern Harrier is known to breed only on

| Shorebird Group | Common Name | Period |
|---|---|---|
| Plover | Blackbellied Plover<br>Lesser Golden Plover<br>Semipalmated Plover<br>Piping Plover<br>Killdeer | N,S<br>S<br>S<br>N,S,B<br>N,S,B |
| Curlew | Whimbrel | N,S |
| Small Sandpiper | Sanderling<br>Semipalmated Sandpiper<br>Least Sandpiper<br>White-rumped Sandpiper | N,S<br>N,S<br>N,S<br>S |
| Medium Sandpiper | Red Knot<br>Pectoral Sandpiper<br>Dunlin<br>Short-billed Dowitcher<br>Common Snipe<br>Upland Sandpiper | S<br>N,S<br>N,S<br>N,S<br>N,B<br>B |
| Godwit | Hudsonian Godwit | S |
| Yellowlegs | Greater Yellowlegs<br>Lesser Yellowlegs<br>Willet | N,S<br>S<br>B |
| Turnstone | Ruddy Turnstone<br>Spotted Sandpiper<br>Purple Sandpiper | N,S<br>B<br>W |
| Oystercatcher | American Oystercatcher | N,S,B |
| Phalarope | Northern Phalarope<br>Red Phalarope | S<br>S |

**Table 5.3** Shorebird presence in the North Atlantic Region, Rhode Island (Helmers, 1992)
N= Northward Migration, S= Southward Migration, W= Wintering, B= Breeding

Block Island (Enser 1995). The Black Rail, another rare species which currently has no status listed for Rhode Island, may potentially utilize salt marshes of Point Judith and other salt ponds (Eddleman 1994).

5. Waterfowl (ducks and geese) are common inhabitants of the salt ponds but use the area most heavily during migration and wintering periods. Historically, waterfowl populations were profusely abundant in the salt ponds prior to the introduction of the permanent breachways. The permanent breachways have caused a rise in salinity levels that virtually eliminated widgeongrass (*Ruppia maritima)*, a primary food for waterfowl using the salt ponds. The effects of accelerated sedimentation levels in the ponds has further aggravated the conditions which formerly allowed submerged vegetation to become established, further limiting food and nest sites for waterfowl.

6. Several species of waterfowl use the salt ponds habitats primarily during migration and as

wintering habitat. The American Black Duck is considered a species of concern by the U.S. Fish and Wildlife Service due to declines caused by habitat loss, competition, hybridization with mallards and changes in nesting and brood rearing success. The black duck breeds within the marshes associated with the salt ponds and these areas provide important wintering habitat for this species and other waterfowl. Midwinter waterfowl counts, conducted annually by the state since the late 1950s, list a variety of wintering waterfowl using the ponds including Black Ducks, Mallards, Canvasback, Bufflehead Ducks, Mergansers, Goldeneyes, Scaup, Redheads, Canada Geese, and Mute Swan (Allin 1995). Numbers of waterfowl recorded during counts made within the past five years pale when compared to historical accounts made prior to man-made impacts, such as the breachways, which affected the food source for many of these birds.

7. One waterfowl species that has proliferated in the salt pond region is the mute swan. The mute swan, common in the ponds in summer and winter, is an non-native species introduced from Europe sometime prior to 1938 (Willey and Halla 1972). These aggressive birds compete with native waterfowl and are suspected of interfering with and adversely affecting native species. Also, there is a significant wintering common loon population in nearshore waters, in the surf zone and occasionally in the salt ponds.

8. The osprey is a large bird of prey which nests and forages along the entire south shore region. These large birds have a wingspan of up to 68 inches, build huge nests of large sticks in dead trees or utility poles and can be seen searching the open waters of the estuary and associated river systems for their primary food (fish), particularly the alewife (*Alosa pseudoharengus)* and blueback herring (*Alosa aestivealis)*. Previously abundant, but reduced to near extinction in the late 1960s due to DDT accumulation, the osprey made a dramatic comeback in recent years. In 1994 there were 44 active osprey nests in the state (Suprock 1994). Osprey nest in Point Judith Pond, Trustom Pond, Ninigret Pond and Winnapaug Pond and feed all along the south shore region.

**E. Mammals**

1. Many species of mammals can be found within the diverse habitats of the salt pond region (Cronan and Brooks 1968). Small mammals such as meadow voles and white-footed mice are ubiquitous and are found from the salt marsh to the upland woodland. Other common small mammals include masked shrew, short-tailed shrew, star nosed mole, rabbits, chipmunk, woodchuck, red, gray and southern flying squirrels, opossum and skunk. Many common species of bats, including the little brown myotis and big brown bat, can be observed foraging on insects over the ponds during the twilight hours of warm summer nights.

2. Many of the economically important furbearing mammals common to the state live and feed in close proximity to aquatic habitats in the region. These species would include red and gray fox, raccoon, muskrat, mink, ermine, and river otter. Large mammals such as the white-tailed deer are abundant throughout the watershed from the salt marshes to the upland forest and can

be observed crossing or feeding along the edges of roads and fields. Recently the coyote has dramatically increased in numbers throughout the state and is common in the salt pond region. One theory for the increase is that coyote populations have increased in direct proportion to the increase in populations of white-tailed deer in the state.

3. There are small but increasing winter populations of seals in the salt pond region including harbor seals, harp seals and possibly gray seals. Seal haulouts occur on rocks in the salt ponds, and on beaches.

**F. Preservation and Enhancement**

1. Rhode Island coastal ecosystems are highly suitable for restoration initiatives which will benefit fish and wildlife as well as a host of other natural resource benefits found in the region. A major restoration of coastal wetlands is being undertaken by a partnership of federal, state, and non-government organizations at the Galilee Bird Sanctuary in Point Judith Pond.

The Galilee Bird Sanctuary is a 128 acre coastal wetland complex owned and managed by the RI Division of Fish and Wildlife. The sanctuary is located east of the port of Galilee and is bounded by the Galilee Escape Road to the north and Sand Hill Cove Road to the south. The area was acquired by the Division of Fish and Wildlife by Executive Order in 1955 for use as a bird sanctuary and has been managed by the Division since that time.

During the 1950s, unconfined dredge spoil from the Port of Galilee was deposited over portions of the western side of the salt marsh which now comprises Galilee Bird Sanctuary. This disposal filled in a tidal channel which existed in this location and significantly altered natural hydrology of the marsh.

During the 1954 hurricane, residents of Great Island were trapped by the extreme flooding of Sand Hill Cove Road. To prevent this from recurring the State Division of Public Works, in 1956, constructed the Galilee Escape Road. Construction of the Escape Road fragmented the previously continuous salt marsh, eliminating in the process about seven acres of marsh. The effect of this fragmentation has resulted in the severe restriction of tidal flushing and has transformed the once productive salt marsh to a brackish tangle of tall reed (*Phragmites australis*), shrubs, and small trees. As a result of these changes, natural coastal wetland habitat for migratory waterfowl, wading birds and shorebirds has been significantly reduced and or eliminated.
The principal goal of the Galilee project is to restore tidal flushing into the Galilee Bird Sanctuary (GBS) in order to reclaim pre-existing natural salt marsh habitat. The rise in natural salinity levels resulting from an influx of salt water to the marsh is necessary to reclaim the marsh which has been overtaken by *Phragmites* and shrub swamp. The restoration project will change the vegetative community composition in favor of salt marsh grasses. The

total acreage predicted for the completed restoration are as follows: Open water intertidal habitat= 13.68 acres, salt marsh habitat= 84.20 acres, common reed= 28.48 acres, uplands= 16.31= +/- acres.

Numerous benefits will result upon successful completion of the restoration project. These include: improvement of habitats for resident and migratory birds, particularly waterfowl (black duck), shorebirds and wading birds; improvement of finfish and shellfish habitats and nurseries; restoration of natural ecosystem function and associated aquatic productivity; socio-economic benefits associated with aesthetics, education and scientific research; and reduction in fire hazards associated with *Phragmites.* It is this type of project which will directly benefit the natural resources of the salt pond region that must be developed and funded in the future.

### 510.3 Critical Habitats

#### A. Fish Habitat

1. The permanent alteration of the breachways that connect the ponds to the ocean and one pond to another has brought about greater changes to the ecology of the ponds than any other human activity. Permanent breachways and associated dredging have changed the ecology, chemistry and biology of the ponds by increasing the rate at which sand accumulates within them and radically altering their salinity and flushing characteristics (Lee 1980).

2. The construction of permanent breachways, as described in Chapter Four, lowered the water level and increased the flushing, which changed the salinity regime from one of seasonally pulsed high and low salinity to one of relatively constant high salinity. Thus, the range of habitat types has been reduced so that low salinity waters preferred by some species for spawning are now restricted to a few small areas in back coves close to the mouths of streams of upwelling groundwater. Dredging, while having navigational benefits, has promoted the development of anoxic waters in the bottom of channels, which significantly reduces oxygenated habitat (Day et al. 1989).

3. Permanent breachways also make it possible for sustained northwest winds in the winter to force much of the water out of the ponds and expose large areas to freezing temperatures. In Ninigret Pond, this periodically kills off oysters. The breachway there has also increased the rate of sedimentation in the tidal delta and transformed formerly deep water habitat into shallow sand flats.

4. The two principal forms of water pollution in the salt ponds are bacterial contamination and nitrogen. Bacterial contamination from septic system effluent (and, in the case of Point Judith Pond, seafood processing wastes and industrial effluents) causes closure of shellfish beds when National Shellfish Sanitation Program criteria are exceeded. Excessive nitrogen

loading to the salt ponds from residential sources can cause massive algal blooms. Decomposition of plant matter depletes the dissolved oxygen necessary for aquatic life. Eventually hypoxia or anoxia (all the dissolved oxygen is consumed) occurs with consequent fish kills, reduced biodiversity of fish and shellfish populations, mass mortality of benthic animals, bacterial slimes, foul smelling odors and in extreme cases, generations of toxic levels of hydrogen sulfide (Nixon 1995). Today, the remaining oyster producing areas of Ninigret and Green Hill are affected by episodes of low oxygen which appear to limit their production. These conditions may continue to be the cause of the expanding areas of soft, highly organic bottom sediments over formerly productive sandy bottom areas that are now virtually devoid of shellfish.

5. Another important cause of water pollution is toxic contaminants including heavy metals, pesticides, and other manmade compounds including polychlorinated biphenyls (PCBs). Lee et al.(1988) conducted a study on the probable effects of toxic pollutants on winter flounder stocks at three sites, including Quonochontaug Pond. They found that certain concentrations of some metals were highly correlated with the presence of humans, and that the presence of neoplasms and macrophage aggregates are associated with high levels of PCBs in the liver. They concluded that man-induced pollution is adversely affecting the "health" of winter flounder from the sites sampled.

**B. Wetlands**

1. The salt pond region covers a vast area of many varied habitats ranging from barriers, salt water and brackish ponds, tidal marshes, freshwater wetlands, upland fields and woodlands. These natural habitat features in combination form diverse landscapes where many forms of plant and animal life thrive. The ocean environment in adjacent Block Island Sound has a profound effect on the nature and types of plant communities and wildlife species using these coastal habitats. The net result of this great diversity in habitats and environmental factors affecting the salt pond region is a productive ecosystem which is a valuable natural resource for the adjacent communities and the entire state.

2. The viability and natural function of the salt pond region ecosystem depends on careful stewardship by human populations. This preserves the tremendous natural resource values of the region to the surrounding communities. Some of these resource values include unpolluted waters, abundant and diverse fish and wildlife populations, and a high aesthetic quality. These are the desirable characteristics that often attract more human development activities, placing further stress on ecosystem function. Unfortunately, alterations to the salt ponds by human populations, including construction of permanent breachways and filling of coastal wetlands, have compromised some of the natural resource values associated with the fish and wildlife populations of the salt ponds. Steps to reverse these activities, where feasible, are strongly recommended.

3. Wetlands are among the most productive ecosystems that are found anywhere on the planet (Figure 5-3). In terms of gross and net primary productivity, salt marshes rank high, nearly as high as in subsidized agriculture (Mitsch and Gosselink 1986). The causes of such

high productivity in salt marshes are subsidies in terms of tides, nutrient import and water abundance which offset stresses associated with extremes in salinity, temperature, flooding and drying. These factors are responsible for tidal marshes being among the most productive ecosystems in the world, with up to 25 metric tons per hectare of plant material (2,500 g/m$^2$/yr) produced annually in the southern Coastal Plain of North America (Niering and Warren 1977). In Rhode Island, measured net primary productivity (aboveground portion only) of cordgrass *Spartina alterniflora* low marsh was 840g dry wt./m$^2$/yr and of *Spartina patens* high marsh was 430g dry wt./m$^2$/yr (Nixon and Oviatt 1973) In the salt pond region, coastal wetlands include salt marshes and freshwater or brackish wetlands contiguous to salt marshes (Figure 5-4).

4. Miller and Egler (1950) described the vegetation found in tidal salt marshes as typically occurring in four or five zones arranged roughly according to elevation in the marsh. Although relatively low in diversity of higher plants (Teal 1962), the vegetative productivity of the tidal salt marsh supports high production of detrital material (decaying organic matter) which in turn is important to the marsh and adjacent estuary as a nutrient source for consumer organisms. The major path of energy utilization in a tidal marsh system is through detrital decomposition (Mitsch and Gosselink 1986). In some cases, detrital material export from the marsh to the adjacent estuary is greater than the phytoplankton-based production and is a major reason why salt marshes are important nursery areas for many commercially important fish and shellfish (Mitsch and Gosselink 1986).

5. The vegetation of the tidal marsh also aids in trapping natural sediment and nutrient loads derived from runoff overland and from material suspended in the water column. The marsh is serving as a filter, maintaining the water quality of the open water habitat. With rising sea level, the filtering and accretion of sediments facilitates growth of the marsh, ensuring continued productivity.

6. Freshwater or palustrine wetlands contiguous to the salt ponds consist of a variety of habitat types that include small ponds, freshwater marshes, wet meadows, bogs, scrub shrub and forested wetlands. According to Tiner (1989) palustrine wetlands are the most common and floristically diverse group of wetlands in Rhode Island. Many of the freshwater wetlands are hydrologically linked to the salt ponds via small streams. These streams carry organisms, nutrients and organic detritus produced within the upland watersheds of the salt ponds, further enhancing the productivity of these ecosystems (Golet et al. 1993). The most abundant palustrine wetland type in the state is forested wetlands, dominated by the presence of woody vegetation 20 feet or taller in height. The red maple swamp is the most common forested wetland found in Washington County covering 21,219 acres (48% of the statewide total of 44,148 acres) with much of this acreage found within the 3 towns comprising the principal watershed to the salt ponds. Acreage of red maple swamp noted for the towns of South Kingston (6384 acres), Westerly (2,241 acres) and Charlestown combined, account for over 50% of the total acreage of this wetland type in

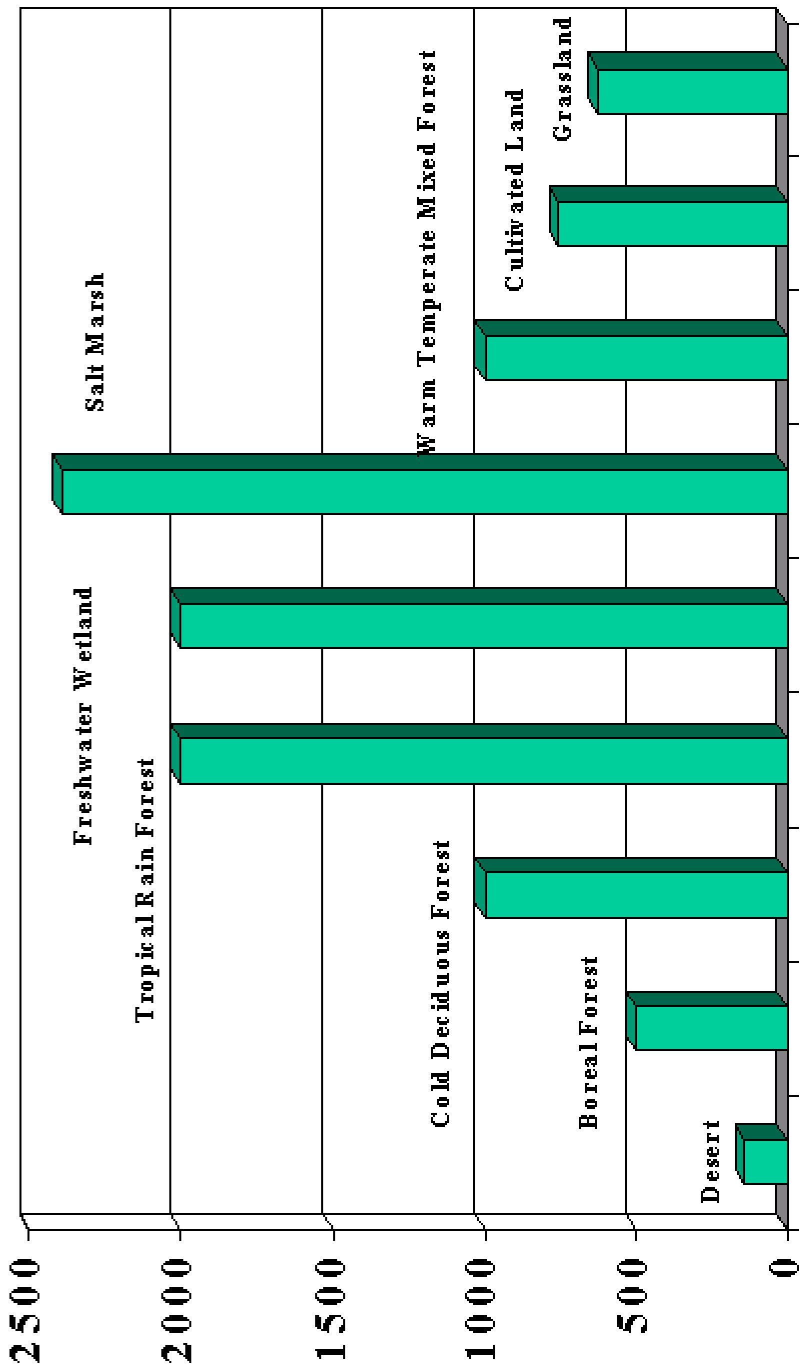


Figure 5-3. Net Primary Productivity of Selected Ecosystems
($g/m^2/yr$) (Adapted from Tiner 1985)

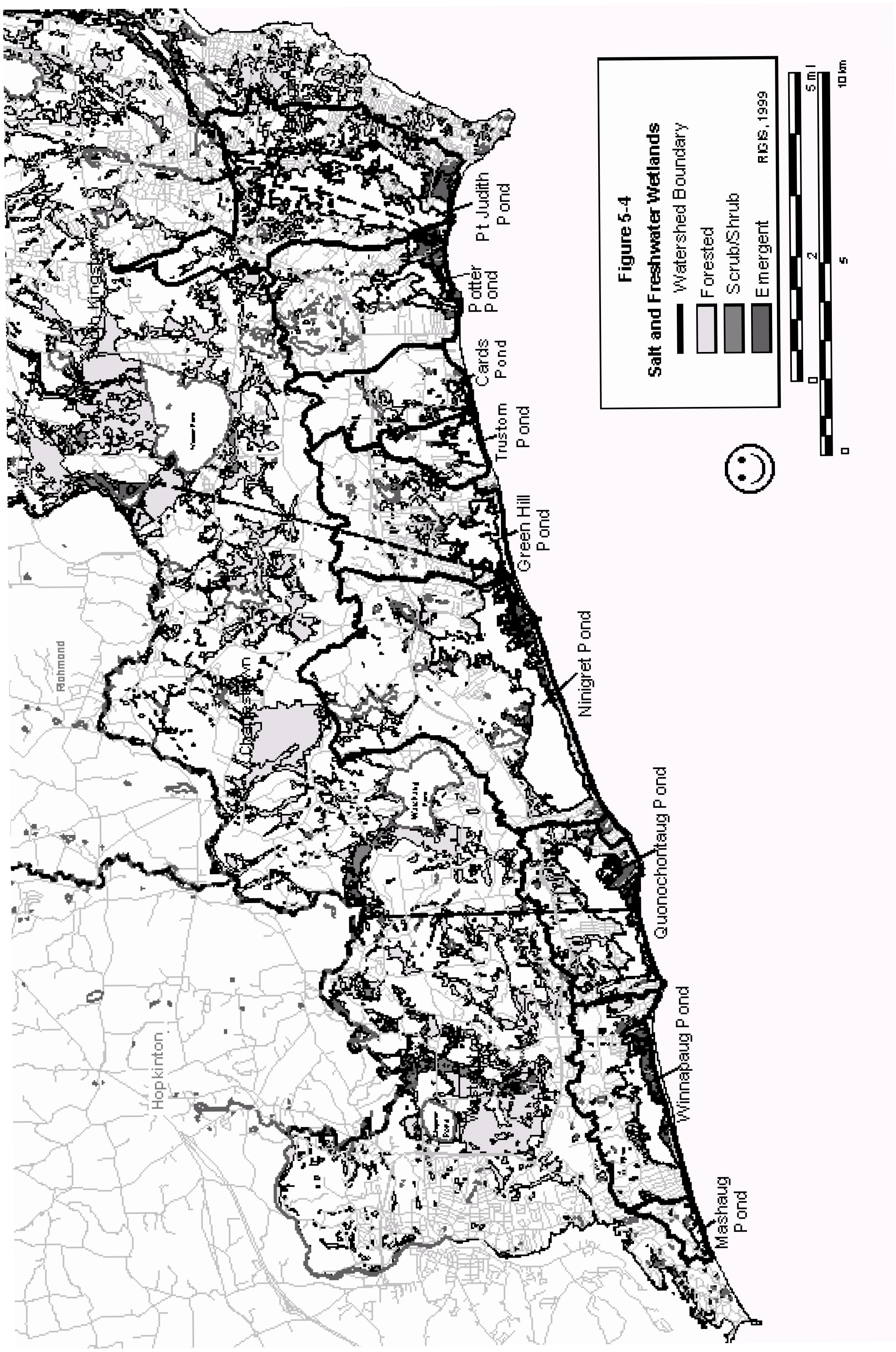
Figure 5-4
Salt and Freshwater Wetlands
Watershed Boundary
Forested
Scrub/Shrub
Emergent
RIGIS, 1999
0 2 5 mi
0 5 10 km
Pt Judith Pond
Potter Pond
Cards Pond
Trustom Pond
Green Hill Pond
Ninigret Pond
Quonochontaug Pond
Winnapaug Pond
Maschaug Pond
Kingston
Charlestown
Richmond
Hopkinton

Washington County.

In addition to wildlife habitat and open space values, the position of red maple swamps along many of the streams in the watershed of the salt ponds is a significant factor affecting the water quality in the ponds. These swamps are important for the maintenance of water quality in the salt ponds as they buffer sensitive waterways from the adverse effects of development activities which contribute pollutant loadings and contaminated runoff that adversely affect biotic life, impacting the entire ecosystem.

7. Wetlands perform a host of functions which are important to society, provide ecosystem benefits, and provide both consumptive and non-consumptive values to humans. Tiner (1989) categorized the benefits which wetlands provide in three groups:

(a) fish and wildlife values,

(b) environmental quality values, and

(c) socio-economic values.

Fish and wildlife values of wetlands vary depending on the type of organism. Fish, shellfish, certain birds and certain mammals are wetland dependent, spending their entire lives in wetland areas. Waterfowl, wading birds, shorebirds and other migratory birds utilize wetlands regularly and during migration for feeding areas, resting areas, courtship and breeding, and raising young. Upland terrestrial animals may use wetlands as feeding areas, for drinking water or as refugia when displaced by development (Tiner 1989). Wetlands are also essential habitats for many rare or endangered animals and plants.

Environmental values of wetlands can be summarized as water quality maintenance, oxygen production, aquatic productivity, and microclimate regulation. Numerous socio-economic values are also associated with wetlands including flood control functions, wave damage protection, hunting, trapping, fishing, and shellfishing, aesthetics, education and research. These natural functions and values associated with wetlands represent items which dramatically affect the quality of life for the communities and residents within the salt pond region.

8. Two forms of salt marsh are generally recognized as dependent on the tidal flooding regime present. The low marsh is regularly flooded by tides, and occurs along the edges of the marsh and along the banks of tidal creeks. The low marsh is dominated by the tall form of smooth cordgrass (*Spartina alterniflora).* The high marsh zone occurs above this zone and is flooded less often than daily, forming a more complex and diverse plant community (Tiner 1989).

The cordgrasses (*Spartina spp.)* are a major source of detritus to the marine food web, and are grazed upon by many organisms, including marsh snails, amphipods, isopods, leaf bugs, fiddler crabs, ribbed mussels, and mud snails (Pelligrino and Carroll 1974). Cordgrass seeds also serve as food for waterfowl and other birds, while the rootstalk of the plant is a major food source for geese and muskrat (Pierce 1977). Spike grasses, found in low dense stands, provide nesting sites for various species of waterfowl and a food source for ducks, small mammals, and marsh and shore birds (Pierce 1977).

The presence of the reed grass *Phragmites australis* is an indicator of disturbed estuarine wetlands, particularly where natural flushing by saltwater has been altered, or sediment loading is occurring (Neiring and Warren 1977). Regular tidal flooding which allows the level of soil water salinity to reach 20 ppt (parts per thousand) is necessary to eliminate reed grass in favor of more desirable salt marsh vegetation (Howard et al. 1978). Phragmites often grows in impenetrable monotypic stands, providing little overall food and cover for waterfowl and generally out-competing and subsequently replacing more desirable vegetation (Cross and Fleming 1989).

9. Tributary wetlands are freshwater wetlands within the CRMC jurisdiction that are connected via a watercourse to a coastal wetland and/or tidal waters. Because of their hydrologic relationship with coastal resources, tributary wetlands require particular protection and management and must be evaluated on a case-by-case basis.

