University of Rhode Island
DigitalCommons@URI

Open Access Master's Theses

1994

# ENVIRONMENTAL AND COASTAL LAND USE ANALYSIS: A PLAN TO REMEDIATE BACTERIAL POLLUTION IN RHODE ISLAND'S GREENWICH BAY

Michael E. Brusseau
*University of Rhode Island*

Follow this and additional works at: https://digitalcommons.uri.edu/theses

Terms of Use
All rights reserved under copyright.

Recommended Citation
Brusseau, Michael E., "ENVIRONMENTAL AND COASTAL LAND USE ANALYSIS: A PLAN TO REMEDIATE BACTERIAL POLLUTION IN RHODE ISLAND'S GREENWICH BAY" (1994). *Open Access Master's Theses.* Paper 553.
https://digitalcommons.uri.edu/theses/553

This Thesis is brought to you by the University of Rhode Island. It has been accepted for inclusion in Open Access Master's Theses by an authorized administrator of DigitalCommons@URI. For more information, please contact digitalcommons-group@uri.edu. For permission to reuse copyrighted content, contact the author directly.

# ENVIRONMENTAL AND COASTAL LAND USE ANALYSIS: A PLAN TO REMEDIATE BACTERIAL POLLUTION IN RHODE ISLAND'S GREENWICH BAY

BY

MICHAEL E. BRUSSEAU

A RESEARCH PROJECT SUBMITTED IN

PARTIAL FULFILLMENT OF THE REQUIREMENTS

FOR THE DEGREE OF MASTER OF

COMMUNITY PLANNING

UNIVERSITY OF RHODE ISLAND

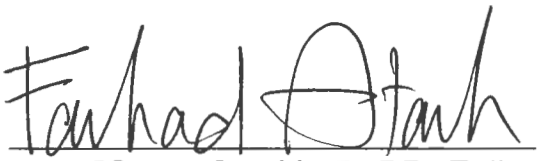
1994

MASTER OF COMMUNITY PLANNING

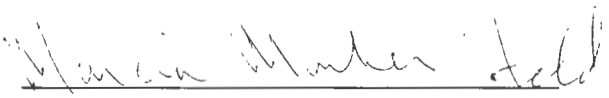
RESEARCH PROJECT

OF

MICHAEL E. BRUSSEAU



APPROVED: MAJOR PROFESSOR DR. FARHAD ATASH



ACKNOWLEDGED: DIRECTOR DR. MARCIA MARKER FELD

## ABSTRACT

In December of 1992, the Rhode Island Department of Environmental Management temporarily closed Greenwich Bay to shellfishing after finding dangerously high levels of fecal coliform. The closure of the Bay to shellfishing has resulted in an estimated loss of $4 million to the City of Warwick, annually. Furthermore, pollution in Greenwich Bay has begun to threaten tourism, recreational activities, environmental quality, and public health.

A comprehensive environmental/land use analysis is conducted to identify potential sources of bacterial pollution and to estimate the impacts these sources are having on the Bay's water quality. Sources of bacterial contamination include: failing septic systems and sewers, stormwater runoff, sewage discharge from boats, and wild and domesticated animals.

A list of stakeholders is provided to identify key governmental agencies and private organizations who have a responsibility or interest in improving Greenwich Bay's water quality. A description of each agency's function and responsibilities as a stakeholder is discussed.

The study concludes with a comprehensive and detailed list of recommendations to remediate the Bay's pollution. The recommendations are broken into several categories including: establishment of a Greenwich Bay Task Force; public education and outreach; additional research; land use management; coastal zone management; wastewater management; and stormwater management.

## ACKNOWLEDGEMENT

There are several people whom I wish to thank. First, I'd like to thank those who served on my Masters Research Committee. Dr. Farhad Atash, Dr. Howard Foster, and Mr. David Westcott for their time, effort, and recommendations.

Next, I would like to thank Mr. Jonathan Stevens Director of Planning for the City of Warwick for his suggestions, guidance, and most of all for giving me the opportunity to work on such a fantastic project. I would also like to thank William Depasquale, Kristin Saccoccio, and everyone at the Warwick Planning Office for their valuable input and a wonderful internship.

Thanks also goes out to all the institutional stakeholders who have contributed information to this study. Best of luck to those who will be implementing the Greenwich Bay Initiative!

Last, but certainly not least, I would like to thank my parents Tom and Ann Brusseau who have been behind me every step of the way during my six years at the University of Rhode Island. I couldn't have done it without you!

## TABLE OF CONTENTS

# LIST OF MAPS



# LIST OF TABLES



# LIST OF FIGURES

# CHAPTER ONE

## INTRODUCTION

### Problem Statement

Greenwich Bay is located in the Upper Narragansett Bay and serves as one of the largest shellfisheries in Rhode Island. It is bordered by several villages within the City of Warwick including Nausauket, Buttonwoods, and Oakland Beach to its north; Chepiwanoxet and Arnold's Neck to its west; Warwick Neck to its east; and Potowomut and the Town of East Greenwich to its south.

In December 1992, the Rhode Island Department of Environmental Management (RIDEM) temporarily closed Greenwich Bay to shellfishing due to high levels of fecal coliform[1]. Fecal coliform is used as an indicator for measuring the presence of disease-causing bacteria which in elevated levels can cause health problems ranging from mild gastrointestinal distress, severe gastroenteritis, to hepatitis, cholera, and typhoid fever.

Although the closure of the Bay was necessary to protect the health, safety, and welfare of the public, it has also had an adverse effect on the local economy. The shellfishing industry, in Greenwich Bay alone, contributed an estimated $4 million in annual revenue to the City of Warwick (Ganz 1993). The closure has already caused serious economic repercussions in Warwick including the loss of jobs to shellfishermen and a loss of revenue to local commercial activities; especially marine-related businesses. Furthermore, primary recreational activities such as swimming have been restricted in

[1]Appendix A provides fecal coliform and total coliform levels from an April 1994 Food and Drug Administration study of Greenwich Bay.

the Warwick and Apponaug Coves and secondary contact activities including boating could conceivably be prohibited if water quality continues to decline. Finally, there is significant concern regarding the future vitality of Greenwich Bay's coastal/marine ecosystem if pollution levels continue to increase.

Recognizing the urgency of this dilemma, the U.S. Food and Drug Administration (FDA) and RIDEM have undertaken and are near completion of a wet and dry weather water quality study of fecal coliform levels in Greenwich Bay. The testing began in spring of 1993 in an attempt to determine whether the state should permanently close Greenwich Bay to shellfishing.

**Objectives of the Study**

Given the impacts permanent closure could have on the City of Warwick, it is important to conduct a study that determines possible sources of pollution and identifies initiatives to mitigate the pollution problem in Greenwich Bay. Although it has been acknowledged that a number of sources contribute pollutants to the Bay, this study will focus primarily on bacterial contamination from improper wastewater treatment and disposal (both on-shore and off-shore) and stormwater runoff from Warwick's coastal neighborhoods.

Research for this study was conducted during a year-long internship with the City of Warwick Planning Department. Hired as an environmental planner, my sole responsibility was the development of a plan to remediate the bacterial contamination of Greenwich Bay. This study will examine the problem from a broader perspective,

provide a more technical approach, offer additional support for previous conclusions, and propose several new recommendations.

The objectives of this study are:

1. To provide an accurate assessment of the physical conditions existing in and around the Bay;

2. To evaluate the impacts of these physical conditions on the Bay's water quality;

3. To determine the approximate location of "hot spots" - those areas within Warwick contributing most to the pollutant loading of the Bay and neighboring water bodies;

4. To identify the various governmental agencies and private organizations who can and should play a role in the reclamation of Greenwich Bay; and

5. To recommend short and long-term remediation initiatives which may be efficiently carried out in a cooperative, coordinated manner by the most appropriate authorities.

**Significance of the Study**

This study will provide several recommendations to facilitate the restoration and preservation of Warwick's most valuable natural resource. A timely and well-coordinated response to the present dilemma facing Greenwich Bay will help to ensure a future of unrestricted use and will inevitably save the City millions of dollars in future remediation costs, lost jobs, and lost revenues from commercial activities and tourism. Moreover, a well planned collaborative effort to ameliorate the existing adverse conditions will help to protect the health, safety, and welfare of the public, restore and

preserve the Bay's water quality for all recreational uses, and ensure suitable habitats for terrestrial and marine organisms alike. It is my contention that the recommendations of this study, if properly administered, will be successful at meeting the goal of attenuating local pollution levels and rejuvenating the vitality of this precious resource. Furthermore, with increasing environmental awareness and a new understanding of the value of coastal resources, this study could conceivably be used to foster the development and implementation of remediation initiatives in other similarly impacted coastal communities.

**Methodology**

Literature will be reviewed to compile information for the analysis of physical/environmental conditions in and around the Bay, identify potential pollution sources, and evaluate the impacts of these sources on Greenwich Bay's water quality. To more effectively examine the physical conditions, the Greenwich Bay coastal region is divided into twenty-three subareas or "Critical Coastal Areas". The subareas are defined based on their proximity to Greenwich Bay and its various coves, as well as physical and man-made features such as major roads, wetlands, streams, and neighborhood boundaries.

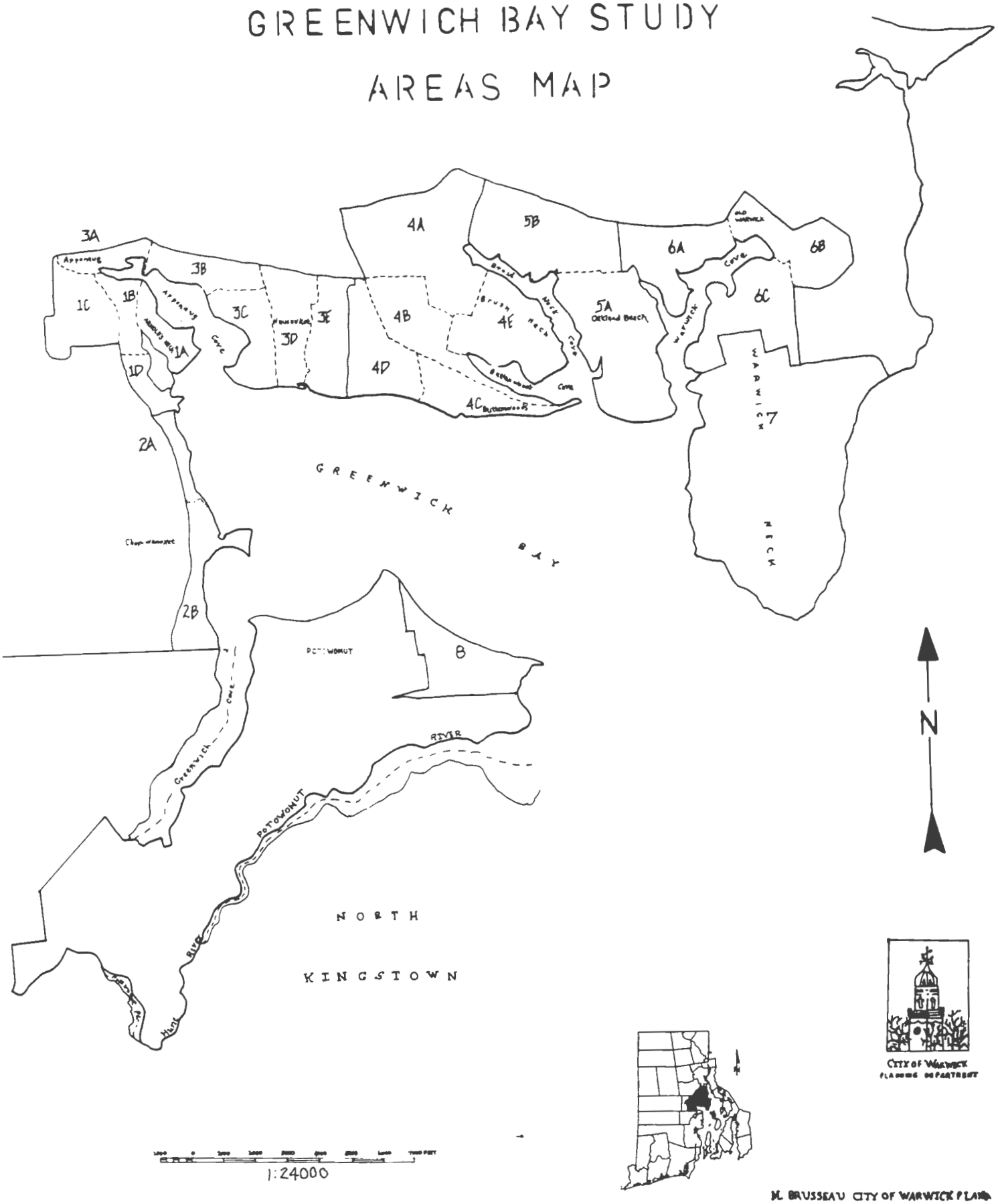
Table 1 - Greenwich Bay Subareas

| **Study Area** | **Subarea** |
|---|---|
| 1. Arnold's Neck/Cowesett Hills Apartments | 1A, 1B, 1C, 1D |
| 2. Chepiwanoxet | 2A, 2B |
| 3. Apponaug/Nausauket | 3A, 3B, 3C, 3D, 3E |
| 4. Buttonwoods | 4A, 4B, 4C, 4D, 4E |
| 5. Oakland Beach | 5A, 5B |
| 6. Old Warwick | 6A, 6B, 6C |
| 7. Warwick Neck | 7 |
| 8. Potowomut | 8 |

# WARWICK, R.I.

## GREENWICH BAY STUDY

## AREAS MAP




SOURCE: U.S. GEOLOGICAL SURVEY - (1975)

CITY OF WARWICK
PLANNING DEPARTMENT

M. BRUSSEAU CITY OF WARWICK PLANNING

An assessment of the existing physical conditions within the Greenwich Bay Study Area will then be conducted focusing on key characteristics such as geology, soils, topography/slopes, and hydrology. These characteristics are then discussed in terms of their influence on wastewater and stormwater pollutants. Population growth and development trends within the Bay's coastal areas will be examined, including a comparison of each subarea's population and housing densities to those of the City and State in 1990. This analysis will facilitate an understanding of the impacts population growth and development has had on the degradation of the Bay. The study will also examine marine activities in coastal areas including a description of water quality and boat density.

Physical/environmental conditions will be examined and synthesized using the map overlay technique. This technique will be used to estimate the relative impacts of each subarea on the levels of pollution within the Bay. From this analysis, "areas of concern" will be delineated. The following maps will be created: Greenwich Bay Study Area Delineation, Surficial Geology, Water Features (coves, streams, ponds, wetlands, drainage basins, direction of runoff and stream flow, etc.), Depth to Seasonal High Water Table, Topography/Slopes, Soils Limitations, Sewer Lines, Storm Drains and Holding Ponds, Housing and Population Density and Boat Counts, Land Use, and Areas of Concern. Finally, the characteristics within each subarea will be considered individually and collectively for their potential influence on bacterial pollution to the Bay.

A method of quantifying the potential pollution impacts of each subarea will be devised to identify specific areas of concern. Excluding the presence of sewers, storm drains, and permeability classifications, each physical/environmental characteristic will be given a score between one and three based on the degree to which it is believed to influence the likelihood of wastewater and stormwater contamination to the Bay. A score of one (1) indicates little or no influence. A score of two (2) indicates moderate influence, while a score of three (3) indicates a severe influence on the derivation, mobility and treatment of wastewater and stormwater contaminants.

The sewer and permeability categories will be handled differently due to the complexity of each. Within the sewers category, subareas will be given a score based on the presence or absence of sewers. A score of one indicates that no sewers exist in the area, while a score of zero indicates the presence of sewers.

Permeabilities will be rated in a similar manner. Those subareas with either excessively high or excessively low permeabilities will be given a score of one (1), as both conditions are known to have an adverse effect on wastewater treatment. Areas with moderate permeabilities will be given a score of zero. Storm drain information will not be quantified. However, major storm drain outfalls will be considered as potential "pollution points", and therefore important places for further water quality monitoring.

Finally, the total score for each subarea will be calculated. Two classifications will be developed based on a "critical threshold number" derived from qualitative data and professional judgement. Subareas falling above the critical threshold number will be classified as principle "areas of concern", while subareas falling below this number will be considered to be of secondary importance. This method will be useful in identifying critical "areas of concern" and examine the relative condition of each subarea. However, it is recommended that additional site-specific analyses be conducted to confirm the actual status of these areas of concern and further isolate the primary sources of contamination.

The evaluation of existing conditions will be followed by a summary and conclusions section. A synopsis of key findings for each subarea and general recommendations for corrective and preventative action will be provided based on the analysis of the information obtained from the physical/environmental assessment.

Next, a stakeholder analysis will be conducted to identify the key agencies, organizations, and citizen's groups which could most effectively carry-out the essential remediation strategies recommended to meet the objectives of the study. Possible funding sources and a tentative phasing plan will also be developed. Clearly, the success of this study will be contingent upon the coordination and cooperation between these institutional stakeholders, many of which have legal mandate authority and/or a strong interest in protecting the Bay's water quality and its increasingly fragile ecosystem.

Finally, a direct and comprehensive list of recommendations will be developed. These recommendations explain the purpose for each initiative, identifies available

funding sources, defines specific stakeholder responsibilities for implementing and overseeing particular actions, and offers a tentative schedule for the completion of specific tasks. General recommendation topics include: establishment of a Greenwich Bay Task Force, public education and outreach, additional research, and improved land use management, coastal zone management, stormwater management and wastewater management.

**Sources of Data**

A myriad of sources will be examined to secure information for this study. Several environmental plans and studies from consulting, engineering, and planning firms are collected. Maps from the Rhode Island Soil Survey, U.S. Department of the Interior Geological Survey, City of Warwick Department of Public Works, and private planning agencies such as Beta Engineering and C.E. Maguire Inc. are also collected. A number of federal and state agencies, municipal departments, and private organizations have also provided essential information in the form of policies, programs, plans and studies. Federal agencies include: the Food and Drug Administration (FDA), Environmental Protection Agency (EPA), and the United States Department of Agriculture's Soil Conservation Service (SCS). State agencies consist of the Coastal Resources Management Council (CRMC), Statewide Planning, and several divisions of the Rhode Island Department of Environmental Management (RIDEM) including: Individual Sewage Disposal Systems (ISDS), Water Resources, Narragansett Bay Project, Groundwater and Freshwater Wetlands, and Fish and Wildlife. Municipal departments such as the

Warwick Public Works Department (DPW), Sewer Authority, Department of Parks and Recreation (Harbor Commission), Building Department and Planning Department have also been helpful. Finally, private organizations such as Save the Bay, Rhode Island Shellfishermen's Association, and the Rhode Island Marine Trades Association provide important information for the study. Plans, reports, surveys, maps, books, interviews and on-site visits will be used to collect the needed data for this study.

**Organization of the Study**

The study will be divided into 6 chapters. Chapter 1 discusses the research problem, the objectives and significance of the study, methodology, literature review, and the organization of the study. Chapter 2 provides the reader with a description of pertinent physical, environmental and man-made characteristics within the Greenwich Bay Study Area and an explanation of how these characteristics may directly or indirectly contribute to the Bay's degraded water quality. Chapter 3 provides a comprehensive analysis of the physical/environmental conditions within each of the Greenwich Bay subareas. Chapter 4 consists of a site-specific summary of the conditions within each subarea, how they affect the Bay, and finally, offers general recommendations for addressing these conditions. Chapter 5 identifies key stakeholders, explains their mission, assigns appropriate tasks to each, and discusses possible funding sources. Major emphasis will be placed on cooperation between key players and a thoughtful approach toward the coordination and implementation of the study.

The final chapter focuses on a variety of specific recommendations such as: establishment of a Greenwich Bay Task Force; increased public education; additional research; improved land use management; coastal zone management; wastewater management; and stormwater management. A tentative schedule for meeting the recommendations of the initiative will also be provided.

# CHAPTER TWO

## PHYSICAL CHARACTERISTICS AND LAND USE

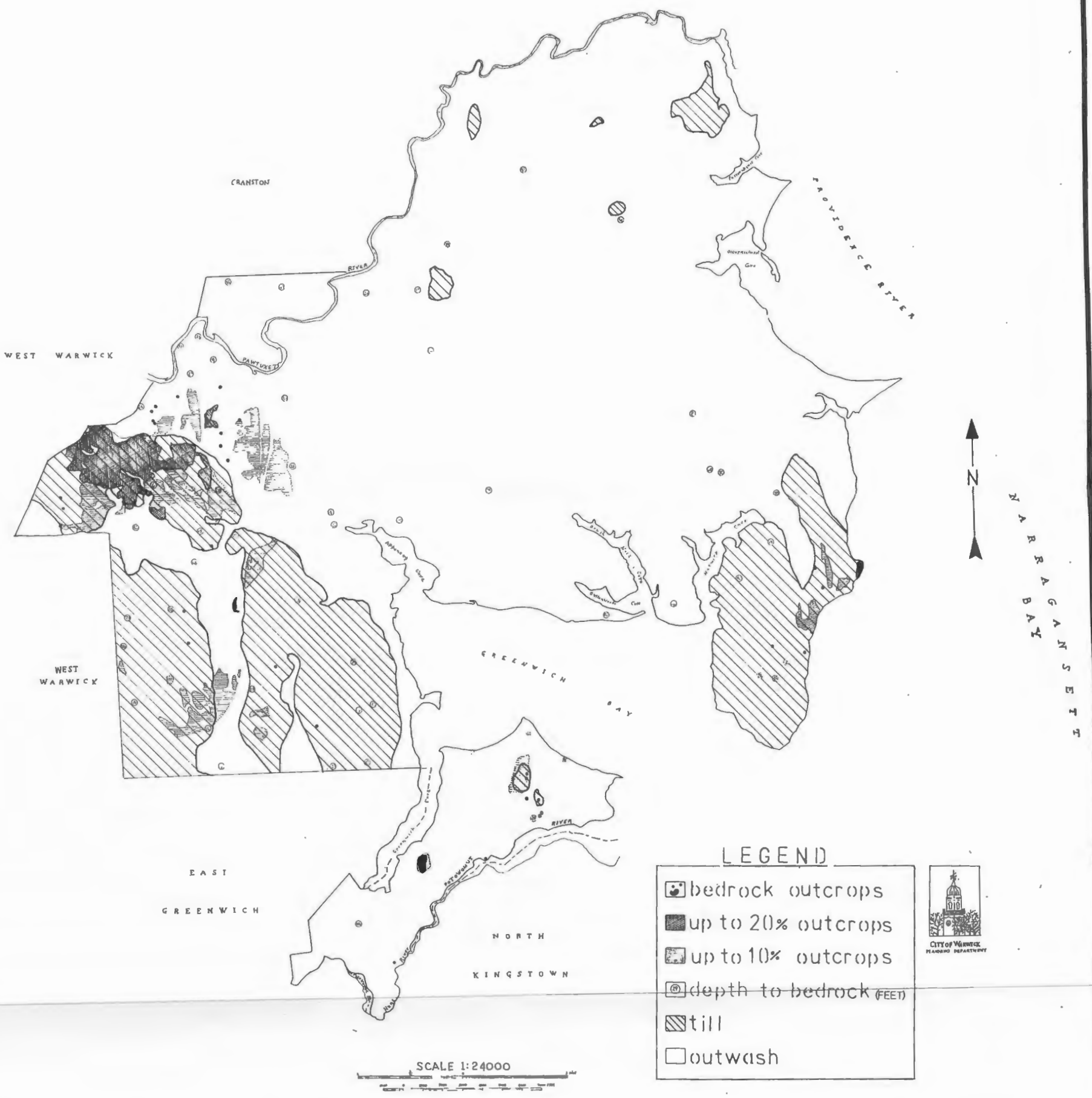
Prior to defining specific pollution sources, a critical examination of physical and environmental characteristics was conducted to evaluate the possible effects these characteristics have on the generation, movement, and treatment of wastewater and stormwater. These characteristics include geology, soils, topography, hydrology (groundwater, surface water, wetlands, drainage basins), wastewater treatment (existence or non-existence of sewers, and septic system design and age), stormwater treatment, population/land use, and boat density.