**C. Submerged Aquatic Vegetation (SAV)**

1. The ecology of the salt ponds and their vegetation changed profoundly as a result of the establishment of permanent breachways. Permanent breachways were constructed to Point Judith and Potter Ponds (1910), Quonochontaug Pond and Winnapaug Pond (1950s), Ninigret Pond (1952) and Green Hill Pond (1962). Lee (1980) provides a thorough discussion of the history and consequences to the salt ponds resulting from the establishment of permanent breachways. The natural productivity of the salt ponds depended on the brackish water estuary conditions that provided ideal habitat to many economically valuable organisms such as fish (oysters, perch, and alewives); migratory waterfowl, particularly ducks; and furbearers (muskrat, otter). The combined effects of elevated salinities approaching that of seawater and the daily tidal fluctuation of water levels in the ponds led to the elimination of plants considered vital as food and cover to fish and wildlife populations. Two groups of wildlife that were adversely affected by these breachways were waterfowl and certain species of furbearers.

2. Prior to the establishment of permanent breachways, widgeongrass *(Ruppia maritima)* was a dominant submerged aquatic plant and often a diverse SAV community existed in brackish to fresh water ponds. According to historical accounts (Lee 1980), this plant was so abundant that it grew like thick meadows over the pond bottom. Although able to withstand a wide range of salinities and thriving in brackish conditions, studies suggested that chloride salts were more toxic to the plant than other salts (Bourn 1935). Widgeongrass is recognized as having worldwide importance as a waterfowl food but has been eliminated from many areas due to human activities (Kantrud 1991). The primary reason for the value of the

plant to waterfowl is that practically all parts are edible and consumed by waterfowl (Martin et al. 1951). Today the rapid rate of sediment deposition in many of the salt ponds further inhibits the establishment of submerged vegetation such that vast areas of the pond bottoms are covered by sand with little if any vegetation. Because of its ability to withstand higher salinities, eelgrass *Zostera marina* is the more prevalent submerged aquatic plant in the ponds.

**D. Barriers**

1. The Barriers are narrow strips of land that occur parallel to the coastline and which are separated from the mainland by a coastal salt pond or tidal wetland feature. They are comprised of unconsolidated materials, mostly sands and gravel, and contain a vegetated dune. These habitats are dynamic and change in shape and extent along with extremes in tides and catastrophic storm events. Vegetation is generally sparse and scattered along the upper zones of the beach (Tiner 1989), including the primary dune species beach or dune grass *(Ammophila brevigulata),* along with other plants such as beach pea *(Lathyrus japonicus),* sea rocket *(Cakile edentula)* and beach orach (*Atriplex arenaria).* Trapping of wind blown sands by dune grass is responsible for the growth and development of dunes.

**E. Terrestrial Habitat**

1. Terrestrial uplands within the salt pond region watershed are composed of a continuum of successional habitats ranging from abandoned fields to mature forest. The uplands are interspersed with and surround smaller sub-watersheds which drain small streams, rivers, swamps and other freshwater wetlands that comprise the entire watershed basin. The land use policies and practices employed within the terrestrial habitats have a direct affect on the overall quality of the watershed's ecosystem. Land use practices which abuse or over develop the land within the watershed will diminish the quality and function of the salt pond region ecosystem. Loss and fragmentation of upland habitat will result in decline or loss of species dependent upon these habitats such as wood turtle and forest interior nesting birds.

2. It was determined in 1985, that Rhode Island was 60% forested; a number that has remained unchanged since 1972 (Dickson and McAfee 1988). This percentage of forest land can be interpreted to be consistent with the lands comprising the salt pond region watershed. Dickson and McAfee (1988) defined forest land as land that is at least 10% stocked with trees of any size or that formerly had such tree cover and is not currently developed for a nonforest use.

Trees of the red oak group are the dominant species in Rhode Island, making up 42% of the growing stock of all species. Red maple is the second most dominant tree species accounting for 22% of the growing stock of tree species. The most common understory woody stem shrubs in Rhode Island are the blueberries (*Vaccinium spp.).* A total of 25 hardwood species and 6 softwood species are found in the State (Table 5-4), many of which are common to the watershed of the salt ponds (Dickson and McAfee 1988).

3. Trees and woody shrubs are an essential component of wildlife habitat, producing vegetative materials in the form of nuts, seeds, fruits, twigs, buds and foliage consumed by herbivorous wildlife. In addition, trees and shrubs themselves provide habitat for insects and other prey animals that are consumed by many other forms of wildlife. The diversity and pattern of forests is one of the primary determining factors of which types and where wildlife live in the terrestrial environment. The structure and form of the vegetation in the forest and other early successional habitats is the critical component of habitat for wildlife.

**F. Fauna**

1. A diverse assemblage of wildlife species inhabit the terrestrial uplands within the watershed. Few wildlife live exclusively in terrestrial upland. Most utilize adjacent wetlands in some way that may include a source of drinking water, a travel corridor or an escape cover when disturbed by predators. Invertebrate and vertebrate animals of a great many forms, ranging from insects to vertebrate animals (amphibians, reptiles, birds and mammals) are found in great abundance throughout the watershed. Many of the common wildlife found throughout the state are found within the salt pond region. These would include many of the species which are described in this chapter.

**G. Human Impacts**

1. The clearing of land for construction and development destroys native vegetation and its natural moderating effects, resulting in increased velocity and quantity of water runoff. This is extremely important in those portions of the watershed characterized by steep slopes with potentially erodible soils. The runoff generated by developed surfaces constitutes a form of water pollution, known as nonpoint pollution, which individually and cumulatively degrades the water quality within the watershed.

2. The degradation of water quality directly affects the species and diversity of flora and fauna living in the salt ponds. Wetland filling and alteration also impacts the ecological function of the remaining saltwater and freshwater wetlands. Many of the wetland resources in the salt pond watersheds are hydrologically linked to the salt ponds via small streams which carry organisms, nutrients and organic detritus produced within the upland watersheds of the salt ponds. These wetlands also serve as habitat for wildlife, and retain flood waters and runoff pollutants during storms.

3. Construction of breachways and associated dredging have changed the ecology, chemistry and biology of the salt ponds by increasing the rate at which sand accumulates within them and altering their salinity and flushing characteristics (Lee 1980). Although it is a popular belief that

greater water exchange between the lagoons and the ocean will enhance water quality as well as fisheries and promote the use of lagoons for boaters, changes to the breachways to increase flushing can have more undesirable affects on the ecology and use of the ponds. Although dredging of the breachways and associated tidal deltas is necessary to maintain the current recreational uses of the salt ponds, CRMC is concerned about the long-term cumulative impacts of intensified recreational boating, increased sedimentation and the associated effects on water quality and fish habitat.

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# Chapter 6
# Storm Hazards

## 600. Findings of Fact

### 610.1 Storm-Surge Flooding and Storm Damage in the Salt Pond Region: Perceptions and Problems

### A. Hurricanes and Tidal Flooding

1. Hurricanes and tidal flooding have caused enormous destruction in Rhode Island, killing hundreds of people and causing millions of dollars in property damage in coastal communities.

2. According to an Army Corps of Engineers (ACOE) report in the 1960s, 71 hurricanes have struck Rhode Island's shore since 1635, with an average frequency of one every seven years (ACOE 1960). While no major hurricanes have swept across the state in the forty years since Hurricane Carol (1954), smaller hurricanes occurred in 1976, 1985, and 1991. The ACOE 1995 Rhode Island Hurricane Study calculates the recurrence interval (from 1886 to present) at closer to one hurricane every 5.4 years; with a tropical storm every 1.7 years. They counted 29 hurricanes and 67 tropical storms in the Ocean State since 1886 (ACOE 1995).

3. The Great Atlantic Hurricane of 1938 killed 262 people and caused $100 million in property damages statewide. In 1954, after many of the coastal areas were rebuilt, hurricane Carol again swept over the barriers, took the lives of 19 people, cut back the headlands, and caused $90 million dollars in property damage (Providence Journal 1979). In September of 1985, Hurricane Gloria was forecasted to pass directly through southern Rhode Island, but it picked up speed and changed direction to strike Connecticut, some 60 miles to the west. High winds caused one of the worst power outages in history, with a total of 334,700 homes and businesses affected with power unable to be restored completely for ten days. Though wind damage was severe, the storm hit at low tide, minimizing the flood and storm surge damage. This storm displayed several similar characteristics to the 1938 and 1954 hurricanes, but luckily factors such as changing path direction, and early warning systems, combined to lessen the overall blow to Rhode Island. Property damage was estimated at $19 million dollars (Rhode Island Office of Statewide Planning 1986). The most recent hurricane to hit Rhode Island was Hurricane Bob in 1991. The storm path of Bob was quite similar to the destructive 1954 Hurricane Carol. Though the storm hit at high tide as a Category 2 hurricane, its center passed over Massachusetts. Rhode Island suffered over $115 million dollars in damage, with spillage of 100 million gallons of untreated sewage into Narragansett Bay and a resulting nine day shellfish bed closing (RIEMA 1995).

**B. Storm Surge Flooding**

1. The Salt Pond Region is susceptible to storm-surge flooding with damage to public buildings, utilities, roads, and engineered structures for shoreline protection. The following historical and physical facts are important to storm hazard mitigation and planning in the Salt Pond Region:

2. Most New England hurricanes have struck the coast on a northward recurving track after paralleling the Atlantic Coast. Rhode Island, as well as Connecticut and Massachusetts, have significant areas of shoreline which project west to east with southern shoreline that lies exposed directly to any storm winds and waves approaching from the south (ACOE 1995).

3. Vulnerability to a hurricane is also enhanced due to significant increases in the forward speed of storms that accompany the storms' "weakening" in category. North of Cape Hatteras, North Carolina, storms weaken but speed up and bring with them faster wind speeds and a greater chance of surge flooding and wave effects. For example, damage from a Category 2 storm at 60 mph could very well be worse than a Category 4 at 20 mph. This phenomenon results from increased wind stresses affecting storm surge generation on the right side of the storm more than a higher category's stronger rotational wind field (ACOE 1995).

4. The glacially derived sediments of the barriers and headlands are highly susceptible to the erosion that occurs when a major storm surge elevates the water level 10 to 20 feet above mean sea level and subjects the unconsolidated sediments of foredunes and bluffs to the direct attack of waves (Providence Journal 1938). Within a few hours during the 1938 hurricane, the bluffs at Watch Hill receded some 35 feet, and the foredune zone at Weekapaug receded 50 feet (Brown 1976). Ideally, the sediments from the barriers and headlands should move offshore to break up the wave action on the beach face.

5. The south shore barriers are sand-starved and have an exceptionally narrow and low profile, which leaves them susceptible to storm-surge and overwash processes. The sand deposition of the late 1980s has been lost at a steady rate since 1987. Following the Blizzard of 1992, the south shoreline was left in a condition similar to 1977. Today, the foredune zone of most barriers and many headland bluffs are lower than the height of the storm surge and overwash processes (Boothroyd 1992).

6. Nor'easters appear in the winter and spring on an even more regular basis than hurricanes, and cause severe flooding and erosion. The degree of damage is dependent upon the duration of the storm and its effect on the tidal cycle (Rhode Island Office of Statewide Planning 1986).

## C. National Flood Insurance Program

1. In response to the devastation of the 1954 hurricane, several of the Salt Pond Region's coastal communities were among the first to join the National Flood Insurance Program (NFIP). All four of the region's towns now participate in the NFIP and have adopted building codes and local ordinances in accordance with the federal standards.

2. As in many states, the NFIP encouraged development in hazardous areas of the coastal zone (Miller 1975). Land values in high hazard areas along the barriers, although subject to general real estate market trends, continue to appreciate. The NFIP has made it easier to build houses in hazardous areas where the local banks were refusing to grant mortgages after the hurricanes of 1938 and 1954 (Miller 1975). The "floodproof" regulations improved the construction standards, but also resulted in increased investment in structures built during the 1980s and 1990s in the flood zones of the salt pond region. The design and construction standards for building within flood zones published by the Federal Emergency Management Authority (FEMA) in 1981 remain in effect despite criticism that the NFIP encourages and subsidizes rebuilding in hazardous areas (Parmentier 1995).

## D. Coastal Barrier Resource System

1. In 1982, the Coastal Barrier Resource System (COBRA) was established to discourage building within hazard areas and minimize the loss of life and property by prohibiting federal funding for bridges, roads, water lines, housing, and insurance on coastal barrier systems. Twenty one areas where COBRA would apply were originally designated in Rhode Island. This listing was updated for Rhode Island in 1992 (Parmentier 1995).

## E. Post Hurricane Recovery and Mitigation Plan

1. The problems of coastal flooding and storm damage were assessed in *Rhode Island's Salt Pond Region: Post Hurricane Recovery and Mitigation Plan*. This plan contains many recommendations for this region regarding hurricane preparedness and post-storm recovery. From this document, completed for the Council by L.R. Johnston Associates (L.R. Johnston Associates 1986), the CRMC initiated the emergency permitting provisions now contained within the RICRMP, Section 180.

# 610.2 Susceptibility to Future Storm Damage in the Salt Pond Region

## A. Storm Surge Area Populations

1. Although the storm surge areas of the state are relatively small, they hold a disproportionate number of residents in their boundaries. Approximately two thirds of Rhode Island's one million residents are concentrated in its 21 coastal communities

(ACOE 1995). The population growth in the south shore region has shown a dramatic increase of 53%, in comparison with a small 3% increase in Providence over the last twenty years (ACOE 1995). Moreover, several of the barriers and much of the low-lying coastal plain around the ponds are densely developed. The 1995 FEMA estimates for the population "threatened" under a severe hurricane scenario (people who fall within FEMA's calculated inundation zones for this study based on 1990 census data) are 15,250 permanent residents and 9,710 seasonal residents for the four communities located in the salt pond region (ACOE 1995).

2. In addition to the resident population, there are thousands of summer tourists that visit the region during the hurricane season. According to the ACOE, summer populations can swell an additional 28% of the resident population for the south shore (ACOE 1995). Many of the out-of-state tourists that live in rental houses during the summer may not be familiar with local authorities, evacuation routes, location of designated shelters, or know what to expect if police-enforced evacuation becomes necessary.

3. The CRMC regulates flood hazard areas under Section 300.3 of the CRMP. The CRMC requires all applicants proposing construction within flood hazard zones to demonstrate all applicable portions of the Rhode Island State Building Code are met. The CRMC suggests guidelines for construction in flood hazard zones under Subsection G. Local municipalities also follow the State Building Code for appropriate construction standards in FEMA flood zones.

**B. High Flood Danger Zones**

1. FEMA designated certain flood prone areas into wave velocity zones (V-zones) and coastal stillwater zones (A-zones). V-zones or coastal high hazard areas subject to wave action are determined by estimating the location where waves three feet or higher may be expected to exist on top of the storm-surge flood waters. A-zones are areas inundated by a 100 year flood but are not subject to wave velocity. The boundaries of the flood zones are delineated on the 1985 FEMA Flood Insurance Maps of the South Shore of Rhode Island (Figure 6-1). These maps incorporate accurate estimates of the extent of storm-surge flooding. (FEMA 1985). Municipal officials verify that construction standards are applied to new development. CRMC is not responsible for reviewing this information; therefore, it is important for the homeowner to ensure that this is correct and included in the project specifications. Large areas on or near barrier beaches are classified as V zones and as A zones. Portions of the inland shore of the salt ponds that were formerly designated A zones have become V zones over the course of time due to erosion, sea level rise, and dune rollover.

2. In addition to the FEMA Flood Insurance Maps, the ACOE, in recent cooperation with FEMA, modeled 536 hypothetical hurricanes and their maximum potential surge inundation to produce a useful planning and evacuation guide for Rhode Island. The

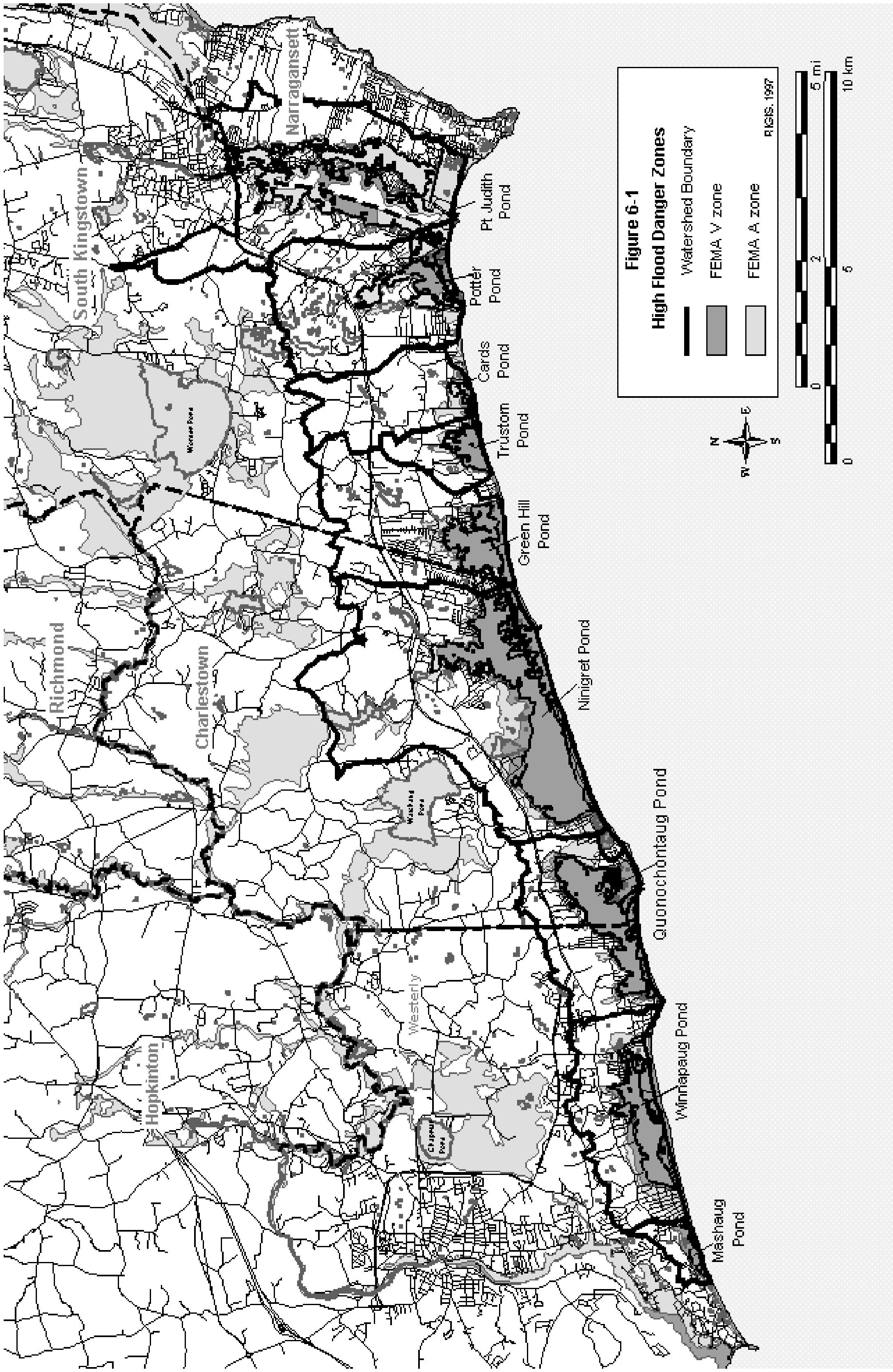
Figure 6-1
High Flood Danger Zones
Watershed Boundary
FEMA V zone
FEMA A zone
RIGIS, 1997
0 2 5 mi
0 5 10 km
N
E
S
W
Narragansett
South Kingstown
Richmond
Charlestown
Westerly
Hopkinton
Pt Judith Pond
Potter Pond
Cards Pond
Trustom Pond
Green Hill Pond
Ninigret Pond
Quonochontaug Pond
Winnapaug Pond
Maschaug Pond

"Rhode Island Hurricane and Evacuation Study: Technical Data Report" (ACOE 1995) predicts likely surge scenarios, identifies the vulnerable population, and examines factors of evacuation such as route, method, and evacuation time. This study employed the National Hurricane Center's Sea, Lake, and Overland Surges from Hurricanes (SLOSH) computerized model. Accompanying the study are two sets of maps: the Inundation Map Atlas, and the Evacuation Route Map Atlas. These maps estimate 80,000 residents affected by a weak hurricane surge scenario, and over 120,000 from a strong surge scenario. To emphasize the need for adequate warning and evacuation procedures, the study cites the average 12 hour hurricane forecast margin of error to be approximately 60 miles, which in a small state like Rhode Island may leave the entire shoreline of Rhode Island vulnerable to direct landfall. Much of Rhode Island is also at risk with landfall predictions in eastern Connecticut, or southern Massachusetts (ACOE 1995).

3. The acquisition of highly vulnerable undeveloped areas by state and private groups is one of the most effective means of minimizing storm damage in flood hazard areas. Acquisition and maintenance of south shore barriers as open space by private groups and state agencies has reduced the amount of potential property damage. State-owned barrier properties, however, have proved difficult to police and to maintain, and there have not been sufficient funds available for appropriate walkover structures, foredune zone management, beach replenishment and education (Olsen and Grant 1973).

4. The creation of temporary storm surge channels, erosion of the barriers, and extensive transport of sediment into the ponds that occurs during hurricanes causes major changes to the salt ponds by altering water circulation and fish and shellfish habitats as well as creating shoals that impede boating. The manner in which cleanup, restoration and repairs proceed after a hurricane will have a major impact on the subsequent ecology and condition of the ponds.

## 610.4 Salt Pond Susceptibility to Storm Damage

### A. Development in Storm Damage Prone Areas

1. It is not feasible, desirable nor appropriate to attempt to "stabilize" or fight the natural cyclical patterns of the sand placement and dune/beach shape and profile of the constantly changing barrier beach shoreline. As evidenced by local efforts in the past, this system will continue to be dynamic, and will cause hardship for those who structurally position themselves within this changing landscape. The pond-specific information below only further emphasizes the limitations to development, the need for common sense development and mitigative measures by homeowners, and the false sense of security structural shoreline protection conveys.

**B. Point Judith and Potter Ponds**

1. There are several features of Point Judith and Potter Ponds that make them different from the other ponds in their susceptibility to storm damage.

(a) The inlet and ocean shoreline of Point Judith Pond are protected by the breakwaters of the Harbor of Refuge. As a result, Sand Hill Cove and Galilee have lower rates of erosion than the area outside the Harbor of Refuge.

(b) Much of the interior shoreline of these ponds is comprised of steep bluffs; therefore, the amount of shoreline submerged during major storm or hurricane flooding is not as extensive as it is around the other ponds. However, the unconsolidated bluffs on Harbor and Great Islands and along portions of the western shores of these ponds are subject to wave erosion during large storms (Lee and Olsen 1985).

(c) Because of their more densely developed shorelines and large numbers of private docks and marinas, Point Judith and Potter Ponds are particularly vulnerable to property damage caused by the destructive force of hurricanes. In spite of the breakwaters, during Hurricane Carol in 1954, Point Judith and Potter Ponds sustained more property damage than other ponds in the region ($3.3 million) (Olsen and Grant 1973).

2. The areas of these ponds that experienced the most destruction in the past are the most susceptible to future hurricane damage. When Hurricane Carol hit the coastline in 1954, houses were swept off their foundations at Matunuck, Jerusalem and Sand Hill Cove, and there was nearly complete destruction of boats and docks at marinas in Galilee, Snug Harbor and the upper pond (Providence Journal 1954). Storm-surge flood waters rose 15 to 20 feet above mean sea level throughout the pond damaging buildings, eroding bluffs, destroying power lines and water mains, and contaminating wells. The bridges to Great Island and to Jerusalem across Potter Pond inlet were destroyed. Roads through Matunuck, Jerusalem and Galilee were buried by several feet of sand and wreckage from destroyed structures (Providence Journal 1954). In 1938, 1944 and 1954 a storm-surge channel was re-established across Sand Hill Cove Beach through the Roger Wheeler beach pavilion at the site of the pre-1815 breachway. In each of these hurricanes, a storm surge channel into Potter Pond was also re-activated across East Matunuck Beach. In 1944 this channel stayed open for several weeks, and it could become the location of a more permanent breachway after the next hurricane. The main line of the South Shore Water System traverses this area and tends north to Snug Harbor across the Succotash Road Bridge. The bridge washed out when the barrier beach did in both the 1938 and 1954 hurricanes.

3. The potential expense and amount of destruction in the next major hurricane is now much greater than in the past. Since major erosion and flooding was last experienced,

there has been a dramatic increase in development within the flood zone of these two ponds. The numbers of houses around the ponds has more than doubled since 1954. In 1980 there were 885 houses within the flood zones, a commercial fleet of 238 boats berthed in the port of Galilee, and over 1,000 recreational boats moored at marinas and private docks along the shoreline during the summer season (Lee and Olsen 1985).

4. Hurricane-driven waves, storm-surge overwash, and elevated tidal currents are major processes transporting sediment and creating shoals farther into the ponds, to areas where tidal currents are usually low. This has created the subtidal shoal inside the Potter inlet as well as the intertidal and subtidal flats extending along the channel and into Bluff Hill Cove in Point Judith Pond (Friedrick 1982).

**C. Ninigret and Green Hill Ponds**

1. Ninigret and Green Hill Ponds lie on a low and level glacial river (outwash) plain separated from the ocean by low narrow barriers. As a consequence, the ponds and the lands around them are particularly susceptible to storm-surge flooding.

2. Because the beaches are sand-starved and in part because of intense recreational and development pressures, the foredune zone is low. The foredune crest is several feet below the storm-surge flood height of the 1938 and 1954 hurricanes, and overwash occurs frequently during winter storms (Olsen and Grant 1973, McGinn 1982).

3. Damage to lives and property was extensive in the hurricanes of 1938 and 1954 when storm-surge water swept over the barriers, raised the water level in the ponds 18 feet higher than normal tides, and flooded large areas around the ponds and their tributaries. The hurricane of 1938 caused in excess of $2.5 million property damage and took the lives of several people (Olsen and Grant 1973). Hurricane Carol, a less severe storm, still caused approximately $400,000 of property damage.

4. The potential for destruction is now much greater than before. There are four times as many houses around the ponds then there were in 1954. Many low areas that were open fields in 1954 are now residential communities vulnerable to flood waters and destruction from wind and wave-tossed wreckage. In 1981 there were more than 700 houses around Green Hill and Charlestown Ponds within the designated flood hazard zones (Lee and Olsen 1985). Many of the houses on the barriers were severely damaged in the blizzard of 1978 and they may be damaged again in severe winter storms of less force and more frequent occurrence (Boothroyd 1979).

5. Cleanup after a major hurricane has been and will be a very costly operation. Vast amounts of debris will once again have to be removed from the oceanfront communities and from residential developments along the inland shores of the ponds. Tons of sand and debris will have to be cleared from the roads leading to and along the barriers.

Based on past experience and the FEMA maps, damage is expected to be particularly severe on the barriers in the Tockwotten Cove area and the East Beach Road communities of Ninigret Pond (FEMA 1985). In Green Hill Pond, the most severe damage from storm-surge flooding is expected to occur on the barrier and in the communities that border the Allen Cove and the Flat Meadow Cove-Limber Point regions (FEMA 1985). Since most of the houses in the flood zones of these two ponds rely on private wells, contaminated drinking water supplies may persist long after the storm has passed.

6. As they have in the past, hurricanes are expected to cause major changes in the environment of the ponds. Previous hurricane waves and storm surge swept the sand dunes into the ponds, creating the extensive back barrier shoals that are now heavily used as shellfishing flats. At least six temporary inlets were cut through East Beach and several through Green Hill Beach in 1938. Future hurricane surges will bring large volumes of sand into the ponds, extend the surge platforms in the ponds, and accelerate shoaling of the flood tidal deltas. There are several active overwash sites along Charlestown Beach and Green Hill Beach that may become temporary inlets in the next major hurricane. It is highly likely that the stone jetties at the Charlestown breachway will again be damaged.

**D. Trustom and Cards Ponds**

1. The lands around these ponds are very low and susceptible to extensive flooding. There was nearly $2 million in property damage in the hurricane of 1938 (Olsen and Grant 1973). However, most of this land is presently open space, either publicly owned as a wildlife refuge or in private hands and used for agriculture. Future storm damage is expected to be minimal when compared to the other ponds.

**E. Winnapaug and Maschaug Ponds**

1. Due to the low elevation of the land around these ponds, the sediment starved erosional nature of the barriers and headlands, and the dense development of both residential and commercial structures on the land surrounding these two ponds, they are particularly vulnerable to storm-surge flooding. The FEMA flood map clearly shows how extensive the highest hazard flood zones are. (Figure 6-1) (FEMA 1985).

2. Of the many hurricanes that have hit Rhode Island's coast, comparative damage estimates were made for only the two most recent major ones and, in each case, the Misquamicut/Winnapaug area sustained the heaviest damage of anywhere along the south shore. Many lives were lost and properties damaged in the hurricane of 1938. The area was rebuilt and destroyed again in 1954 during Hurricane Carol. In less than half an hour, the storm-surge reduced 200 cottages, inns and businesses to rubble (Olsen and Grant 1973). Although no lives were lost, property damage was estimated to have been several million. Damages were further increased by high levels of sewage and petroleum in flood waters.

3. Natural and man-made debris will be a serious problem in the next hurricane. During the hurricane of 1938 and 1954, pieces of houses which had been on the barrier and on the Misquamicut headland, were washed across the ponds or swept through neighborhoods and acted as battering rams on houses which would have otherwise stayed intact. Much of the wreckage from Misquamicut was swept by flood waters across a mile of field and deposited at the base of Shore Road. It took weeks for emergency crews to haul away the rubble. In 1938, fallen trees delayed access to the shore after the storm (Miller 1975). On Atlantic Avenue, where washover sand was swept from the beaches and buried cars on the road, cleanup crews worked for days with heavy machinery to make the road suitable for public access.

4. Cleanup after the next major hurricane will be a much more costly operation than it was in the past. Development has more than doubled since 1954 in the flood hazard zones around these ponds. Much of the new construction is on the Misquamicut barrier and the Misquamicut headland. When structures nearest the beach are dislodged and transported by storm-surge overwash, they batter structures further inland. This includes so-called "breakaway walls" which have been shown to cause damage to other structures during severe storms, including winter storms and hurricanes. More public utilities have been built in high flood danger zones in recent years adding greatly to the cost of reconstruction. In addition to roads and power lines, there are now water mains, cable TV lines and phone lines that cross the barrier in places where surge channels broke in past hurricanes.

5. Past construction along the shore in Weekapaug and Misquamicut is increasingly vulnerable to erosion. The Misquamicut headland and the western end of the barrier have been eroding at an average rate of 2 feet per year since 1940 (Regan 1976) and the structures in these areas are therefore more vulnerable to the extreme erosion that accompanies a hurricane because they are closer to the water. During the hurricane of 1938, the high bluff at Watch Hill receded some 35 feet and the large foredunes on the Misquamicut barrier near the Weekapaug breachway receded 50 feet, all within a few hours (Olsen and Grant 1973). With the exception of the eastern end of the barrier, most of the headland and the barrier spit are much lower than the predicted storm-surge heights from another hurricane of the magnitude of the 1938 or 1954 hurricanes, and so provide little protection to communities in Misquamicut or around the pond shore. The height of the foredune crest by little Maschaug Pond is only 8 feet at mean sea level. The hurricane storm surge is predicted to be 15 to 18 feet above mean sea level along the Misquamicut headland and Atlantic Avenue.

6. As in the past, the next hurricane can be expected to bring major changes to the ponds. Sand will be transported over the barrier into the ponds. Surge channels will cut through the beach, and the inlet that formed cutting through Misquamicut Beach in the last two hurricanes can be expected to do so again (Brown 1976). Hurricane-driven waves, storm-surge overwash, and elevated tidal currents can be expected to transport sediment

and create shoals farther into the ponds.

**F. Quonochontaug Pond**

1. Quonochontaug Pond is separated from the waters of Block Island Sound by a barrier spit stretching between the headlands of Weekapaug Pond and Quonochontaug Neck. The pond and the low lands around it are very susceptible to storm-surge flooding (Figure 6-1) (FEMA 1985).

2. There has been a long history of damage to lives and property in the vicinity due to coastal flooding from hurricanes. In the hurricane of 1938 and again in 1954, substantial houses, roads, and power lines were demolished as the storm surge swept across the barrier and headlands, depositing tons of debris in the fields along the northern shore of the pond. In 1938 and again in 1954 approximately a million dollars of damage was done to construction in the high hazard zones around this pond. (Figure 6-1) (Olsen and Grant 1973).

3. In recognition of the importance of a healthy barrier, a civic group of private citizens has purchased the barrier, has restricted development, and is actively managing it to promote sustainable multiple uses. Still, the barrier is sand starved and susceptible to future overwash and frontal erosion. In the years since 1930, the west end of the barrier has been eroding at an average rate of about two feet per year (Regan 1976). Predicted surge heights for a storm like Hurricane Carol exceed the height of existing foredunes. Foredune heights on the western end of the barrier range from 8.9 to 17.3 feet above mean sea level and 22 feet on the west end, yet hurricane surge heights are expected to reach 15 to 18 feet above mean sea level on the east end and 23 feet above mean sea level on the west end (Olsen and Grant 1973, FEMA 1985).

## 610.5 Emergency Preparedness Information for the Salt Pond Region

**A. Preparations**

1. In addition to the obvious preparations of educating the public, training of emergency personnel, acquisition of adequate emergency equipment, and the installation of warning systems, there are other planning tasks communities can undertake in advance of a storm, that will minimize damage and speed recovery from a storm event. Hazard mitigation and post storm redevelopment planning are two very important steps in preparing for a major storm. Land use controls and appropriate construction standards can be applied to new construction and post storm reconstruction. Though public pressure may lean towards rebuilding to pre-storm conditions, it is important to realize the opportunity to apply setbacks, new construction standards, mitigation measures such as relocation and acquisition of unbuildable property, etc., during post-storm reconstruction.

**B. Evacuation routes**

1. An evaluation of a number of factors effecting evacuation of the south shore, including the roadway system, likely evacuation destinations, traffic, seasonal population, severity of storm, etc., was conducted by the Army Corps of Engineers for the Hurricane Evacuation Study (ACOE 1995). This transportation analysis was utilized to compose an evacuation route map that illustrates evacuation zones and shelters for each affected community. Municipal and state emergency management officials have the Inundation Map Atlas and the Evacuation Map Atlas, both products of this study, for each community. This information would be most useful if it resulted in municipal signs posting appropriate evacuation routes on roadways. It is recommended by FEMA that coastal communities use an 8 hour clearance time estimate for well-publicized daytime evacuations. Night time evacuations should allot 10 hours for clearance. In addition to the actual evacuation time, officials must add the time required for dissemination of information to the public, which can vary from community to community. It is a community decision to conduct an evacuation based on information made available to municipal officials. The ACOE recommends that the evacuation be complete before the arrival of gale-force winds. The ACOE, under a weak hurricane scenario, estimates 86,000 people in affected inundation areas for the state. In the Salt Pond Region, estimates for people in vulnerable areas under a weak hurricane scenario are 17,350 people, with an estimated population of 17,690 likely to evacuate the four towns (Table 6-1). Estimates for strong hurricane scenarios raised the number to 25,970 people vulnerable in the salt pond region, with 25,170 likely to evacuate.

**C. Shelters**

1. In order to evaluate the likely shelter populations for various areas in the SAMP jurisdiction, a behavioral analysis was performed on the population located within projected inundation zones. This “vulnerable population” categorization obviously varies depending on the strength of the storm. As stated under evacuation information, the ACOE estimates that 86,000 people are affected under weak hurricane scenarios for the state. In the salt pond region, estimates are 17,350 people in vulnerable areas, with an estimated population of 17,690 likely to evacuate the four towns. Strong hurricane scenarios estimate 25,970 vulnerable people in the salt pond region, with 25,170 people likely to evacuate. The likely demand on public shelters is 3,020 persons under weak storm conditions, and 4,140 under strong storm conditions. The total shelter capacity of the SAMP towns is 9200 people. Charlestown, however, currently has approximately thirty less spaces available than the expected demand under a severe hurricane scenario. Following is a table for further information regarding evacuation information by town (ACOE 1995).

**Table 6-1.** Town Populations, Evacuation Predictions, & Shelter Capacities (U.S. Army Corps of Engineers 1995).

| Town | Vulnerable Population | Evacuation Population | Shelter Demand | Shelter Capacity |
|---|---|---|---|---|
| **Westerly** | | | | |
| **weak** | 4,160 | 4,740 | 760 | 1,900 |
| **strong hurricane** | 7,120 | 7,130 | 1,110 | 1,900 |
| | | | | |
| **Charlestown** | | | | |
| **weak hurricane** | 1,480 | 1,820 | 500 | 600 |
| **strong hurricane** | 2,510 | 2,690 | 630* | 600 |
| | | | | |
| **South Kingstown** | | | | |
| **weak hurricane** | 5,510 | 4,820 | 1,050 | 5,600 |
| **strong hurricane** | 7,310 | 6,690 | 1,370 | 5,600 |
| | | | | |
| **Narragansett** | | | | |
| **weak hurricane** | 6,200 | 6,310 | 710 | 1,100 |
| **strong hurricane** | 9,030 | 8,660 | 1,030 | 1,100 |

* Demand greater than capacity

## D. Disaster assistance

1. Federal disaster assistance provides opportunities for post disaster hazard mitigation through funding options and technical assistance. Although most disaster assistance for public facilities is funded 75% by the federal government for restoration to pre-disaster conditions, some flexibility in funding is available that permits facilities to be rebuilt or relocated so that future vulnerability to flooding is reduced. Most of this financial assistance comes through the FEMA. In Rhode Island, the Rhode Island Emergency Management Authority (RIEMA) is responsible to the Governor for carrying out the emergency management programs in the State and for coordinating disaster response and recovery activities of state agencies and municipalities with FEMA (L.R. Johnston Associates 1986). Their basic responsibilities are:

(a) Pre-Disaster: Organization, planning, coordination, education, and training for emergency preparedness and management, including the Emergency Operations Plan (EOP).

(b) Post-Disaster: Coordinating disaster response and recovery of state agencies and municipalities with FEMA and any other necessary federal agencies, including:

(i) initial damage assessment from municipalities to assess needs and magnitude of damage;
(ii) detailed damage assessments at Governor's request for major disaster declaration by the President, if necessary;
(iii) requests for federal and state disaster assistance funds.

**E. Post-Storm Response for the Region**

1. Plans for the reconstruction of roads, bridges and other facilities should be made in conformance with current FEMA standards. In order to be eligible for federal funding to rebuild state and town roads, plans must be available before the flood damage occurs. These plans must incorporate current flood protection construction standards. Bridge reconstruction plans should be prepared for Succotash Road Bridge, Great Island Bridge, Harbor Island Bridge and causeway, the Seaweed Cove causeway (Potter Pond) and the Charlestown Beach Road bridge, including provisions for relocating or reconstructing the public water mains and power lines that cross these bridges. Local municipalities should check with RIEMA and RIDOT. The period of time following a major storm event provides a unique opportunity to incorporate hazard mitigation by not compounding the loss of the storm with the mistake of rebuilding structures in hazardous areas again. Current understanding of sediment transport, wave energy, flood zone proximity, building standards, etc., should be utilized to avoid repeat destruction (L.R. Johnston Associates 1986). Municipal and state officials can reduce future flood damages by:

(a) Discouraging development in vulnerable areas
- adopt strict construction standards or prohibit by regulation
- acquire development rights or property in vulnerable areas
- limit services and facilities to undesirable areas for building

(b) Follow appropriate building standards on new construction to minimize damages

(c) Protect natural features that provide flood protection

(d) Remove existing development from vulnerable areas
- prohibit redevelopment in same location, create setbacks
- do not replace damaged public facilities in vulnerable areas

2. As part of their emergency operations plans and/or comprehensive plans, towns should make plans for debris removal and disposal which designate disposal sites for the large volumes of debris, recognizing that landfills in three of the four towns are closed and that no offshore site has been approved. Storm debris is likely to contain sand, wood, brick, concrete, metal, furniture; as well as the potential for hazardous materials combined from households, including gas, oil, and cleaners. Temporary sites for debris storage need to be identified by each municipality, as well as a plan for burning and other long term disposal of debris. Disposal sites should be located conveniently near areas where large amounts of debris are expected to accumulate.

(a) Sites that may be considered in the Point Judith and Potter Ponds area include: Galilee—Fishermen's Memorial State Park, Upper Pond—Marina Park, Snug Harbor—Water Tower Park, Matunuck—RIDEM field north of Succotash Road, Jerusalem—land west of the State Pier.

(b) Candidate sites for the Ninigret and Green Hill area include: In Green Hill and Limber Point Area — Green Hill Beach Association parking lot, North Green Hill Pond, and Sea Lea Colony Areas — Baptist Church lot, Tockwotton Cove, Cross Mills, and East Beach Road—Naval Air Base.

3. Municipal open space acquisition committees and RIDEM should make priorities for the acquisition of features most vulnerable to storm-caused erosion and flood damage. Candidate sites include Charlestown Beach, Green Hill Beach, Matunuck Beach and the eastern end of East Matunuck Beach.

4. Within 2-3 days of a hurricane, local emergency management officials and state RIEMA officials must provide the regional FEMA office with dollar assessments of damage for prescribed categories of structures in order for the Governor to request a formal declaration of disaster from the President, and federal disaster relief funds. Local teams of experts should be organized ahead of time to assist officials in each town with these tasks (Regan 1976).

5. A fund at the state level should be established through creative sources (i.e. vanity license plates, real estate transfer tax, etc.) to purchase post-storm damaged properties to end the cycle of continual re-development of substandard, hazardous lots.

6. FEMA should consider stopping the provision of subsidizing insurance for new structures that cannot meet current erosion setbacks.

**610.6 Natural Hazard Risk Reduction through Mitigation Planning**

**A. The Rhode Island Emergency Management Authority**

1. RIEMA has developed a framework through the Rhode Island Hazard Mitigation Project to promote hazard mitigation in partnership with state and local jurisdiction to:

- C Improve the sustained hazard mitigation capability of state and local jurisdictions.
- C Improve building codes, zoning ordinances, and infrastructure design standards, and develop adequate enforcement capability to minimize risks associated with known hazards.
- C Establish public and private partnerships to promote, plan, and coordinate activities that enhance mitigation.
- C Develop an integrated, multi-hazard mitigation plan.

2. The Rhode Island Hazard Mitigation Project is based on the goals of the 1995 National Mitigation Strategy to combat the increased losses and costs due to disasters through local, state and federal agencies, the private sector and the public-at-large (Lee et al. 1996). The project is a cooperative effort between the State Hazard Mitigation Committee with assistance from the University of Rhode Island Coastal Resources Center/Sea Grant Program. The Town of Charlestown is the first pilot community to complete a local hazard mitigation plan which will be used as a model for other cities in the state.

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# Chapter 7
# Cultural and Historical Resources

## 710 Findings of Fact

### 710.1 Introduction

#### A. Historical and Cultural Resources

1. It is well documented that the Rhode Island Salt Pond Region contains numerous archaeological sites dating back 10,000 years including Native American settlements, fortifications, and historical resources. Historic and cultural resources are extremely valuable to the state's citizens and visitors for educational, recreational, and economic purposes.

2. For the past 4,000 years, the Salt Pond Region has been densely occupied. Numerous settlements, resource processing areas, and burial grounds are located around the salt ponds. Information recovered from these sites have helped archaeologists learn about the development of an horticultural economy and changes in Native American settlement patterns, and the changes which occurred in Native American culture as a result of European contact.

### 710.2 Human Interactions with the Salt Ponds

#### A. Early Activities

1. Evidence of the earliest human activity in the Salt Pond Region is an Indian fishing camp on the west side of Potter Pond which probably existed between 1000 and 500 B.C. (Lee 1980). During this time, sea level was about 10 feet lower than it is today, so the camp was most likely located on a freshwater stream that flowed out of Kettlehole Pond, which is now the upper basin of Potter Pond. There is evidence of freshwater fish but no salt water fish or shellfish in this early site (Lee 1980). The land around Potter Pond contains evidence of many other Native American sites including clusters of wigwams, presumably places where Indian people established their summer gardens. Shell middens, stone tool making areas, and burial places are also present. The Potter Pond area is designated as the Potter Pond Archaeological District by the Rhode Island Historical Preservation and Heritage Commission (RIHPHC) and represents many of the ways Indian people used the land around the salt ponds beginning around 4,000 years ago.

2. Evidence of several hundred years of shellfish gathering is present at the Charlestown

Foster Cove site on Ninigret Pond. The site was examined by archaeologists from the RIHPHC in the 1970s and found to contain at least four separate shell deposits including oyster, quahog, scallop, soft-shelled clam, mammal bone, native ceramics, and lithics including, jasper, chert, and quartz. A radiocarbon date of 1120 +/- 80 years before present was obtained from a sample of oyster shell. Today the site is listed on the National Register of Historic Places (RIHPHC in press).

3. There are two other sites of major significance for American Indian culture in the salt pond region: the Charlestown hill country and the Narragansett Indian tribal reservation. North of Route 1, in the Charlestown hill country, are many archaeological sites from the years following King Phillip's War. These sites include small, eighteenth and nineteenth-century farmsteads, represented in some cases by the foundations of houses and outbuildings, and in others by less visible depressions marking the place where a dwelling once stood. These sites are along dirt cartpaths and along roads such as King's Factory Road, Prosser Trail, and Narragansett Trail, which mark the course of more ancient Indian paths and trails. Before the 18th century, Indian people used this hill country periodically for hunting and gathering. In the years after the war, however, as much of the best farming land and fishing places were sold by the Ninigret family, many families moved into this less desirable area on a more permanent basis (RIHPHC in press).

4. As trade with the Europeans developed in the early 1600s, the Indians became an important source of wampum, which was used as legal tender by the Puritans from 1630 to 1670 (Salwen and Meyer 1978). Fort Ninigret on Fort Neck Cove in Ninigret Pond probably served as a major wampum manufacturing center during the 1600s. It also served as a defensible settlement and trading center in the polity of the Eastern Niantic Sachem Ninigret, who was one of the most influential leaders in southern New England from the 1640s to his death in 1679. The large number of wampum beads and the quantity of wampum debris found at the site suggest the important role that Ninigret's people played in the wampum trade in southern New England. Today this site is owned by the state and listed on the National Register of Historic Places (RIHPHC in press).

**E. Changing Landuses and Landscapes**

1. For at least 300 years from 1600 to 1900, the salt ponds were bountiful estuaries full of fish and shellfish, with rich agricultural lands surrounding them. The salt ponds served as important sources of food and income throughout this period. Every fall and spring residents of the Salt Pond Region would dig open the breachways to ensure the passage of migrating fish and to maintain the brackish water conditions necessary for oysters, smelt, perch, blue crabs, eels, and alewives. Other sources of food and income included trapping of muskrat, mink, otter, and fox during the 1930s (Lee 1980).

2. The salt ponds became more valuable for their recreational uses as summer visitors

from inland cities and towns began to visit during the 1800s. Narragansett Pier developed into a popular resort in the late 1800s; and in 1876, the Narragansett Pier railroad was built, which linked the pier to the main Stonington and New York line (Lee 1980). Summer cottage communities began to build up along the barrier beaches and the salt ponds were increasingly enjoyed by boaters, picnickers, painters and bathers (Lee 1980).

3. After World War II ended there was a dramatic increase in the numbers of houses built in the salt pond watersheds. The development of highways connecting Providence to the south shore provided an opportunity for commuters working in Providence to reside in the salt pond region.

## 710.3 The Rhode Island Historical Preservation and Heritage Commission

### A. Rhode Island Historical Preservation and Heritage Commission Projects

1. The RIHPHC has funded systematic archaeological surveys for Trustom and Potter Ponds. These surveys demonstrated that Potter Pond was far more densely settled than previously thought. The number of sites located on Potter Pond and the important information they contain led to the creation of the Potter Pond Archaeological District, which is listed on the National Register of Historic Places.

2. The RIHPHC has located many sites in small projects conducted in the other salt ponds, but a large scale survey of these salt ponds is needed. Surveys of Maschaug, Little Maschaug, Winnapaug, Quonochontaug, Ninigret, Green Hill, Cards, and Point Judith Ponds are a high priority of the RIHPHC. A further priority of the RIHPHC is to survey the land within the SAMP boundary area north of Route 1, which has never been extensively examined. The information derived from such surveys would enable the RIHPHC to make more informed management decisions and long term plans for the protection of the archaeological resources in the salt pond area.

3. The salt pond region also contains many significant historical sites and buildings. A full listing of historic and architectural resources for each town in the salt pond area can be found in the comprehensive town surveys conducted by the RIHPHC. These resources are important to Rhode Island's history and culture, and possess great aesthetic value. Unfortunately, many of the historical and archaeological sites in the region have been altered or destroyed. Threats to archaeological sites in the salt ponds region include erosion, development, and vandalism. It is the responsibility of the RIHPHC to review CRMC applications to ensure that archaeological resources will not be adversely effected, and to periodically monitor the condition of National Register sites. These fragile and nonrenewable resources are vital links to the past of the salt ponds area and should be recognized and protected as such, not only by those agencies who govern their use, but also by other involved regulatory bodies, as well as local residents.

4. Archaeological and historic sites provide a unique and educational quality to the resource value of the salt ponds and thus deserve consideration for protective measures. Increased public interpretation and educational programs can help to stimulate interest and assure long term appreciation and protection for these fragile resources.

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## Chapter 8
## Cumulative and Secondary Impacts

### 810. Findings of Fact

### 810.1 Introduction

#### A. Cumulative Impact Management

1. One of the criticisms of state and local coastal resource regulatory and management programs is that they are unable to protect coastal resources from incremental degradation due to a willingness to accept a little degradation with each action, the absence of a holistic ecosystem perspective, and the use of "halfway measures" that "simply forestall the inevitable" (Odum 1982, Houck 1988). The concept of cumulative impact management has been a part of our national environmental policy since 1978 when the Council on Environmental Quality (CEQ) Guidelines (40 C.F.R. §1508.9 et seq. 1978) mandated federal agencies to identify the cumulative impacts of major federal actions. Since the Coastal Zone Management Act is required to be consistent with the National Environmental Policy Act and the CEQ Guidelines, all state coastal programs are mandated to consider cumulative impacts. The 1990 amendments of the Coastal Zone Management Act of 1972 created a Coastal Zone Enhancement Program to encourage states to strengthen their coastal zone management programs in the area of cumulative and secondary impacts of development. As part of this initiative the Rhode Island CRMC undertook a Cumulative and Secondary Impact Study of Development in the Salt Pond Region and the Narrow River watersheds. Based on the findings of the Council, land use classifications, management practices, innovative technologies, and coastal ecosystem planning methods were developed as part of revisions to the SAMPs.