### Geology

Local geology was examined to gain a better understanding of the sub-surface conditions in which Warwick's septic systems function. Regions of glacial outwash, glacial till, and/or bedrock outcrops were defined (see Map 2). Glacial outwash is composed of well sorted, stratified, sand and gravel deposited by glacial meltwater. These areas are generally well drained, have rapid percolation rates, and permit quick diffusion of septic effluent. Outwash is generally well-suited for storing and providing groundwater. However, the potential for groundwater contamination from wastewater systems increases where percolation rates are excessively rapid and water tables are high.

# WARWICK, R.I.

## SURFICIAL GEOLOGIC CHARACTERISTICS MAP




SOURCES: U.S. GEOLOGICAL SURVEY (1955)
U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE (1981)

M. BRUSSEAU CITY OF WARWICK PLANNING DEPT.
JULY 1993

**Map 2 Surficial Geology**

Glacial till is composed of unsorted, nonstratified, boulders, gravel, sand, silt and clay. These areas often have bedrock beneath the surface at shallow depths and sometimes contain a layer of compacted and/or cemented fined grained sediment called "hardpan". Hardpan is nearly impenetrable to liquids and therefore may inhibit water from percolating through to the substratum. This condition, combined with the typically slow percolation rates of tills themselves, may cause groundwater to accumulate above the hardpan resulting in the development of a "perched water table". A perched water table can severely limit proper treatment and disposal of septage by causing the surfacing of wastewater or seepage along the edges of slopes (called lateral seepage), particularly after heavy rains. Tiny pores within glacial tills are also known to "clog" when overwhelmed with sewage solids, or when bacterial mats form around septic system distribution lines. This also can result in septic system failure and surfacing of septage. Furthermore, glacial till is composed of boulders and cobbles which can significantly decrease the volume of soil required for adequate purification within a septic system absorption field.

Bedrock, at or close to the surface can cause serious problems for septic systems by reducing the amount of space available to purify wastewater between the absorption field and groundwater surface. Also, wastewater dispersed over bedrock can enter fractures and be discharged directly into water bodies with little, if any, purification whatsoever.

## Soils

The effects of physical soil characteristics on the dispersal and purification of wastewater are among some of the most important information to examine in regard to septic system failure (see Map 3). Furthermore, soil properties are known to have an enormous influence on stormwater treatment, infiltration, and overland runoff. The principal soil characteristics examined for this study include soil texture, soil structure, compaction, permeability, drainage class, stoniness, slope, potential for flooding, and the physical characteristics of the parent material.

## Topography/Slopes

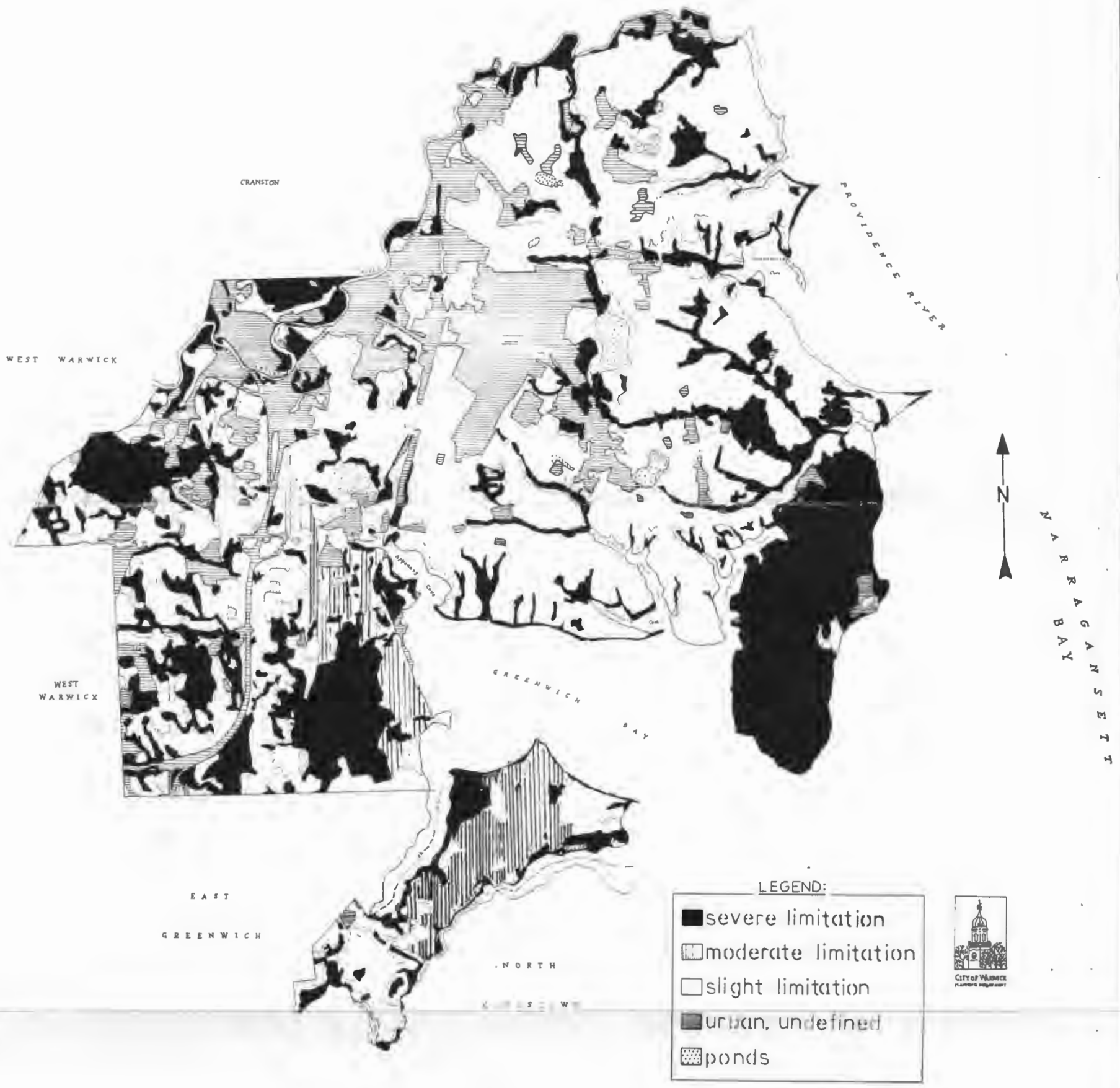
A topography/slopes map was created to define areas having steep slopes. Steeply sloping areas (greater than 15% slope) are poorly suited for the proper installation and operation of septic systems and can lead to lateral seepage, erosion and sedimentation, and facilitate runoff and pollutant transport from urban, residential, and agricultural land uses (see Map 4). Slopes adjacent to Greenwich Bay and its coves are of particular concern especially when combined with other physical constraints such as high water tables, shallow depths to impervious or restrictive soil horizons, and slow percolation rates.


**Map 3 Soils Limitations**

# WARWICK, R.I.

## SOIL LIMITATIONS

## FOR SEPTIC SYSTEMS



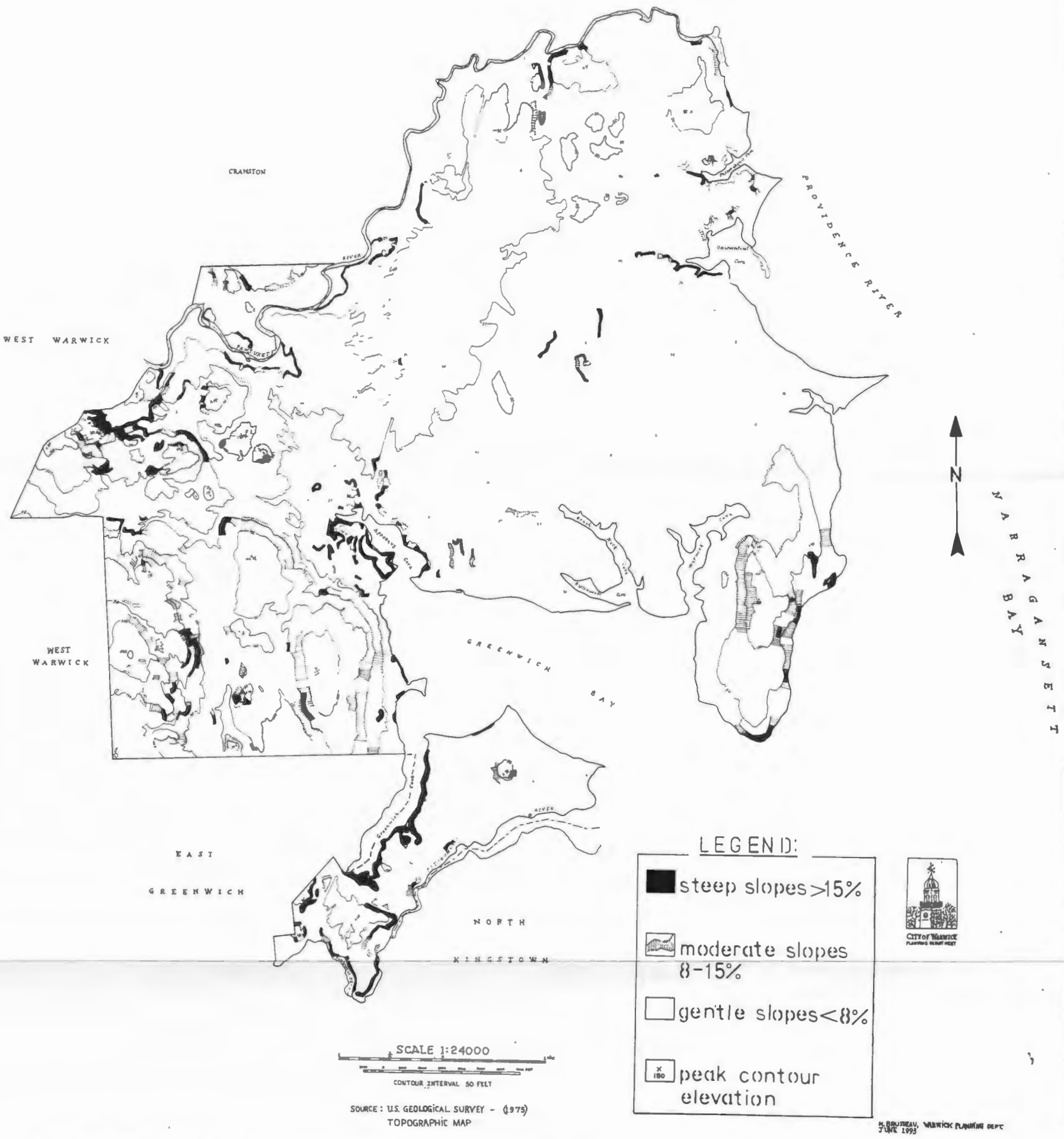

SOURCES: U.S. GEOLOGICAL SURVEY - (1975)
U.S.D.A. SOIL CONSERVATION SERVICE - (1981)

M. BRUSSEAU, WARWICK PLANNING DEPT
JUNE 1995

**Map 3 Soils Limitations**

# WARWICK, R.I.

## TOPOGRAPHIC/SLOPES MAP



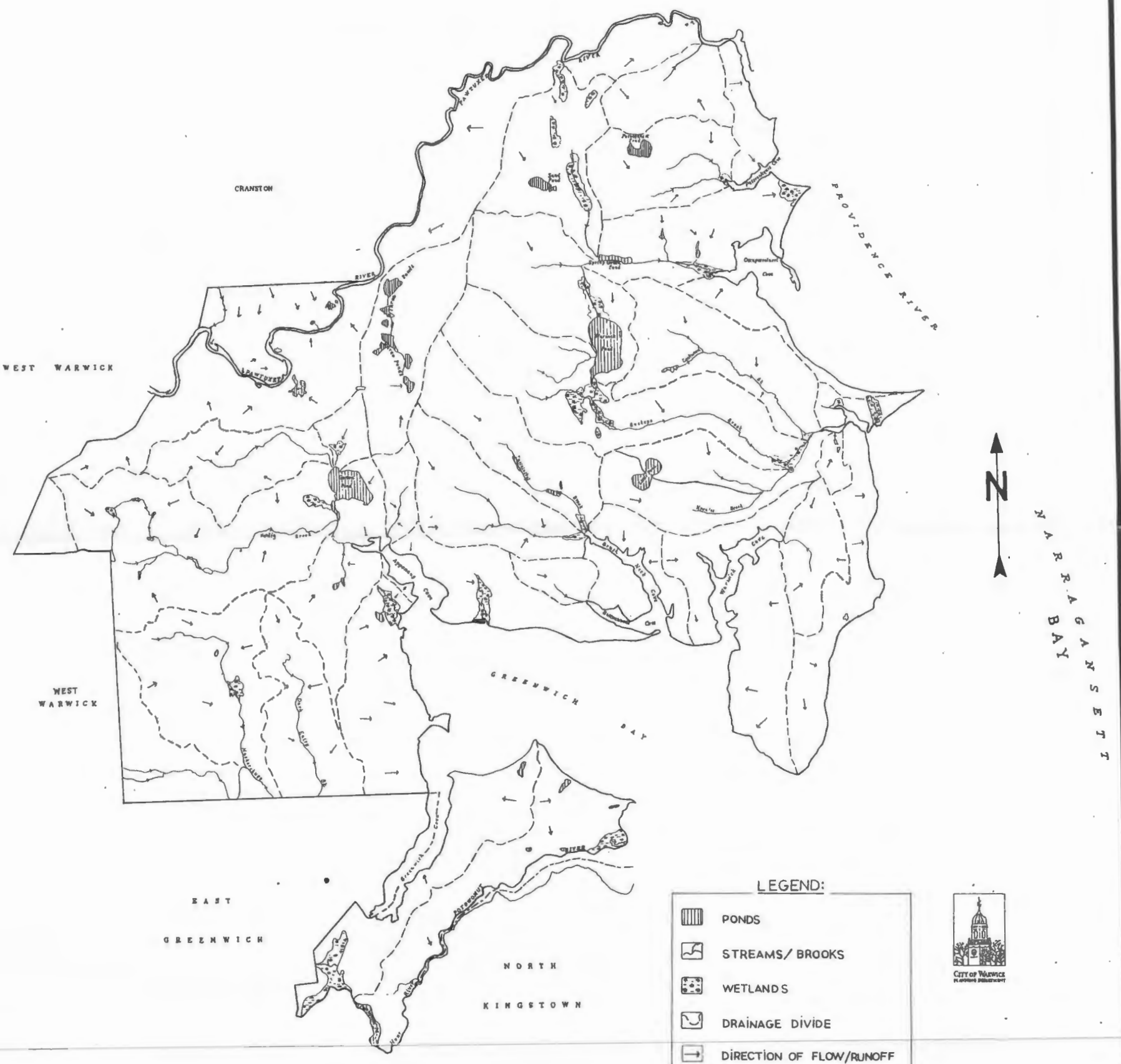
## Hydrology

A number of issues relating to hydrology are investigated including the delineation of drainage basins, direction of stream flow and stormwater runoff, identification of streams, rivers, ponds and wetlands, and the propensity of particular areas toward flooding. In addition, approximate depth to ground water and water quality classification within Greenwich Bay and its coves is examined.

A water features map was created showing drainage basins, ponds, streams and wetlands, and the direction of runoff and surface water flow (see Map 5). This is important in defining the points of origin, and the places of deposition of pollutants transported across the surface of the land by stormwater runoff. Stormwater runoff has been identified as a significant contributor of bacterial pollution to Greenwich Bay (RIDEM Division of Water Resources 1991). Proper design and installation of stormwater management devices is essential if significant reductions in pollutant loading are to occur. However, it should be recognized that stormwater runoff is a mode of pollutant transport and not a source, *per se*. Actual sources contributing to elevated levels of fecal coliform include: failed or improperly designed on-site wastewater systems, broken or leaking sewage lines, illegal sewage tie-ins, and wildlife. Geldreich, et.al. (1968) suggested that fecal contamination of stormwater in urban areas originates primarily from cat, dog, and rodent deposits. Other pollutants associated with stormwater include; hydrocarbons, metals, organic compounds, nutrients, salt, sediment, and trash.

# WARWICK, R.I.

SURFACE WATER FEATURES MAP




**Map 5 Water Features**

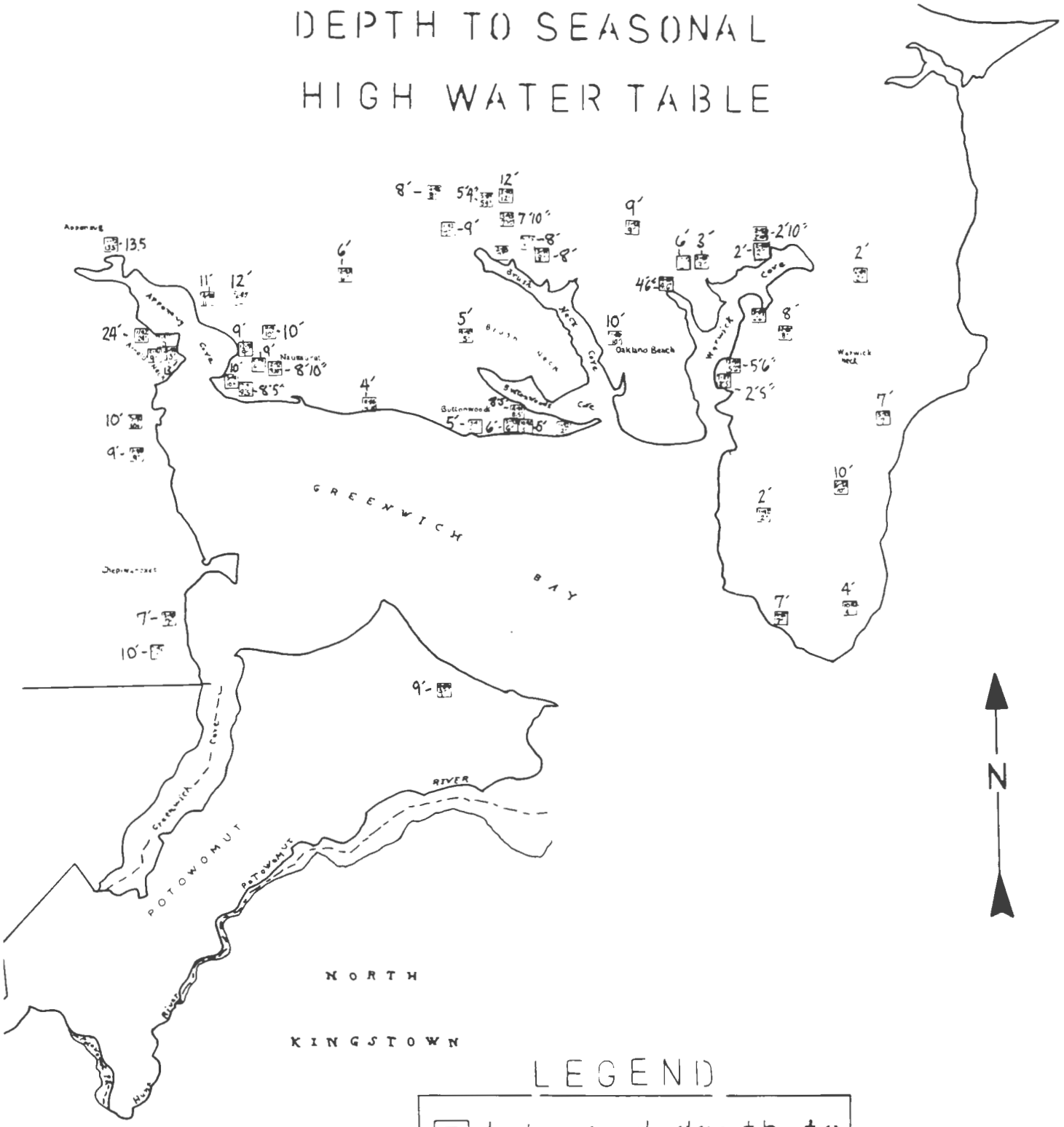
Depth to water table was also mapped (See Map 6) by utilizing site-specific information obtained from the RIDEM's ISDS on-site inspections and by confirming this information with other sources such as the *Soil Survey of Rhode Island* (USDA 1981) and Warwick's *Wastewater Facility Plan* (Maguire 1978). This information proved valuable in identifying high water tables, (ie., areas of poor drainage, slow percolation rates, hardpan). As described previously, poor drainage, hardpan etc., can inhibit purification of septage, cause lateral seepage or surfacing, and subsequent runoff of untreated wastewater. In addition to threatening surface water quality, a high water table increases the likelihood that groundwater contamination will occur by reducing the distance between the bottom of the soil absorption field and the groundwater surface; thus, restricting sufficient physical, biological, and chemical purification of wastewater contaminants. Peterson and Ward (1989) found that "enteric bacteria will be transported beyond 120 cm (4 ft) of suitable soil depth [beneath the absorption field] in coarse grained soils". Contaminated groundwater can also contribute to the degradation of water quality in the Bay if groundwater enters streams, or resurfaces and runs off into the Bay.