### 810.2 State Cumulative Impact Management

#### A. Mechanisms for Managing Cumulative Impacts

1. At least ten coastal states are involved in the process of managing and regulating for cumulative impacts through mechanisms like "mini" National Environmental Policy Acts which evaluate the environmental effects of a proposed action (Vestal and Rieser 1995). Other states like Connecticut depend on state Coastal Management Acts which contain specific policies, standards and adverse impact criteria used to evaluate direct, cumulative and secondary effects on sensitive coastal resources (Vestal and Rieser 1995). State land use planning is also used to control incremental coastal environmental impacts. Development of resource goals and long-range comprehensive plans allow communities to establish a broader context for site-specific regulatory decisions; and comprehensive

plans guide development to those areas where the least ecological damage will occur (Vestal and Rieser 1995).

**B. Managing Cumulative Impacts in Rhode Island**

1. The Rhode Island Land Development and Subdivision Review Enabling Act of 1992 (Act) implies consideration of cumulative impacts by requiring each city and town to develop land development and subdivision regulations in accordance with the community comprehensive plan, capital improvement plan, and zoning ordinance; and to ensure the consistency of all local development regulations with state agency regulations. The Act also requires that local regulations address the protection of the existing natural and built environment and the mitigation of all significant negative impacts of any proposed development on the existing environment. Each city and town in Rhode Island has the same procedure for integrating the approval of state regulatory agencies into the local review and approval process for land development and subdivision, allowing for review of potential cumulative impacts by CRMC and RIDEM. In addition, municipal Comprehensive Plans must be consistent with state agency regulations, including the CRMC Coastal Resources Management Program.

## 810.3 Recognizing Cumulative Impacts

**A. Definition**

1. Cumulative impacts can be defined as the total effect on the environment of development activities and/or natural events taking place within a geographic area over a particular period of time. They are not restricted to on-site impacts, but may include off-site impacts which exist or are going to exist based on current land use planning. Cumulative impacts can result from traditionally unregulated changes in land and water uses. For example, actions such as incremental changes in the intensity of use of a site, post-development failure to maintain septic systems, or excessive use of fertilizers may have greater impact than the original regulated activity (Vestal and Rieser 1995).

**B. Cumulative Impacts in the Salt Ponds**

1. In the Salt Pond Region, there may be many different actions occurring across the salt pond watersheds which can have a cumulative impact on both land and water resources. For instance, roads, driveways, decks and roofs from residential development all contribute to storm-water runoff in the salt ponds across the entire watershed. Individually minor alterations in impervious surfaces can be associated with sedimentation and runoff of bacteria and nitrogen to the ponds. High density development and traditional subdivisions can obscure scenic vistas and public access to the salt ponds. These changes within the salt pond watersheds impact the long-term value of the land

and its ability to sustain human, fish and wildlife populations.

2. In order to quantify the cumulative environmental impact of any single action within a group of similar or dissimilar activities it is necessary to determine the relationships between spatial and/or temporal modification of habitat and identifiable living resource losses (Ludwig et al. 1995). For instance, the cumulative impact of many ISDS in the salt pond watersheds are an increase in the amount of nitrogen to groundwater and to the salt ponds. The cumulative effect of more nitrogen in the groundwater and to the salt ponds are increases in nitrogen available to phytoplankton and macroalgae which can grow in mass quantities and shade out eelgrass beds and other aquatic vegetation. Blooms of nuisance algae can result in anoxic or hypoxic conditions where oxygen levels are completely removed or lowered resulting in lowered survival of larval fish, mortality of some species of benthic invertebrates, and loss of habitat for some mobile species of fish and shellfish that require higher concentrations of oxygen, such as lobster and codfish (EPA 1993).

## 810.4 Examples of Cumulative Impacts

### A. Cumulative impact scenarios

1. Multiple small-scale, unrelated land development changes can have even greater harmful effects on natural processes than larger-scale projects. For instance, ten single-family residences located on one acre lots with their own water hook-up, driveway, septic system and private dock can have more of an impact than a ten unit condominium project located in one large structure on a ten acre shore lot with public water, community waste-water treatment and a community dock. Area of imperviousness is decreased, less habitat is fragmented, the dock utilizes less shoreline, and the potential for shading aquatic vegetation is minimized (Vestal and Rieser 1995).

2. The effects of dredging projects, both large and small, often go far beyond the obvious direct impacts of a project. Yet the indirect and secondary effects include increased suspended loads of nutrients, a temporary reduction in phytoplankton production due to increased turbidity, and increased commercial and recreational boat traffic. Increased boat use may, in turn, lead to longer term reductions in water quality due to the discharge of oil, sewage and debris from the vessels (Vestal and Rieser 1995).

3. Increasingly, in many coastal areas the land now being proposed for development presents major site-specific challenges (Vestal and Rieser 1995). In the last twenty years development in the salt pond watersheds has increased two-fold. Areas which can accommodate growth without major effects on coastal ecosystems have already been developed and there is growing pressure to develop areas considered unsuitable for development because of wetlands, high water table, or small lot sizes. These areas are also potential critical areas for fish and wildlife. Development pressures can threaten

fragmentation of the landscape and increase sources of nonpoint source pollution for coastal waters.

## 810.5 Cumulative Impact Research in the Salt Pond Watersheds

### A. Cumulative Impact Concerns

1. There are many direct actions related to human development which occur site specifically within the salt pond watersheds. These actions were monitored over the last ten years through the development of the 1984 Salt Pond Region SAMP and the 1997 Salt Pond Region Cumulative and Secondary Impact Study. Findings of both these studies indicate existing development has already resulted in cumulative impacts with serious implications for the health of the water resources and habitat of the salt ponds. Development in the salt pond watersheds over the last forty years has resulted in an overall increase in impervious areas, ISDS, population, domestic pets, lawn fertilizers, and a decrease in vegetated buffer zones for riparian and coastal waters. The cumulative impacts of these changes are increases in the source and greater transmission of pollutants [sediments, nitrogen, phosphorus, pathogen indicators, hydrocarbons, heavy metals and road salts] to the salt ponds. It is therefore necessary that the Council consider the cumulative impacts of development when evaluating proposed projects and require appropriate measures to mitigate negative impacts, where possible.

**B. In this revision of the Salt Pond Region SAMP the Council is primarily concerned about the following land use changes and development, and the resulting cumulative impacts.**

1. Individual Sewage Disposal Systems - ISDS can typically achieve an average of only 20 percent nitrogen removal during the infiltration and percolation of septic tank effluent (Siegrist and Jenssen 1990). In densely developed areas which use ISDS as the sole form of sewage removal, nitrogen loading to groundwater can contaminate drinking water supplies. When these areas are adjacent to coastal embayments fed by groundwater springs and streams, the cumulative effect of many ISDS can also be a problem for coastal water quality, which in turn impacts aquatic vegetation, fish and shellfish habitat and the marine species food chain.

2. Impervious Areas - Increasing impervious surfaces reduces the recharge of groundwater (public water supplies), and reduces the flow of freshwater from streams to coastal waters. Groundwater recharges streams and other surface waterbodies, thereby maintaining stream flow during periods of low flow or drought conditions (EPA 1995). Modifications to the quantity or quality of groundwater discharged into surface water ecosystems can have major economic repercussions as a result of adverse impacts on recreation, public health, fisheries, and tourism (EPA 1995). Groundwater is the principal

source of freshwater to the salt ponds and is responsible for defining the basic ecology of these estuaries (Lee and Olsen 1985). Groundwater either directly discharges into the ponds up through the bottom sediment, through springs along the edges of the ponds, or discharges into streams which then flow into the ponds (Grace and Kelley 1981). Groundwater is the only source of public drinking water for the Ninigret, Green Hill, Trustom, Cards and Potter Pond watersheds. Flushing and salinity gradients are largely dependent on stream flow and groundwater input to the ponds (Deason 1982). A reduction in freshwater recharge would increase salinity levels in the ponds which could affect fish and shellfish distributions. Most importantly, flushing would be reduced, accentuating the pollution problems which already exist (Deason 1982).

3. Stormwater Runoff - Increasing impervious areas impacts the potential quantity and quality of stormwater runoff. Stormwater runoff can carry sediments, nutrients, oxygen-demanding substances, road salts, heavy metals, petroleum hydrocarbons and pathogenic bacteria and viruses. Stormwater discharges to coastal waters and tributary streams increases as impervious areas increase within the watershed. Pathogens carried in stormwater runoff from storm drains are flushed into the salt ponds during storm events and are responsible for high levels of bacteria contamination and shellfish harvesting closures.

4. Vegetation Removal and Soil Erosion - Buffer zones or vegetated areas adjacent to water resources are important landscape features which help to prevent erosion and control the transport of sediment into adjacent wetlands and water bodies. Buffer zones are valuable for removing pollutants and excess nutrients from surface water runoff and in some cases from the underlying groundwater. Residential and commercial development removes considerable areas of vegetation from the landscape and increases impervious areas. The cumulative effects of many individual unvegetated areas can result in increased sedimentation to the coastal ponds, and less removal of pollutants from surface and groundwater.

5. Dredging the Stabilized Breachways and Tidal Deltas - The permanent alteration of the breachways and associated dredging have changed the ecology, chemistry and biology of the salt ponds by increasing the rate at which sand accumulates within them and altering their salinity and flushing characteristics (Lee 1980). In Ninigret and Green Hill Ponds, the stabilization of the Charlestown breachway in 1962 radically changed the ecology in the ponds, depleting the formerly productive estuarine fisheries (Olsen and Lee 1982). Shoaling caused by the Charlestown breachway is believed to reduce tidal circulation in Ninigret and Green Hill ponds (Olsen and Lee 1982). Although it is a popular belief that greater water exchange between the lagoons and the ocean will enhance water quality as well as fisheries and promote the use of lagoons for boaters, dramatic changes to the breachways to increase flushing can have undesirable effects on the ecology and use of the ponds. Maintenance dredging of the breachways and associated tidal deltas is necessary to maintain the current recreational uses of the salt ponds, and

proper planning is needed to manage the cumulative impacts of intensified recreational boating.

6. Barrier Beach and Flood Zone Development - Development on barrier beaches and in flood zones increases the risk of life and property loss during storms and storm surges. The Salt Pond Region is susceptible to storm-surge flooding with damage to public buildings, utilities, roads, and engineered structures for shoreline protection. Although the storm surge areas of the Salt Pond Region are relatively small, they hold a disproportionate number of residents in their boundaries. It is important that setbacks, new construction standards, and mitigation measures such as relocation and acquisition of unbuildable property are applied during post-storm reconstruction. Development in flood storage areas, in particular around the Misquamicut/ Winnapaug Pond area, has reduced the capacity for flood storage.

7. Residential Activities - Fertilizer, pesticide and household chemicals all have the potential to enter groundwater or contribute to storm water runoff from many individual residential lots. These sources of nonpoint pollution are increasing in the salt pond watersheds with each new development. Controls on the use of lawn and garden fertilizers, pesticides and chemicals are necessary to limit the potential cumulative impacts of many residential activities. Domestic pets are also a concern because they provide a source of nitrogen to groundwater and surface water runoff.

8. Marinas, Docks, and Recreational Boating - Marinas and boats can introduce heavy metals, petroleum hydrocarbons, solvents, antifreeze, antifouling agents, nutrients, bacteria, floatable/plastics, and creosote from pilings (Lee and Olsen 1985, Amaral et al. 1996). Vessel discharge of sewage has been correlated with unsafe increases in fecal coliform bacteria during high boat-use times (Gaines and Solow 1990, Amaral et al. 1996). Chromated copper arsenate (CCA), used as a wood preservative, can accumulate in biota and sediments, and is considered a priority pollutant by the EPA. Docks can also impact eelgrass beds and other submerged aquatic vegetation. The height of a dock above the bottom and the orientation of the dock are two major independent factors affecting the survival of eelgrass beds beneath and adjacent to docks (Burdick and Short 1995). Jet skis and boat propellers can damage eelgrass beds and contribute to erosion of the shoreline by increasing wave action in the salt ponds.

9. Public Water and Sewer Facilities - The experience of many communities nationwide is that sewer systems encourage high density development and increase runoff contamination of adjacent water bodies (Pye et al. 1983, RI Programs for the Environment 1982). In the Salt Pond Region there could be several cumulative and secondary impacts from the construction of water and sewer lines to accommodate existing and proposed development. Once an area is sewered, many of the constraints that limit development may disappear. Sites which have soils which do not meet percolation standards or minimum depth to groundwater requirements can support new development provided

they have sewers available. Frequently these are also the few areas of the watershed that remain undeveloped and consequently provide buffer zones for critical habitats of fish and wildlife or water quality. Further development of public water systems for expanding development can alter the groundwater hydrology of the salt pond watersheds. A public water supply system that draws from the watershed of one salt pond and exports it to the watershed of another alters the flow of freshwater to both salt ponds.

10. Wetland Alteration - Wetlands perform important hydrologic, water quality, and habitat functions, which can be stressed by small changes or impacts. Alteration of wetland hydrology or sediment budgets, increased surface runoff through ditching, and wetland conversion to agricultural fields or developable lots are just some of the examples where small alterations can result in a cumulative impact on the wetland or where ecological functions of the wetland are lost (EPA 1992). The continental United States has lost over 50% of the original wetlands since the founding of the nation, primarily through draining and filling. Residential development has the potential to impact the ecological function of the remaining freshwater wetlands through draining and filling. Many of the wetland resources in the salt pond watersheds are hydrologically linked to the salt ponds via small streams which carry organisms, nutrients and organic detritus produced within the upland watersheds of the salt ponds. These wetlands also serve as habitat for wildlife, and retain flood waters and runoff pollutants during storms.

11. Noise and Lighting Impacts on Habitat - Elevated light and noise can be a problem for wildlife around the salt pond watersheds. The cumulative effect of noise and lighting from many residential lots and increased recreational uses may discourage nesting by shore birds and breeding for many wildlife species.

**810.6 The outcome of cumulative impacts: cumulative effects on the salt pond ecosystem**.

**A. Cumulative impacts increase the amount and strength of pollutants entering the salt pond watersheds and the salt ponds; fish and wildlife habitat is degraded and fragmented; and the aesthetic and recreational values of the region are reduced. The following pollutants and physical disturbances are the result of cumulative impacts.**

1. Sediments. Suspended sediments constitute the largest mass of pollutant loadings to surface waters (EPA 1993). Immediate adverse impacts of high concentrations of sediment are increased turbidity, reduced light penetration and decreases in submerged aquatic vegetation (Chesapeake Bay Local Government Advisory Committee 1988), reduced prey capture for sight-feeding predators, impaired respiration of fish and aquatic invertebrates, reduced fecundity, and impairment of commercial and recreational fishing resources.

2. Nutrients. Excessive nutrient loading to marine ecosystems can result in eutrophication and depressed dissolved oxygen levels due to elevated phytoplankton populations. Eutrophication-induced hypoxia and anoxia have resulted in fish kills and widespread destruction of benthic habitats (EPA 1993). Surface algal scum, water discoloration, and the release of toxins from sediment may also occur. Species composition and size structure for primary producers may be altered by increased nutrient levels (EPA 1993, GESAMP 1990).

3. Pathogen indicators. Fecal coliform bacteria provide evidence that an estuary is contaminated with fecal material that may contain pathogenic bacteria and viruses harmful to people. Often, the pathogenic viruses and bacteria do not adversely impact aquatic life, such as fish and shellfish. However, shellfish may accumulate bacteria and viruses that cause human diseases when ingested. Therefore, officials restrict shellfish harvesting in contaminated waters to protect public health. Pathogen indicators also impair swimming uses because some pathogenic bacteria and viruses can be transmitted by contact with contaminated water (EPA 1994). Nationwide, 37% of shellfish waters are limited or restricted due to pathogens related to septic systems and 38% due to urban runoff (EPA 1993).

4. Hydrocarbons and Heavy Metals. Petroleum hydrocarbons are derived from oil products, which originate with auto and truck engines that drip oil. Many do-it-yourself auto mechanics dump used oil directly into storm drains (Klein 1985). Concentrations of petroleum-based hydrocarbons are often high enough to cause mortalities in aquatic organisms (EPA 1993). Oil and grease contain a wide variety of hydrocarbon compounds. Some polynuclear aromatic hydrocarbons (PAHs) are known to be toxic to aquatic life at low concentrations. Hydrocarbons have a high affinity for sediment, and they collect in bottom sediments where they may persist for long periods of time and result in adverse impacts on benthic communities. Lakes and estuaries are especially prone to this phenomenon (EPA 1993).

5. Road Salts. In northern climates, road salts can be a major pollutant. Klein (1985) reported on several studies by various authors of road salt contamination in lakes and streams and cases where well contamination had been attributed to road salts in New England. Snow runoff produces high salt/chlorine concentrations at the bottom of ponds, lakes and bays. Not only does this condition prove toxic to benthic organisms, but it also prevents crucial vertical spring mixing (Bubeck et al. 1971, Hawkins and Judd 1972). There are no accurate estimates of road salt loading to groundwater or the salt ponds.

6. Loss of Aquatic Habitats. Eelgrass (Zostera marina) habitat in the salt ponds is disappearing as a result of increased phytoplankton and macroalgae growth from excessive nutrient loading. Over the last 32 years the areal extent of eelgrass beds in Ninigret Pond declined by 41 percent (Short et al. 1996). This decline in eelgrass

habitat is strongly correlated to the increases in the density of residential development in the salt pond watersheds. Eelgrass is important habitat for bay scallops, winter flounder, and several crab species; the loss of eelgrass beds will negatively impact these valuable fin and shellfish. Loss of aquatic grass beds due to nutrient loading is a major issue in the Chesapeake Bay where the striped bass fishery declined with the loss of this critical habitat (Kemp et al. 1983).

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# Chapter 9
# Regulations

## 900. Introduction

### A. The Rhode Island Coastal Resources Management Program

1. The Rhode Island Coastal Resources Management Program (RICRMP) should be referred to for specific regulatory requirements on buffers, setbacks, subdivisions, recreational docks, barrier beach development, beach replenishment and any other activities which occur within the Salt Pond Region.

### B. Application Process

1. The RICRMP has three categories of applications: Category A, B and A*:

    (a) Category A activities are routine matters and activities of construction and maintenance work that do not require review of the full Council if four criteria are met: buffer zone compliance, abutter agreement, and proper state and local certifications.

    (b) Category A* applications are put out to public notice for the benefit of the abutters to the affected property and local and state officials.

    (c) Category B applications are reviewed by the full Council and the applicant must prepare in writing an environmental assessment of the proposal that addresses all of the items listed in Section 300.1 of the RICRMP and any additional requirements for Category B applications listed for the activity in question.

2. A Category A review may be permitted for A* activities provided that the Executive Director of CRMC determines that all criteria within Section 110.1 A of the RICRMP and the relevant SAMP requirements and prerequisites are met. The proposed activity shall not significantly conflict with the existing uses and activities and must be considered to be a minor alteration with respect to potential impacts to the waterway, coastal feature, and areas within RICRMP jurisdiction.

3. The following activities which occur within the Salt Pond Region require a CRMC assent (application approval).

    (a) Activities within 200 feet of a coastal feature (see RICRMP for specific category). (Category A, A*, B)

    (b) Watershed Activities (specific activities taking place within the SAMP watershed).

(i) New subdivisions of 6 units or more, or re-subdivision for a sum total of 6 units or more on the property proposed after March 11, 1990 irrespective of ownership of the property or the length of time between when units are proposed. (Category B)

(ii) Development requiring or creating more than 40,000 square feet of total impervious surface. (Category A*/B)

(iii) Construction or extension of municipal, private residential hook-ups to existing lines, or industrial sewage facilities, conduits, or interceptors (excluding onsite sewage disposal systems outside the 200' zone). Any activity or facility which generates or is designed, installed, or operated as a single unit to treat more than 2,000 gallons per day, or any combination of systems owned or controlled by a common owner and having a total design capacity of 2,000 gallons per day. (Category A*/B)

(iv) Water distribution systems and supply line extensions (excluding private residential hook-ups to existing lines). (Category A*/B)

(c) All roadway construction and upgrading projects. (Category A*/B)

(d) Development affecting freshwater wetlands in the vicinity of the coast. (Category A/B)

4. For projects involving the following, refer to Section 320 of the RICRMP for the appropriate category.

(a) Construction or extension of public or privately owned sanitary landfills.

(b) New mineral or aggregate (sand/gravel) mining.

(c) Processing, transfer, or storage of chemical and hazardous materials.

(d) Electrical generating facilities of more than 40 megawatts capacity.

(e) All commercial in-ground petroleum storage tanks of more than 2,400 barrels capacity, all petroleum processing and transfer facilities [residential prohibited].

(f) Proposed new or enlarged discharges (velocity and/or volume) to tributaries, tidal waters, or 200' shoreline feature contiguous area.

(g) Solid waste disposal.

(h) Desalination plants.

In addition to the activities listed above, if the Council determines that there is a reasonable probability that the project may impact coastal resources or a conflict with the SAMP or RICRMP, a Council Assent will be required in accordance with all applicable sections of this program.

5. All applicants shall follow applicable requirements as contained in the RICRMP, including any specific requirements listed under water types in section 200 and additional Category B requirements in Section 300, the requirements and prerequisites in Section 320 for Inland Activities, and any regulations in this SAMP chapter.

6. Applicants proposing the above listed activities are required to submit the following with their applications:

(a) A Stormwater Management Plan prepared in accordance with Section 300.6 and as described in the most recent version of the *Rhode Island Stormwater Design and Installation Manual*,

(b) An Erosion and Sediment Control Plan prepared in accordance with the standards contained in Section 300.2.

(c) An Existing Conditions Site Map and a Proposed Final Site Map as required in Section 320 of the RICRMP and as specified in the section for Site Plan Requirements in the *Rhode Island Stormwater Design and Installation Standards Manual*.

7. Preliminary determinations may be filed for any project by the municipality or the applicant. Preliminary determinations provide advice as to the required steps in the approval process, and the pertinent ordinances, regulations, rules, procedures and standards which may be applied to the proposed development project. Any findings and recommendations resulting from this preliminary review shall be utilized if the applicant returns to file a full assent request for the project, and will be forwarded to the Council as part of the staff reports for major development plans. Applicants for Category B activities within the SAMP watershed are required to utilize the Council's Preliminary Determination process in accordance with applicable requirements of the Land Development and Subdivision Review Enabling Act (G.L.R.I. 45-23-25 et seq.). Where the Council finds there is a potential to damage the coastal environment, the Council will require that suitable modification to the proposal be made.

**B. Variances and Special Exceptions are granted by the Council under section 120 and 130 of the RICRMP respectively.**

1. Applicants desiring a variance from a standard must make the request in writing and address five criteria:

(a) The proposed alteration conforms with applicable goals and policies in Parts Two and Three if the RICRMP.

(b) The proposed alteration will not result in significant adverse environmental impacts or use conflicts.

(c) Due to conditions at the site in question, the standard will cause the applicant an undue hardship.

(d) The modification requested by the applicant is the minimum necessary to relieve an undue hardship.

(e) The undue hardship is not the result of any prior action of the applicant.

The application is only granted an assent if the Council finds that the above criteria are met.

2. Special exceptions may be granted to prohibited activities to permit alterations and activities that do not conform with a Council goal for the areas affected or which would otherwise be prohibited by the requirements of the RICRMP only when the applicant has demonstrated that:

(a) The proposed activity serves a compelling public purpose which provides benefits to the public as a whole as opposed to individual or private interests. The activity must be one or more of the following: (1) an activity associated with public infrastructure such as utility, energy, communications, transportation facilities; (2) a water-dependent activity that generates substantial economic gain to the state; and/or (3) an activity that provides access to the shore for broad segments of the public.

(b) All reasonable steps shall be taken to minimize environmental impacts and/or use conflict.

(c) There is no reasonable alternative means of, or location for, serving the compelling public purpose cited.

**C. Coordinated Review with Municipalities**

1. Under the Subdivision Review Act, one or more pre-application meetings shall be held for all major land developments or subdivision applications (Land Development and Subdivision Review Enabling Act, G.L.R.I. 45-23-25 et seq.). Pre-application meetings may be held when a preliminary determination is filed with the CRMC, or informally when the municipality requests information from CRMC. All major land development projects as defined under the act and residential subdivisions of 6 units or more shall be considered major land development plans and should file a preliminary determination request with CRMC. The purpose of these meetings is to:

X Identify and discuss major conflicts and possible design alterations or modifications to obviate conflicts.

X Discuss the likely onsite impacts of alternatives or modifications and on the ecosystem as a whole.

X Ensure that there is consensus among the regulatory agencies on any changes, and that conflicts with permit requirements do not arise.

**D. Federal Consistency**

1. Activities involving a direct or indirect federal activity (includes activities that require a federal permit, such as an Army Corps of Engineers Permit) also require Council review in accordance with the Federal Consistency process contained in the Section 307 of the Coastal Zone Management Act. The Council has developed a handbook to assist those subject to Federal Consistency review. Persons proposing an activity involving a direct or indirect federal activity are referred to the most recent version of this handbook.

**E. Coastal Nonpoint Pollution Control Program**

1. Section 6217 of the Coastal Zone Management Act amendments of 1990, required each coastal state with a federally approved coastal management program to develop and submit a Coastal Nonpoint Pollution Control Program (CNPCP) to the EPA and the National Oceanic and Atmospheric Administration (NOAA) by July 1995. Rhode Island's CNPCP, developed by the RIDEM, the Department of Administration and the CRMC, applies to four general land use activities: agriculture, urban (new development, septic systems, roads, bridges, highways, etc.), marinas, and hydromodifications. There are also management measures to protect wetlands and riparian areas, and to promote the use of vegetative treatment systems (EPA 1993).

**910.1 Municipal Responsibility**

**A. The Town officials and administration involved in construction, approval of construction and/or regulations regarding the zoning, density, and build-out of development are the municipal arm of this SAMP.**

1. Local authorities are responsible for applying the regulations and land use policies to ensure proper application of this plan. Towns should exercise particular consideration of subdivisions because of the potential impacts from stormwater, sewage disposal, infrastructure demands, and decreased open space.