**Floodplains, Wetlands, Streams, and Ponds**

Floodplains and wetlands provide flood storage, natural pollutant attenuation, aquifer recharge and are considered ecological havens for many species of fish and wildlife. However, these areas are often "sinks" for a variety of pollutants including bacteria, metals, organic compounds, nutrients and sediment.

# WARWICK, R.I.

## DEPTH TO SEASONAL HIGH WATER TABLE




SOURCES: U.S. GEOLOGICAL SURVEY (1975)
DEM ISDS (1975-1993)

CITY OF WARWICK
PLANNING DEPARTMENT
MICHAEL BRUSSEAU

As flooding occurs, excess water is absorbed by the soil through the process of infiltration and percolation. Continuous infiltration may result in the inundation of ISDS's as soils become saturated and groundwater levels rise. Under these conditions, septic system failure, as well as the surfacing and runoff of septage and other contaminants may occur. Frequently flooded areas include land contiguous to coastal zones, wetlands, and floodplains. Within the Greenwich Bay Study Area, Oakland Beach, Baker's and Mary's Creek, Hardig Brook, northeastern Potowomut (between Sandy Point and Marsh Point) and land adjacent to Warwick, Brushneck, Buttonwoods, and Apponaug Coves are especially susceptible to flooding.

Wetlands are typically located in topographically low-lying areas. Because of this position along the landscape, wetlands may become repositories for pollutant laden runoff derived from contiguous uplands. Some wetlands lie at elevations so low that the local water table may be intersecting the ground's surface causing inundation of the land; while other wetlands are fed by streams or intermittent seasonally high water tables. If local groundwater becomes polluted from failed septic systems, underground storage tanks, broken or leaking sewer lines or industrial injection wells, contamination of floodplains and wetlands may result. Discharge from streams and aquifers as well as tidal influences within coastal wetlands appears to have significantly contributed to pollutant loading and degradation of Greenwich Bay's water quality.

Large populations of wildlife such as migratory water fowl contribute to the bacterial contamination and elevated levels of fecal coliform around and within wetlands (not to mention large contributions in residential areas from domesticated animals).

Wetlands adjacent to Mary's Creek near Arnold's Neck; Baker's Creek in Nausauket; and Tuscatuket Brook in Brush Neck Cove are considered wetland areas of concern. The wetlands surrounding these streams have been identified as "actual pollutant sources" along Greenwich Bay (RIDEM Division of Water Resources 1991).

Natural freshwater bodies are known to act as confluents of pollution and are often responsible for transporting contaminants to receiving waterbodies. Every contaminant generated and "released" within the Greenwich Bay watershed can end up being transported via stream or groundwater flow to the Bay. Fecal coliform levels near the mouths of Hardig Brook, Maskerchugg River, Mary's Creek and Baker's Creek have exceeded FDA criteria for shellfishing in both wet weather and dry weather measurements (RIDEM Division of Water Resources 1989-1993). An in-depth analysis of these streams, Gorton's Pond, and their watersheds are vital to the success of a plan to remediate pollution in the Bay.

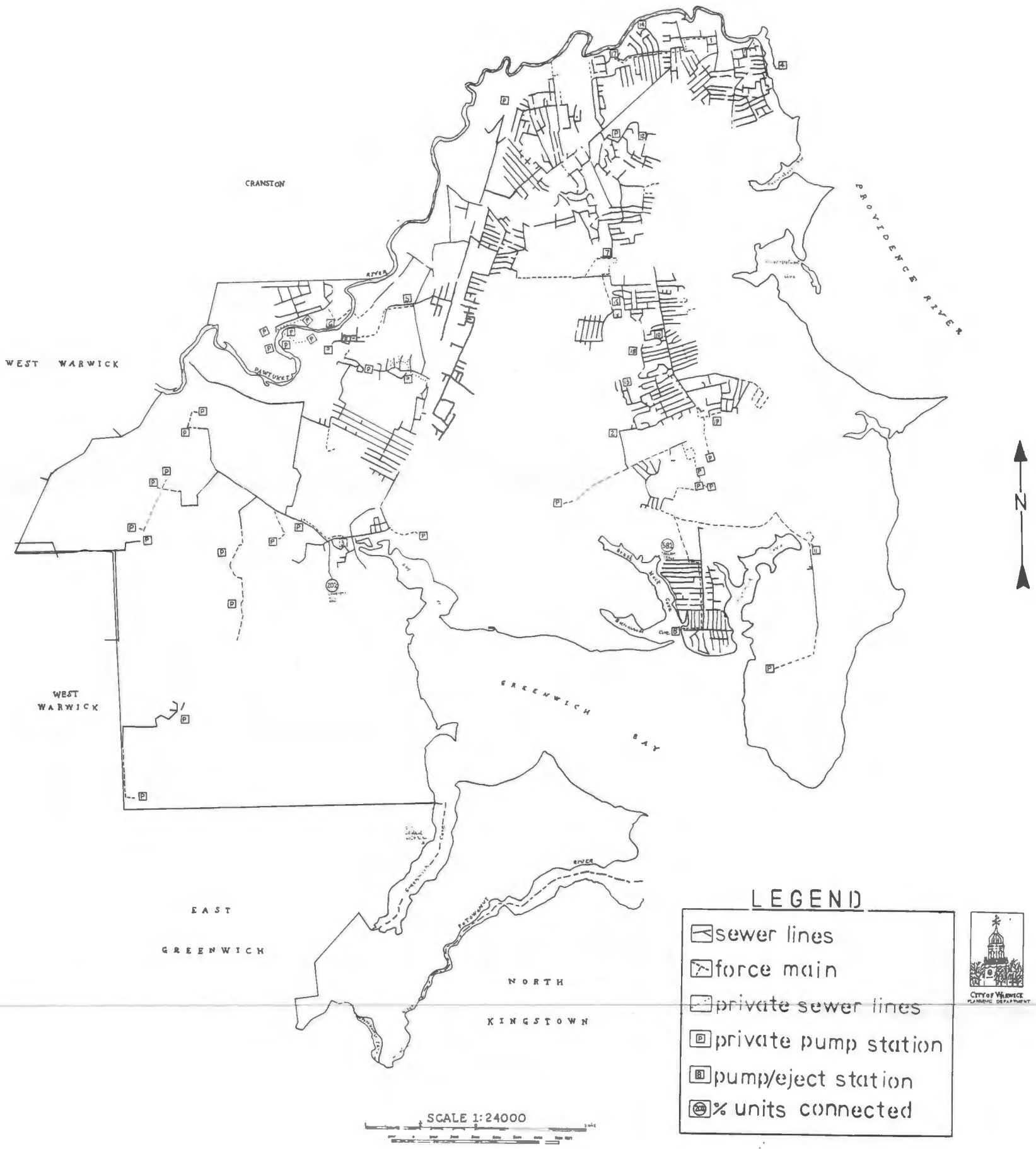
**Wastewater Treatment**

The method of wastewater treatment (ie., sewers, septic systems, cesspools) were also examined. Localities within the Greenwich Bay Study Area that are sewered include Oakland Beach and Apponaug. However, many residents are not connected to the lines provided (see Map 7). All other neighborhoods rely solely on septic systems or cesspools for wastewater treatment, many of which were designed before stringent ISDS regulations were developed in 1968. Many of these antiquated on-site systems have not

been maintained, repaired, or replaced and would likely not meet modern ISDS specifications.

# WARWICK R.I.

## SEWER LINES MAP




SOURCES: U.S. GEOLOGICAL SURVEY (1975)
BETA ENGINEERING (1992)

M. BRUSSEAU CITY OF WARWICK PLANNING DEPT.
JULY 1993

Beta Engineering (1992) developed and distributed an ISDS questionnaire to all Warwick residents living in unsewered areas of the City. The purpose of the questionnaire was to gain a better understanding of the conditions and rate of failure among local ISDS systems. Questions were formulated to address such matters as septic system size, age, and condition, water consumption, and user habits. Septic systems were considered to be failing if an affirmative response was given to one or more of the following questions:

1) Does the home owner ever have to restrict water use due to system backup?

2) Has the septic system ever been repaired, replaced or altered in the past 10 years?

3) Does the septic system have to be pumped on a regular basis (6 months or less)?

Based on these criteria, the total number of residential problems reported within the Greenwich Bay Study Area was 777 or 47.3 percent of the total number of questionnaires returned (see Appendix B for results of the questionnaire relating to the Greenwich Bay Study Area). This finding is based on the number of questionnaires returned and not the number of questionnaires distributed, and should therefore, be considered with caution. Despite this caveat, the findings indicate a significant number of malfunctioning septic systems due in part to physical constraints such as shallow depth to bedrock, high seasonal water table and slow percolation rates. However, properly functioning septic systems installed in excessively permeable soils may also contribute to local groundwater and surface water contamination, yet were not addressed by the

questionnaire. Poor treatment and rapid diffusion of wastewater are common characteristics of excessively permeable soils which ultimately threaten local water quality. Finally, it should be noted that the information provided by this questionnaire is based on homeowners' opinions and best estimates. This should not be considered a scientific survey, and therefore is subject to some degree of error.

**Stormwater Runoff**

Urban stormwater runoff appears to have contributed significantly to the degradation of Greenwich Bay's water quality. A myriad of pollutants have been introduced to the Bay throughout the years including: bacterial and pathogenic contaminants, heavy metals, organic compounds, nutrients, salt, trash and sediment. These pollutants come from a variety of sources including roads, highways, parking lots, and intensively developed industrial, commercial, and residential land. Each pollutant has a unique effect on the Bay's water quality depending on its concentration and physical, chemical, and microbiological characteristics.

Impervious and unvegetated surfaces, steep slopes, and slowly percolating/poorly drained soils are conducive to high rates of runoff. Urban areas with high traffic flow, and dense industrial and commercial development are notorious for generating large quantities of polluted stormwater runoff. Although the focus of this study is on bacterial contaminants, it is imperative to discuss all pollutant types. A brief summary of the types, origins and effects of major "runoff pollutants" are provided below.

### Organic Pollutants

"Organics" include many pollutants such as petroleum products, pesticides, solvents, cleaning agents, PCB's and many other chemical compounds. These pollutants enter the Bay from storm drains or direct overland flow and originate primarily from roads, parking lots, and commercial and industrial activities. Organic compounds can persist in benthic sediments for decades until being resuspended by the turbulence of storms, dredging, or other disruptive activities. Some of these pollutants have been found to cause cancer and other health effects in fish, shellfish, and humans and are known to be toxic to fresh and saltwater organisms.

### Heavy Metals

Heavy metals such as copper, lead, zinc, chromium, and cadmium, are common in urban runoff. Sewage from failed septic systems and wastewater treatment facilities; runoff from highways and parking lots; and, industrial activities, contribute heavy metals to Greenwich Bay. Heavy metals present a variety of health risks if ingested by humans and are hazardous to fresh and saltwater organisms.

### Bacteria/Pathogens

The discharge of bacterial contaminants from stormwater runoff has had a dramatic impact on the water quality and use of Greenwich Bay. Sources of bacterial contaminants include failed septic systems, broken sewer lines, illegal sewage "tie-ins" to storm drains, stormwater runoff, and animal feces. Bacterial contaminants are primarily responsible for health restrictions on shellfish harvesting and primary contact recreational activities within the Bay.

**Nutrients**

Phosphorus and nitrogen are nutrients common in stormwater runoff. Nutrients from anthropogenic (man-induced) sources may result in the accelerated growth of plants and algae called "cultural eutrophication". The natural "break-down" of dead plant matter by bacteria depletes the amount of dissolved oxygen in water. When oxygen levels become significantly low the water body is said to be in a state of "hypoxia". Hypoxic and conditions are considered to be detrimental to the propagation of aquatic life. Nitrogen is the "limiting nutrient" in salt waters and is therefore primarily responsible for eutrophication in marine environments. According to the Coastal Resources Council (1985), "eutrophication affects the abundance and distribution of fish and shellfish species". The eutrophication of marine environments is also believed to be a factor in the development of toxic algal blooms which can kill shellfish or cause illness in humans who consume shellfish. Primary sources of nitrogen in runoff include atmospheric deposition, fertilizers (especially lawn fertilizers applied to sandy soils), wild and domesticated animal waste and sewage.

**Salt**

High levels of salt (sodium chloride) are undoubtedly discharged to the Bay each year. Salt is commonly used as a snow removal or de-icing agent on local roads, highways, and parking lots. Elevated levels of salt can be detrimental to freshwater and saltwater organisms, especially in wetlands or poorly flushed water bodies.

**Sediment and Suspended Solids**

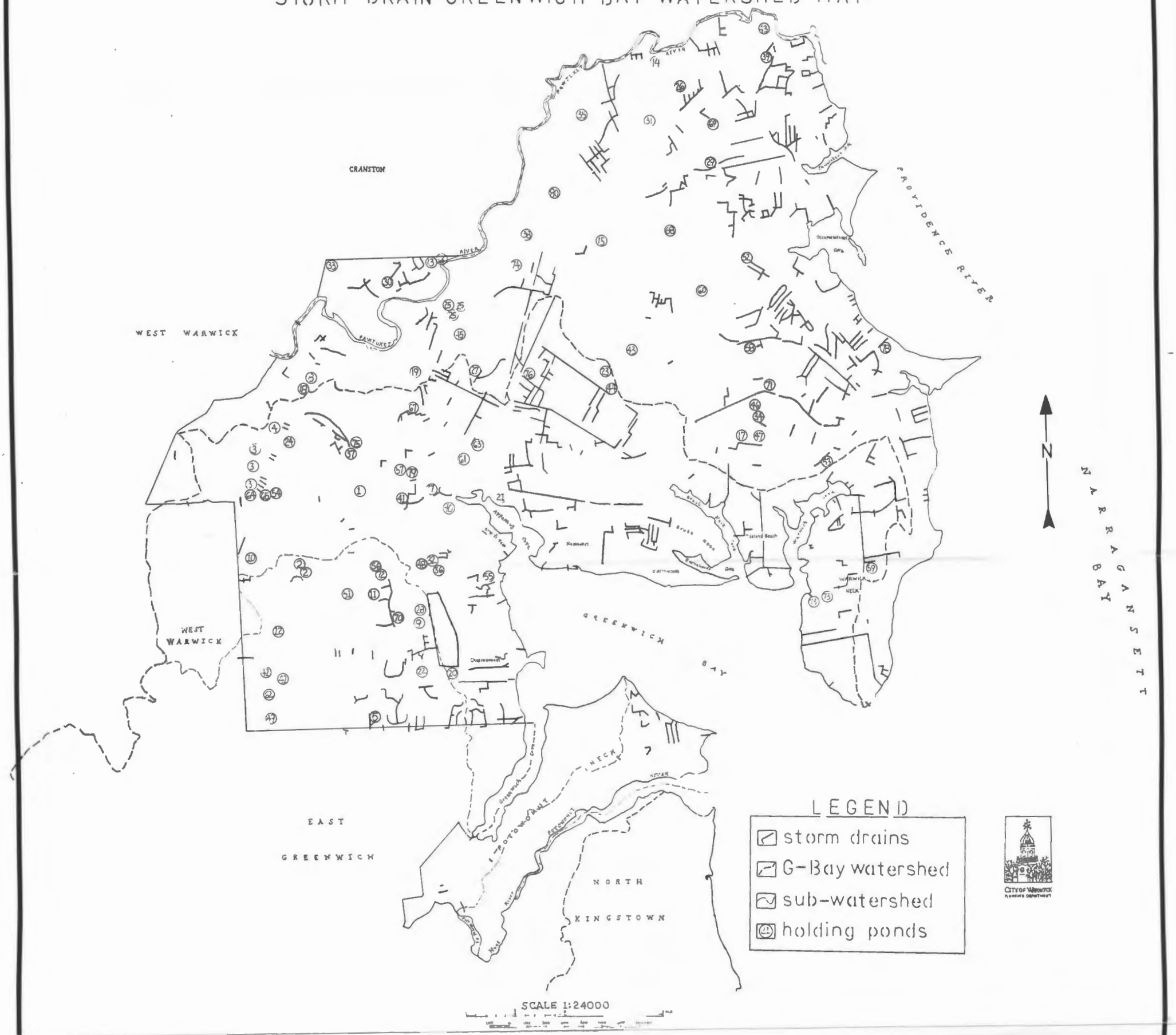
Erosion, as well as runoff from roads, large construction sites, and agricultural activities, can result in the deposition of large volumes of sediment into a water body. Sediment loads can adversely effect stormwater drainage, and decrease the storage volume of wetlands, ponds and streams. A number of specific problems may arise from sedimentation including: loss of flood storage, disruption of aquifer recharge areas, loss of natural pollutant attenuation in wetlands, and restriction of navigational passageways. Sedimentation may also result in the loss of freshwater and saltwater habitats including benthic habitats such as shellfish beds. Other contaminants, particularly hydrocarbons, have been shown to adhere to sediments transported by stormwater.

Subareas 1C and 3A (Apponaug), 2A and 2B (Chepiwanoxet), 4A and 4B (Buttonwoods), 5A and 5B (Oakland Beach), and 6A (Old Warwick) are all considered to be in need of improved stormwater management. RIDEM Office of Environmental Coordination (1988) classified Apponaug Cove as having a "high magnitude" of nonpoint pollution especially in terms of nutrients, solids/silt, and dissolved oxygen. The use support classification for this area was considered to be "nonsupport". The Greenwich Bay-Chepiwanoxet area was classified as having a "moderate to high magnitude" of runoff pollution due to high levels of pathogens. A use support classification of "partial support" was given for this area. The high levels of pathogens contributed by urban stormwater and the East Greenwich Wastewater Facilities warranted the use support classification; "threatened".

The impacts of pollutant-laden runoff on the Bay and other local water resources are immense. Improved stormwater regulation and management as well as increased public education are essential to the maintenance of Warwick's saltwater and freshwater resources. The Greenwich Bay Watershed and the location of Warwick's storm drains and holding ponds are shown in Map 8.

# WARWICK, R.I.

## STORM DRAIN-GREENWICH BAY WATERSHED MAP




SOURCES: U.S. GEOLOGICAL SURVEY - (1975)
CITY OF WARWICK ENGINEERING DEPT. (1993)

M. BRUSSEAU, WARWICK PLANNING DEPT
DECEMBER 1993

**Map 8 Storm Drains**

**Land Use/Density Patterns**

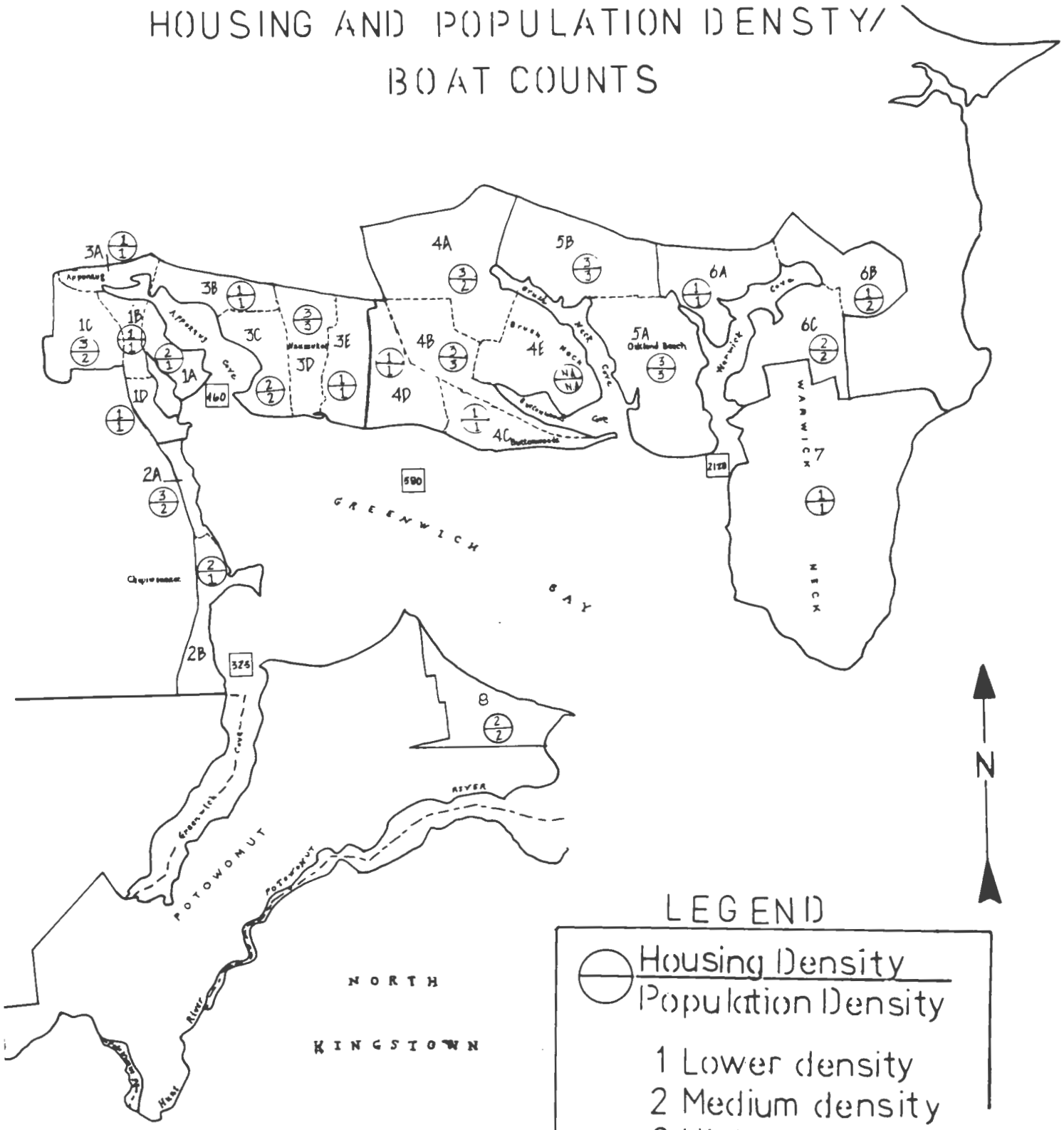
Land use and density patterns were considered very important factors in this analysis. When combined with adverse physical and environmental conditions, high density residential districts can contribute more contamination than low density developments (see Map 9). Bicki and Brown (1991) found a "highly significant correlation between bacterial levels in surface water and increasing density of ISDSs". "On-site sewage disposal system densities greater than 0.17/ISDS/acre (5.9 acres/ISDS) resulted in closure of shellfish harvesting beds in watersheds having soils with severe limitations for on-site sewage disposal". Locations having no sewers, dense populations, and poor environmental conditions were considered especially problematic due to the higher concentration of potential pollution sources.

Land use is also an essential factor to consider when identifying key sources of contamination. Residential, commercial, industrial, and agricultural land uses can generate different types and quantities of pollutants; while open space and conservation areas tend to help protect zones of environmental sensitivity. The Greenwich Bay Study Area consists primarily of residentially-developed land with sporadic commercial development. Concentrations of commercial development occur in subarea 2A along Boston Post Road, subareas 1C and 3A (Apponaug/Cowesett Hills district), and in subarea 5B along West Shore Road. Waterfront businesses are located in subareas 1A, 2A, 5A, 6A and 7. Subarea 4E (Brush Neck) consists solely of open space. Limited industrial development occurs in subareas 1C (Apponaug/Cowesett Hills district), 3A (Apponaug), and 3B (Apponaug/Nausaukett) (see Map 10). Finally, mode of pollutant

transport (ie., runoff, infiltration, groundwater and surface water flow) can also be influenced by site characteristics and land use.

# WARWICK, R.I.

## HOUSING AND POPULATION DENSTY/ BOAT COUNTS




### LEGEND

Housing Density / Population Density

1 Lower density
2 Medium density
3 Higher density

Boat Count

1:24000

SOURCE: U.S. GEOLOGICAL SURVEY (1975)
R.I. MARINE TRADE ASSOCIATION (1990)
KRISTIN SACCOCCIO (1993)

M.BRUSSEAU

CITY OF WARWICK
PLANNING DEPARTMENT


# Existing Land Use Warwick, R.I.

**Source: Warwick Planning Department**

**Development**

The Greenwich Bay coastline experienced rapid development during the three decades prior to World War I. Improvements to the transportation system, specifically the extension of trolley lines and the electrification of railroads, resulted in the growth of previously undeveloped areas such as Oakland Beach (1873) and Buttonwoods (1881) (Warwick Land Use Plan 1987). These villages were originally developed as summer resorts which offered valuable visual and recreational access to Greenwich Bay. A second major development boom, primarily residential, occurred between 1920 and 1930. During this period, Warwick experienced its greatest population increase to date, increasing 72.9 percent to reach a total population of 23,196 in 1930 (Figure 1)[2]. As local demand for housing grew, many summer cottages, particularly in Oakland Beach and Buttonwoods, were converted to year-round housing units (Warwick Land Use Plan 1987). Residential development continued to increase significantly in the following decades, particularly in the 15 years following World War II. A major out-migration from Providence was largely responsible for this rapid development. From 1930 to 1940, Warwick's population increased from 23,196 to 28,757; an increase of 23

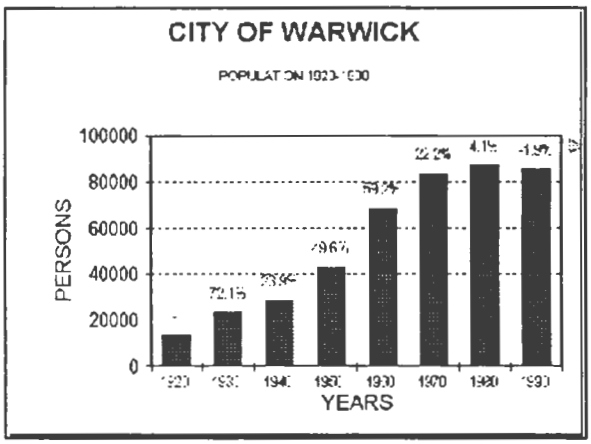



**Figure 1**
Source: Warwick Department of Economic and Community Development,1990

[2]Figures 1, 2, and 3 are created by Kristin Saccoccio (1993).

percent. This trend of increasing population continued into the 1980's, with the greatest growth occurring between the years 1940-50 and 1950-60, with increases of 49.6 and 59.2 percent, respectively. During the latter period, the popularization of the automobile and the emergence of low-cost home mortgage programs initiated by the Veterans Administration (VA) and the Federal Housing Administration (FHA) resulted in a major boom in single family housing construction which continued into the 1970's (Warwick Land Use Plan 1987). From that time until 1985, nearly half of all new residential development centered around the construction of multi-family housing units, condominiums, and apartments. During the same period, the percentage of vacant land decreased 27.6 percent. Warwick's growth has remained relatively stable since 1980.

**Population and Housing Densities**

Based on the 1990 U.S. Census of Population and Housing, the City of Warwick had a population density of 3.8 persons per acre. This figure is more than twice that of the State of Rhode Island's average (the second most densely populated state in the union), which was 1.49 persons per acre in 1990. The City's housing density was also higher than that of the State (Table 2).

Table 2 - Population and Housing Densities, 1990

| Subarea | Total Acres | Housing Unit Density per acre | Housing Units | Population Density per acre | Total Population |
|---|---|---|---|---|---|
| Rhode Island | | .62 | 414572 | 1.49 | 1003464 |
| Warwick | | 1.57 | 35141 | 3.8 | 85427 |
| 1A | 61.9 | 1.86 | 115 | 4.33 | 268 |
| 1B | 40.2 | 1.17 | 47 | 2.74 | 110 |
| 1C | 102.0 | 4.47 | 456 | 6.01 | 613 |
| 1D | 52.3 | 1.30 | 68 | 1.85 | 97 |
| 2A | 42.7 | 4.00 | 171 | 6.51 | 278 |
| 2B | 116.7 | 1.86 | 217 | 3.40 | 397 |
| 3A | 45.2 | 1.26 | 57 | 2.15 | 97 |
| 3B | 86.1 | 1.08 | 93 | 3.23 | 278 |
| 3C | 102.7 | 1.96 | 201 | 4.91 | 504 |
| 3D | 105.2 | 2.47 | 260 | 6.74 | 709 |
| 3E | 103.9 | 0.69 | 72 | 1.82 | 189 |
| 4A | 289.5 | 2.27 | 657 | 6.49 | 1879 |
| 4B | 129.2 | 2.57 | 332 | 7.87 | 1017 |
| 4C | 109.0 | 1.17 | 127 | 2.40 | 262 |
| 4D | 116.7 | 1.44 | 168 | 3.66 | 427 |
| 4E City Park | 163.3 | NA | NA | NA | NA |
| 5A | 266.6 | 3.78 | 1007 | 9.56 | 2549 |
| 5B | 232.1 | 3.21 | 745 | 9.01 | 2091 |
| 6A | 133.3 | 1.25 | 167 | 3.54 | 472 |

| | | | | | |
|---|---|---|---|---|---|
| 6B | 129.5 | 1.41 | 183 | 4.76 | 616 |
| 6C | 184.0 | 1.84 | 338 | 5.11 | 940 |
| 7 | 813.7 | 0.36 | 293 | 0.94 | 764 |
| 8 | 193.9 | 2.17 | 421 | 5.07 | 983 |
| **Total** (study area) | **3,619** | **NA** | **6,196** | **NA** | **15,541** |

Source: U.S. Census of Population and Housing, 1990.

With the exception of subarea 7, the population densities of each of the twenty-three subareas in the Greenwich Bay Study Area were found to be in excess of the state's population density. Twelve of the twenty-three (52 percent) had considerably higher population densities than the City's average. Those areas included 1A, 1C, 2A, 3C, 3D, 4A, 4B, 5A, 5B, 6B, 6C, and 8. Subareas 5A (9.56 persons per acre), 5B (9.01 persons per acre), and 4B (7.87 persons per acre) were among the most densely populated areas in the study (Figure 2).

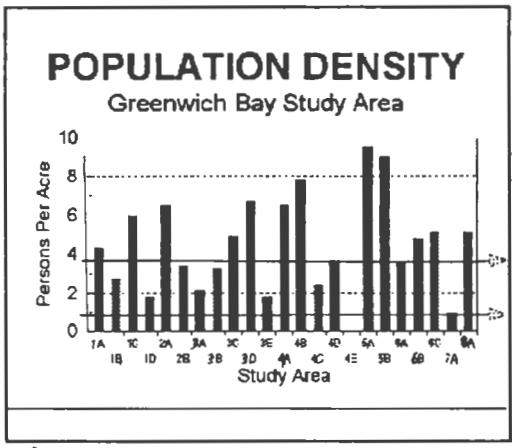



**Figure 2**
Source: U.S. Census of Population and Housing, 1990

Analysis of housing densities within the Greenwich Bay Study Area showed similar results. Each subarea, excluding subarea 7, had more housing units per acre than did the State of Rhode Island. Again, twelve of the twenty-three subareas (52 percent) had a higher housing density than the City (Figure 3). Included in the 52 percent were 1A, 1C, 2A, 2B, 3C, 3D, 4A, 4B, 5A, 5B, 6C, and 8. The areas of highest density, based on housing units per acre, were 1C (4.47 housing units per acre), 2A (4 housing units per acre), 5A (3.78 housing units per acre), and 5B (3.21 housing units per acre).

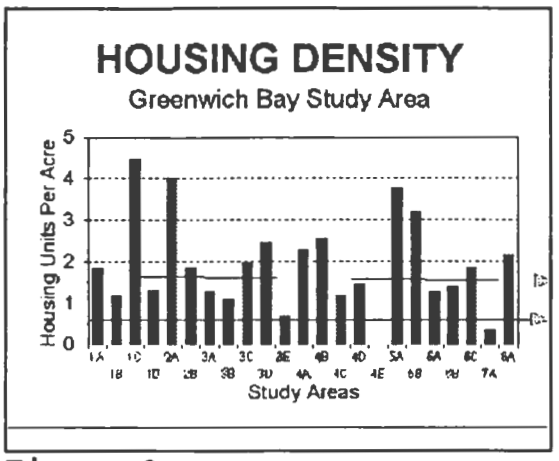



**Figure 3**
Source: U.S. Census of Population and Housing,1990

**Marine Activity**

According to the RIDEM Water Resources Division (1990), Apponaug Cove and Greenwich Cove have a water quality classification of SC, while both the southeastern portion of Apponaug Cove and the northernmost reach of Greenwich Cove are classified as SB. Warwick Cove is also classified as SB. An SC classification restricts shellfish harvesting for human consumption and primary recreational activities, but does permit boating and other secondary contact recreation; while an SB classification permits shellfish harvesting for human consumption only after depuration (the transplanting of shellfish from contaminated waters to more pristine waters so as to allow natural purification before harvesting) (RIDEM Division of Water Resources 1990). The remainder of Greenwich Bay as well as the Brush Neck and Buttonwoods Coves are classified as SA, the highest water quality classification. Although the RIDEM has classified Greenwich Bay proper as SA, the actual water quality has been poor enough to warrant complete closure of shellfishing beds within the Bay since December of 1992.

Large numbers of recreational boats in the Apponaug, Greenwich, and Warwick Coves are considered to be significantly impacting water quality in the Bay during the summer months. Based on the Interstate Shellfish Sanitation Conference (ISSC) Marina Formula, Apponaug Cove, with an estimated 460 moored vessels, has thirty-eight times the maximum recommended number of boats. Warwick Cove has 2,120 boats, a figure one hundred and six times the number suggested for the area; while the boat count in Greenwich Cove is five times greater than the suggested number (RIDEM Division of Water Resources 1991).

In addition to these seemingly high boat counts, none of the marinas within Greenwich Bay or its coves are equipped with marine sewage pump-out facilities (RIDEM Division of Water Resources 1991). The direct discharge of untreated sewage into the Bay is the primary means of eliminating wastewater by local boaters.

The Coastal Resources Center (1983) devised a "waters" classification scheme to categorize coastal lands based on their suitability for particular uses. Six classifications were developed, including:

Type 1 - Natural/Undisturbed Conservation Area
Type 2 - Low Intensity/Residential
Type 3 - Commercial Activities/Marinas and Boatyards
Type 4 - Multi-Purpose/Fishing, Boating, and Commerce
Type 5 - Recreation and Commercial Ports
Type 6 - Industrial and Commercial Activities

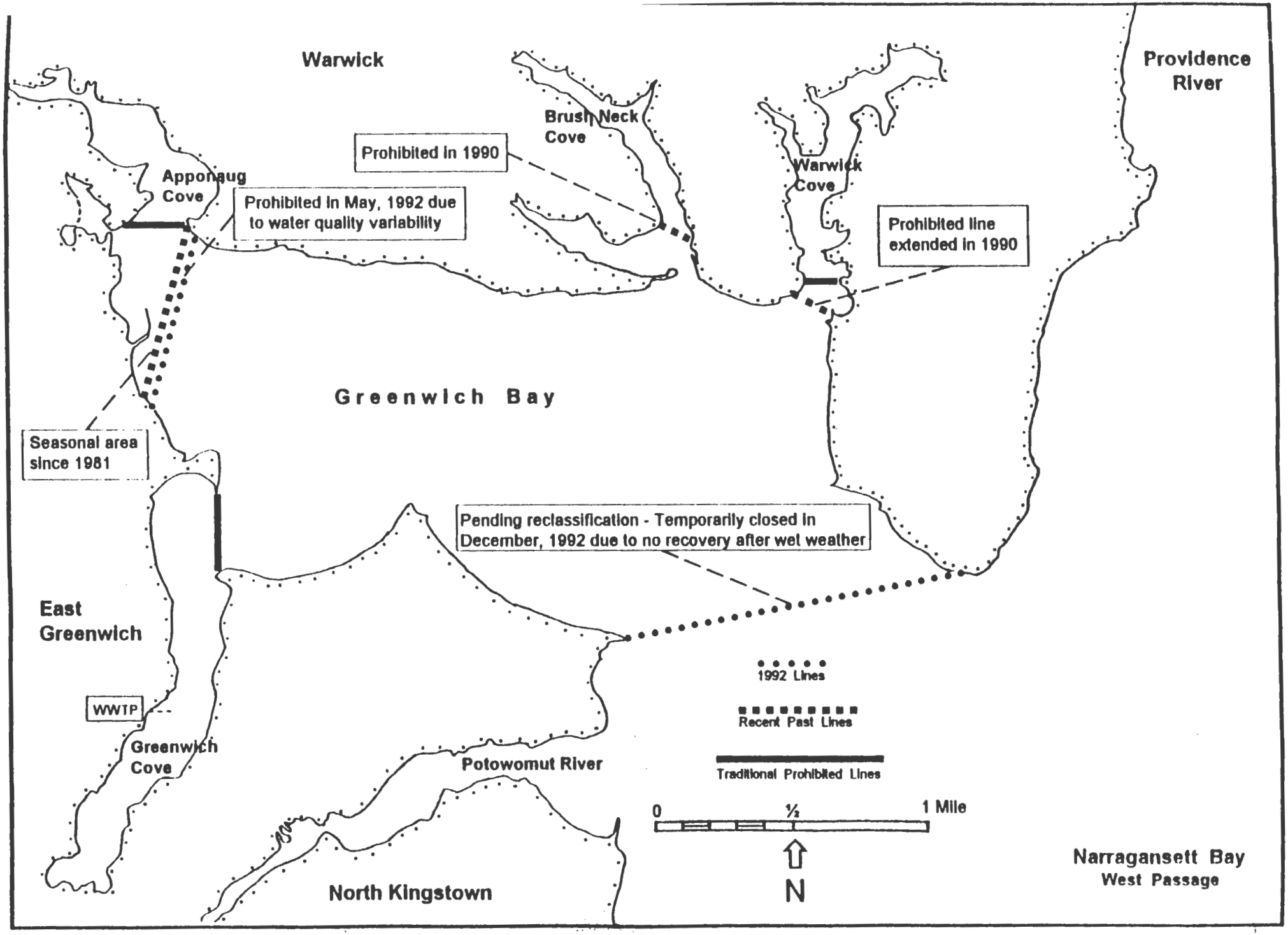
These classifications not only provide a basis from which to regulate future coastal development, but actually depict the present land use along Greenwich Bay's shoreline. Table 3 provides information pertaining to water quality and land use within the Greenwich Bay Study Area. Map 11 describes Greenwich Bay shellfishing classifications over time.

Table 3 - Water Use Classifications

| **Waterbody** | **Contiguous Subarea(s)** | **Water Use Class (Type)** | **Coastal Land Use** | **Water Quality Class** (desired) |
|---|---|---|---|---|
| Greenwich Bay | NA | 4 | Open Waters | SA (not in compliance ) |
| Southern Greenwich Cove | NA | 1 | Natural Undisturbed | SC |
| Northwestern Greenwich Cove | 2B | 5 | Ports Industrial Waterfronts | SC |
| Chepiwanoxet Shoreline | 2A, 2B, 1D | 2 | Residential | SB Seasonal closure 1D & 2A |
| Apponaug Cove | 1A, 3A, 3B, 3C | 3 | Marinas Boatyards Commercial | SC |
| Nausauket-Buttonwoods Shoreline | 3C, 3D, 3E, 4D, 4C | 2 | Residential | SA Not in compliance |
| Buttonwoods Cove | 4B, 4C, 4E | 1 | Natural Undisturbed | SA Not in compliance |
| Brush Neck Cove | 4A, 4E, 5A, 5B, | 1-2 | Natural Undisturbed Residential | SA Not in compliance |
| Southern Oakland Beach-Greenwich Bay | 5A | 2 | Residential | SA Not in compliance |
| Warwick Cove | 5A, 6A, 6B, 6C, 7 | 3 | Marinas Boatyards Commercial | SB not in compliance |

| | | | | |
|---|---|---|---|---|
| Warwick Neck Shoreline | 7 | 2 | Residential | SA<br>Not in compliance |
| Potowomut/Sally Rock to Sandy Point | 8 | 2 | Residential | SA<br>Not in compliance |
| Northeastern Greenwich Cove-Goddard Park | NA | 1 | Natural Undisturbed | SB<br>Not in compliance |
| Potowomut River | NA | 1 | Natural Undisturbed | B |

Sources: Coastal Resources Center, 1984 and RIDEM Water Resources, 1990.




**Map 11 Greenwich Bay Shellfishing Classifications Over Time** FDA 1993

# CHAPTER THREE

## ANALYSIS OF EXISTING CONDITIONS

The following is an evaluation of each subarea based on the previously described physical and land use characteristics.

### Arnold's Neck/Cowesett Hills Apartments

Subarea 1A is a small but moderately populated district bordered by Apponaug Cove to the east and Thatch Cove and its contiguous salt marsh to the west. This neighborhood consists of single family homes, as well as waterfront business located along its eastern boundary.

Arnold's Neck is situated on a small, steeply sloping (greater than 15%) knoll composed of unconsolidated and stratified coarse sand and gravel which is moderate to poorly suited for septic system use (United States Department of Agriculture 1981). These excessively permeable, non-compacted soils result in percolation rates which are among the most rapid within the Greenwich Bay Study Area. These rates often exceed 30 inches per hour (RIDEM ISDS Division 1975-1993). A high percolation rate such as this provides little in the way of physical, chemical and biological purification of septic system effluent which may ultimately result in groundwater degradation and the eventual contamination of the Bay.

Despite this limitation, this area is very well drained. Depth to water table has been found to be in excess of 24 feet at times (RIDEM ISDS Division 1975-1993).

Although the local water table appears to be relatively deep, the fluctuation of daily tides may cause the groundwater surface to rise. As a result, the distance between the water table and wastewater system may be considerably less. As the tide goes out and the water table lowers, contaminants may percolate through the soil substratum and travel along the slope of the water table discharging directly into the coves and nearby wetlands. After the contaminants enter the coastal wetlands they are then drawn out with the ebb of the tide. Further investigation is needed in this area in regard to possible contamination from high percolation rates and the process previously explained.

While periodic flooding may occur along the low-lying areas of Arnold's Neck, flooding does not appear to be a major cause of septic system failure. Most homes are situated above frequently flooded areas.

Another probable source of bacterial pollution is the many boats berthed in Apponaug Cove. According to the Rhode Island Marine Trade Association (1990) the number of vessels berthed in the Cove is 460. Because there are no marine pump-out stations located in Apponaug Cove, boats not equipped with functional marine sanitation devices (MSDs) discharge raw, untreated sewage into the Bay, a practice which contributes to increased fecal coliform counts.

Subareas 1C and 1B are extensively developed with homes, businesses, and industry, and have historically been a hub of activity in Warwick. Stormwater runoff from this area appears to be a major contributor to the degradation of water quality in Greenwich Bay. Nutrients, heavy metals, synthetic organic chemicals, salt, as well as virus-carrying bacteria are often typically found in common urban runoff. Impervious

surfaces such as streets, parking lots and buildings inhibit infiltration of precipitation and meltwater causing excess water to rapidly runoff. The resulting runoff accumulates pollutants and eventually makes its way to local streams, ponds, and wetlands before entering Apponaug Cove and Greenwich Bay. Wetlands are often instrumental in storing excess water and "absorbing" pollutants. However, prolonged accumulation and exposure to contaminants such as has been exhibited in these subareas, can reduce the wetland's ability to absorb additional pollutants. There are no documented storm drains in study area 1 with the exception of one outfall located off the southern most tip of Arnold's Neck. Apponaug is partially sewered. However, many buildings in the area remain unconnected. The Warwick Sewer Authority (June 1993) reported that Cowesett Hills Apartments, having 499 units, had only 99 units (19.9%) presently connected to sewer lines. Finally, it should be noted that water fowl habitating in, or migrating to, the nearby coastal wetlands may contribute to elevated levels of bacterial contamination as well.

**Chepiwanoxet**

Subarea 2a is moderate to densely populated (generally greater than 6 dwelling units per acre) due primarily to the presence of condominiums and apartment complexes. Subarea 2B is slightly less dense. Both sections are primarily used for residential, and commercial land uses. High population density (homes with on-site sewage disposal systems) and potential for direct runoff to the Bay from parking lots and roads are major pollution concerns. Four major storm drains discharge directly into Greenwich Bay in

study area 2. Locations having storm drains within subarea 2A have moderate and severely constrained soils for septic systems. A number of storm drains located just west of subareas 2A and 2B on the inland side of Boston Post Road appear to be potential sources of polluted stormwater to the Bay. No sewer lines exist in this district. No ledge is apparent in this area and the seasonal high water table is in excess of seven feet (RIDEM ISDS 1993).