CRMC evaluates projects that fall under this plan as referenced earlier, even if development is not completed all at once. A developer still falls under the CRMC major subdivision review conditions upon additional construction. Stormwater concerns, sewage disposal concerns, buffers, etc. may be difficult to accommodate with the addition of new lots. Therefore it is important for municipalities to apply SAMP regulations to initial development of a subdivision.

## 920. Water Quality

### A. Introduction

1. The evidence presented in Chapter 3 Water Quality indicates that water quality continues to be degraded in the Salt Pond Region due to existing residential sources of nitrogen and bacteria. Although research conducted at the University of Rhode Island suggests a correlation between housing density and the symptoms of eutrophication in the salt ponds, there is no clear nitrogen loading threshold which CRMC can apply to each individual activity and development. Accordingly, CRMC addresses nitrogen loading through conservative land use regulations and nitrogen reducing technologies.

2. The installation and operation of nitrogen removal systems is permissible under the RIDEM *Rules and Regulations Establishing Minimum Standards Relating to Location, Design, Construction and Maintenance of Individual Sewage Disposal Systems.* CRMC requires nitrogen removal systems as noted in Table 9-1 and in Section 920.1.

3. In addition to the impacts of nitrogen, other nonpoint sources of pollution like sediment from erosion and road runoff, petroleum hydrocarbons from vessel engines and road salts are also a concern. As impervious areas increase within the salt pond watersheds these pollutants have a greater potential to reach coastal waters.

4. Table 9-1 summarizes the Land Use Classification System, with the requirements for nitrogen reducing technologies, buffer zone and setback requirements. The CRMC land use classification maps which regulate land use densities and other activities in the SAMP region follow Section 920.1. The following are the definitions, policies, regulations and recommendations which correspond to the three CRMC land use classifications.

**Table 9-1.** CRMC Land-Use Classification Requirements for Density, Setbacks, Buffer Zones and Nitrogen Reducing Technologies for activities within 200' of a coastal feature and all watershed activities as defined in Section 900.B.3 and 900.B.4.

| Land-Use Classification | Definition | Coastal Buffer Zone Requirement[1] | Construction Setback Requirement[1] | ISDS Setback Requirement[1] | Nitrogen Reducing Technology Requirement[1,2] |
|---|---|---|---|---|---|
| **Developed Beyond Carrying Capacity** | Lands developed or undeveloped at < 80,000 square feet [SE or Var] | Coastal buffer based on RICRMP §150 [Var] | Coastal buffer plus 25' | Nitrogen reducing technology required [SE, Var] | New ISDS installations or alteration [4] [SE, Var] |
| **Critical Concern** | Lands developed or undeveloped at 120,000 square feet and have sensitive salt pond or watershed resources [SE or Var] | 200' [SE or Var] | Coastal buffer plus 25' | 225' [SE, Var] | Lands subdivided after adoption of SAMP that do not meet the CRMC density requirement and substandard lots of record [SE, Var]. |
| **Self-Sustaining** | Lands developed, undeveloped at 80,000 square feet [SE or Var] | 150' [SE or Var] | Coastal buffer plus 25' | 200' [SE, Var] | Lands subdivided after adoption of SAMP that do not meet the CRMC density requirement and substandard lots of record [SE, Var]. |

[SE or Var] indicates if relief from the requirement or regulations requires a Special Exception, Variance or both.

[1] CRMC Land-Use Classification Requirements for Density, Setbacks, Buffer Zones and Nitrogen Reducing Technologies are for activities within CRMC jurisdiction (See Section 900.B.3 and 900.B.4)

[2] A Special Exception is required for relief from the density requirement, coastal buffer, construction setback, ISDS setback or nitrogen reducing technology requirement unless the lot is preplatted (see Section 920.1, Land Use Classification for Watershed Protection), and cannot accommodate the requirement.

[3] Nitrogen reducing technologies are alternative wastewater systems which can reduce total nitrogen concentrations by at least 50%.

[4] As defined by the Rhode Island Department of Environmental Management, Rules and Regulations establishing Minimum Standards Relating to Location, Design, Construction and Maintenance of Individual Sewage Disposal Systems, as amended.

* A grace period will be allowed for applicants who have ISDS applications pending and/or approved, with assigned ISDS file numbers, by the RIDEM Division of Water Resources ISDS Section prior to April 12, 1999. These applications will not be subject to the requirements contained herein. Applications accepted by RIDEM Division of Water Resources ISDS Section on or after April 12, 1999 shall be subject to the requirements contained herein.

**920.1 Land Use Classification for Watershed Protection**
**(See Figures 9-1, 9-2, 9-3 and 9-4)**

**A. Self-Sustaining Lands**

1. Definitions

(a) Self-Sustaining Lands are undeveloped or developed at a density of not more than one residential unit per 80,000 square feet. Within these areas, the nutrients discharged to groundwater by septic systems, fertilizers and other sources associated with residential activities may be sufficiently diluted to maintain on-site potable groundwater. However, the one residential unit per two acre standard is not considered sufficient to reduce groundwater nitrogen concentrations to levels which will prevent eutrophication, or mitigate for dense development in other portions of the watershed.

(b) A tributary is any flowing body of water or watercourse which provides intermittent or perennial flow to tidal waters, coastal ponds, coastal wetlands or other down-gradient watercourses which eventually discharge to tidal waters, coastal ponds or coastal wetlands.

(c) Tributary wetlands are freshwater wetlands within the watershed that are connected via a watercourse to a coastal wetland and/or tidal waters.

(d) Land suitable for development shall be defined as the net total acreage of the parcel, lot or tract remaining after exclusion of the areas containing, or on which occur the following protected resources: coastal features as defined within Chapter 46-23 GLRI and/or the CRMP Section 210; freshwater wetlands, as defined in the RIDEM Freshwater Wetlands Rules and Regulations, including the 50' Perimeter Wetland, and the CRMC *Rules and Regulations Governing the Protection and Management of Freshwater wetlands in the Vicinity of the Coast* and lands to be developed as streets and roads shall also be excluded from the calculated acreage of developable land. The division of a tract, lot or parcel not subject to municipal regulation under the provisions of Chapter 45-23 *et seq*, for the reasons set forth therein, shall remain subject to the jurisdiction of the requirements of Chapter 46-23 *et seq*, the RICRMP and this section.

(e) Nitrogen reducing technologies are alternative wastewater treatment systems which reduce total nitrogen concentrations by at least 50%. Total nitrogen reduction is the annual mean difference by percentage between total nitrogen concentrations in the effluent of the septic or primary settling tank and the concentrations taken at the end of the treatment zone as defined by the specific technology.

2. Policies and Regulations

(a) Subdivisions (as defined in Section 325 of the RICRMP) shall not exceed an average density of one residential unit per 80,000 square feet for Self-Sustaining Lands. For the purposes of this section, the allowable number of units in conformance with this standard shall be calculated on the basis of available land suitable for development. Land suitable for development shall be defined as the net total acreage of the parcel, lot or tract remaining after exclusion of the areas containing, or on which occur the following protected resources: coastal features as defined within Chapter 46-23 GLRI and/or the CRMP Section 210; freshwater wetlands, as defined in the RIDEM Freshwater Wetlands Rules and Regulations, including the 50' Perimeter Wetland, and the CRMC *Rules and Regulations Governing the Protection and Management of Freshwater wetlands in the Vicinity of the Coast*. The division of a tract, lot or parcel not subject to municipal regulation under the provisions of Chapter 45-23 *et seq*, for the reasons set forth therein, shall remain subject to the jurisdiction of the requirements of Chapter 46-23 *et seq*, the RICRMP and this section.

(b) The number of allowable units in a cluster shall be calculated on the basis of lands suitable for development within the subdivision as defined above in Section 920.1A.1.d and in accordance with all local ordinances.

(c) Any major land development project or any major subdivision of land (as defined in RIGL 45-23 et. seq.) within Self-Sustaining Lands, occurring after November 27, 1984, must meet the minimum density requirement of one residential unit per 80,000 square feet. Relief from this regulation requires a Special Exception as defined in Section 130 of the RICRMP. Lands which were subdivided prior to November 27, 1984, and do not meet the CRMC density requirement as defined in Section 920.A.1, require a Variance as defined in Section 120 of the RICRMP.

(d) Nitrogen reducing technologies as defined in Section 920.1.A.1.e are required for any lands subdivided after April 12, 1999 that do not meet the CRMC density requirement (80,000 square feet) for activities within 200' of a coastal feature and all watershed activities as defined in Section 900.B.3 and 900.B.4. Relief from this regulation requires a Special Exception as defined in Section 130 of the RICRMP, unless the lands were subdivided prior to April 12, 1999 and cannot accommodate the requirement. A nitrogen reducing technology cannot be used as mitigation to increase dwelling densities on parcels which can support the density requirement.

(e) A minimum 200' setback from the salt ponds, their tributaries, and coastal wetlands, including tributary wetlands, is required for ISDS in Self Sustaining Lands for activities within 200' of a coastal feature and all watershed activities as defined in Section 900.B.3 and 900.B.4. Relief from this regulation requires a Special Exception as defined in Section 130 of the RICRMP, unless the lands were subdivided prior to April 12, 1999 and cannot accommodate the requirement.

(f) A 150' buffer zone from the salt ponds, their tributaries, and coastal wetlands, including tributary wetlands, is required for activities within 200' of a coastal feature and all watershed activities as defined in Section 900.B.3 and 900.B.4 in Self Sustaining Lands. Relief from this regulation requires a Special Exception as defined in Section 130 of the RICRMP, unless the lands were subdivided prior to November 27, 1984 and cannot accommodate the requirement.

(g) The installation of sewers is prohibited, unless all of the following conditions are met:

(i) the property meets the RIDEM regulatory siting requirements for the installation of a conventional ISDS,

(ii) the proposal is agreeable to both the town and the CRMC,

(iii) a deed restriction is attached to the property ensuring no further subdivision, and

(iv) the properties to be sewered are within 500 feet of an existing sewer line or are within a subdivision which abuts the sewer easement.

(h) Public water service is considered a low priority. When new public water supplies are proposed, the source wells and the distribution lines shall remain within a single watershed and not divert groundwater from one salt pond watershed to another.

(i) The Council recognizes that in areas abutting the salt ponds, their tributaries and other critical resource areas, existing nitrogen reducing technologies may not be sufficient to reduce groundwater nitrogen concentrations to levels which will prevent further eutrophication in the salt ponds. If new technology improves the nitrogen removal capability of these systems and new research indicates the need for further nitrogen removal, CRMC will reevaluate the need for increased nitrogen removal.

3. Recommendations

(a) Some lands, as presently zoned by the towns, may not meet the density requirements for Self Sustaining Lands (80,000 square feet) or Lands of Critical Concern (120,000 square feet). In such cases the CRMC will require the towns to be consistent with CRMC density requirements, where possible, during CRMC review of town zoning changes to the Comprehensive Plan.

(b) The Council recommends the use of cluster development as a means to preserve open space, agricultural lands and aesthetic qualities, reduce impervious surfaces and the costs of development, and minimize the environmental impacts of development.

(c) For activities outside CRMC jurisdiction but within the SAMP boundaries, CRMC strongly recommends that the towns adopt CRMC regulations for ISDS setbacks and nitrogen reducing technologies as identified in Table 9-1.

(d) The Council recommends the use of wastewater management districts and the protocols established in the Rhode Island Septic System Inspection Handbook for septic system inspection and pump-out to limit the occurrence of failed on-site sewage disposal systems.

**B. Lands of Critical Concern**

1. Definitions

(a) Lands of Critical Concern are presently undeveloped or developed at densities of one residential unit per 120,000 square feet. These lands may be adjacent to or include one or more of the following:

- X sensitive areas of the salt ponds that are particularly susceptible to eutrophication and bacterial contamination;
- X overlie wellhead protection zones or aquifer recharge areas for existing or potential water supply wells;
- X areas designated as historic/archaeologic sites;
- X open space;
- X areas where there is high erosion and runoff potential;
- X habitat for flora and fauna as identified through the Natural Heritage Program, large emergent wetland complexes, and U.S. Fish & Wildlife lands; and
- X fisheries habitat.

(b) A tributary is any flowing body of water or watercourse which provides intermittent or perennial flow to tidal waters, coastal ponds, coastal wetlands or other down-gradient watercourses which eventually discharge to tidal waters, coastal ponds or coastal wetlands.

(c) Tributary wetlands are freshwater wetlands within the watershed that are connected via a watercourse to a coastal wetland and/or tidal waters.

(d) Land suitable for development shall be defined as the net total acreage of the parcel, lot or tract remaining after exclusion of the areas containing, or on which occur the following protected resources: coastal features as defined within Chapter 46-23 GLRI and/or the CRMP Section 210; freshwater wetlands, as defined in the RIDEM Freshwater Wetlands Rules and Regulations, including the 50' Perimeter Wetland, and the CRMC *Rules and Regulations Governing the Protection and Management of Freshwater wetlands in the Vicinity of the Coast* and lands to be developed as streets and roads shall also be excluded from the calculated acreage of developable land. The division of a tract, lot or parcel not subject to municipal regulation under the provisions of Chapter 45-23 *et seq*, for the reasons set forth therein, shall remain subject to the jurisdiction of the requirements of Chapter 46-23 *et seq*, the RICRMP and this section.

(e) Nitrogen reducing technologies are alternative wastewater treatment systems which reduce total nitrogen concentrations by at least 50%. Total nitrogen reduction is the annual mean difference by percentage between total nitrogen concentrations in the effluent of the septic or primary settling tank and the concentrations taken at the end of the treatment zone as defined by the specific technology.

2. Policies and Regulations

(a) Subdivisions (as defined in Section 325 of the RICRMP) shall not exceed an average density of one residential unit per 120,000 square feet for Lands of Critical Concern. For the purposes of this section, the allowable number of units in conformance with this standard shall be calculated on the basis of available land suitable for development. Land suitable for development shall be defined as the net total acreage of the parcel, lot or tract remaining after exclusion of the areas containing, or on which occur the following protected resources: coastal features as defined within Chapter 46-23 GLRI and/or the CRMP Section 210; freshwater wetlands, as defined in the RIDEM Freshwater Wetlands Rules and Regulations, including the 50' Perimeter Wetland, and the CRMC *Rules and Regulations Governing the Protection and Management of Freshwater wetlands in the Vicinity of the Coast*. The division of a tract, lot or parcel not subject to municipal regulation under the provisions of Chapter 45-23 *et seq*, for the reasons set forth therein, shall remain subject to the jurisdiction of the requirements of Chapter 46-23 *et seq*, the RICRMP and this section.

(b) The number of allowable units in a cluster shall be calculated on the basis of lands suitable for development within the subdivision as defined above in Section 920.1.B.1.d and in accordance with all local ordinances.

(c) Any major land development project or any major subdivision of land (as defined in RIGL 45-23 et. seq.) within Lands of Critical Concern, occurring after April 12, 1999, must meet the minimum density requirement of one residential unit per 120,000 square feet. Relief from this regulation requires a Special Exception as defined in Section 130 of the RICRMP. Lands which were subdivided prior to April 12, 1999, and do not meet the CRMC density requirement as defined in Section 920.A.1, require a Variance as defined in Section 120 of the RICRMP.

(d) Nitrogen reducing technologies as defined in Section 920.1.A.1.e are required for any lands subdivided after April 12, 1999 that do not meet the CRMC density requirement for Lands of Critical Concern (120,000 square feet) for activities within 200' of a coastal feature and all watershed activities as defined in Section 900.B.3 and 900.B.4. Relief from this regulation requires a Special Exception as defined in Section 130 of the RICRMP, unless the lands were subdivided prior to April 12, 1999 and cannot accommodate the requirement. A nitrogen reducing technology cannot be used as mitigation to increase dwelling densities on parcels which can support the density requirement.

(e) Lands of Critical Concern which are also zoned for 80,000 square feet by municipal zoning regulations may be developed at densities of one residential unit per 80,000 square feet only if a nitrogen reducing technology is used as the method of sewage removal. [In the event that a property has frontage on a sewer line then hooking up to the sewer will be mandatory].

(f) A minimum 225' setback from the salt ponds, their tributaries, and coastal wetlands, including tributary wetlands, is required for ISDS in Lands of Critical Concern for activities within 200' of a coastal feature and all watershed activities as defined in Section 900.B.3 and 900.B.4. Relief from this regulation requires a Special Exception as defined in Section 130 of the RICRMP, unless the lands were subdivided prior to April 12, 1999 and cannot accommodate the requirement.

(g) A 200' buffer zone from the salt ponds, their tributaries, and coastal wetlands, including tributary wetlands, is required for all development activities within 200' of a coastal feature and all watershed activities as defined in Section 900.B.3 and 900.B.4 in Lands of Critical Concern. Relief from this regulation requires a Special Exception as defined in Section 130 of the RICRMP, unless the lands were subdivided prior to November 27, 1984 and cannot accommodate the requirement.

1. Activities permitted within the buffer strip may include various management options consistent with CRMC's Buffer Zone Management Guidance, and, in Type 2 waters, one dock per lot of record as of November 27, 1984.

2. Activities prohibited within the buffer strip include sewage disposal systems or leach fields, surfaced roadways, culverts, bulkheads, riprap and lawns. Fertilizers shall not be applied within the buffer zones except where necessary to establish vegetation in areas that are eroding or need to be restored.

(h) The installation of sewers is prohibited, unless all of the following conditions are met:

(i) the property meets the RIDEM regulatory siting requirements for the installation of a conventional onsite sewage disposal system,

(ii) the proposal is agreeable to both the town and the CRMC,

(iii) a deed restriction is attached to the property ensuring no further subdivision; and

(iv) the properties to be sewered are within 500 feet of an existing sewer line or are within a subdivision which abuts the sewer easement.

(i) Public water service is considered a low priority. When new public water supplies are proposed, the source wells and the distribution lines shall remain within a single watershed and not divert groundwater from one salt pond watershed to another.

(j) The Council recognizes that in areas abutting the salt ponds, their tributaries and other critical resource areas, existing nitrogen reducing technologies may not be sufficient to reduce groundwater nitrogen concentrations to levels which will prevent further eutrophication in the salt ponds. If new technology improves the nitrogen removal capability of these systems and new research indicates the need for further nitrogen removal, CRMC will reevaluate the need for increased nitrogen removal.

3. Recommendations

(a) Some lands, as presently zoned by the towns, may not meet the density requirements for Lands of Critical Concern (120,000 square feet). In such cases the CRMC will require the towns to be consistent with CRMC density requirements, where possible, during CRMC review of town zoning changes to the Comprehensive Plan.

(b) The Council recommends the use of cluster development as a means to preserve open space, agricultural lands and aesthetic qualities, reduce impervious surfaces and the costs of development, and minimize the environmental impacts of development.

(c) Lands of Critical Concern should be priority areas for additional measures to minimize pollution loadings from development through municipal, state or federal acquisition for open space and conservation easements and/or tax relief and aquifer protection ordinances.

(d) For activities outside CRMC jurisdiction but within the SAMP boundaries, CRMC strongly recommends that the towns adopt CRMC regulations for ISDS setbacks and nitrogen reducing technologies as identified in Table 9-1.

(e) The Council recommends the use of wastewater management districts and the protocols established in the Rhode Island Septic System Inspection Handbook for septic system inspection and pump-out to limit the occurrence of failed on-site sewage disposal systems.

## C. Lands Developed Beyond Carrying Capacity

1. Definitions

(a) Lands Developed Beyond Carrying Capacity are developed at densities of one residential or commercial unit on parcels of less than 80,000 square feet, and frequently at higher densities of 10,000 square feet or 20,000 square feet. Intense development associated with Lands Developed Beyond Carrying Capacity is the result of poor land use planning and predates the formation of the Council. High nutrient loadings and contaminated runoff waters from dense development have resulted in a high incidence of polluted wells and increased evidence of eutrophic conditions and bacterial contamination in the salt ponds. Most of the ISDS in these areas predate RIDEM regulations pertaining to design and siting standards, and have exceeded their expected life span.

(b) A tributary is any flowing body of water or watercourse which provides intermittent or perennial flow to tidal waters, coastal ponds, coastal wetlands or other down-gradient watercourses which eventually discharge to tidal waters, coastal ponds or coastal wetlands.

(c) Tributary wetlands are freshwater wetlands within the watershed that are connected via a watercourse to a coastal wetland and/or tidal waters.

(d) Land suitable for development shall be defined as the net total acreage of the parcel, lot or tract remaining after exclusion of the areas containing, or on which occur the following protected resources: coastal features as defined within Chapter 46-23 GLRI and/or the CRMP Section 210; freshwater wetlands, as defined in the RIDEM Freshwater Wetlands Rules and Regulations, including the 50' Perimeter Wetland, and the CRMC *Rules and Regulations Governing the Protection and Management of Freshwater wetlands in the Vicinity of the Coast* and lands to be developed as streets and roads shall also be excluded from the calculated acreage of developable land. The division of a tract, lot or parcel not subject to municipal regulation under the provisions of Chapter 45-23 *et seq*, for the reasons set forth therein, shall remain subject to the jurisdiction of the requirements of Chapter 46-23 *et seq*, the RICRMP and this section.

(e) Nitrogen reducing technologies are alternative wastewater treatment systems which reduce total nitrogen concentrations by at least 50%. Total nitrogen reduction is the annual mean difference by percentage between total nitrogen concentrations in the effluent of the septic or primary settling tank and the concentrations taken at the end of the treatment zone as defined by the specific technology.

2. Policies and Regulations

(a) Nitrogen reducing technologies as defined in Section 920.1.C.1.e are required for all new installations or replacement of existing ISDS for activities within 200' of a coastal feature and all watershed activities as defined in Section 900.B.3 and 900.B.4 in Lands Developed Beyond Carrying Capacity. Relief from this regulation requires a Special Exception as defined in Section 130 of the RICRMP, unless the lands were subdivided prior to April 12, 1999 and cannot accommodate the requirement.

(b) Regular maintenance and, when necessary, the upgrading of ISDS are of the highest priority in unsewered densely developed areas.

(c) Densely developed lands on Great Island and Harbor Island in Narragansett and at the northern end of Point Judith Pond in South Kingstown are in close proximity to existing sewer lines; in these areas extension of sewer service is a priority.

(d) Public water service is a high priority for Lands Developed Beyond Carrying Capacity because of the high incidence of poor groundwater quality in these densely developed areas. When new public water supplies are proposed, the supply wells and service areas for public water supplies shall be kept within individual watersheds. The export of groundwater from one watershed to another should be minimized.

(e) For existing development, buffer zones along the perimeter of salt ponds, their tributaries and tributary wetlands, and other shoreline features shall be required in accordance with Section 150 of the RICRMP, as amended. For new development, buffers shall be an absolute minimum of 25' in width. Variances to the buffer standard shall be consistent with the conditions for relief in Section 150 of the RICRMP.

(f) The Council recognizes that in areas abutting the salt ponds, their tributaries and other critical resource areas, existing nitrogen reducing technologies may not be sufficient to reduce groundwater nitrogen concentrations to levels which will prevent further eutrophication in the salt ponds. If new technology improves the nitrogen removal capability of these systems and new research indicates the need for further nitrogen removal, CRMC will reevaluate the need for increased nitrogen removal.

3. Recommendations

(a) Undeveloped areas previously platted at extremely high densities are priority areas for amendments to zoning ordinances and other actions to provide for reduced density, i.e, a minimum of 80,000 square feet.

(b) For activities outside CRMC jurisdiction but within the SAMP boundaries, CRMC strongly recommends that the towns adopt CRMC regulations for nitrogen reducing technologies as identified in Table 9-1.

(c) The Council recommends the use of wastewater management districts and the protocols established in the Rhode Island Septic System Inspection Handbook for septic system inspection and pump-out to limit the occurrence of failed on-site sewage disposal systems.

**D. Research Needs**

1. Watershed boundary clarifications.

(a) The watershed boundary around Silver Lake in South Kingstown needs to be identified as part of the Narrow River watershed or Point Judith Pond. Groundwater flow data will need to be collected around the pond to complete the analysis.

(b) The watershed boundary around Wakefield in the Town of South Kingstown needs to be corrected for the tidal portions of the Saugatucket River and a decision needs to be made about what parts of the Saugatucket River to include in the watershed boundary for Point Judith Pond.

2. The impacts of road salt, pesticides and petroleum hydrocarbons in stormwater runoff to the salt ponds needs to be assessed and the conclusions included as an addendum to the SAMP.

Figure 9-1. Land Use Classification System for the Town of Westerly.