Soils, in general, are moderately limited for septic systems and slopes are moderate along the Bay. These slopes enhance runoff, and the possibility of lateral seepage of septic effluent. Supporting this hypothesis is a citation in RIDEM's *Water Resources Shoreline Report* (1991) which mentions the seepage of sewage out of a retaining wall from a cesspool in Chepiwanoxet as a "significant source of pollution".

Restrictions on further development may be essential where high density populations such as apartment complexes and condominiums currently exist. Extension of sewers to the area should be considered. Further, the City's impending purchase of the Chepiwanoxet peninsula to preserve open space and prevent further pollution is an important demonstration of commitment in this area.

**Nausauket /Apponaug**

Study area 3 is a moderately dense, single family residential neighborhood. The highest population densities are concentrated in subareas 3D and 3C (6 or more dwelling units per acre), respectively. Nausauket, not being sewered, relies exclusively on septic systems or cesspools. Most homes appear to have been built prior to the 1968 RIDEM

ISDS regulations and may, like many other areas, be in need of septic system repair or replacement.

This district is underlain by glacial outwash with no bedrock near the surface. The soils, which have been classified as slight, moderate, and severely constrained for septic system use, have rapid permeabilities and the seasonally high water table is generally deeper than eight feet. Severely constrained soils comprise approximately 1/3 of this study area's land with "wetness" being the major cause of the "severe" classification in this region.

Surface runoff flows west into Apponaug Cove, and to the east into Baker's Creek and its contiguous wetland. Baker's Creek drains this area and has been identified as an "actual pollution source" (more accurately a conduit) of bacteriological contamination to the Bay (RIDEM Water Resources 1991). Steep slopes along Apponaug Cove and Baker's Creek promote runoff and may cause seepage to occur in the area. Study area 3A has no documented storm drains within its district. However, a network of storm drains exist north of subarea 3B. These storm lines drain the densely populated southern Greenwood area. Stormwater is discharged into a small stream which flows southerly through subarea 3B, and into the northernmost inland reach of Apponaug Cove. Subareas 3B and 3C have just a couple of storm drains each. Each district has a stormwater outfall which discharges into Greenwich Bay.

**Buttonwoods**

Subarea 4E is the location of Warwick City Park. Designated for open space/conservation, this area is undeveloped and contributes little pollution to Brush Neck and Buttonwoods Coves. Lack of development, and low boat densities undoubtedly contribute to higher water quality here, compared to the other harbors and coves. Subareas 4A, 4B, 4C, and 4D are primarily composed of residential development with some commercial development concentrated along the northern edge of subarea 4A. Sections 4A and 4B are very densely populated (6 or more dwelling units per acre), while sections 4C and 4D have low population densities (open space/2-3 dwelling units per acre).

Study area 4 lies on glacial outwash. There are currently no sewer lines within this district. No impervious surfaces appear at or near the surface. However, the seasonally high water table averages approximately 6 feet in depth and may therefore impede proper treatment of on-site septic wastewater, especially in the spring and fall when precipitation is high and evaporation and transpiration are moderate (RIDEM ISDS 1993).

Soils are classified as having only slight limitations for septic systems in the area, with the exception of soils adjacent to local brooks feeding into Buttonwoods and Brush Neck Coves. Topography is generally flat to gently sloping. Runoff from Study area 4 drains into two primary brooks and into Brush Neck and Buttonwoods Coves. Sub areas 4C and 4D drain directly into Greenwich Bay. An extensive network of storm

drains, located to the north of subarea 4A in the Greenwood/Green Airport section of the City discharges into Tuscatuket Brook which drains into Brush Neck Cove.

Subareas 4C and 4D contribute less contamination than most other subareas. However, in the future, land use controls, careful consideration of environmental conditions, and proper septic system design and installation should be ensured. Special attention should be paid to the heavily populated subareas 4A and 4B, and their impacts on environmentally-sensitive locations such as the area's bathing beaches and the streams and wetlands which discharge into the Bay.

**Oakland Beach**

Oakland Beach (study area 5) is one of the most densely populated district in the Greenwich Bay Study Area and is composed almost exclusively of residential properties with the exception of the Oakland Beach recreation area and a few parcels supporting commercial activities. Originally, the homes in Oakland Beach were designed and used as summer cottages. Today, most of these dwellings are used for families on a year-round basis. According to the Warwick Sewer Authority (1993) only 58 percent of these homes are presently tied into the existing municipal sewer lines provided. Local contamination would be significantly decreased if mandatory connections were enforced. Developed long before RIDEM ISDS regulations, the remainder of homes rely on antiquated septic systems or cesspools which if not adequately maintained, repaired or upgraded have likely far exceeded their approximate life expectancy of 25 years (RIDEM ISDS 1993). An estimated 350-375 housing units, within subarea 5A, still rely

exclusively on on-site septic systems or cesspools for treatment and disposal of household wastewater.

Study area 5 is covered by glacial outwash with no evidence of bedrock or other impervious surfaces at shallow depth within the soil. Soils are almost exclusively classified as having only "slight limitations" for septic systems in the area (United States Department of Agriculture 1981). Insufficient information was found on the depth to seasonal high water table. However, the flat, low lying (just above sea level) nature of Oakland Beach indicates the possibility for periodic flooding and a locally high water table. Slopes are nearly non-existent in this area. Precipitation either infiltrates into the ground or runs off into Warwick Cove, Brush Neck Cove, or directly into Greenwich Bay. Storm drains in subarea 5A, for the most part, discharge to the west into Brush Neck Cove. However, one major storm drain discharges near the inlet of Warwick Cove. A "primary" storm drain runs the length of Oakland Beach from north to south, bisecting the study area, and discharging into Brush Neck Cove.

Subarea 5B has considerable commercial development along West Shore Road which undoubtedly contributes urban runoff into Brush Neck and Warwick Coves. The RIDEM *Shoreline Survey Reappraisal Report* (1991) had identified a few point sources that actually contribute bacterial pollution to the Bay. These points are located sporadically along Brush Neck Cove's eastern bank.

Boats berthed in Warwick Cove are a definite contributor to local contamination. Brush Neck Cove has no marinas and exhibits a higher water quality classification.

However, according to RIDEM Division of Water Resources (1990), Brush Neck Cove's water quality has begun to decline in recent years.

### Old Warwick

The Old Warwick study area is located in the northwestern section of Warwick Neck and surrounds the northern reaches of Warwick Cove. This district has generally low to medium population density. Land use is almost entirely residential with the exception of some waterfront commercial operations located in subareas 6A and 6C.

Soils are generally poorly suited for septic systems in subareas 6B and 6C due to slow percolation rates, wetness, and stoniness. Subarea 6A's soils are rated slight, moderate, and severely limited for septic systems. Much of this subarea is considered urban by the *Rhode Island Soil Survey* (1977), making it a probable contributor of pollution through urban runoff. Topography, in general, is gently sloping in this area. Runoff drains into Warwick Cove from this subarea. Subareas 6B and 6C drain directly into Warwick Cove or into a local stream before discharging into the Cove.

### Warwick Neck

Warwick Neck is the least densely populated district in the Greenwich Bay Study Area averaging one (1) dwelling unit per acre. The predominant land uses in this subarea include low and medium density residential. With the exception of one short sewer line, this subarea relies exclusively on individual sewage disposal systems.

Geologically, Warwick Neck is composed of glacial till overlying bedrock. Bedrock outcrops, as well as shallow depths to bedrock, occur along the central region and western side of the area. While slopes are predominantly gentle or moderate in this area, some steep slopes do occur along the eastern and southern periphery. Shallow depth to groundwater, soil characteristics, and the local geology suggest the presence of a highly compacted or cemented, fine textured soil commonly referred to as hardpan. Hardpan is often nearly impervious and may support a "perched water table". Aside from the hardpan, the soils in this study area are fine textured with a slow percolation rate. These conditions often are conducive to suitable treatment, however, extremely slow percolation rates can cause septic system failure in the form of surfacing of septage, especially after heavy rains.

Slopes can facilitate overland flow of the septage and eventual deposition into the Bay or Warwick Cove. Another problem associated with these conditions is lateral seepage. Lateral seepage occurs when wastewater percolates down to a restrictive layer of soil, flows along the interface and seeps out along the side of a hill. Another difficulty with glacial tills is the potential for tiny soil pores to become clogged by solids strained out during natural filtering. Evidence suggests that slow percolation rates, and high water tables have caused septic system failures in this area.

In addition, slow percolations usually inhibit infiltration and induce a greater volume of stormwater runoff. However, stormwater runoff from this district appears to have had only moderate impacts on the Bay's water quality (RIDEM Office of

Environmental Coordination 1988). Storm drains in subarea 7 drain west into Greenwich Bay and east into Narragansett Bay.

Warwick Cove berths more boats (2120) than any other cove in Greenwich Bay. Boats appear to be a major contributor to the elevated fecal coliform levels in Warwick Cove. Conversely, Brush Neck and Buttonwoods Coves, which has limited moorings and one small boat club, have lower fecal coliform levels than all other coves in Greenwich Bay.

**Potowomut**

Because much of Potowomut consists of the minimally-developed Goddard Memorial State Park (open space/conservation area), it was not necessary to examine the entire area. However, one principal study area was defined. This district, subarea 8, is a moderately populated residential neighborhood (averaging 4-5 dwelling units per acre). Potowomut is not sewered and therefore relies on individual sewage disposal systems for wastewater treatment.

Soils in this area are generally slightly limited for on-site septage treatment. However, a small percentage of land in this area is restrictive to septic systems due to wetness, bedrock outcrops, or shallow depth to bedrock. Land use restrictions and the establishment of a Greenwich Bay Protection District would be helpful in addressing problems in this study area.

Greenwich Cove receives wastewater from East Greenwich's wastewater treatment facility. This source, however, is regulated and is in compliance with the Rhode Island

Point Discharge Elimination Systems (RIPDES) permits (RIDEM Permitting Division 1993). Greenwich Cove has several marinas which berth a total of 323 vessels (RI Marine Trade Association 1990). These boats undoubtedly contribute to fecal bacteria contamination.

# CHAPTER FOUR

## GENERAL RECOMMENDATIONS FOR CRITICAL SUBAREAS

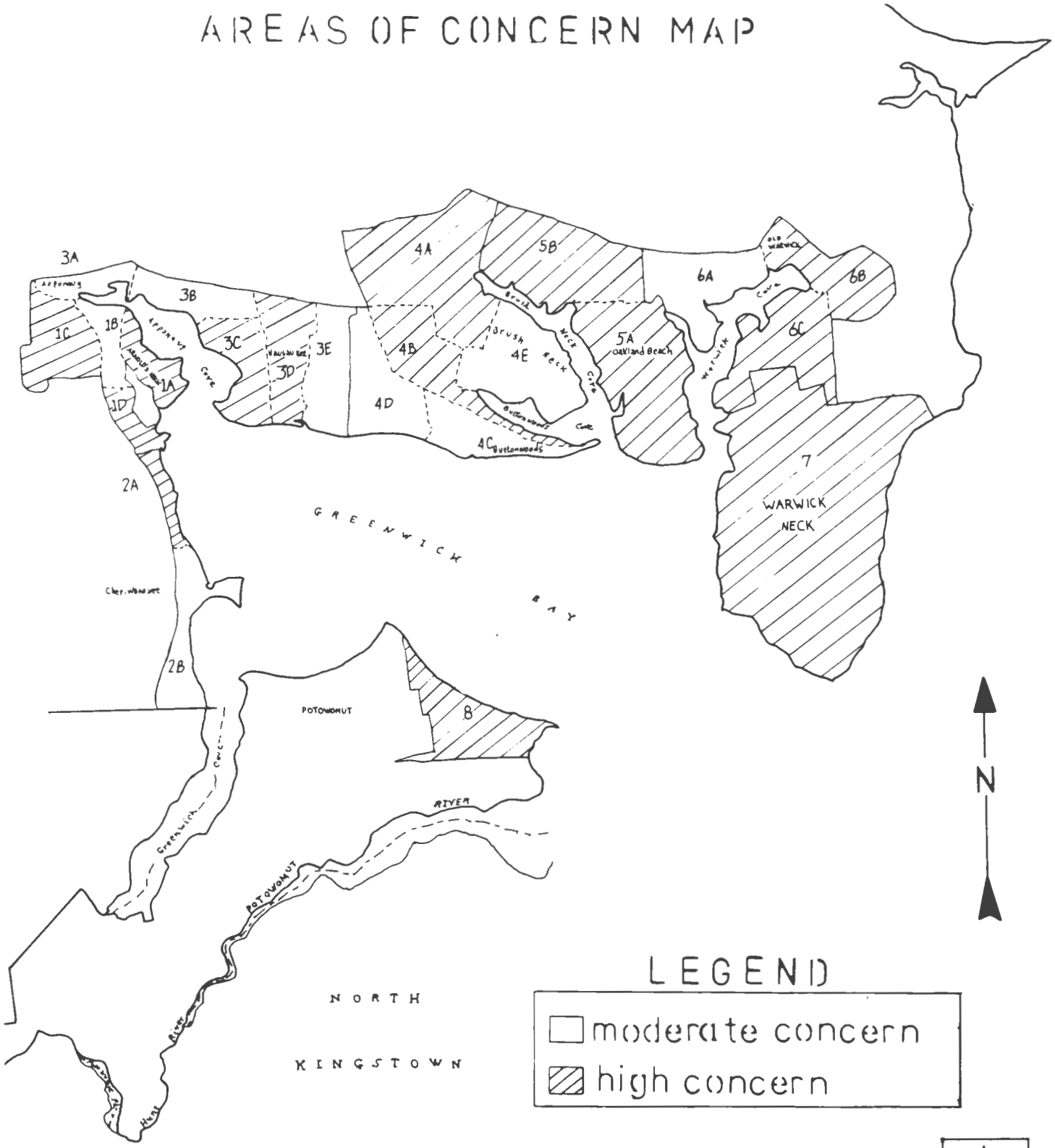
The preceding analysis has identified several causes and critical source areas from which local bacterial pollution appears to originate. Based on careful examination of environmental conditions in and around the Bay and local land use patterns, it is apparent that primary sources of bacterial contamination include: septic system and cesspool failures, broken or cracked sewer lines, stormwater runoff, and sewage discharge from boats.

A quantitative method of analysis was designed to identify areas of greatest concern. This method assigned numerical values to the physical conditions which are most often responsible for promoting or contributing to bacterial pollution in surface water and groundwater. After each subarea was examined, a total for each category was computed. Subareas with the highest numbers (17 and over) were considered areas of concern, while subareas with lower totals were considered to pose less of a threat. The purpose of this technique was to get a general "feel" for the overall conditions of the various districts within the study area - not to establish an absolute scientifically-based hierarchial classification. The analysis, therefore, should be considered in light of this rationale.

Districts defined as areas of concern included: 1A, 1C, 1D, 2A, 3C, 3D, 4A, 4B, 5A, 5B, 6B, 6C, 7, 8 (see Map 12).

# WARWICK, R.I.

## AREAS OF CONCERN MAP



The following is a summary of the conditions and general recommendations for the above areas. Subareas with similar characteristics will be discussed collectively.

Subareas 1A (Arnold's Neck), 1C (Cowesett Hill Apartments/Southwest Apponaug), 1D (West Arnold's Neck), and 2A (North Chepiwanoxet) shared similar physical characteristics, however, 1C and 2A were more densely populated. The primary reasons for their classification as "areas of concern" are: rapid permeabilities, moderate to severely constrained soils for septic systems, high proportions of impervious (paved) surfaces, and proximity to environmentally sensitive areas. Both 1A and 2A are situated along the coast of Greenwich Bay, while 1C is the most removed area in this group. Subarea 1C is also the only area that has been sewered.

General recommendations for these areas are as follows: sewer extensions, mandatory sewer hook-ups, and surface water quality testing in area 1C and 2A, installation of innovative septic systems, improved stormwater management in subareas 1C and 1D, stricter land use standards for future development, increased enforcement of ISDS regulations, and, inspection, maintenance, repair and upgrade of on-site septic systems are recommended throughout this study area. The installation of at least two marine pump-out facilities is recommended for Apponaug Cove.

Proposed road construction along Post Road in 1995, as well as the existing sewer infrastructure in this area would help to facilitate the installation and connection of sewer lines. However, limits on development and stringent stormwater management regulations should be imposed so as to avoid other

detrimental effects such as uncontrolled development which often occurs after sewers are installed.

The major constraints on wastewater and stormwater treatment in subareas 3C (West Nausauket) and 3D (East Nausauket) include moderate to high population and housing densities, moderate to severe soil limitations, high proportions of impervious surfaces, and moderate slopes. No sewers are provided in either area.

Recommendations include higher standards for land development such as larger house lot requirements, inspection, maintenance, upgrade, and repair of on-site septic systems, wastewater management, and monitoring of Baker's Creek to help identify inland sources of contamination. Gorton's Pond should be monitored for the presence of fecal coliform. An examination of the flushing rate of the pond as compared to the survival period of the bacteria of concern should be conducted to establish whether the Greenwood section of the City is significantly contributing to bacterial loading in Apponaug Cove[3]. Stormwater management should be improved in subarea 3D.

Subarea 4A (Buttonwoods/Brush Neck) and 4B (North Buttonwoods/Brush Neck) are classified as areas of concern due to the dense population, high water table, moderately constrained soils, and a high proportion of impervious surfaces.

Recommendations for this area include upgraded stormwater treatment, higher standards for land development, inspection, maintenance, repair, and upgrade of on-site septic systems, wastewater dye tracing, and, water quality testing in local streams.

---

[3]The life span of pathogens in a saltwater environment is influenced by several factors including temperature, sediments, nutrients, light, dissolved oxygen, and type of microorganism. Typical survival rates range between a few hours and four months; bacterial and viral pathogens can still have effects as far as 10 kilometers from their source (Coastal Urban Areas Committee on Wastewater Management 1993).

Subareas 5A (Oakland Beach) and 5B (Northwest Oakland Beach) were among the densely populated areas in the Greenwich Bay Study Area. This area was originally developed as a summer resort for the purpose of weekend and seasonal habitation only. The on-site septic systems prevalent in this area were not designed to handle the capacity of effluent created by the present day, year-round use. Other limiting factors include proximity to sensitive areas, periodic flooding, and impervious surfaces. Subarea 5A is sewered, yet, only 58 percent of the housing units are connected. Area 5B is not sewered.

Homes located in subarea 5A should be required to tie-in to the existing sewers. The establishment of larger house lot requirements would be helpful in guarding against inappropriate development in this area. Upgraded stormwater and wastewater management, land use restrictions, and inspection, maintenance, repair, and upgrade of septic systems would help to improve conditions in both districts. Sewer extensions are recommended in subarea 5B. In general areas 4 and 5 will require bacterial monitoring in up-stream reaches to find "hot spots". The limited scope of DEM's source monitoring would indicate that an additional program, increasing upstream monitoring, would be valuable. At least three marine pump-out facilities should be established in Warwick Cove.

Severe soil limitations, high water tables, high proportions of impervious subsurfaces (hardpan and bedrock), and proximity to environmentally sensitive areas are the primary limitations in subarea 6B (Northern Old Warwick), 6C Southern Old

Warwick), and 7 (Warwick Neck). This area, not being sewered, relies exclusively on on-site sewage disposal systems.

Recommendations for these areas include establishment of larger house lot requirements, use of alternative/innovative on-site septic systems, increased ISDS enforcement (systems have been allowed to be installed in places of exceedingly shallow depths to groundwater), inspection, maintenance, repair, and upgrade of on-site sewage disposal systems, and, periodic water quality testing. At least three (3) marine pump-out facilities should be installed at marinas within Warwick Cove.

Subarea 8 (Potowomut) is the final locality classified as an area of concern. This district is characterized by close proximity to environmentally sensitive areas, impervious subsurfaces, and a moderately dense population.

Inspection, maintenance, repair, and upgrade of on-site septic systems, wastewater management, consideration of future communal septic sewage treatment and higher standards for land development are recommended for this area. At least two (2) marine pump-out facilities should be installed in Greenwich Cove to lower the level of contamination contributed by vessels berthed in this Cove. Also, cooperation from the Town of East Greenwich and continued compliance of its wastewater treatment facility is essential to monitoring and controlling bacterial contamination in Greenwich Cove.

Finally, an outreach and education program should be established for the purpose of informing the citizens of Warwick about issues relating to the water quality degradation of Greenwich Bay. Further research in all subareas should be conducted.

The analysis of data in this study has been analogous to the piecing together of a puzzle. Each bit of data, like a puzzle piece may appear to be of little importance by itself, yet when considered collectively begin to create a coherent "picture" of the problem at hand. Although time, costs, technological and human limitations constrain the absolute diagnosis of the problems associated with a project of this magnitude, an enormous amount of information has been collected and interpreted which shows consistent patterns from which logical inferences have been made. As data was compiled, considerable cross-checking occurred which continued to support the findings. Further site-specific analyses such as water quality monitoring, ISDS inspections, additional research, and ongoing plan evaluation is recommended to help in providing further information to address the variety of problems at hand. General recommendations for each subarea are summarized in Table 4.

Table 4 - Site-specific Recommendations

| Subarea | SE [4] | ST | SS | ISWT | HSLD | IE | MRUR | IMPF | WQ | ED |
|---|---|---|---|---|---|---|---|---|---|---|
| 1A Arnold's Neck | | | X | | X | X | X | X | X | X |
| 1B Arnold's Neck | | | | | X | | X | | | X |
| 1C Cowesett Hills | X | X | X | X | X | X | X | | X | X |
| 1D Arnold's Neck | | | X | | X | | X | | | X |
| 2A Chepiwanoxet | X | | | X | X | | X | X | | X |
| 2B Chepiwanoxet | X | | | X | X | | X | | | X |
| 3A Apponaug | | | | X | X | | X | | X | X |
| 3B Apponaug/ Nausauket | X | | | | X | | X | | | X |
| 3C Nausauket | X | | | | X | | X | | | X |
| 3D Nausauket | | | X | X | X | | X | | X | X |
| 3E Nausauket | | | | | X | | X | | | X |
| 4A Buttonwoods | | | X | X | X | | X | | X | X |
| 4B Buttonwoods | | | X | X | X | | X | | X | X |
| 4C Buttonwoods | | | X | | X | | X | | X | X |
| 4D Buttonwoods | | | | | X | | X | | X | X |
| 4E Brush Neck | | | | | X | | X | | X | X |
| 5A Oakland B. | | X | | X | X | | X | X | X | X |
| 5B Oakland B. | X | X | X | X | X | | X | | X | X |
| 6A Old Warwick | | | | X | X | | X | X | | X |

*SE (sewer extension), *ST (sewer tie-in), *SS (innovative septic systems), *ISWT (improved stormwater treatment), *HSLD (higher standards for future land development), *IE (increased enforcement/upgrade of ISDS regulations), *MRUR (inspection, maintenance, repair, upgrade, or replacement of existing ISDS), *IMPF (installation of marine pumpout facilities), *WQ (water quality monitoring, dye tracing) *ED (education). SHADING REPRESENTS AREAS OF MOST CONCERN.

| Subarea | SE | ST | SS | ISWT | HSLD | IE | MRUR | IMPF | WQ | ED |
|---|---|---|---|---|---|---|---|---|---|---|
| 6B Old Warwick | | | X | | X X | X | X | | X | X |
| 6C Old Warwick | | | X | | X X | X | X | X | X | X |
| 7 Warwick Neck | | | X | | X X | X | X | X | | X |
| 8 Potowomut | | | | | X | | X | | | X |

*SE (sewer extension), *ST (sewer tie-in), *SS (innovative septic systems), *ISWT (improved stormwater treatment), *HSLD (higher standards for future land development), *IE (increased enforcement/upgrade of ISDS regulations), *MRUR (maintenance, repair, upgrade or replacement of existing ISDS), *IMPF (installation of marine pump-out facilities), *WQ (water quality monitoring) *ED (education).

SHADING REPRESENTS AREAS OF MOST CONCERN.

# CHAPTER FIVE

## INSTITUTIONAL STAKEHOLDERS

Significant challenges exist in coordinating an effective, comprehensive environmental remediation and protection strategy for Greenwich Bay. Priority agenda items need to be agreed upon and appropriate and timely actions taken to ensure the attainment of the goals of this study. The following is a list describing key institutional stakeholders that are either required, or have indicated an interest in becoming involved in a Greenwich Bay remediation initiative beginning with local agencies, followed by state and federal agencies, and finally private/non-profit organizations.

### Local Agencies

#### Warwick Sewer Authority

The Warwick Sewer Authority is a quasi-governmental agency of the City, with an autonomous board consisting of 5 members. The Authority operates similar to a private enterprise in that it is not dependent upon taxes for its operating revenue. It derives income for the installation of sewer lines and expansion of its wastewater treatment capacity through sewer assessment and usage fees, municipal referendum, bond income, and loans from the State Revolving Loan Program (SRLP). The Sewer Authority budget for the current fiscal year is $6,514,548. Included in that amount is $2,434,548 in operating expenses and $4,080,000 in capital improvements (Warwick Sewer Authority 1993).

Currently, the City is only approximately 30 percent sewered and the demand for expansion of sewer lines is intense, both within and outside the study area. In 1990, the Sewer Authority commissioned a $1 million Wastewater Facilities Plan which calls for $17 million for the expansion and upgrade of Publicly Owned Treatment Works (POTW) and approximately $100 million in sewer extensions over the next 15 years (Beta Engineering Inc. 1992).

The Authority also administers a grant/loan program for the upgrade of ISDS systems. The maximum funding available for a system upgrade is $4000. This amount is broken down as follows: 40 percent or $1600 in the form of a grant and 60 percent or $2400 in a low interest loan. Approximately 50 individuals a year participate in the program (Warwick Sewer Authority 1993).

Based on this, it is apparent that the Sewer Authority is an agency with substantial institutional standing. Gaining consensus and cooperation from the Sewer Authority, therefore, will be a critical step in achieving success. Existing programs and resources should be expanded and supplemented in assisting a Greenwich Bay remediation initiative.

**Warwick Department of Public Works**

DPW is responsible for the maintenance and upgrade of the municipal street drainage system. The city-wide street drainage map is currently in the process of being digitized on RIGIS. In coastal areas prone to septic system failures, homeowners have been known to discharge their systems into the street drainage. DPW may become

instrumental in the identification of such violations. The Water Department, a division of DPW, also has the authority to administer a water conservation program which would be very helpful in reducing the total volume of municipal wastewater discharge.

According to section 604.5 Storm and Surface Water Drainage of the City of Warwick Zoning Ordinance:

> "... all storm and surface water drainage systems shall be approved by the City of Warwick, Director of Public Works, before the issuance of a building permit. All runoff shall be provided for, on-site and/or off-site, if discharged into a municipal drainage system. In no instance shall runoff be discharged onto abutting lots or into any freshwater or coastal wetlands. Storm systems shall be designed by a Rhode Island registered engineer unless other designer is deemed acceptable to the Director of Public Works".

This regulation, if strictly enforced and accompanied by new performance standards should result in an increased protection of the City's environmentally sensitive areas.

**Warwick Planning Department**

The Planning Department is primarily responsible for environmental protection, land use management, historic preservation, and capital budget planning. The Department provides Warwick's citizens and the City's boards and commissions with technical support in these areas. In addition to developing mapping and database management, the Department is responsible for the implementation of the City's Comprehensive Plan.

The Department is planning an update of the City Zoning Ordinance and Subdivision Regulations to be completed by the Fall of 1994. Rhode Island law requires all municipal zoning ordinances to be amended to conform with the R.I. Zoning Enabling Act of 1991 by July 1, 1994. This mandate presents an opportunity for strengthening zoning controls which can ultimately enhance and protect Greenwich Bay's water quality.

Those zoning districts impacting the Greenwich Bay Study Area include several residential districts with legal lot sizes as small as 7,000 square feet. Furthermore, environmental factors which often constrain the development of these lots are frequently passed over in deference to state requirements. However, cities have been delegated the authority to enact and enforce stricter standards than those of the State provided there is a clear relationship between the regulation and public benefit. More stringent requirements should be considered in the upcoming zoning ordinance revision.

The Warwick Planning Board has exclusive authority in the permitting or restricting of subdivision proposals. However, there is little in the way of stormwater

regulations which would help to ensure attainment of the zero-runoff policy, control deposition of suspended solids, or provide adequate stormwater treatment for the prevention of surface water contamination.

**Warwick Department of Parks and Recreation/Harbor Management Commission/Harbormaster**

A 1990 City ordinance created a Harbor Management Commission with broad and comprehensive authority over Warwick's coastal areas. The Commission has the authority to regulate: public access to the shoreline, mooring fields, coastal development, sewage disposal, and marine recreational activities. The Commission derives funding from mooring fees, totaling approximately $40,000 per year (Planning Department 1993). While the Department of Parks and Recreation serves the Commission in an administrative capacity relating to marine recreation activity and appropriations for the Harbormaster, the Planning Department serves the Commission in the area of environmental protection and coastal zone management. The Harbor Management Commission in conjunction with the Planning Department, are currently negotiating for the installation of eight marine pump-out facilities throughout Greenwich Bay and its coves.

The Harbormaster, while principally involved in public safety, has the authority to enforce the R.I. Marine Sanitation Devices (MSDs) statute, which requires most vessels to install and use sewage holding tanks.

The Harbor Management Commission had met only infrequently in the first two years of its existence. However, the current administration has made new appointments and recharged this vital body. Two of the five members now hold Masters of Marine Affairs degrees from the University of Rhode Island. The Commission is planning to revise the City's 1988 Harbor Management Plan beginning in May of 1994 and has agreed to incorporate new strategies which would support a Greenwich Bay Remediation Initiative to further protect the City's coastal waters.

**Warwick Building Department**

The Building Department is responsible for the permitting and inspection of all new building construction within the City. Through permit application procedures and site inspections, the Building Department has the authority to inspect structures and enforce building codes. The Department has the authority to prohibit building which is considered to be detrimental to the natural environment. The Department is also responsible for making determinations regarding upgrade of septic systems concurrent with modifications to existing structures. Finally, the Code of Ordinances offers the Department limited authority over erosion and sedimentation control. The development of stricter standards would be very helpful in ensuring environmental protection on construction sites.

## Adjoining Municipalities

### Town of East Greenwich

The Town of East Greenwich occupies approximately one and a half miles of shoreline along the western side of Greenwich Cove. This densely developed area undoubtedly impacts the Bay. However, a complete analysis of this area was not conducted in this study. Further research in this area and complete cooperation from the Town is essential to the success of a Greenwich Bay Remediation Plan.

With the exception of coastal storm drains, the East Greenwich Sewer Treatment Facilities is the only point pollution discharger to Greenwich Bay. The facility treats and discharges approximately 700,000 gallons of wastewater per day into Greenwich Cove (East Greenwich Wastewater Facilities 1994). According to RIDEM's Office of Permitting (1993) the facility has, in recent years, maintained compliance with the Rhode Island Point Discharge Elimination Systems (RIPDES) pollution standards. Continued monitoring and improved quality assurance of this point discharge would substantially enhance Greenwich Bay's water quality in the future.

### Town of North Kingstown

North Kingstown is a community located along Warwick's southern border. Because much of North Kingstown's land drains into Narragansett Bay and the Potowomut River it is believed that the community may have substantial impacts on Greenwich Bay's water quality. Further research is imperative to identify the extent of

pollution contribution from this community. Cooperation with the Town is essential to the complete success of a Greenwich Bay Remediation Plan.

## State Agencies

### Department of Environmental Management

RIDEM is responsible for the implementation and enforcement of the State's environmental code. Through its broad mandate, it is responsible for review of permit applications, site inspections, and the effectuation of control measures for wetlands alterations, groundwater and surface water protection, stormwater discharge, and other development-related impacts. Furthermore, the agency provides minimum standards, coordinated programs, and technical assistance to municipalities, as evidenced by the *Nonpoint Source Management Plan* and the *Soil and Erosion Control Handbook.*

The Division of Water Resources is responsible for maintaining a program of water quality management, including monitoring, overseeing coastal development, and enforcement of water quality regulations. The Division of Water Resources is currently working closely with USFDA on water quality testing in Greenwich Bay. Both the Narragansett Bay Project (NBP), a branch of the Division of Water Resources, and URI's Coastal Resources Council are excellent resources through which a variety of specific project and planning information can be obtained.

The Division has the authority, under regulations promulgated by the EPA's 1993 amendment of the National Point Discharge Elimination Systems (NPDES) Act, to require pollution discharge permits for owners of large impervious surfaced areas (ie.,

parking lots, buildings). Such permitting, requiring on-site filtration (zero-runoff) and other mitigation policies and practices, will undoubtedly be instrumental in reducing erosion and stormwater runoff from future development sites.

The Narragansett Bay Project (NBP) is responsible for implementing the *Narragansett Bay Comprehensive Coastal Management Plan* (CCMP). NBP staff has agreed to coordinate RIDEM efforts with the City of Warwick and other agencies and have recently confirmed their commitment to work in cooperation with Save the Bay and the Warwick Planning Department on public education and outreach for addressing Greenwich Bay's pollution problem.

The Division of Groundwater and ISDS has administrative authority over the development, permitting, and enforcement of ISDS regulations. The Division has been delegated the power to promulgate rules pertaining to the design and installation of ISDSs as well as the permitting of communal and innovative ISDSs. RIDEM's Department of ISDS has indicated an interest in a Greenwich Bay remediation initiative and has pledged to perform 1500 ISDS inspections in the coastal areas surrounding the Bay beginning in 1994. These inspections will provide necessary information regarding relative (subarea to subarea) ISDS failure rates, identify the types and condition of systems installed in areas of concern, and generate additional site-specific physical/environmental information. The Division has also received a $50,000 grant from EPA to hire a coordinator for the proposed Greenwich Bay Initiative public education and outreach program (Greenwich Bay Task Force Meeting January 1993).

The Division of Fish, Wildlife, and Estuarine Resources is responsible for the management of the State's fisheries including the maintenance of a sustainable shellfish yield. The Division is currently considering developing a shellfish management plan for Greenwich Bay which may provide scientific evidence to justify additional funding for a Greenwich Bay Remediation Initiative.

The Office of Environmental Coordination (OEC) is considered to be the "lead office for the state's nonpoint strategy" (RIDEM Office of Environmental Coordination 1988). OEC, along with the Non-Point Source program and Section 319 grants from the Clean Water Act are recognized as indispensable components of any stormwater management plan proposed for the Greenwich Bay Watershed.

**Coastal Resources Management Council**

The CRMC is a quasi-governmental agency established in 1971 through Chapter 23 of the General Laws of Rhode Island. The Council's primary mission is to preserve, protect, and manage the state's coastal resources. The authority of the Council over land areas is limited to that necessary to carry out effective resource management programs.

The CRMC has jurisdiction over all of Rhode Island's coastal areas including: (1) tidal waters; (2) shorelines abutting tidal waters or coastal ponds; and/or, (3) 200 feet inland from any coastal features (coastal beaches, dunes, wetlands, cliffs, bluffs, embankments, rocky shores, and man-made shorelines) (Coastal Resources Center 1983). The Council has designated critical conservation areas along the Bay as Type 1. These

areas are strictly regulated to allow for the protection and propagation of coastal and marine fish and wildlife.

Prohibited activities or alterations near Type 1 waters include: dredging and the disposal of dredge spoils, construction of shoreline protection structures (groins, seawalls, breakwaters, revetments etc.), and excavation on abutting shoreline features unless the primary purpose of the modification or activity is to maintain or enhance the area as a conservation zone or as a natural buffer against storm surge.

The CRMC has also developed Special Area Management (SAM) plans for the State's sensitive environmental coastal areas. Examples of SAM plans include: *Rhode Island's Salt Pond Region: A Special Area Management Plan* (Coastal Resources Center 1984) and the *Narrow River Special Area Management Plan* (Coastal Resources Center 1986). The Salt Pond SAM plan was based on eight primary goals including: (1) to maintain the exceptional scenic qualities of the Salt Pond region, and a diversity in the mix and intensity of the activities they support; (2) to prevent expansion near areas of the salt ponds that are contaminated by potentially harmful bacteria or eutrophic conditions; (3) to ensure that groundwater will not be polluted; (4) to preserve and enhance the diversity and abundance of fish and shellfish; (5) to restore barrier beaches, salt marshes, and fish and wildlife habitats damaged by past construction or present use; (6) to prepare a post-hurricane restoration plan; (7) to maintain Point Judith harbor as a commercial fishing port and provide for expansion of port facilities; and (8) to create a decision-making process appropriate to the management of the region as an ecosystem.

The Greenwich Bay Study Area should be considered as a candidate for SAM plan in the future.

Finally, CRMC has authority and responsibility to ensure proper stormwater design, installation, and maintenance in accordance with the Coastal Zone Act Reauthorization Amendments (CZARA), Section 6217, of 1990. These nonpoint source controls will be fundamental in providing adequate water quality protection to Greenwich Bay and its freshwater tributaries.

**Department of Transportation**

The Department of Transportation currently has a number of road construction projects planned within the Greenwich Bay Watershed including the Apponaug Circulator, and future work along Post, Centerville, and Bald Hill Roads. Through the Federal Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991, RIDOT is authorized to expend additional funds on environmental remediation, including stormwater management during the reconstruction of state roads and highways. RIDOT is required to obtain permits in environmentally sensitive areas if particular construction activities are to occur. The Federal Highway Administration's (FHWA) Environmental Policy Statement of 1990 provides the framework for RIDOT to ensure that the environment is given full consideration along with engineering, social, and economic factors in its decision-making (Palumbo 1994). The Department uses best management practices (BMPs) and contemporary erosion and sedimentation control techniques to meet the objectives of the Rhode Island Department of Environmental Management's

Antidegradation Policy and to reduce the potential for adverse environmental impacts. However, the retrofit of stormwater management devices does not occur unless road construction is taking place at the particular location of interest.

The installation of sewer lines during road construction (piggy-backing) can provide the City with an opportunity to save capital expenditure funds which otherwise would be invested in traffic control, backfilling, and paving. Pedar Schaefer Director of Finance for the City of Warwick in a recent memorandum affirmed that installation of sewer lines during road construction can save the City of Warwick as much as 50 percent of the costs incurred if the project was attempted alone (Schaeffer 1994). The cost assessed to each homeowner for a sewer hook-up would therefore be $4,000 rather than $8,000 (Schaeffer 1994).

RIDOT projects may pose significant threats to Greenwich Bay's water quality if sound pollution mitigation actions are not seriously considered and implemented in the future.

## Federal Agencies

### Food and Drug Administration

FDA is responsible for monitoring and regulating food quality including the quality of Rhode Island's shellfish harvest. FDA has a research lab in Davisville, R.I. which has been conducting a major water quality study in Greenwich Bay since the temporary closure of the Bay to shellfishing was first instituted in December of 1992. A decision as to whether the Bay should be permanently closed is pending the results of the FDA's study.

### Army Corps of Engineers

The Army Corps has regulatory jurisdiction over all construction or filling activities taking place in U.S. waters, including wetlands. The enabling legislation granting authority to the agency are Section 10 of the Rivers and Harbors Act of 1899 and Section 404 of the Clean Water Act[5]. Section 404 governs the permitting process for discharge of dredged or filled material. The Corps also retains primary authority over Federal flood and coastal erosion protection projects. The Army Corps in conjunction with RIDEM's Narragansett Bay Project is currently considering a stormwater management research project for 1994.

---

[5]For more information pertaining to Federal and State legislation governing coastal waters (Greenwich Bay) see Appendix E.

**Environmental Protection Agency**

The Environmental Protection Agency (EPA) is the lead agency responsible for implementing the Safe Drinking Water Act; Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA); Toxic Substances Control Act (TOSCA); Section 346(a) of the Food, Drug, and Cosmetic Act; Resource Conservation and Recovery Act (RCRA); and the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA or Superfund) (Portney et al. 1992). It is also responsible for the enforcement of the provisions of the Clean Water Act and the Clean Air Act. Congress mandated that EPA set water and air quality standards and determine the best control technologies (BCT) to achieve these standards.

The Army Corps of Engineers, in cooperation with EPA, has permit authority for the filling and dredging of wetlands and other water bodies. EPA retains veto power over the issuance of permits under Section 404 of the Clean Water Act. While EPA seldom exercises its veto power, it has done so when the Army Corps of Engineers has failed to give due consideration to the value of wetlands when issuing 404 permits. EPA's office of water (OW) administers programs and grant opportunities for pollution prevention demonstration programs. As a result of this ongoing study, RIDEM has agreed to work with the City of Warwick to secure a Clean Water Act Section 319 grant for $165,000 to help residents of Oakland Beach tie-in to existing sewerage infrastructure (Greenwich Bay Task Force Meeting 1994).

The Rhode Island Clean Water Protection Financing Authority is a division of the Environmental Protection Agency which provides states with feed money for use in

revolving funds. Money is allocated for use in water quality protection projects. This authority may provide much needed funding for the implementation of this plan.

EPA has a laboratory located in Narragansett, R.I. which can provide research and technical assistance in the areas of oceanography. The lab may be helpful in providing information pertaining to tidal fluctuations, circulation patterns, and flushing rates for Greenwich Bay and its coves.

**National Oceanographic and Atmospheric Administration (NOAA), Coastal Resources Center/Sea Grant**

NOAA has a Coastal Research Center located at the URI Bay Campus in Narragansett, Rhode Island. This facility performs ongoing oceanographic research which could benefit a Greenwich Bay Remediation Initiative. Grants through Sea Grant and other sources could aid in furthering public outreach and education, as well as research.

**Soil Conservation Service**

The Soil Conservation Service is a division of the U.S. Department of Agriculture which provides information and performs research for planners, developers, engineers, and environmentalists regarding the suitability of soils for particular purposes such as land development, septic system installation, stormwater management, agriculture, and wildlife habitat. The Soil Conservation Service can provide site-specific soil information through on-site investigations. This information would be very helpful in further defining

(from a site-specific standpoint) environmental conditions and their impacts on stormwater and wastewater movement and treatment within the Greenwich Bay Study Area.

## Private/Non-Profit Organizations

### Save the Bay

Save the Bay is a 15,000 member non-profit advocacy organization which has promoted the restoration and preservation of Narragansett Bay as well as other critical water resources over the past two decades. Save the Bay recently received a $45,000 grant from the Rhode Island Foundation for Citizens Monitoring and other environmental advocacy programs (Save the Bay 1993). The organization would be very helpful in providing essential public education and community outreach in the Greenwich Bay Study Area and has demonstrated an interest in becoming involved in the clean-up of Greenwich Bay.

### Rhode Island Shellfishermen's Association

The Rhode Island Shellfishermen's Association is an alliance of individuals sharing an interest in the preservation of Rhode Island's shellfishing resources with the primary intention of sustaining commercial growth. This organization has been especially impacted by the closing of the Bay to shellfishing and has indicated a willingness to become involved in a remediation plan for the Bay.

**Rhode Island Marine Trades Association**

The Rhode Island Marine Trades Association is an organization comprised of local marine businesses. The Association attempts to ensure the passage of beneficial coastal legislation and supports the use of best management practices, special area management plans, establishment of marine pump-out facilities, and other environmental protection practices and policies.

**Local Citizens**

Gaining consensus from local residents will be one of the most important, and perhaps difficult, challenge the city will face in implementing a reclamation plan. Citizens need to be adequately informed about the problems and solutions, as well as the costs and benefits of implementing a plan to address the current pollution problem in the Bay. Without the support of local citizens, the plan will almost certainly fail. Citizens from Warwick, East Greenwich, and North Kingstown should be included in a remediation plan and their diverse concerns and needs fully considered. Newspaper articles, advertisements, and public information pamphlets distributed by mail are inexpensive ways of educating and informing large numbers of people within a relatively small geographic area such as the Greenwich Bay study area. Table 5 provides a summary of the stakeholder analysis.