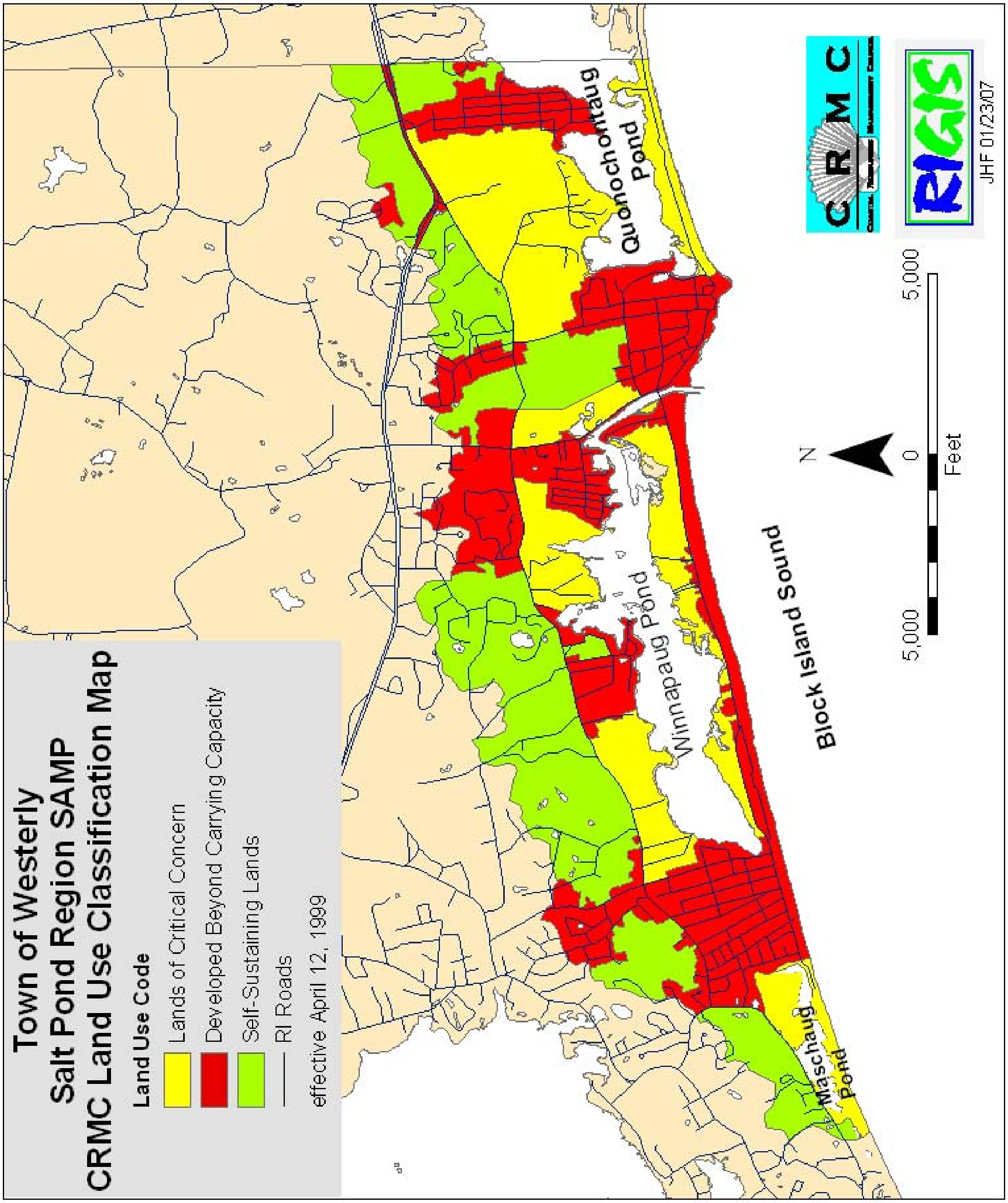


Figure 9-2. Land Use Classification System for the Town of Charlestown.

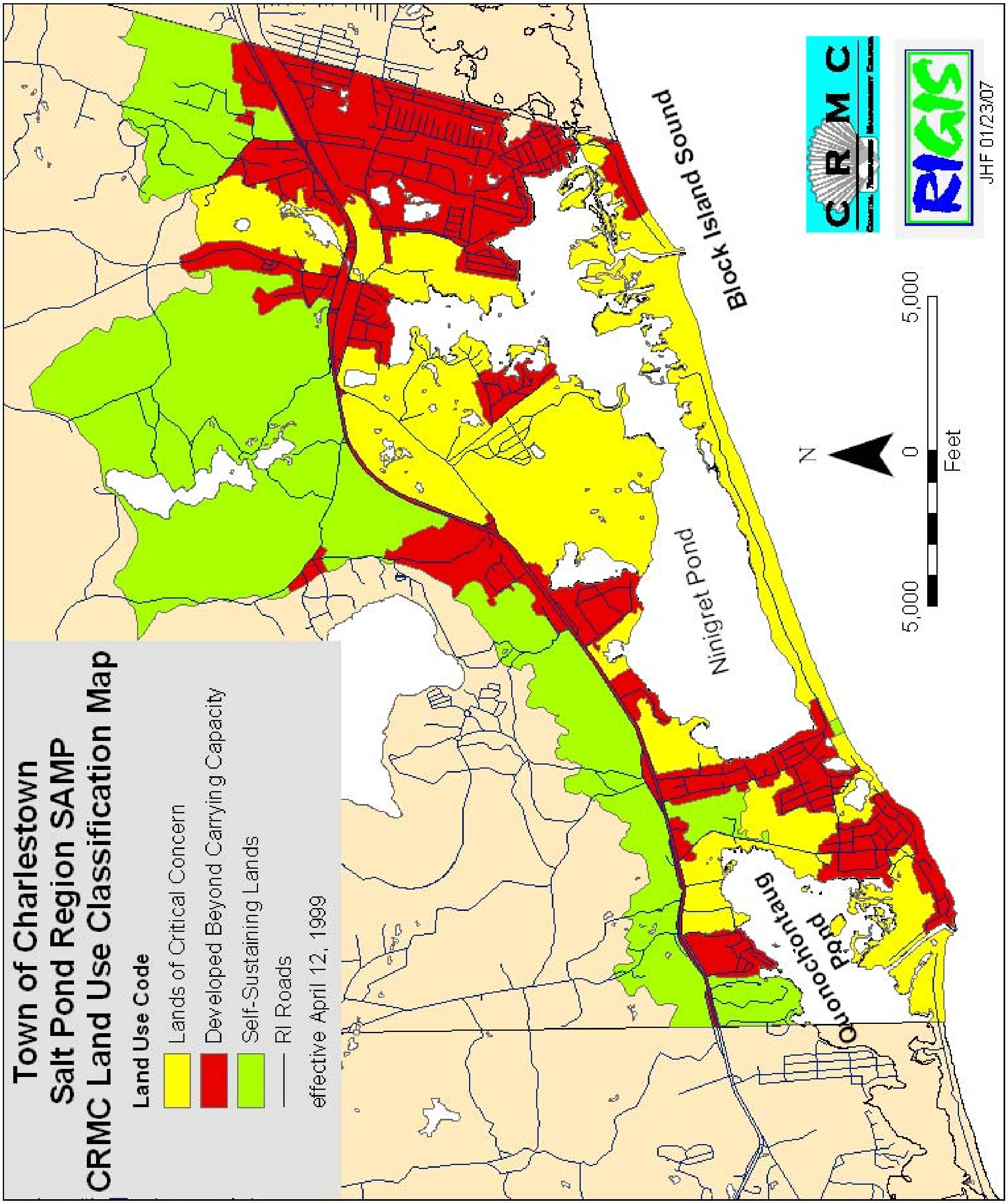


Figure 9-3. Land Use Classification System for the Town of South Kingstown.

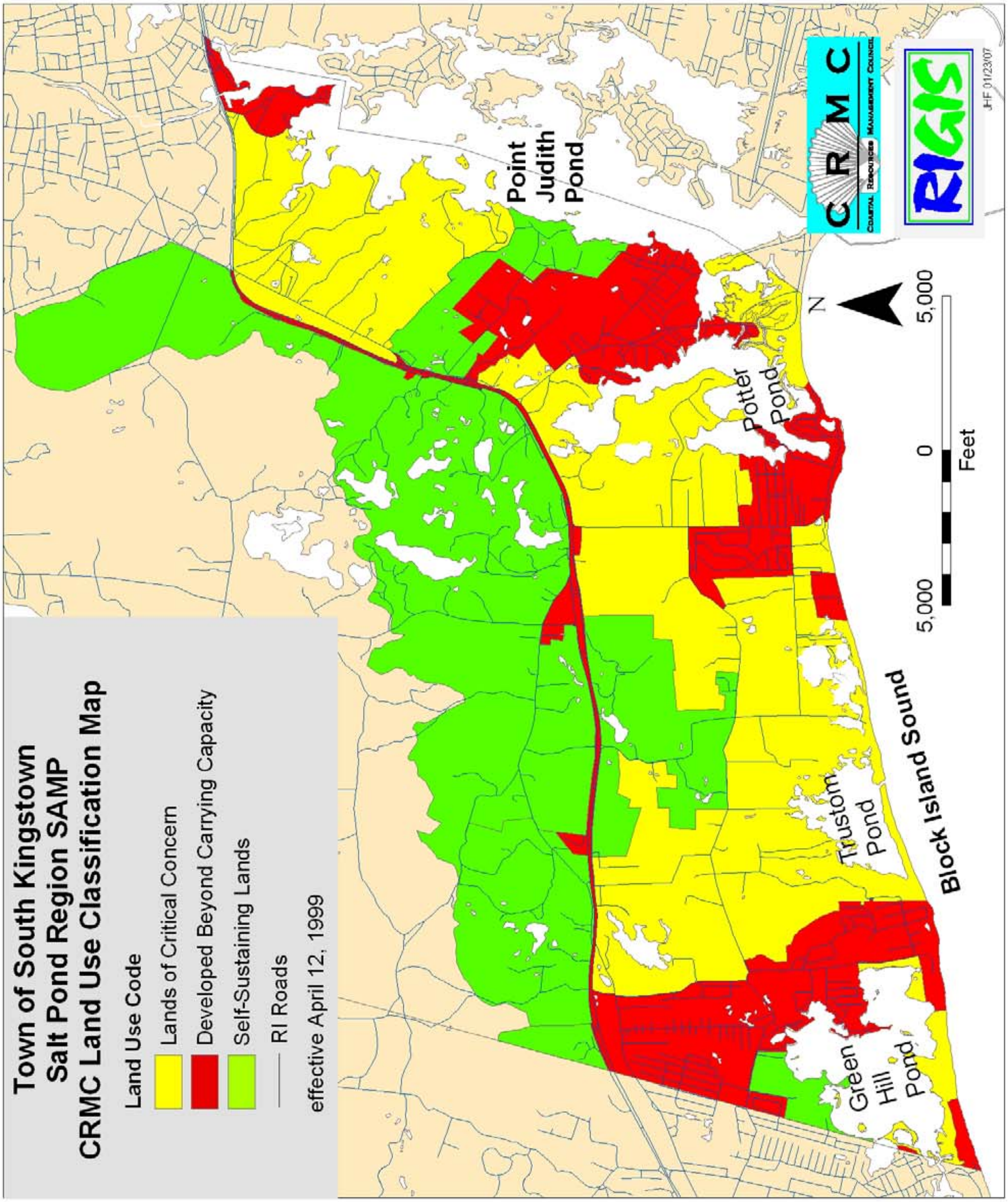
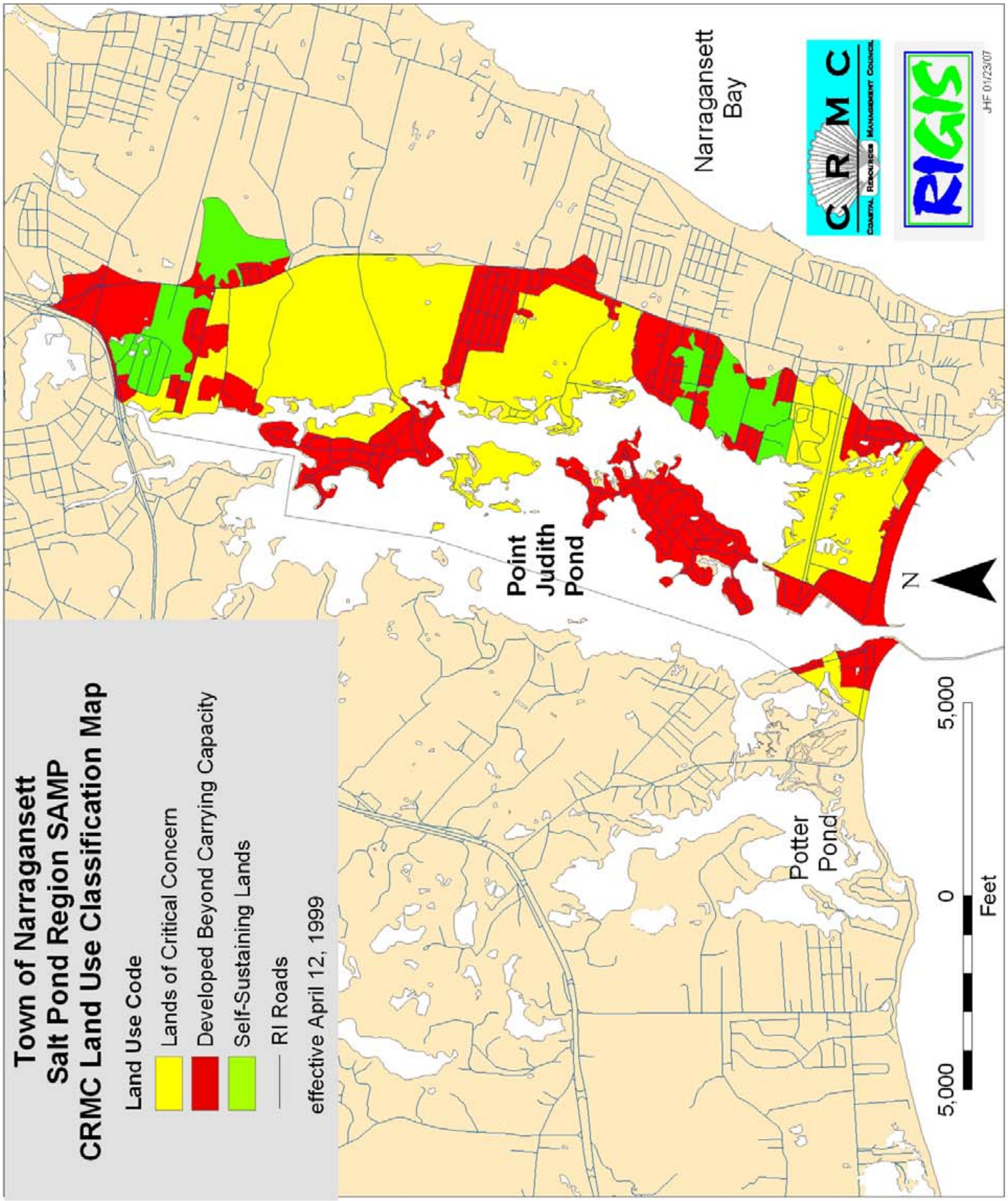


Figure 9-4. Land Use Classification System for the Town of Narragansett.



## 920.2 Control of Pollution from Storage Tanks

1. Definitions

(a) Underground Storage Tanks (UST) include any one or more underground tanks and their associated components, including piping, used to contain an accumulation of petroleum product or hazardous material.

2. Policies and Regulations

(a) Except for propane and compressed natural gas, burial of domestic USTs is prohibited in the Salt Pond Region.

(b) Commercial USTs must meet all current state standards and applicants must apply for a CRMC permit. Applicants must demonstrate an adequate construction design and means for monitoring for leakage, and shall replace all leaking tanks according to RIDEM regulations.

3. Recommendations

(a) CRMC recommends that homeowner's close their petroleum USTs by contacting RIDEM and following the proper procedures as indicated in the RIDEM UST regulations.

## 920.3 Oil Spills

### A. Contingency Plans

1. Oil spills shall be treated in accordance with the Rhode Island Oil Spill Contingency Guide (RIDEM 1980).

2. Point Judith and Potter Ponds. A spill in lower Point Judith Pond should be contained within the port area. However, there are both substantial fishing boat traffic and strong currents in the port which will complicate oil cleanup operations. In many cases the best practical containment strategy if oil enters the lower pond will be to divert oil to the shore on the Jerusalem side of the channel. Every effort shall be made to keep the oil from entering Potter Pond through Gooseberry Hole or East Pond under the Great Island Bridge.

3. Ninigret and Green Hill Ponds. Every effort shall be made to deflect an offshore oil spill away from the breachway and the ponds and toward the ocean beaches. The fast currents in the breachway make it a difficult place to deploy booms or mops. If oil cannot be kept out of the breachway, it should be contained along the banks just inside the breachway where the channel widens and currents are slower. A boat launch ramp and access for heavy equipment are available from the parking lot on the east side. Sand from the area should be used to block small channels and create impoundments.

4. Trustom and Cards Ponds. Since these ponds are only temporarily breached, there is less

danger of oil entering them. However, if a spill occurs when the breachways are open, every effort should be made to fill them in with sand from the adjacent beach.

5. Quonochontaug Pond. Every effort should be made to deflect an offshore oil spill from the breachway of the pond, and toward the ocean beaches. The fast currents in the breachway and the boulders off the mouth make it a difficult place to deploy booms. If oil cannot be kept out of the breachway, containment booms and mops may be deployed in the dogleg of the breach or where the breachway empties into the pond and currents start to dissipate. Oil should be deflected toward the tidal creaks in nearby salt marshes instead of being allowed to spread throughout the pond. Launching facilities for small boats and access for heavy equipment are available on the eastern side of the breachway.

6. Winnapaug Pond. Every effort should be made to deflect an offshore oil spill from the breachway of the pond, and toward the ocean beaches. The fast currents in the breachway (4 knots) make it a difficult place to deploy booms for containment and cleanup. If oil cannot be kept out of the breachway, efforts should be made to use booms or barriers to protect the large salt marsh along the pond's southern shoreline and to prevent the oil from spreading westward into the large basin of the pond.

## 930. Geologic Processes

### A. Introduction

1. The findings of fact presented in Chapter 4, Geologic Processes, identify the resources and management problems associated with human use and alteration of the breachways, barriers and headlands along the south shore.

## 930.1 Dredging Navigation Channels and Basins

### B. Policies

1. Dredging in the salt ponds is appropriate for the breachway sediment basins and as needed for habitat restoration in the deltas.

2. It is compatible with this plan to manage the level of water in Maschaug Pond and to remove excess stormwater in a manner which does not threaten the stability of the beach.

3. Improvement dredging for navigation in Point Judith Pond shall be confined to the harbor area designated by the Narragansett Pier Quadrangle Map in the CRMP, Figure 9-5 and defined as follows:

(a) A line running southerly from the southern end of the eastern jetty of the Point Judith Pond breachway and following the eastern side of the navigation channel, as designated by the U.S. Army Corps of Engineers, to the East Gap of the Harbor of Refuge.

(b) A line running generally southerly along the seaward side of the western jetty and breakwater of the Harbor of Refuge.

(c) A line running generally northerly and then westerly 200 feet into the pond and parallel to the Galilee bulkhead to the southwestern end of the Great Island bridge.

(d) A line running generally northerly along the Jerusalem shoreline 200 feet into the pond and parallel to state-owned property.

(e) A line along the eastern side of the Great Island bridge.

(f) A straight line running from the western tip of Little Comfort Island to the eastern tip of High Point.

(g) A straight line from the border between the RL80 and open space zones on Gooseberry Island westerly to the boundary between the open space and commercial zones southerly of Kenport Marina on Succotash Road.

(h) A line running south from Gooseberry Road across Gooseberry Hole to the northern-most tip of Gooseberry Island.

4. Applicants for Assents to dredge in the port area shall demonstrate to the CRMC that the action will not cause significant sedimentation outside the Point Judith Port area, particularly in Bluff Hill Cove and the segment of Potter Pond adjacent to the Gooseberry Hole inlet.

5. The preferred option for the disposal of sands dredged from lower Point Judith Pond is replenishment of the Sand Hill Cove and East Matunuck beaches in the configuration shown in Figure 9-6.

6. In Potter Pond, non-navigational dredging shall be limited to habitat restoration and enhancement. Dredging to restore flow at the following sites is a priority, since it will restore water circulation and salt marsh habitat in areas adversely affected by port filling:

(a) Potter Pond-Succotash Salt Marsh tidal channels as indicated in Figure 9-5
(b) Segar Cove-Seaweed Cove Causeway
(c) Stone Bridge over Buckie Brook

7. Breaching of coastal ponds in general, may be appropriate under various circumstances to restore habitat and improve drainage. Breaching requests will be handled on a site-by-site basis and evaluated on proposed benefits versus drawbacks, including impacts due to the time of year. RIDEM Fish and Wildlife shall be consulted for any proposed breaching project.

8. Other habitat restoration and enhancement projects shall be undertaken only after an evaluation of the impacts has been made by a competent coastal geologist, biologist, and engineer, and it is demonstrated that the project conforms to the management goals for this Plan.

Figure 9-5. The port area of Point Judith Pond.

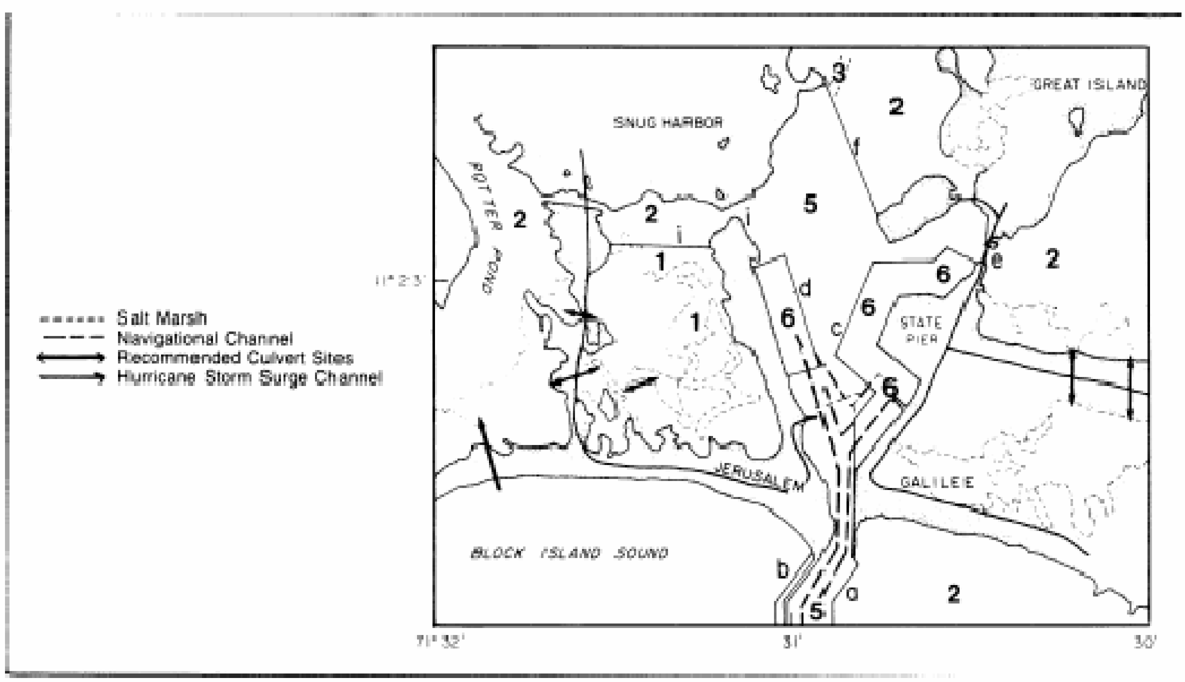



**Figure 9-5.** The port area of Point Judith Pond. Numbers denote water use caegories as defined in Section 200 of the RICRMP. Letters denote boundary line designations. These supercede the designations in the RICRMP and are defined in Section 930.1C.2 of this SAMP.

Figure 9-6. Design for Berm, Foredune, Bluff, and Dike Replenishment.

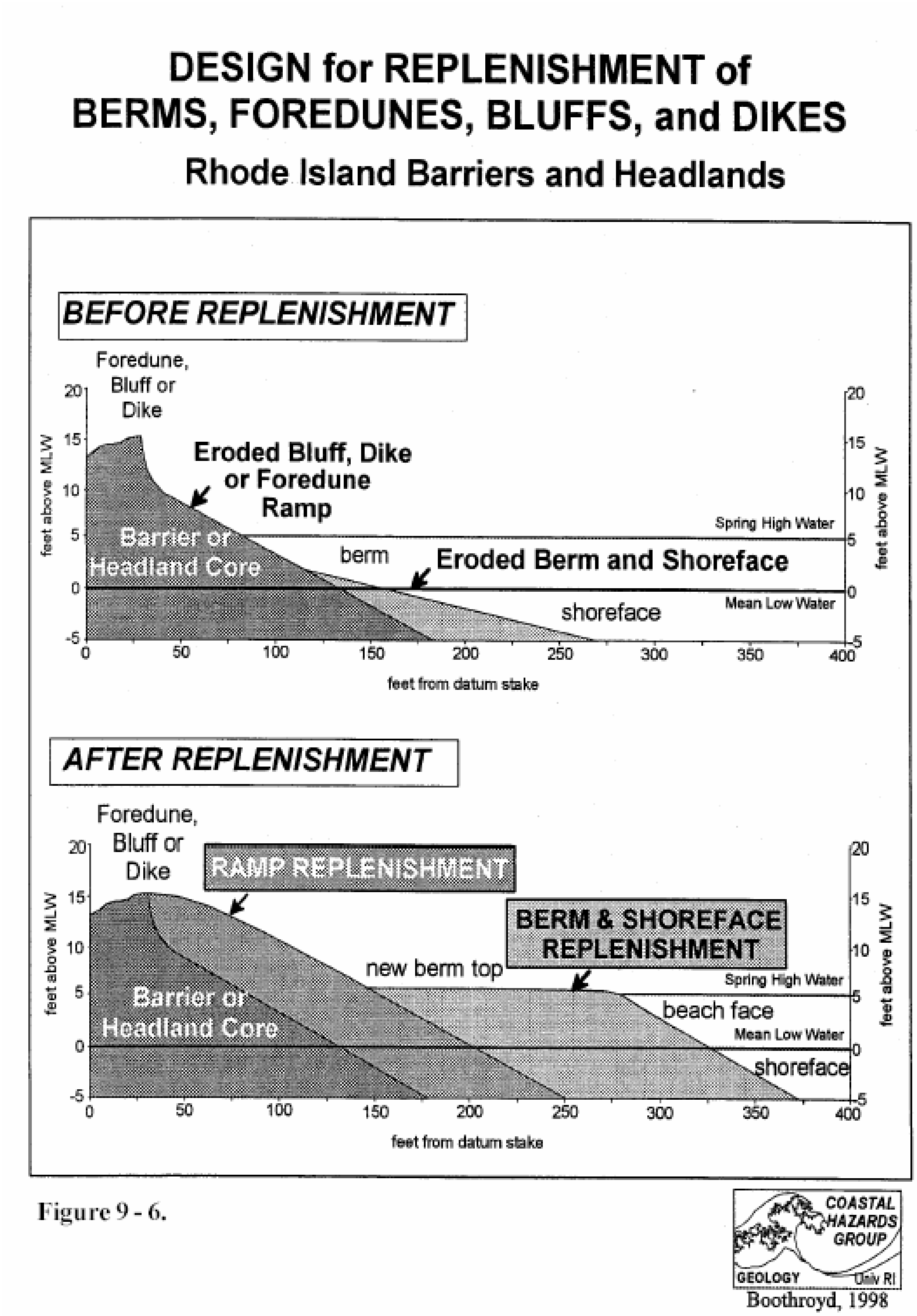



Figure 9 - 6.