Table 5 - Institutional Stakeholders

| Principal Stakeholder | Responsibilities |
|---|---|
| Warwick Sewer Authority | Sewer service area expansion.<br>POTW capacity.<br>Sewer tie-in database.<br>ISDS upgrade grant/loan program.<br>Study innovative ISDS designs and implement work schedule. |
| Warwick Departments of Public Works and Planning | Street drainage database.<br>Street and street drainage maintenance and upgrade. |
| Warwick Planning Department | Preparing database and maps.<br>Preparing new subdivision regulations<br>Preparing new zoning ordinance.<br>Serving Zoning, Planning, Harbor, and Conservation Boards. |
| Warwick Parks and Recreation<br>Harbor Management Commission<br>Harbormaster | Siting of marine pump-out stations.<br>Performing MSD/mooring inspections.<br>Revision Harbor Management Plan. |
| Warwick Building Department | ISDS certificate of integrity<br>Issuing building permits (may require RIDEM suitability determination). |
| RIDEM Water Resources/US Food and Drug Administration | Continued water quality testing.<br>RIDEM to administer new EPA regulations (ie. requiring permits for nonpoint sources such as large parking lots). |
| RIDEM/ISDS<br>Warwick Sewer Authority<br>CRMC | Promulgate rules allowing the permitting of new innovative ISDSs. RIDEM to do 1500 ISDS inspections. Wastewater management. Apply for funding. |

| Principal Stakeholder | Responsibilities |
|---|---|
| RIDEM Water Resources<br>Narragansett Bay Project | NPS abatement projects, habitat restoration, public outreach and technical assistance. Enforcement and management of Greenwich Bay as a conditionally approved shellfish area. |
| RIDEM ISDS/Groundwater<br>USFDA<br>Narragansett Bay Project | ISDS inspection program. Employment of coordinator for public education and outreach. |
| R.I. Coastal Resources Management Council | Regulating coastal development, SAM plans, NPS regulations and enforcement |
| R.I. Department of Transportation | Stormwater, erosion, sedimentation control. |
| Army Corps of Engineers<br>RIDEM Narragansett Bay Project | Stormwater/drainage study |
| Environmental Protection Agency | Regulatory standards, funding. |
| R.I. Clean Water Protection Financing Authority | Administration of Federal and State Revolving Funds, POTW sewer extension funds. |
| NOAA<br>R.I. Coastal Resources Center<br>Soil Conservation Service | Research/Information |
| Save the Bay/Neighborhood Groups | Public Outreach |
| R.I. Shellfishermen's Association | Public Outreach/Citizen Monitoring |
| R.I. Marine Trades Association | Promotion of pump-out facilities, lobbying for legislation. |
| East Greenwich/East Greenwich Wastewater Facilities/North Kingstown | Water quality, public outreach, cooperation |
| Private Citizens | Support |

# CHAPTER SIX

## RECOMMENDATIONS

After careful consideration of the conditions in and around Greenwich Bay, analysis of water sampling data, along with review of previous studies, it appears that the elevated levels of fecal coliform bacteria in Greenwich Bay can be attributed to a variety of sources. Clearly, point and nonpoint source pollutant loading from improperly functioning and/or failing septic systems and stormwater runoff (including streams and rivers) are considered major contributors while seasonal sewage discharges from vessels, illegal sewer tie-ins, broken or exfiltrating sewer lines, and wastes from wild and domesticated animals present additional concerns. The age and design of septic systems, densely developed land, and poor environmental conditions which exist in key sub-watersheds around Greenwich Bay presents a compelling argument in favor of these findings. However, it is acknowledged that additional water quality sampling and site-specific and watershed-based studies need to be performed to further identify key pollutant sources and substantiate the findings of this study.

The closure of Greenwich Bay to shellfishing is a critical warning to those with an interest in the Bay's well-being. To combat the adverse impacts of urbanization within the Greenwich Bay Study Area, basic remedial actions must be taken. However, a plan will only be successful if all parties identified agree on the strategies, and work in a cooperative manner to implement them. The following recommendations provide a foundation for remedying these problems in a timely, cost-effective manner.

## I. PUBLIC, PRIVATE, AND INSTITUTIONAL CONSENSUS BUILDING AND COOPERATION

**A. Establish a Greenwich Bay Task Force, comprised of representatives from each of the key stakeholders mentioned in Chapter Five (Warwick Planning Department).**

One purpose of having a task force is to combine efforts, garner diverse expertise, maximize efficiency, and minimize redundancy. Subcommittees pertaining to public education outreach, land use management, wastewater management, and stormwater management should be established to coordinate the implementation of these recommendations. Special emphasis should be placed on obtaining the support of neighborhood groups and local private citizens.

## II. PUBLIC EDUCATION AND OUTREACH

**A. Educate home owners in Critical Coastal Areas on how antiquated or improperly designed, installed, and maintained ISDSs can pollute the Bay, and what actions can be taken to help improve the Bay's water quality (Warwick Planning Department, Narragansett Bay Project, Save the Bay, neighborhood associations and other interest groups).**

The Greenwich Bay Initiative needs to reach out to those in the affected neighborhoods. Citizens need to understand how the program will effect them and what they can do to help in this cause. The public also needs to be educated about the causes of pollution, the costs and dangers which stem from pollution, water conservation

techniques, ISDS management, recycling, and the penalties for illegal pollution activities. Program initiatives should be presented in a clear, concise, and graphic manner so citizens, both young and old, can understand how the Bay's water quality has become so seriously degraded, and how they and their friends and neighbors can make a difference. This program should focus primarily on mobilizing action and garnering public support for the initiatives presented.

The City of Warwick and the Town of East Greenwich, Narragansett Bay Project, and Save the Bay should sponsor public forums in cooperation with local neighborhood associations, the R.I. Shellfishermen's Association, Marine Trades Association, and other interest groups. These forums can provide opportunities for high quality personal interaction on a neighborhood by neighborhood basis. Funding should be appropriated toward the printing of pamphlets and brochures modeled after literature written by Save the Bay (1990); EPA Office of Water (1993); Chesapeake Bay Foundation (no date available); Massachusetts Bay Program (1990); MaGuire (1982a), University of Rhode Island College of Resource Development (1991, 1993), as well as any number of quality State and Federal publications available.

**B. Establish a Citizen's Monitoring Program in Critical Coastal Areas (Save the Bay, RIDEM, local citizen's monitoring groups, and neighborhood associations).**

This program would educate and raise public awareness to the importance of water quality, and at the same time furnish governmental agencies with valuable information pertaining to the status of local water resources. Individuals and concerned

citizens groups could be asked to volunteer in a campaign which would consist of periodic water sampling of coastal water bodies[6]. Save the Bay, RIDEM Water Resources, and the NBP could provide technical assistance, and perhaps funding to these programs.

## III. LAND USE MANAGEMENT

**A. The City's zoning ordinance and subdivision regulations should be amended to incorporate measures designed to address contemporary environmental concerns (Warwick Planning Department and City Council).**

Stricter stormwater management controls (ie., street sweeping use of best management practices) and water quality performance standards as well as further study of stormwater pollutant loading should be incorporated into the revised subdivision regulations. Rezoning of undeveloped coastal areas would be helpful in controlling pollution associated with dense residential development. Apponaug, Nausaukett, Oakland Beach, Old Warwick, western Brush Neck, and parts of Chepiwanoxet consist primarily of residential lots, as small as 7000 square feet. Extra effort should be made to ensure that the remaining subareas are protected from future high density development. The size of buffer strips could be increased to provide maximum environmental protection.

[6]For a current list of Rhode Island's volunteer citizen monitoring organizations, as well as their contact persons, addresses, and phone numbers: see the *Rhode Island Citizen Volunteer Water Quality Monitoring Programs - Informational Directory*. Department of Environmental Management Division of Water Resources, 1992.

**B. Establish a Greenwich Bay Protection District overlay ordinance**

Warwick's Planning Department should submit to the City Council an ordinance establishing a Greenwich Bay Protection District (GBPD). This district would encompass the Critical Coastal Areas defined in the body of this plan.

The GBPD would combine features of a traditional management district (setbacks, minimum lot size, etc.) with state-of-the-art stormwater management techniques based on stringent water quality standards. The ordinance could also establish standards for the maintenance and performance of individual septic systems. These standards could easily be enforced in areas where financial assistance was allocated for the upgrade or replacement of ISDSs. The district could also serve as an area of identification for special policies, wastewater management, public outreach, and financial assistance programs. A variety of other alternative land use/zoning techniques should be considered to help ensure environmental protection. The following is a list of recommended land use/zoning techniques along with a brief description of the method and how it may be applied.

**C. Cluster Development**

Cluster development is a subdivision land use technique which allows for the clustering of several homes on a parcel of land while at the same time preserving an equal area of land for open space; especially in environmentally sensitive areas. Cluster developments are useful for several purposes including: (1) cluster development is efficient and compatible with the goal of preserving rural character, (2) it helps to protect

environmentally sensitive areas, such as Greenwich Bay's shoreline from the encroachment of unconstrained development, (3) supports a variety of alternative designs and spatial layout, (4) provides a variety of price ranges for a community's housing supply, and (5) provides an effective strategy for judicious development by providing public services such as sewers and open space (Town of Hopkinton 1991).

The net result of cluster zoning is to provide benefits for the homeowner, the developer, and the community, alike. One advantage is a general decrease in infrastructure costs because roads, sewers, communal septic systems, stormwater management devices, and water supplies can be "clustered" limiting the expense of extending utilities great distances or to "far removed" places. This technique can facilitate the wastewater and stormwater management in these areas and provides undevelopable buffers and open space in areas of concern. This land use technique is currently used by the City of Warwick and should be more seriously considered as a viable alternative if circumstances warrant its use. East Greenwich and North Kingstown should also consider this technique for preserving special areas of concern.

**D. Planned Unit Development**

Planned Unit Developments (PUDs) advocate the clustering of buildings, permits a mixture of land uses on a large common parcel rather than on a "lot-by-lot" basis, and provides for large tracts of open space. This type of development allows for more productive use of the land, helps to preserve natural and cultural resources, provides an opportunity for lowering development costs, and reduces expenses related to the

development of public infrastructure, services, and their maintenance. Furthermore, the PUD provides more flexibility and diversity than many other land use techniques. Like cluster developments, this technique can protect and preserve coastal areas by clustering development on half a parcel; while leaving the other half untouched. PUD's and cluster developments should be required to have state-of-the-art stormwater and wastewater treatment infrastructure. The City of Warwick currently uses this land use technique and should consider its use if development in environmentally sensitive areas becomes inevitable. The towns of East Greenwich and North Kingstown should also consider this land use control.

**E. Transfer of Development Rights**

Transfer of development rights have been used by municipalities interested in the preservation of farms and cultural and natural resources, as well as to ensure that land is developed in a slow, orderly fashion. This technique allows the transfer of a development right from an area of environmental sensitivity to a more appropriate location. Although the City of Warwick does not currently use this technique, it may be a suitable method for keeping growth centered in areas suitable for development while maintaining areas unsuitable for development for recreation, open space, natural resource preservation, and enhancement of tourism. This technique is not without pitfalls, however, and has been met with opposition by land owners who feel that the technique infringes on their private property rights.

**F. Site Plan Review**

The purpose of the site plan review is to protect and maintain a community's natural, cultural, and rural integrity, and to ensure the public's health, safety, welfare, and morals. This technique allows a city to deny a building permit that would be contrary to the best interests of its citizens. However, if a municipality bases its site plan review process on arbitrary and capricious standards of review there is great potential for unfair exclusionary practices to occur. The technique allows planners to review overall site features such as circulation and parking, utilities, stormwater management, site design, environmental impacts, and landscaping. The City of Warwick currently uses this technique but should consider more stringent site plan regulations in areas of concern.

**G. Building Permit Caps**

Building permit caps are valuable in places where utilities, infrastructure (ie., sewer and water) or public services are not sufficient to serve a community's rapid development. The building cap limits the number of building permits issued each year if infrastructure such as sewers are not available and can help to preserve open space, cultural and natural resources, as well as ensure the availability of adequate services to all property owners. The City of Warwick does not use this land use control at present. However, this method would be ideal for limiting growth in areas not currently sewered. These ordinances are most useful when considered concurrent with capital budgets and comprehensive plans.

The City should work with other governmental agencies and the Towns of East Greenwich and North Kingstown to perform research in order to further distinguish high-risk areas from moderate and low impact areas. Based on this additional information, more site-specific measures may be taken such as watershed and stormwater protection overlay districts.

## IV. WASTEWATER MANAGEMENT

**A. $1 Million from a June, 1994 bond referendum[7] should be infused into the existing Warwick Sewer Authority grant/loan program for the replacement of improperly functioning or failed ISDS systems in Critical Coastal Areas and the criteria for receiving assistance modified to facilitate broader participation (Warwick Sewer Authority).**

Presently, households in the City with failing or antiquated septic systems are eligible for a 60 percent loan; 40 percent grant combination with a maximum $4000 grant (Warwick Sewer Authority 1993). Program requirements should be modified to ensure the availability of these new resources to those who qualify. Within a Critical Coastal Area, the grant and loan ratio could be calculated on an individual applicant's ability to pay and the maximum level of financial assistance increased to $9,000. The program's objective would be to service an average of 200 homes per year, over a three year period.

---

[7]The $1 million dollar figure comes from the City of Warwick Planning Department, 1994.

The level of available funding could help promote the purchase and installation of innovative septic systems. Any person receiving a grant would be required to perform routine maintenance and provide documentation. The grant/loan program would provide incentives for the homeowner to rehabilitate his/her failing system.

**B. Revise the Warwick Sewer Facilities Plan (Warwick Sewer Authority).**

As a primary stakeholder and facilitator of wastewater initiatives in Warwick, the Sewer Authority should consider revising or amending the Sewer Facilities Plan to include a study of innovative ISDS designs and/or rehabilitation programs which could be endorsed as legitimate alternatives to sewering. In instances where ISDS rehabilitation or redesign is not practical, sewer expansion into Critical Coastal Areas around Greenwich Bay should be included as a high priority action item within the facilities plan. The facilities plan for the Warwick Wastewater Treatment Plant should be amended to give consideration to sewering northern Oakland Beach and Apponaug/Chepiwanoxet with further study on the feasibility of connecting all 499 units in the Cowesett Hills Apartment complex. Currently, only 99 (20 percent) of the units are tied-in to the existing municipal sewerage system. Further investigation into the ratio of units tied-in to existing sewer lines should be conducted for other area condominiums and apartment complexes as well as multi-family and single family homes in the study area. Warwick's Wastewater Facility is currently operating at 65-75 percent of its capacity (Greenwich Bay Task Force Meeting 1993). If combined with an aggressive

water conservation plan, the wastewater facility could further process and treat an enormous volume of sewage.

**C. The City of Warwick should fund the installation/extension of sewer lines for those high density developments in the Chepiwanoxet area adjacent to Post Road (RIDOT, Warwick Planning Department, Warwick Sewer Authority).**

The land use south of Apponaug along Route 1 consists largely of dense condominium and office complex developments which have a history of ISDS failures. Population density, and environmental constraints (high water table, slopes, stoniness) combined with the lack of available open space severely restricts viable alternatives for this area and appears responsible for contributing high levels of fecal coliform to Hardig Brook and Apponaug Cove.

The City should fund a RIDOT sewer line installation/extension as part of the reconstruction of Post Road (Rt. 1). RIDOT in conjunction with the City's capital budget funding would pay for design, excavation, and installation of sewer lines. The estimated cost to the City would be $2.5 million dollars (Warwick Planning Department 1994). Sewer extensions should be considered in Arnold's Neck/Cowesett Hills (subarea 1C), Chepiwanoxet (subarea 2A), and Oakland Beach (subarea 5B). Strict stormwater regulations and housing density controls should accompany any areas that are sewered and existing lines should be inspected where feasible.

**D. Adoption of a City-wide Water Conservation Plan (Warwick Department of Public Works, Save the Bay, Narragansett Bay Project, Warwick Planning Department, Warwick Water, citizens).**

This action would reduce wastewater flows to the municipal sewage treatment plant thereby allowing more service without exceeding current treatment capacity. Furthermore, water conservation efforts would reduce household loadings to on-site sewage disposal systems, thereby reducing the potential pollutant loadings to underlying groundwater which may ultimately discharge into Greenwich Bay. The City should implement a City-wide water conservation effort modeled after the Kent County Water Authority (KCWA) project which recently realized a 12 percent reduction in water consumption over one year in Kent County, R.I. (Brown 1993).

The KCWA project, conducted an aggressive public education campaign and installed water saving devices for toilets, sinks, and shower heads in 726 homes. This resulted in a reduction of 8,470 gallons of water annually (Brown, 1993). The potential water savings, given an entire service-wide water conservation program, is estimated to be 211,750,000 gallons annually with an even larger potential for water-use reduction in Warwick Water's service area (Brown 1993). A similar demonstration project should be initiated by the Warwick Water Department in critical coastal areas. The subsequent savings in water consumption translated into monetary savings could be used as a tool for promoting voluntary installation of water saving devices. Reductions in water usage will lower black and gray water discharges to both on-site septic systems and publicly owned treatment facilities. Save the Bay (1990) found:

Over 95 percent of waste entering a septic system is water, and reducing the flow of water into the septic tank is one of the easiest and least expensive ways to extend the life of a septic system. Excess water flowing into the tank hampers solids and grease from settling out of the wastewater. The bacteria in the septic tank work on a gradual basis, and the longer the wastewater remains in the tank, the better it is cleansed.

Three water conservation tips for homeowners might include: repair leaking faucets and toilets, use water conservatively, and install faucet aerators, toilet flush dams, water-conserving toilets, and low-flow showerheads to reduce the volume of water used.

**E. Increase the ratio of sewer tie-ins in Oakland Beach and Apponaug/Cowesett Hills by phasing-in a policy of mandatory hook-ups in sewered areas while providing financial incentives for low-income homeowners (Warwick Sewer Authority, RIDEM/EPA, Warwick Planning Department).**

All homes and commercial enterprises located in Critical Areas which are on a sewer line should be required to tie-in to the municipal sewer system. Currently, in Oakland Beach, as many as 42 percent (approximately 375 households) who have access to a sewer line are not connected to the municipal system. A mandatory tie-in program should have an immediate beneficial effect on local water quality and could be attained at relatively low cost.

To help achieve this objective, the Warwick Sewer Authority has agreed to administer a program over a three-year period which will provide grants of up to 75 percent to eligible residents to tie-in to the municipal sewer system. Residents identified by Federal Housing and Urban Development (HUD) standards as having low to moderate income would be eligible for a 75 percent grant and a 25 percent loan. Units which are owner-occupied and fall above the low-to-moderate income level would be eligible for a 50 percent matching grant (Warwick Planning Department 1994). Commercial property, marinas, and rental units would not be eligible for a grant award. However, connection would be required within a reasonable time period (ie., eighteen months). All units, regardless of land use, which carry a sewer assessment should be required to connect to the municipal sewer system within a three year frame.

The cost of hooking-up approximately 450 households, assuming a cost per unit of $1,500 each, is $675,000. The City of Warwick has recently been awarded a $164,635 EPA Clean Water Section 319 grant, with an additional $91,405 match, in which some of Warwick's share will come from inkind contributions (Warwick Planning Department 1994). This would provide for approximately 163 tie-ins.

**F. The RIDEM Division of ISDS has agreed to perform 1500 on-site ISDS inspections in Critical Coastal Areas over the next 3 years (RIDEM ISDS).**

Although the performance standards used in determining ISDS failures might be a bit lenient, documented failures should provide grounds for requiring the upgrade of ISDSs, especially if financial assistance has been provided from the Sewer Authority.

**G. A "Certificate of Integrity" program should be established by the City of Warwick for all Critical Coastal Areas (Warwick Building Department).**

A Certificate of Integrity should be a prerequisite for any real estate transfer, rental agreement or issuance of a building permit. A certificate application would be prepared by a certified Engineer testifying as to the system's ability to meet contemporary standards for septic system design and treatment. Overseen by the Building Department, this program would be fee-driven and have mandatory fines for non-compliance.

**H. RIDEM should consider conditionally permitting some innovative-designed septic system retrofits in Critical Areas as part of a test project (RIDEM ISDS, University of Rhode Island).**

RIDEM ISDS Division could facilitate the testing of innovative septic system designs in this manner, and possibly accelerate the permitting process if such systems prove successful under restrictive conditions. Initial studies have shown that many innovative ISDS designs are effective at reducing levels of biological oxygen demand

(BOD), nitrogen, and to a lesser extent, bacteria. Some alternative systems such as the sand filter model have been thoroughly tested and are now officially approved for use in other states. The greater flexibility provided by innovative systems may prove to be an invaluable tool in a Greenwich Bay protection strategy, especially in low and medium density areas with environmental constraints such as shallow depth to bedrock, stoniness, poor drainage, excessively rapid or extremely slow percolating soils, and on severe slopes. In addition, more stringent standards and enforcement pertaining to minimum depth to groundwater, size of absorption field, design, installation, and maintenance of ISDSs would be of critical importance toward ensuring appropriate on-site wastewater treatment. The following is a cursory look at several currently available state-of-the-art innovative ISDS and communal wastewater treatment systems. Alternative septic systems should be used to retrofit existing systems on "grandfathered" land in environmentally sensitive areas, only. Undeveloped, environmentally sensitive land should not be developed and must be avoided to ensure environmental preservation.

**Mound System**

Soil is excavated and new fill brought to the site. A mound of fill is created above the surface of the ground to provide a sufficient soil media (soil texture, structure, and cross sectional area) in which to treat the sewage discharge. The septic system, installed beneath the original ground level, pumps effluent to a perforated pipe installed within the mound. The effluent is percolates down through the mound which provides sufficient distance between the bottom of the perforated pipe and the groundwater surface (three feet in Rhode Island) to ensure adequate treatment and diffusion of the effluent.

The mound system can be used in areas which have shallow depth to groundwater or bedrock, stony soils, or are poorly drained. Disadvantages of this system include the need for periodic maintenance, increased utility bills due to the operation of a pump, and the cost of purchasing and hauling extra fill to the site. There is also a possibility for lateral seepage to occur with this design.

**Alternating System**

Alternating systems utilize two absorption fields. When one absorption field becomes saturated, it shuts off to allow the soil within that field to dry. The other field is then employed until its field becomes saturated. This design is useful with systems which have been installed in exceptionally slow percolating or poorly drained soils. Disadvantages of these systems are the costs incurred from the purchase, installation, and maintenance of the two absorption fields and the need for a large lot to accommodate both absorption fields.

**Dosing system**

A dosing system intermittently discharges small volumes of effluent throughout the day and night rather than discharging large quantities at specific times of high use (after showers, or when having guests). The system, therefore can discharge sewage while a family sleeps rather than at peak daylight times when most black and grey water is generated. A holding tank stores the sewage and discharges small volumes of sewage periodically allowing the absorption field to treat the effluent and dry prior to the next "dose". Disadvantages of this system include periodic maintenance to its pump and an

increased utility bill. Like all innovative systems, the cost of this design will be greater than that of a conventional system.