Boothroyd, 1998

### C. Prohibitions

1. All dredging for navigational purposes is prohibited in Potter Pond.

2. In Ninigret and Green Hill Ponds, non-navigational dredging shall be prohibited unless limited to habitat restoration and enhancement. Such projects may be undertaken only after an evaluation of the impacts has been made by a competent coastal geologist and biologist and it is demonstrated that the project conforms to the objectives of this Plan.

3. All dredging activities in or adjacent to Cards Pond are prohibited by the Council except where the purpose is to (a) permit more efficient seasonal flushing between Cards Pond and the ocean, or (b) improve or restore fish habitats in Cards Pond Stream. Habitat restoration may be undertaken only after an evaluation of the impacts has been made by a competent coastal geologist and biologist and it is demonstrated that the project conforms to the objectives of this Plan.

### D. Standards

1. Maintenance dredging of the channel from Snug Harbor to Ram Point in Point Judith Pond shall be limited to the channel as shown on NOAA Nautical Chart 13219 with a maximum depth of 5 feet below mean low water. Particular care shall be taken to avoid damage to known winter flounder spawning sites (See Chapter Five) in the upper pond. Dredging of the channel and the upper pond shall be avoided during the January through March flounder spawning season.

2. Bulkheads and piers may be constructed on state-owned property north of the state pier at Jerusalem (See Figure 9-5) and widening the present channel to the west sufficiently to service new docks along the bulkhead. A new bulkhead shall not extend eastward of the mean high water mark, since filling will force the existing ebb spit farther into the navigation channel. Depths of the access channel and new berthing areas shall not exceed 15 feet.

3. The access channel to Snug Harbor and High Point may be increased to a depth of 15 feet.

4. The present Galilee turning basin may be extended to the west and south as indicated in Figure 9-5.

5. The channel along the north side of the Galilee bulkhead may be deepened to a maximum of 10 feet to permit berthing of larger vessels.

6. Bulkheads or piers may be constructed on the state-owned property on Great Island (see Figure 9-5) and the area between the bulkhead and the channel dredged to a depth not exceeding 10 feet.

7. Channel dredging in Ninigret Pond shall be limited to the restoration and maintenance of a single channel no more than 30 feet wide and 3 feet deep up the center of the tidal channel and across the flood-tidal delta, and of a channel no more than 2 feet deep and 12 feet wide to Creek Bridge through Tockwotten Cove. Such channels must follow the winding path of the

major existing channel at that time. The channel across the tidal delta may be maintained only when the catch basin has accumulated less than 50 percent of its capacity of sand.

## E. Municipal and State Recommendations and Initiatives

1. Sediment and Breachways

(a) A sediment catch basin on the north side of the Ninigret breachway should be maintained. The design plans implemented in 1985 indicate a basin with a maximum depth of 10 feet and a capacity of 10,000 cubic yards. Sand removed from the basin should be used to replenish Charlestown Beach. Sand should be placed on the beach in the configuration shown in Figure 9-6.

(b) Frequent breaching of Cards Pond by the U.S. Fish and Wildlife Service is encouraged during summer months to help alleviate eutrophic conditions and reduce bacterial contamination.

(c) The outlet breachway of Cards Pond should be opened in the evening hours during the summer bathing season in order to minimize possible safety hazards in this popular beach area. Lifeguards should be given notice so they can extend patrols to cover the breachway.

(d) The U.S. Fish and Wildlife Service is encouraged to consider more frequent breachings of Trustom Pond. This could improve the growth of macrophytes preferred by waterfowl and, if accompanied by appropriate data collection, would provide much needed data on the effects of increased flushing and salinity on a hypereutrophic system.

(e) Municipal and state transportation planners should develop plans for road maintenance projects that account for washover and sea level rise. These plans should elevate the road bed and adjust the drainage to account for these factors. Perpetual re-establishment of low-lying roadways creates floodways and encourages perpendicular driveways to meet the substandard grade, thus creating surge channels for storm overwash and flooding.

(f) There is considerable information suggesting that substitution of a permanent channel between Potter Pond and Gooseberry Hole with a seasonal breachway directly to the Sound adversely affected the fish and shellfish populations in Potter Pond. If a major storm or hurricane forms a new breachway between Potter Pond and the Sound which remains open after the storm, it should not be filled in until salinity and tidal-current measurements, and other measurements deemed necessary, have been made to determine the effects of a direct connection to the Sound. Such information can be used to evaluate whether a seasonal breachway to the Sound, combined with a tide gate at Succotash Bridge results in water quality and habitat improvements.

(g) Establish a public education and outreach position within the town government to disseminate information on coastal erosion (among other topics) to the general public, especially coastal landowners and real estate agents dealing in coastal properties. Short publications or pamphlets distributed to shorefront property owners would aid compliance with CRMC regulations and make citizens better caretakers of the coastal zone.

**F. Research Needs**

1. There is a need for better understanding the correlation between oceanographic forces and shoreline response. With knowledge of the wave climate and surge elevations and currents during storms and the subsequent sediment transport, the effects of hurricanes and severe winter storms could be better predicted. The Council should approach the Rhode Island Sea Grant program and the NOAA Coastal Services Center to initiate research.

2. The Council supports the funding of the ongoing collection and maintenance of shoreline change data including regular updates of shoreline change rates and continuation of the beach profile network.

## 940. Living Resources and Critical Habitats

**A. Introduction**

1. The Findings of Fact as presented in Chapter 5, Living Resources and Critical Habitats identify the history of overfishing and habitat degradation in the Salt Pond Region. There are over a hundred species of finfish and shellfish which utilize the salt ponds at some stage in their life cycle. The most popular species, the quahogs, oysters and flounder are all declining. The habitat on which these fish and shellfish species depend is also declining; eelgrass loss in Ninigret Pond alone was 40 percent over the last thirty-two years (Short et al. 1996). Other habitat fragmentation occurs within the salt pond watersheds and is impacting wildlife species like the Piping Plover, a federally listed endangered species.

**B. Definitions**

1. Tributary wetlands are freshwater wetlands within the watershed that are connected via a watercourse to a coastal wetland and/or tidal waters.

2. A tributary is any flowing body of water or watercourse which provides intermittent or perennial flow to tidal waters, coastal ponds, coastal wetlands or other down-gradient watercourses which eventually discharge to tidal waters, coastal ponds or coastal wetlands.

**C. Policies**

1. It is CRMC policy to consider the trends and status of fish and wildlife species and their habitats within the region when making decisions about development and recreational uses.

2. Winter flounder spawning grounds shall not be disturbed during the December-May spawning season.

3. All shellfish areas in the salt ponds are shellfish management areas and as such, are a high priority for protection.

4. The Rhode Island Natural Heritage Program must be consulted by the applicant if the project falls within a critical habitat as designated on Figure 9-7. If a species is listed on the RIDEM rare and endangered list, on the federal list, or both, RIHPC will be contacted to provide stipulations, recommendations and/or comments to the CRMC before the Council issues a decision.

5. It is the Council's policy to manage and protect submerged aquatic vegetation (SAV) from loss and degradation. Projects proposed in tidal and non-tidal waters will be evaluated by CRMC staff on a case-by-case basis. If CRMC permitting staff determines that SAV is present, the applicant may be required to provide additional information regarding this resource and the project's likely impact, as well as mitigation of impacts.

6. Breaching should be allowed to occur naturally with no building of high blocking dunes to keep water out.

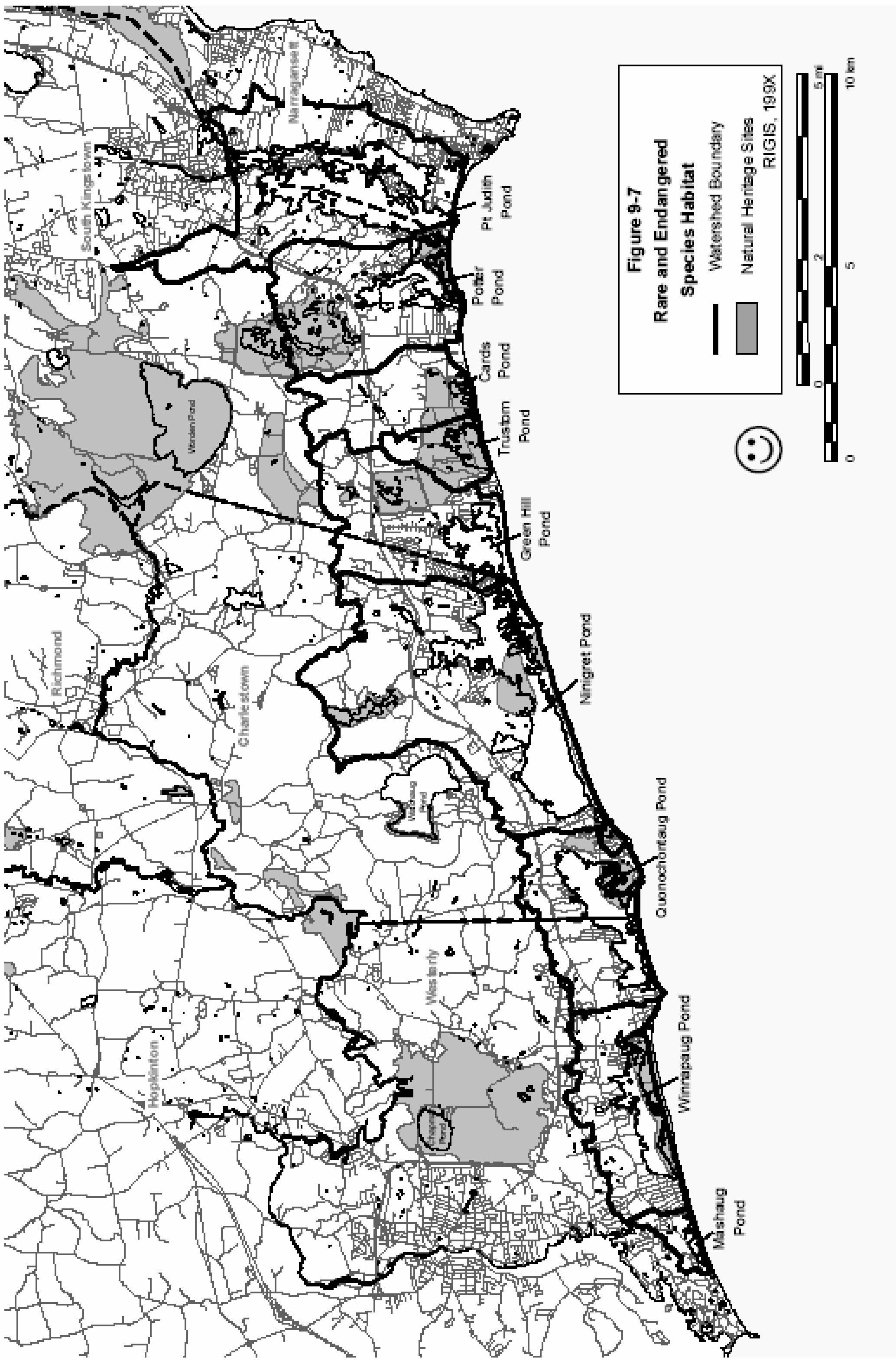
7. The black duck is targeted through the North American Waterfowl Plan and RIDEM Fish and Wildlife Species as a high priority species for conservation. This species and its vegetated habitat therefore have a high priority for protection by the Council.

8. The Council shall consider project impacts on waterfowl species including their habitat and nutritional resources such as vegetation, shellfish, and fish.

9. Limited phragmites control programs may be approved by the Council in areas that are degraded due to phragmites overrun.

10. Buffer zones will be the maximum width under the RICRMP Section 150 in areas that abut Factory Pond Brook to protect anadromous fish runs.

Figure 9-7. Rare and Endangered Species Habitat.



**D. Prohibitions**

1. Filling of, or other alterations to coastal wetlands (refer to RICRMP section 210.3) are prohibited within the Salt Pond Region. An alteration to a coastal wetland is defined in the RICRMP Section 300.12 to include, but shall not be limited to: filling, removing, grading (defined in RICRMP Section 300.2.A), dredging and dredge materials disposal (defined in RICRMP Section 300.9.A), any significant cutting or removal of vegetation, and excavation, draining, damming, and/or diverting of hydrological flows in a coastal wetland. Furthermore, any activity, including the aforementioned, taking place in an area adjacent to a coastal wetland which impacts the coastal wetland, shall be considered an alteration to coastal wetlands. Activities which shall not be considered alterations include, but shall not be limited to: minor disturbances associated with the approved construction or repair of shoreline protection facilities in accordance with Section 300.7, minor disturbances associated with approved residential docks and walkways constructed in accordance with standards set forth in Section 300.4, insignificant or minor cutting or pruning of vegetation in accordance with a Council approved management or restoration plan, and approved mosquito population control programs.

2. Alteration or disturbance of Piping Plover habitats during nesting is prohibited.

3. Dredging is prohibited in winter flounder areas during spawning season and if anadromous fish restoration projects are ongoing.

**E. Standards**

1. Excavation of any mudflats or other inter or sub-tidal sediments requires consultation with RIDEM Fish and Wildlife.

2. Prior to any dredging project the applicant may be required to remove any shellfish present in the sediments and transplant them to a RIDEM/CRMC approved site. Appropriate sites include RIDEM spawner sanctuaries or sites deemed appropriate by Marine Fisheries Council or RIDEM Fish and Wildlife and CRMC.

**F. Recommendations**

1. Fisheries Steward

One or more salt pond fisheries stewards should be hired and charged with the following responsibilities:

(a) Monitor salt pond fisheries resources and fishing effort, particularly in areas known to be productive. The assistance of volunteer monitoring groups like the Rhode Island Salt Pond Watchers and university researchers should be encouraged.

(b) Select small areas known for shellfish (quahogs and softshell clams) productivity and intensively manage growth and harvest to insure a continued recreational fishery through seeding, predator control, controlled fishing effort, and special regulations for softshell clams harvested from these areas. A major purpose of such initiatives is to demonstrate the potential of such areas to produce sustained annual harvests if the public cooperates.

(c) Assist in the development of public education programs on the salt ponds and their fisheries. This is an appropriate project for academics, nonprofits, and volunteer groups. Although many efforts are on-going, funding limits the effectiveness of these programs.

(d) Identify major issues for future research and monitoring.

(e) Prepare annual reports on the conditions of the ponds, watersheds and fisheries, activities undertaken and accomplished, and priorities for the following year. This report would be presented to the Rhode Island Marine Fisheries Council, CRMC, funding agencies and the public.

2. Educational programs, informing the general public as to the function of the different habitats (wetlands, aquatic and open water, terrestrial) and their value to society, should be initiated. These programs should be aimed at community residents and local elementary and secondary schools. Emphasis at the community level should be placed on how land gifts and dedications, conservation easements, and special registration of unique amenities found on private properties will serve to protect critical habitats.

3. The Rhode Island Marine Fisheries Council is encouraged to reduce the daily recreational catch limit for quahogs to two quarts per person. Closing beds to shellfishing when the average hourly catch falls below half a quart per person is recommended. Beds should be re-opened to fishing when the population has recovered.

4. Prudent management suggests that careful consideration be given to the potential importance of quahog brood stocks in areas closed to shellfishing by regulation or areas physically difficult to exploit. These populations may play an important role in sustaining heavy fishing in accessible areas. Brood stocks may include the population in the dense grass beds in Ninigret. RIDEM is encouraged to continue to support the research that will identify such brood stocks. In light of the present level of exploitation, recruitment in traditional grounds should be carefully monitored in Point Judith and Ninigret Ponds and appropriate steps taken if there is evidence of a significant decline in these populations.

5. The physical disturbance caused by scallop dredges has a high potential of disrupting flounder spawning, damaging eggs and juveniles and destroying SAV beds. When scallop beds overlap areas known to be important for flounder spawning, the scallop season should not be extended beyond December 31, or if an extension is deemed desirable, harvesting with dragged gear should be prohibited.

6. Monitoring and management of flounder fisheries in the salt ponds must recognize discrete sub-populations within individual ponds. A special effort should be made to identify the range of sub-populations and the location of discrete spawning grounds. The protection of spawning grounds should be a priority.

7. Experience with eel fisheries worldwide has demonstrated that this species is particularly

susceptible to overfishing.  The south shore eel fishery can be important and merits careful monitoring and management.

8.  Researching the connection between fish and their habitat is essential to the management of the salt pond species.  The RIDEM Division of Fish and Wildlife should make this a priority in future research initiatives.

9.  Wetland restoration projects within the watershed are strongly recommended to maintain and improve the health and viability of the wildlife and finfish populations of the ponds.

10. CRMC encourages conservation easements to be held by towns, and such organizations/ agencies as land trusts, the Nature Conservancy, and the Audubon Society.  Additionally, conservation easements may be granted to the CRMC directly.

11.  The CRMC encourages the appropriation of such monies by the individual towns, local communities, private land trusts, conservation groups, and the Nature Conservancy for the preservation of lands in the salt pond watersheds.  Priorities for acquisition and preservation should include those lands which support rare, uncommon or endangered species, wetlands, lands with steep banks and slopes, and lands with significant cultural resources.

**G.  Research Needs**

1.  Identify degraded and previously altered wetlands for restoration activities similar to the Galilee Bird Sanctuary project.

2.  Study fyke netting affects on flounder populations

3.  Study settlement characteristics of an effluent in receiving waters

4.  Study apparent reason for decline of quahogs, oysters, and flounder.

5.  Study impacts of fish and scallop trawling on SAV in salt ponds.

6.  Study impacts of aquaculture, particularly use of exotic species such as the European oyster.

**950.  Storm Hazards**

**A.  Introduction**

1.  Much of the development around the salt ponds is vulnerable to coastal flooding and storm surge destruction.  Between 1980 and 1988, coastal property values in Rhode Island increased 60 percent, from $32 million to $53 million (Flesner 1989).  In order to protect private and public property and prevent the hazards associated with hurricanes and storm flooding CRMC developed policies and regulations to support existing hazard mitigation efforts by the Rhode Island Emergency Management Agency (RIEMA).

**B. Policies**

1. Reconstruction After Storms

(a) When catastrophic storms, flooding, and/or erosion has occurred at a site under Council jurisdiction, and there is an immediate threat to public health and safety or immediate and significant adverse environmental impacts, the Executive Director may grant an Emergency Assent under Section 180 of the RICRMP.

(b) A CRMC Assent is required of all persons proposing to rebuild shoreline structures which have been damaged by storms, waves, or other natural coastal processes in the Salt Pond Region. When damage to a structure is greater than 50 percent, post-storm reconstruction shall follow all standards and policies for new development in the area in which it is located and according to the CRMC.

(c) Setback requirements from RICRMP Section 140 shall be applied.

(d) All construction within Federal Emergency Management Agency (FEMA) Flood Zones must follow the required construction standards for the flood zone in which the structure is located. Municipal officials need to certify that these standards are correct and present on any application for activity submitted before the CRMC.

(e) A CRMC maintenance assent is required for all persons proposing to repair structures which have been destroyed less than 50 percent by storms, waves, or natural processes.

(f) Washover sand, where feasible, should be left on non-paved roads, driveways, and parking lots, in order to allow the natural barrier rollover to continue and to maintain the higher elevation. Loose gravel may be placed over this sediment. When highway resurfacing or maintenance is to be done by RI Department of Transportation, elevations shall be upgraded to new appropriate heights for the region as determined by CRMC, and proper drainage shall accompany these elevation changes where appropriate. This avoids the re-establishment of low roadways within overwash areas that perpetuate flooding and flood damage.

(g) The Council encourages post-storm reconstruction applicants to increase setbacks further from the coastal feature than the previous development without expanding the footprint.

2. Restoration of Storm-Surge Channels and Temporary Inlets

(a) New inlet channels breached to Potter Pond through East Matunuck Beach may be filled in with sand or gravel only after an evaluation of the impacts of a direct connection between Potter Pond and the ocean has been made (see Chapter 4, Geologic Processes).

(b) New inlet channels cut across the beach to Quonochontaug, Winnapaug or Maschaug Ponds may be immediately filled in with sand or gravel by the local municipality.

(c) Dredging of washover sand shall be permitted for navigation in the Green Hill Pond

Inlet, the Bluff Hill Cove Inlet and in the main breachway channels. Any dredging of overwashed sand elsewhere within the ponds shall be limited to habitat restoration and enhancement in conformance with Section 420.1 of this Plan. All dredged sand shall be placed on the adjoining ocean beach.

(d) Sand transported on to paved roads leading to the beaches shall be plowed back onto the beaches and not into adjacent wetlands. Sand shall be placed on the beaches in the manner described in Figure 9-6 of this Plan.

3. Beach replenishment should be considered the method of choice for shore protection. Sources of sand for nourishment should come from inlet and harbor dredging when feasible, and from potential offshore sources where deemed appropriate by CRMC or its technical experts.

## C. Prohibitions

1. Filling, removing or grading is prohibited on beaches, dunes, undeveloped barrier beaches, coastal wetlands, cliffs and banks, and rocky shores adjacent to Type 1 and Type 2 waters, and in the Salt Pond Region unless the primary purpose of the alteration is to preserve or enhance the area as a natural habitat for native plants and wildlife or as part of a beach nourishment/ replenishment project. In no case shall structural shoreline protection facilities be utilized in this manner. Limited filling, removing, or grading may be permissible in the port area of Point Judith Pond to maintain its existing use.

2. Post-storm reconstruction of structures greater than 50 percent destroyed is prohibited from occurring within setback zones.

## D. Standards

1. Construction Standards in Flood Zones [High Hazard Areas]

(a) A significant amount of construction within Rhode Island's coastal zone has the potential to fall within a Federal Emergency Management Agency (FEMA) designated flood zone. The approximate limits of the flood zones and the associated base flood elevations are shown on FEMA's Flood Insurance Rate Maps, which are commonly available at municipal building official's offices. It is extremely important (and required) to know if your project falls within a flood zone and the associated building standards that must be adhered to for that zone to minimize the inevitable damage that occurs when building in a flood hazard area. The CRMC requires all applicants proposing construction within flood hazard zones to demonstrate that applicable portions of the Rhode Island State Building Code (RISBC), specifically RISBC-8, which contains specific requirements for flood zone construction. Municipal building officials can provide information on the requirements and restrictions that apply to a specific building site. A letter from the building official conferring that all the necessary building requirements for a flood zone must accompany any application for construction work within the RICRMP management area, and this SAMP.

**E. Recommendations**

1. There is a need for better understanding the correlation between oceanographic forces and shoreline response. With knowledge of the wave climate and surge elevations and currents during storms and the subsequent sediment transport, the effects of hurricanes and severe winter storms could be better predicted.

2. Ongoing collection and maintenance of shoreline change data including regular updates of shoreline change rates and continuation of the beach profile network should be supported.

3. Public Education

(a) More information on coastal erosion for the general public, especially coastal landowners and real estate agents dealing in coastal properties should be provided. Short publications or pamphlets distributed to shorefront property owners would aid compliance with CRMC regulations and make citizens better caretakers of the coastal zone.

4. Storm/Flooding

(a) Homeowners should be aware of the flood zone designation of their property, the associated storm/flooding risk, and the accompanying building standards with which they must comply. The Municipal building official retains local information regarding designation and standards.

(b) Seasonal visitors as well as renters and town officials should be aware of evacuation routes and locations of shelters.

(c) Acquisition priorities should be set by municipalities and the state for areas vulnerable to storm/flood hazards.

(d) Town/State public works and emergency management officials should post roadside evacuation route signs in all pre-identified coastal flood/storm evacuation areas.

(e) Incentives should be provided to homeowners to relocate structures destroyed less than 50 percent through State or Federal assistance (Upton-Jones Amendment), tax breaks and hazard mitigation money provided by the Federal Emergency Management Authority.

5. Priority sites that need additional elevation because they are particularly susceptible to overwash or temporary breaching include the parking lots at East Matunuck Beach, Roger Wheeler Beach, Charlestown Breachway (parking lot), Charlestown Beach, Green Hill Beach, and Misquamicut State Beach.

## 960. Historical and Cultural Resources

### A. Introduction

1. The historical and cultural resources of the Salt Pond Region are a valuable asset to the communities in Westerly, Charlestown, South Kingstown and Narragansett. CRMC considers preservation of these resources as a high priority for the SAMP and utilizes the CRMC application process to ensure that the Rhode Island Historical Preservation Commission has the opportunity to research various locations in the Salt Pond Region.

### B. Policies

1. Applications for major activities within the salt ponds watershed shall be forwarded to RIHPC for review and comment as part of the standard CRMC regulatory process.

2. Areas pre-identified by RIHPC as likely archeological sites due to prior knowledge, or conducive environmental factors including, but not limited to, proximity to salt and freshwater, small south-facing slopes, and well drained soils, are shown in Figure 9-8. Though other areas may exist and RIHPC reserves the right to require additional information and potential digs, these areas are identified to give applicants a sound idea of areas of concern. Applicants for activities proposed within these areas will likely be required by RIHPC to perform a phase I archeological investigation.

3. The CRMC will await the response of RIHPC prior to completion of its own staff review and subsequent Council decision. Unless a special exception occurs, the Council will incorporate the RIHPC guidance into its regulatory decision-making and permit stipulations. If a proposed project is located in a demarcated RIHPC area of interest, it may be helpful to contact RIHPC prior to filing an application with CRMC, in order to be aware of their potential concerns.

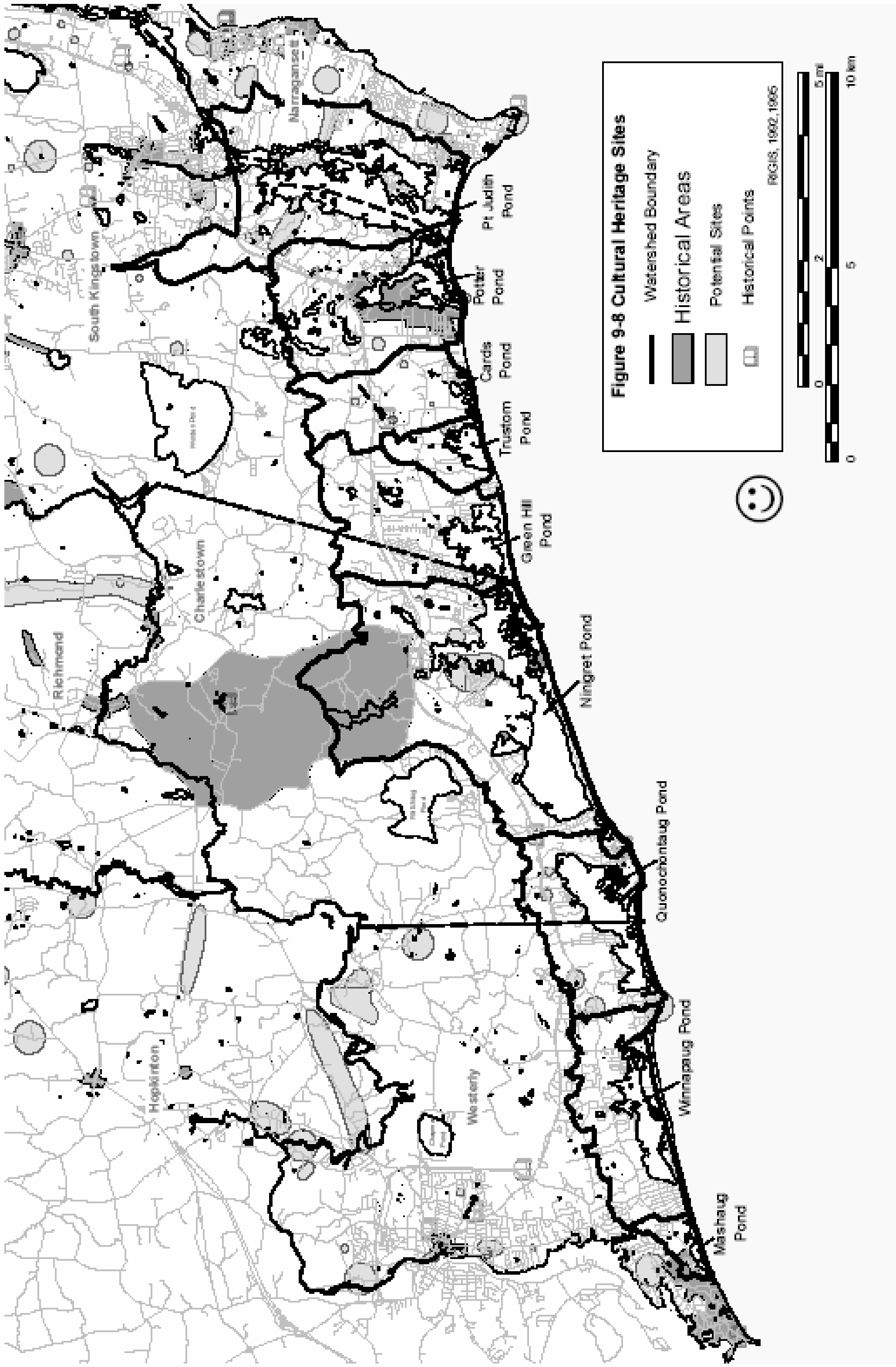
4. Where possible, those sites identified by RIHPC as having potential historical or archeological significance will be incorporated into the buffer zone by extending the boundary of the buffer where appropriate.

### C. Recommendations

1. The Council encourages sites identified by the RIHPC as having historical or archeological significance to be priorities for acquisition and preservation programs, and other preservation techniques such as open space easements, land dedications, transferring of development rights, etc. See RIHPC for further guidance on targeted areas.

2. It should be a high priority for RIHPC to conduct a detailed survey of areas pre-identified as likely to contain archeological or historical resources.

Figure 9-8. Cultural Heritage Sites.



## 970. Cumulative Impacts

### A. Introduction

1. Managing for cumulative impacts is becoming one of the major issues for CRMC as nitrogen loading to the salt ponds increases and more and more people move to the salt pond watersheds. CRMC will be focusing on the cumulative impacts of ISDS, impervious areas, stormwater runoff, vegetation removal and soil erosion, dredging the stabilized breachways and tidal deltas, barrier beach and flood zone development, residential activities, marinas, docks, and recreational boating, public water and sewer facilities, wetland alteration and noise and lighting impacts on habitat. All of these activities have the potential to cause effects in the ecosystem which increase the probability of shellfish closures, fish habitat degradation and loss, eutrophication, sedimentation of shellfish beds and much more.

### B. Definitions

1. Cumulative impacts are the total result of land use, water use and development activities or actions taking place anywhere within the Salt Pond Region over any period of time.

2. Cumulative effects are the physical, biological, or chemical outcome of a series of actions or activities on the environment.

3. The Salt Pond Region includes the environment within the surface watershed boundaries as delineated on the land use classification maps in Chapter 9.

### C. Policies

1. It is the Council's policy to minimize cumulative impacts by anticipating and appropriately siting land and water uses and development activities to avoid cumulative effects to the salt ponds.

2. It is the Council's policy to consider the cumulative impacts of ISDS, impervious areas, stormwater runoff, vegetation removal and soil erosion, dredging the stabilized breachways and tidal deltas, barrier beach and flood zone development, residential activities, marinas, docks, and recreational boating, public water and sewer facilities, wetland alteration and noise and lighting impacts on habitat. These cumulative impacts are explained in Chapter 8, Findings of Fact.

3. The Council recognizes that an increase in the amount and strength of pollutants entering the salt pond watersheds may result from the cumulative impacts identified in 920.2 B 2. Therefore, the Council will consider the cumulative effects of these actions with particular consideration to nutrients, pathogen indicators, hydrocarbons and heavy metals, road salts, fragmented habitats, and loss of aquatic habitats.

4. It is the Council's policy to minimize nitrate loading to groundwater from each individual lot in Lands Developed Beyond Carrying Capacity, residential and commercial substandard lots which are designated as Self-Sustaining Lands or Lands of Critical Concern, and all lands abutting the salt ponds.

## D. Standards

1. In those areas which are designated as Lands Developed Beyond Carrying Capacity, alternative technologies that reduce nitrogen loading to groundwater and directly to the salt ponds in overland runoff are required for new development. This includes, according to the type of development: nitrogen reducing technologies; narrower road widths; clustering of development to reduce road lengths with remaining open space maintained adjacent to surface waters; restrictions on layouts of subdivision cul-de-sacs and roadways to reduce impervious surface and encourage infiltration of stormwater; use of pervious materials for driveways; restrictions on the number of parking spaces per square foot of commercial development to match average daily use - not potential maximum, and requirements that all overflow parking be constructed using pervious materials; and more accessible alternative transportation such as pedestrian, bicycle and mass transit.

2. In those areas which are designated as Self-Sustaining Lands or Lands of Critical Concern, residential and commercial development on substandard lots, and on all lots abutting the salt ponds alternative technologies that reduce nitrogen loading to groundwater and directly to the salt ponds in overland runoff are required. This will include according to the type of development: nitrogen reducing technologies; narrower road widths; clustering of development to reduce road lengths with remaining open space maintained adjacent to surface waters; restrictions on layouts of subdivision cul-de-sacs and roadways to reduce impervious surface and encourage infiltration of stormwater; use of pervious materials for driveways; restrictions on the number of parking spaces per square foot of commercial development to match average daily use - not potential maximum and requirements that all overflow parking be constructed using pervious materials; and more accessible alternative transportation such as pedestrian, bicycle and mass transit.

## E. Recommendations

1. The Council encourages the Salt Pond Region towns to adopt ordinances to minimize impervious surfaces in order to reduce cumulative impacts and transport of pollutants to the salt ponds. Possible management options include the following:

(a) Narrower road widths;

(b) Clustering of development to reduce road lengths with remaining open space maintained adjacent to surface waters;

(c) Restrictions on layouts of subdivision cul-de-sacs and roadways to reduce impervious surface and encourage infiltration of stormwater;

(d) Use of pervious materials for driveways;

(e) Restrictions on the number of parking spaces per square foot of commercial development to match average daily use - not potential maximum - and requirements that all overflow parking be constructed using pervious materials;

(f) More accessible alternative transportation such as pedestrian, bicycle and mass transit.

(g) Waste-water Management Districts

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# Chapter 10
# Land Preservation and Acquisition

## 100. Acquisition of Environmentally Sensitive Lands

### A. Current Initiatives for Preservation of Open Space

1. The most effective method to reduce potential water quality pollutants from land-based sources is through property acquisition. The CRMC is working with the South Shore Management Area Work Group organized by the Department of Environmental Management's Land Conservation and Acquisition Program to identify priority acquisitions along the south shore and the Narrow River. This group includes representatives from the towns of Westerly, Charlestown, South Kingstown, Narragansett and North Kingstown, the Audubon Society, The Nature Conservancy, local land trusts, the University of Rhode Island, Senator Chafee's office, the Rhode Island Natural Heritage Program, the Fish and Wildlife Service and other local nonprofit organizations.

2. Property acquisitions are not only beneficial for resource protection, they have been proven to be an economic benefit to Rhode Island communities. The Aquidneck Island Partnership recently completed an economic perspective on open space (Johnston 1997) where the economic benefits of open space and Greenways were compared to net losses often imposed by residential and other development (Johnston 1997). One important conclusion of the report is that higher property values are associated with properties located closer to open space parcels, and lower property values are associated with properties farther from open space (Johnston 1997). Because open space requires few town services, and hardly any infrastructure, open space land provides more in revenues than it costs to maintain (Johnston 1997).

### B. Acquisition of lands within the Salt Pond Region

1. Acquisition of lands within the Salt Pond Region has grown as a concept for preservation of existing scenic and natural resources. There are many governmental and private programs whose purpose is to preserve lands and structures with exceptional qualities. Following is a break down of local, state, federal and non-profit programs:

2. Local

(a) The towns of South Kingstown and Narragansett have land trusts which raise funds for acquisition of land around the salt ponds and in other areas of the town. Since 1983 the South Kingstown Land Trust has preserved over 600 acres of land through outright purchase or property easement. The Narragansett Land Trust has preserved over 165 acres since 1986 in areas around Point Judith Pond and the

Narrow River.

3. State - The Rhode Island Department of Environmental Management

(a) In the late 1980s, voters in Rhode Island approved four major open space bond issues and numerous local referenda resulting in an investment of more than $100 million for recreation and open space land acquisition (DEM Land Preservation Programs 1997). Municipalities and nonprofits can apply for funds through the Open Space and Recreation Bond Fund Land Acquisition Program to purchase fee title or conservation easements to purchase recreational lands or important open space, or to develop recreational facilities.

(b) The Rhode Island Land Protection Plan, adopted in 1996, identifies five major categories of land preservation: agriculture, forests, drinking water protection, recreation and natural heritage/biodiversity. Properties are reviewed for possible acquisition by RIDEM's Division of Planning and Development.

(c) Agricultural Land Preservation Program - The Farmland Preservation Act of 1981 is a state program where farmland is preserved through the acquisition of development rights, defined as the difference between the fair market value of the land and the agricultural value. To date, this program has succeeded in protecting 32 active farms, totaling 2,609 acres.

(d) Shoreline Access Grant Program - provides matching funds to communities for projects which improve public access to the shoreline.

(e) Natural Heritage Preservation Revolving Loan Fund - The RIDEM administers a fund that will allow preservation societies, land trusts, non-profit organizations, and local communities to preserve, in perpetuity, open space/agricultural lands deemed of scenic or ecological value. The monies are available on a revolving loan basis ($250,000 maximum loan) and are for lands not less than 5 acres.

(f) The Forest Legacy Program - Congress passed the Farms for Future Act in 1991 which created the Forest Legacy Program. This program allows the state to acquire land or interest in land, while the seller is allowed to retain title to the land or timber rights to the property.

3. Federal Programs

(a) Wildlife Restoration Act (Pittman-Robinson Act) (16 U.S.C. 669 et seq.) - In 1937, federal legislation was passed to provide for the enhancement and protection of wildlife resources for public use. Funds for this program are derived from excise taxes on the manufacture of arms and ammunition including handguns and archery.

(b) US Fish and Wildlife Sport Fish Restoration Act (Dingell-Johnson/Wallop Breaux Act) (16 U.S.C. 777 et seq.) - This program is funded by revenues collected from manufactures and importers of fishing rods, reels, and other fishing equipment. Allocation of these funds is based upon land and water area and fishing licenses.

(c) North American Wetlands Conservation Act Program (NAWCA) (16 U.S.C. 4401 et seq.) - Rhode Island will receive $1 million in 1997 and has the potential to receive $1 million a year from NAWCA for the next ten years to protect waterfowl habitat along the south shore of the state. The project area includes all or part of North Kingstown, South Kingstown, Narragansett, Charlestown and Westerly.

(d) The USFWS also has acquisition programs for the various National Wildlife Refuges including Ninigret National Wildlife Refuge, Trustom National Wildlife Refuge and Pettaquamscutt Cove National Wildlife Refuge.

4. Non-government Organizations

(a) National organizations like the Audubon Society and The Nature Conservancy own lands along the south shore for protection of biodiversity and habitat for plant and wildlife.

(b) Other private organizations like the Weekapaug Foundation and the South County Conservancy also make important land acquisitions.

(c) Many nonprofit organizations do not make land acquisitions but provide the necessary water quality data and resource information for others to use in making acquisition decisions. Groups like the Salt Pond Watchers provide valuable data for bacteria and chemistry samples taken during the spring, summer and fall months.

5. Private Land-owners - The most permanent protection afforded to sensitive lands is the prevention of their alteration through direct acquisition. It is the mutual responsibility of local groups and municipal and state agencies to promote such efforts in order to ensure continued existence of these fragile resources. A conservation easement is a contract between a landowner and the state, a town, or conservation group or land trust, in which the landowner agrees not to develop her/his land, but to preserve it in its natural state. The easement permanently prevents residential, commercial and industrial development of the property, improper or unnecessary removal of vegetation, and the dumping or excavation of any materials. Executing the contract commits the landowner to "donating" development rights to the state, town, conservation group or land trust, but retains all other rights of ownership not restricted by the agreement.

**C. Recommendations**

1. Critical Resource or Conservancy Zoning

(a) The towns are encouraged to make provisions in their respective zoning ordinances for the re-zoning of critical areas for conservation purposes in an effort to preserve the unique amenities of the watershed. Possible techniques to accomplish these goals are transfer of development rights, cluster developments and overlay districts where specific ecological concerns are addressed in the town comprehensive plan.

2. Municipal Easements

(a) Municipal agencies are encouraged to utilize provisions of their respective subdivision ordinances to maintain open space areas through dedication and easements.

**Literature Cited**

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U.S. Fish and Wildlife Sport Fish Restoration Act. 1950. 16 U.S.C. 777 et seq.

Wildlife Restoration Act. 1937. 16 U.S.C. 669 et seq.

# METADATA

**Salt Pond SAMP Map File Information**

Figure 1-1 Salt Pond Watershed [sp11.map]
Figure 3-3 Areas Close to Shellfishing, Green Hill & Ninigret Ponds [URI-CRC]
Figure 3-4 Areas Closed to Shellfishing in Point Judith Pond [URI-CRC]
Figure 3-5 Teal Brook and Factory Brook [3-5.map]
Figure 4-1a Glacial Geology [spglac.map]
Figure 5-4 Wetlands [sp54.map]
Figure 6-1 High Flood Danger Zones [sp61.map]
Figure 9-1 Land Use Classification for Water Quality Protection in South Kingstown [skspbw.map]
Figure 9-2 Land Use Classification for Water Quality Protection in Narragansett [naspbw.map]
Figure 9-3 Land Use Classification for Water Quality Protection in Charlestown [chspbw.map]
Figure 9-4 Land Use Classification for Water Quality Protection in Westerly [wstspbw.map ]
Figure 9-7 Rare and Endangered Species Habitat [sp94.map]
Figure 9-8 Cultural Heritage Sites [sp95.map]

All files listed are in UTM meters NAD 83

| | | | Figure | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CRMC File** | **DESCRIPTION** | **RIGIS File** | **1-1** | **3-3** | **3-4** | **3-5** | **4-1a** | **5-4** | **6-1** | **9-1** | **9-2** | **9-3** | **9-4** | **9-7** | **9-8** |
| ct83.cdf | crmc town polygons | s44btp88.e00 | x | | | | x | x | x | | | | | x | x |
| saltrds.dbd | salt pond samp watershed roads | s44trd96.eoo | x | | | | x | x | x | | | | | x | x |
| Allrds83.dbd | RI road lines | s44trd96.e00 | x | | | | x | x | x | | | | | x | x |
| Hydpol83.dbd | fresh water body polygons | s44hhp88.e00 | x | | | | x | x | x | | | | | x | x |
| ssspu3.dbd | all salt pond polygons except mashaug and trustom | s44btp88.e00 (created) | x | | | | x | x | x | | | | | x | x |
| sssp2u3.dbd | mashaug and trustom pond polygons | s44hhp88.e00 | x | | | | x | x | x | | | | | x | x |
| twnbd83.cdf | RI town boundary lines | s44btl88.e00 | x | | | | x | x | x | | | | | x | x |
| bisndu3.dbd | BI sound polygon | s44btp88.e00 (created) | x | | | | x | x | x | | | | | x | x |
| 10kblack.cdf | 10 k scale blocks-black | original | x | | | | x | x | x | | | | | x | x |
| 10kw.dbd | 10 k scale blocks-white | original | x | | | | x | x | x | | | | | x | x |
| 5miw.dbd | 5mi scale blocks-white | original | x | | | | x | x | x | | | | | x | x |
| 5mib.dbd | 5mi scale blocks-black | original | x | | | | x | x | x | | | | | x | x |
| cardsu3.dbd | cards pond watershed | created (URI-CRC) | x | | | | x | x | x | | | | | x | x |
| ninigu3.dbd | ninigret pond watershed | created (URI-CRC) | x | | | | x | x | x | | | | | x | x |

Metadata Cont.

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| grnhilu3.dbd | green Hill pond watershed | created (URI-CRC) | x | | | | x | x | x | | | | | x | x |
| trustmu3.dbd | trustom pond watershed | created (URI-CRC) | x | | | | x | x | x | | | | | x | x |
| potteru3.dbd | Potter's pond watershed | created (URI-CRC) | x | | | | x | x | x | | | | | x | x |
| ptjudiu3.dbd | Pt Judith pond watershed | created (URI-CRC) | x | | | | x | x | x | | | | | x | x |
| **CRMC File** | **DESCRIPTION** | **RIGIS File** | **1-1** | **3-3** | **3-4** | **3-5** | **4-1a** | **5-4** | **6-1** | **9-1** | **9-2** | **9-3** | **9-4** | **9-7** | **9-8** |
| quonieu3.dbd | quonochontaug pond watershed | created (URI-CRC) | x | | | | x | x | x | | | | | x | x |
| winnapu3.dbd | winnapaug pond watershed | created (URI-CRC) | x | | | | x | x | x | | | | | x | x |
| mashauu3.dbd | maschaug pond watershed | created (URI-CRC) | x | | | | x | x | x | | | | | x | x |
| fldzn3.dbd | FEMA flood zones | s44hfx90.e00 | | | | | | | x | | | | | | |
| wetq27u3.dbd | wetlands | q27wwt93.e00 | | | | | | x | | | | | | | |
| wetcrmc3.dbd | crmc wetlands | q**wwt93.e00 | | | | | | x | | | | | | | |
| rspecu3.dbd | rare species habitat | s44nrs93.e00 | | | | | | | | | | | | x | |
| hist92u3.dbd | potential historical sites | hist92.e00 (URI/EDC) | | | | | | | | | | | | | x |
| histdist.dbd | historic sites | S44chs95.e00 | | | | | | | | | | | | | x |
| histsite.dbd | historic districts | s44chd95.e00 | | | | | | | | | | | | | x |
| glac83.dbd | glacial geology polygons | s44ggl88.e00 | | | | | x | | | | | | | | |
| RILAND.cdf | RI state line boundary including coastline | s44bri89.e00 | | | | x | | | | x | x | x | x | | |
| Hydropol.dbd | All freshwater lakes, ponds & reservoirs | s44hhp88 | | | | z | | | | x | x | x | x | | |
| Streams.dbd | Centerlines of all feshwater rivers & streams | s44hh188 | | | | x | | | | x | x | x | x | | |
| NA | Areas closed to shellfishing | Created (URI-CRC) | | x | x | | | | | | | | | | |
| hydcst.dbd | salt ponds on south shore (that are fresh) | original | | | | x | | | | | | | | | |
| salt.dbd | salt ponds on south shore (that are fresh) | original | | | | x | | | | | | | | | |

Metadata Cont.

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| chspfnl.dbd | CRMC Land use classification boundary, Charlestown | original | | | | | | | | | | x | | | |
| naspfnl.dbd | CRMC Land use classification boundary, Narragansett | original | | | | | | | | | x | | | | |
| skspland.dbd | CRMC Land use classification boundary, South Kingstown | original | | | | | | | | x | | | | | |
| wsspfnl.dbd | CRMC Land use classification boundary, Westerly | original | | | | | | | | | | | x | | |
| sklt.dbd | Polygon for lands of critical concern | t32zmz94.e00 (S.K. Zoning) | | | | | | | | x | | | | | |

CRMC files are Maptitude™ geographic files converted from 1997 RIGIS ArcInfo™ *.e00 files. CRMC files are in some cases only relavent portions of the corresponding RIGIS *.e00 file. CRMC metadata available.

Metadata Cont.

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| grnhilu3.dbd | green Hill pond watershed | created (URI-CRC) | x | | | | x | x | x | | | | | x | x |
| trustmu3.dbd | trustom pond watershed | created (URI-CRC) | x | | | | x | x | x | | | | | x | x |
| potteru3.dbd | Potter's pond watershed | created (URI-CRC) | x | | | | x | x | x | | | | | x | x |
| ptjudiu3.dbd | Pt Judith pond watershed | created (URI-CRC) | x | | | | x | x | x | | | | | x | x |
| **CRMC File** | **DESCRIPTION** | **RIGIS File** | **1-1** | **3-3** | **3-4** | **3-5** | **4-1a** | **5-4** | **6-1** | **9-1** | **9-2** | **9-3** | **9-4** | **9-7** | **9-8** |
| quonieu3.dbd | quonochontaug pond watershed | created (URI-CRC) | x | | | | x | x | x | | | | | x | x |
| winnapu3.dbd | winnapaug pond watershed | created (URI-CRC) | x | | | | x | x | x | | | | | x | x |
| mashauu3.dbd | maschaug pond watershed | created (URI-CRC) | x | | | | x | x | x | | | | | x | x |
| fldzn3.dbd | FEMA flood zones | s44hfx90.e00 | | | | | | | x | | | | | | |
| wetq27u3.dbd | wetlands | q27wwt93.e00 | | | | | | x | | | | | | | |
| wetcrmc3.dbd | crmc wetlands | q**wwt93.e00 | | | | | | x | | | | | | | |
| rspecu3.dbd | rare species habitat | s44nrs93.e00 | | | | | | | | | | | | x | |
| hist92u3.dbd | potential historical sites | hist92.e00 (URI/EDC) | | | | | | | | | | | | | x |
| histdist.dbd | historic sites | S44chs95.e00 | | | | | | | | | | | | | x |
| histsite.dbd | historic districts | s44chd95.e00 | | | | | | | | | | | | | x |
| glac83.dbd | glacial geology polygons | s44ggl88.e00 | | | | | x | | | | | | | | |
| RILAND.cdf | RI state line boundary including coastline | s44bri89.e00 | | | | x | | | | x | x | x | x | | |
| Hydropol.dbd | All freshwater lakes, ponds & reservoirs | s44hhp88 | | | | z | | | | x | x | x | x | | |
| Streams.dbd | Centerlines of all feshwater rivers & streams | s44hh188 | | | | x | | | | x | x | x | x | | |
| NA | Areas closed to shellfishing | Created (URI-CRC) | | x | x | | | | | | | | | | |
| hydcst.dbd | salt ponds on south shore (that are fresh) | original | | | | x | | | | | | | | | |
| salt.dbd | salt ponds on south shore (that are fresh) | original | | | | x | | | | | | | | | |

Metadata Cont.

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| chspfnl.dbd | CRMC Land use classification boundary, Charlestown | original | | | | | | | | | | x | | | |
| naspfnl.dbd | CRMC Land use classification boundary, Narragansett | original | | | | | | | | | x | | | | |
| skspland.dbd | CRMC Land use classification boundary, South Kingstown | original | | | | | | | | x | | | | | |
| wsspfnl.dbd | CRMC Land use classification boundary, Westerly | original | | | | | | | | | | | x | | |
| sklt.dbd | Polygon for lands of critical concern | t32zmz94.e00 (S.K. Zoning) | | | | | | | | x | | | | | |

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