**Aeration System**

Aeration systems provide treatment primarily for the purpose of denitrification, however, they have had some success for treating bacteria. Aerobic bacteria inhabit the system and digest and treat the sewage. These systems can reduce eutrophication in seaside communities and can protect aquifers from high levels of nitrogen which are known to cause metahemoglobanemia (Blue-baby Syndrome in infants). Aeration systems are more expensive than traditional systems and require more maintenance.

**Holding Tank**

Holding tanks can be useful where an absorption field is not feasible or for communal systems operating within wastewater management districts. The sewage is held on-site in the holding tank and periodically pumped, collected, and transported to a wastewater treatment facility for treatment. The costs of periodically pumping the tank as well as hauling and treating the sewage can be prohibitive.

**Step system**

This system is used on properties having steep slopes. The septic system chambers are stepped-down along the slope to follow the location's topography, therefore allowing adequate separation distance between the system and the groundwater table surface as well as the distance from the ground surface and the top of the treatment system. The purpose of this design is to provide an adequate cross-sectional area of soil for sewage treatment and to avoid lateral seepage. The sewage is pumped to the first

chamber which is highest on the slope and trickles down through three consecutive chambers. The pump required to draw the effluent upslope can contribute to expenses relating to its purchase, maintenance and the electricity to operate it.

**Sand Filter System**

Garbage Magazine (1993) describes one sand filter design in the following way:

> With sand filters, the flush flows by gravity to an underground septic tank. A filter pump draws off the clearest effluent from the tank's middle section; solids are stored in the tank's bottom; automatic float switches prevent scum from clogging the filter.
>
> The septic-tank pump doses the sand filter from four to six times daily. Effluent collects at the bottom of the filter and is pumped through a network of pipes in the raised distribution bed. Each dose is alternately directed to one-half of the distribution bed. While the other half "rests," its sand dries and microbes digest organic matter. Finally, treated wastewater percolates through the bottom of the bed into native soil.

Garbage Magazine (1993) estimates the cost of these systems to range between $5,000 and $26,000 depending on environmental conditions. The systems, if properly installed and maintained can provide the equivalent of advanced secondary treatment.

**More Stringent Standards**

The RIDEM Division of ISDS standards should be strictly enforced and periodically revaluated. Requiring larger absorption fields may help sewage treatment in poorly suited soils, environmentally sensitive areas, or in areas of shallow depth to impervious layer, bedrock, and watertable if the lot is of sufficient size. Also, adherence and reevaluation of specifications regarding setbacks from water bodies, and depth to watertable is essential. In conclusion, innovative septic systems are a great wastewater treatment alternative in presently developed areas which have environmental constraints. However, the best way to ensure protection from bacterial pollution within environmentally sensitive areas is simply to restrict development. <u>These systems must not be used to allow development in areas which are currently undeveloped.</u>

**I. An innovative communal system designed for the Sandy Point section of Potowomut should be considered as a demonstration project (RIDEM ISDS, Warwick Sewer Authority).**

The cost of sewering this area is not considered an economically feasible option because of the distance to the nearest wastewater treatment facility and the scarcity of development along the way. However, collector lines could be installed, and a communal treatment system installed. The estimated cost of this project is $2.5 million (Warwick Sewer Authority 1993). Communal treatment systems are also recommended in cluster and planned unit developments. Districts having communal sewage treatment

should also be required to participate in a wastewater management program to ensure proper performance and maintenance of the system.

**J. The City should consider establishing wastewater management districts in areas of concern which cannot feasibly be sewered.**

This option would provide an opportunity for ensuring adequate wastewater management in areas which cannot be feasibly sewered or in areas where septic systems have a high rate of failure such as Old Warwick (subareas 6A and 6C) and Warwick Neck (subarea 7). Wastewater management districts would require periodic inspection, pumping, maintenance, and repair or replacement of failing ISDSs. This technique, however, is often accompanied by citizen opposition because individuals or neighborhoods may feel "singled-out" for addressing the problems of the "City'. A model wastewater ordinance is provided in Appendix C.

## V. COASTAL MANAGEMENT

**A. Warwick should revise its 1988 Harbor Management Plan to reflect the increasing concern for protecting the water quality of Greenwich Bay (Warwick Harbor Management Commission and Warwick Planning Department).**

Each of the Harbor Management Commission's members have read a draft of this study and have received it with great enthusiasm. The Commission has indicated a commitment to incorporate the initiatives of a plan, as pertaining to them, into their Harbor Management Plan to be revised during the summer of 1994.

**B. Improve the impact of recreational marine activity by establishing a "Boater's Pledge" Program (Warwick Department of Parks and Recreation, Warwick Harbor Management Commission, Warwick Harbormaster, Save the Bay, Warwick Planning Department).**

Modeled after a project started by the EPA Gulf of Mexico Program (no citation available), the City, at the time of collecting mooring fees, would request that all vessel owners sign a pledge card promising to operate in a manner so as not to pollute Greenwich Bay. The pledge would alert the boating public as to the importance of proper wastewater management, litter control, and other policies for preserving the Bay, while providing an impetus for public support. The pledge card and an easily identifiable decal would identify those making a commitment to pollution-free boating practices.

**C. Work toward establishing Greenwich Bay as a Federal "no discharge zone" (RIDEM, Warwick Harbormaster, Warwick Harbor Management Commission, Warwick Department of Parks and Recreation, Warwick Planning Department).**

RIDEM has delegated authority to the City's Harbormaster to enforce regulations prohibiting direct discharges of Marine Sanitation Devices (MSDs) into coastal waters. A city or town is entitled to half the fine imposed for such violations. To facilitate compliance of no discharge rules, additional assistant harbormasters should be hired and the harbormaster's position established as a full-time position to allow for off-season inventory and planning. The tool for modeling and implementing these changes is through the Harbor Management Ordinance and Harbor Management Plan which will be

updated to incorporate specific water quality issues, implementation schedules, and funding sources. The Harbor Management fund would allocate $60,000 toward the harbormasters' salaries (Warwick Planning Department 1994). The installation of marine pump-out facilities should provide an extra incentive for boaters to comply to the no discharge regulation.

**D. A sufficient number of marine pump-out facilities should be installed at commercial marinas throughout the Bay (RIDEM, Warwick Planning Department, Warwick Harbor Management Commission).**

An adequate number of marine pump-out facilities should be installed in Greenwich Cove, Greenwich Bay, Warwick Cove, and Apponaug Cove where boat and mooring use are high. At this time no pump-out facilities exist in the Greenwich Bay Study Area. According to RIDEM (1993) a non-transient harbor such as Greenwich Bay should have one (1) pump-out facility for every 600 boats. Based on this criteria the agency has estimated a need for three (3) facilities in Warwick Cove; two (2) facilities in Apponaug Cove; and two (2) facilities in Greenwich Cove. The Warwick Planning Department has recently helped to secure eight (8) applications for RIDEM/EPA 75/25 grant money to site pump-out stations in Fiscal Year 1995. Other sources of funding may include:

**The Non-Governmental Water Pollution Control Facilities Fund:** As part of the Rhode Island Clean Water Act Environmental Trust Fund, this source provides grants

to private colleges, hospitals, non-profit organizations and public utilities for water pollution control devices such as marine pump-out facilities.

**Federal Clean Vessel Act:** This act provides up to 75 percent of the costs of constructing, repairing, operating, and maintaining marine pump-out facilities in areas of need.

**Rhode Island Aqua Fund:** This state funding source was developed specifically for mitigating and preserving Narragansett Bay's water quality.

**Wallop-Breaux Boating Access Fund:** This fund is a federal funding source which consists of 75 percent federal funding in conjunction with a 25 percent state contribution. "These monies can be used for development and acquisition of fishing piers and boat launch ramps, parking lots at access areas, education and enforcement programs for boating safety, fish stocking and habitat improvement, aquatic research, public information, and new marine pump-out facilities" (RIDEM Water Resources/Narragansett Bay Project 1993). The fund is created through the use of taxes collected from boaters and fishermen.

**E. Conduct further site-specific studies of Critical Coastal Areas around Greenwich Bay (RIDEM, Warwick Planning Department, Warwick Sewer Authority, Save the Bay, Coastal Resources Center, local universities).**

Studies should focus on: 1) older ISDSs to determine if there is proper treatment and dispersion of wastewater, 2) continued water quality testing (wet weather and dry weather), 3) the Bay's flushing action and hydrologic patterns to fully understand overall

long-term behavior and residence times of pollutants in the Greenwich Bay ecosystem, and 4) watershed-based land use and pollution source analysis of streams and wetlands discharging into the Bay. These site-specific studies can assist in targeting those areas that are contributing significant amounts of pollutants to Greenwich Bay. The City of Warwick should consider providing a matching fund for possible federal grants secured through the authorization of the Clean Water Act anticipated in the upcoming months.

**F. Sensitive coastal lands in which dense development would present irreversible environmental degradation should be acquired by City, State, and private interest groups for the purpose of conservation, as exemplified by the City of Warwick in its purchase of Chepiwanoxet Point, a ten acre peninsula located along Greenwich Bay's western shoreline (Warwick Planning Department, RIDEM, Nature Conservency, Audobon Society).**

**G. CRMC should develop a Special Area Management (SAM) Plan for Greenwich Bay (CRMC).**

Recognizing the fiscal constraints for developing and implementing such a program, a SAM Plan would extend the Coastal Resources Management Council's authority in regulating source pollutants. This effort would require approximately $200,000 in initial funding and $100,000 per year, thereafter (Warwick Planning Department 1993). Development of a SAM plan would also demonstrate the State's long-term commitment to Greenwich Bay while spawning much needed scientific analysis

of this ecosystem. An excellent example of a SAM Plan is *Rhode Island's Salt Pond Region: A Special Area Management Plan* (Coastal Resources Center 1985).

## VI. STORMWATER MANAGEMENT

As mentioned previously, the city should consider the following stormwater management initiatives:

1. Subdivision Regulations should be revised to require performance standards for the attenuation of soluble pollutants, storage volume, and rate of runoff, runoff mitigation, grading, and maximum impervious lot coverage.

2. Preservation/acquisition of open space to prevent urban development and deter the construction of roads, parking lots, and buildings which increase the percentage of impervious surfaces therefore inducing urban runoff.

**A. Adopt a Comprehensive Stormwater Management Program, based on the Bay's watersheds, which addresses proper design, installation, inspection, and maintenance of storm drainage systems (Warwick Departments of Public Works and Planning, Coastal Resources Management Council, RIDEM, RIGIS).**

Improved stormwater management would be helpful in eliminating the effects of all "runoff pollutants" (ie., metals, organics, bacteria/pathogens, nutrients, salt, sediment and trash) to the Bay and other local surface water bodies. This program would involve: 1) identifying and mapping watershed boundaries, 2) potential sources of runoff contamination (ie., landfills, industrial discharge/runoff, commercial/road runoff,

underground storage tanks, failing septic systems, salt piles etc.), 3) identification and location of receiving water bodies, 4) examination, management and mitigation techniques addressing nonpoint and point sources, 5) establishment of water quality protection zones or Special Area Management Plans, including more stringent land use regulation (zoning, minimum lot size, cluster developments, subdivision, drainage requirements, zero-runoff, and land use cover). The Scituate Reservoir Watershed Management Plan (1990) and the Hunt Aquifer Wellhead Protection Plan (1994) may serve as good guides for stormwater mitigation strategies.

Part of the program could include the creation of a comprehensive data base on the Rhode Island Geographic Information System (RIGIS) including location of stormwater pollution sources as well as control and treatment devices, (ie., culverts, detention/retention basins, vegetated swales, buffer strips, man-made wetlands, pollution sources etc.). Environmental conditions hydrology, geology, soils etc., and transportation, sewer network, and stormwater management information are also of great importance and therefore, should be compiled and digitized. Information might also be obtained from the pending 1994 Army Corps stormwater study.

Where possible, the City should make use of the most effective engineering devices for stormwater storage and treatment including: infiltration trenches, settling basins, wet basins, extended detention dry basins, retention basins, constructed wetlands, vegetated filter strips, vegetated swales, and riprap channels. "Natural engineering techniques" should be preferred over structural techniques. Optimization of storage, treatment, and on-site infiltration is important to the success of a Greenwich Bay

remediation plan. Watershed studies of Hardig Brook, Baker's Creek, Mary's Creek, Potowomut River and Tuscatuket Brook should be conducted.

**B. Supplement the Army Corps of Engineer's stormwater research project by allocating funds from a June, 1994 drainage bond for additional drainage studies including mapping and nonpoint source retrofit demonstration projects (Warwick Planning Department, Public Works, Army Corps of Engineers, Narragansett Bay Project).**

**C. The City should work with the Rhode Island Department of Transportation (RIDOT) to identify, design and construct stormwater devices in drainage basins impacting Greenwich Bay water quality (Warwick Departments of Planning and Public Works, Warwick Sewer Authority, RIDOT).**

**D. Allocate funding from a June, 1994 City Bond Referendum for Drainage Remediation Projects (Warwick Department's of Planning and Public Works and Warwick Sewer Authority).**

Based on research, documentation, monitoring and mapping performed in cooperation with the Army Corps of Engineers' stormwater study, as well as studies performed with anticipated city bond revenues for further stormwater research, Warwick's Department of Public Works could design and construct locally-effective

stormwater mitigation projects in the areas identified as critical to the remediation of Greenwich Bay's water quality.

**E. City of Warwick Should Voluntarily Adopt State Stormwater Runoff Regulations normally applied to communities exceeding a population of 100,000. (Warwick Departments of Planning and Public Works).**

**F. The City should adhere to strict sediment and erosion control standards as outlined in the Department of Administration's 1992 Enabling Act.**

The City should also regularly maintain existing stormwater control devices including: culverts, detention/retention basins, and infiltration trenches which inevitably become clogged with sediment, leaves, sticks, and trash. This objective would help to ensure more effective stormwater removal, storage, and treatment. An aggressive street sweeping schedule should also be included in this program.

Appendix E provides a list of municipal stormwater control tips.

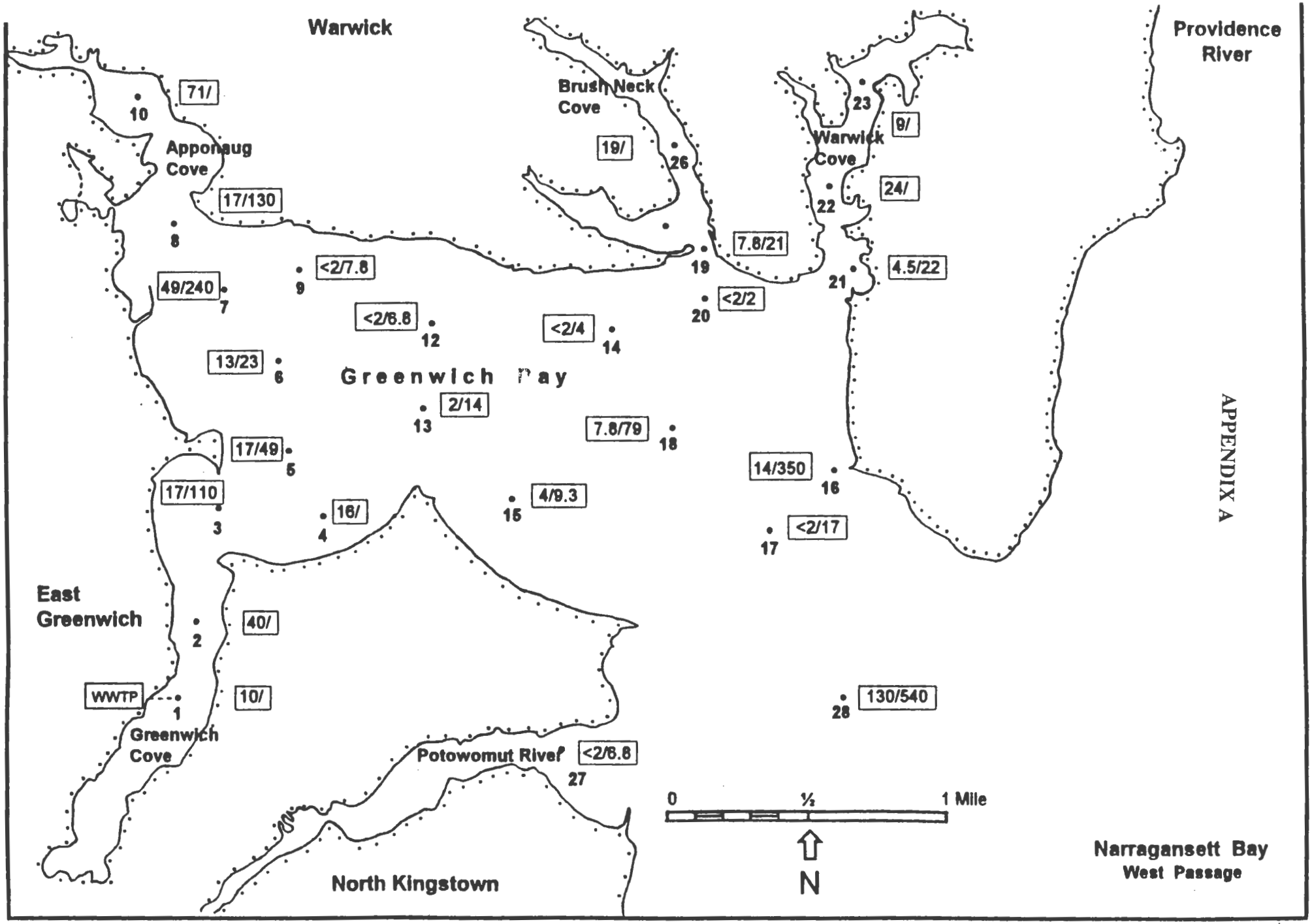
Table 6 provides a summary of the preceding recommendations.

Table 6 - Recommendations

| Recommended Action | Agency | Cost | Schedule | | |
|---|---|---|---|---|---|
| **I. Institutional Consensus and Cooperation** | | | 94 | 95 | 96 |
| a. Greenwich Bay Task Force<br>-education and outreach<br>-wastewater management<br>-stormwater management | WSA<br>WHMC<br>CRMC<br>RIDEM<br>Save the Bay<br>Shellfish Assoc.<br>Etc. | Inkind | X | X | X |
| **II. Public Education and Outreach** | | | 94 | 95 | 96 |
| a. Public education and outreach program designed to educate the public as to the problem, ramifications of the problem and proposed resolutions. | WSA<br>Save<br>the Bay<br>CRMC<br>DEM | $10,000 | X | X | X |
| b. Citizens Monitoring Campaign | Save the Bay | Inkind | X | X | X |
| **III. Land use Management** | | | 94 | 95 | 96 |
| a. Revise local zoning and subdivision regulations to include stormwater management controls and other initiatives to mitigate the pollutant loading to Greenwich Bay. Consider other land use control techniques. | Warwick Planning Department | $38,000 | X | | |
| b. Greenwich Bay Protection District Overlay | Warwick Planning | Inkind | X | | |
| **IV. Wastewater Management** | | | 94 | 95 | 96 |
| a. $1M infused into existing grant/loan program for replacement of improperly functioning or failed ISDS's in Critical Coastal Areas. | WSA | $1M | X | | |
| b. Revise the Sewer Facilities Plan to include study of innovative ISDS systems in appropriate "areas of concern". Re-examine the need for sewer line extensions in areas where alternative ISDS's can not be accommodated. | WSA<br>RIDEM<br>Warwick Planning Department | Inkind | X | | |
| c. $2.5M for Sewer Line Extension along Post Road. | WSA | $2.5M | X | | |
| d. Adopt a Water Conservation Plan | Water Dept. | | X | X | |
| e. Studies in Critical Coastal Areas, of wastewater renovation, groundwater modeling and hydrologic flushing patterns of Greenwich Bay. | Warwick<br>CRMC<br>RIDEM<br>CRC | Yet to be determined | X | X | X |
| f. Mandatory Sewer tie-ins in Oakland Beach with financial incentives. | WSA<br>319 EPA Grant | $510,000<br>$165,000 EPA Grant | X | X | |
| g. RIDEM ISDS perform 1500 on-site ISDS inspections in Critical Coastal Areas over the next three (3) years. | RIDEM | Inkind | X | X | X |
| h. Institute a "Certificate of Integrity" program certifying the adequacy of septic systems. | Bldg. Dept.<br>WSA | Inkind | | X | X |

| | | | | | |
|---|---|---|---|---|---|
| i. RIDEM conditionally permit some innovative septic systems in Critical Coastal areas:wastewater management. | RIDEM WSA | Inkind | | X | X |
| j. Consider $2.5M for a demonstration project featuring communal innovative septic system design in Potowomut. | RIDEM WSA | $2.5M | | X | X |
| **V. Coastal Management** | | | 94 | 95 | 96 |
| a. Revise Harbor Plan and Ordinance to proactively address the water quality issue. | HMC | $20,000 | X | | |
| b. Hire full time Harbormaster and additional part-time assistants. | HMC | $60,000/year | X | X | X |
| c. Facilitate installation and use of marine pump-out facilities. | RIDEM HMC | 75% Federal Match for eligible projects Approx. $100,000 | | X | X |
| d. Work Toward establishing Greenwich Bay as a federal "no discharge" area. | Harbormaster WHMC RIDEM Warwick Planning Dept. | Inkind | | X | |
| e. Purchase of sensitive coastal lands where development would present excessive environmental degradation. | Warwick Planning Dept. RIDEM | Aprox. $400,000 | X | X | X |
| f. Develop a "Special Area Management Plan" (SAM) with a primary focus on viral contaminants, nutrients, metals and hydrocarbons. | CRMC | | | X | X |
| g. Boaters Pledge | Harbormaster | $2,000 | X | X | X |
| **VI. Stormwater Management** | | | 94 | 95 | 96 |
| a. Adopt Comprehensive Stormwater Management Program. | DPW Warwick Planning Dept. WSA, RIGIS | Inkind | X | X | X |
| b. Conduct Greenwich Bay Watershed Drainage Study including Mapping with a Demonstration stormwater retrofit project to follow. | Planning DPW Army Corp. NBP | $ 500,000 Drainage Bond | X | X | |
| c. RIDOT stormwater mitigation projects. | RIDOT Warwick Planning Dept. DPW | | X | X | X |
| d. Bond - Stormwater Remediation | Warwick DPW | $1M | X | | |
| e. City of Warwick should voluntarily adopt stormwater runoff regulations typically for communities which exceed 100,000 in population. | Warwick Planning Dept. DPW | Inkind | X | X | X |

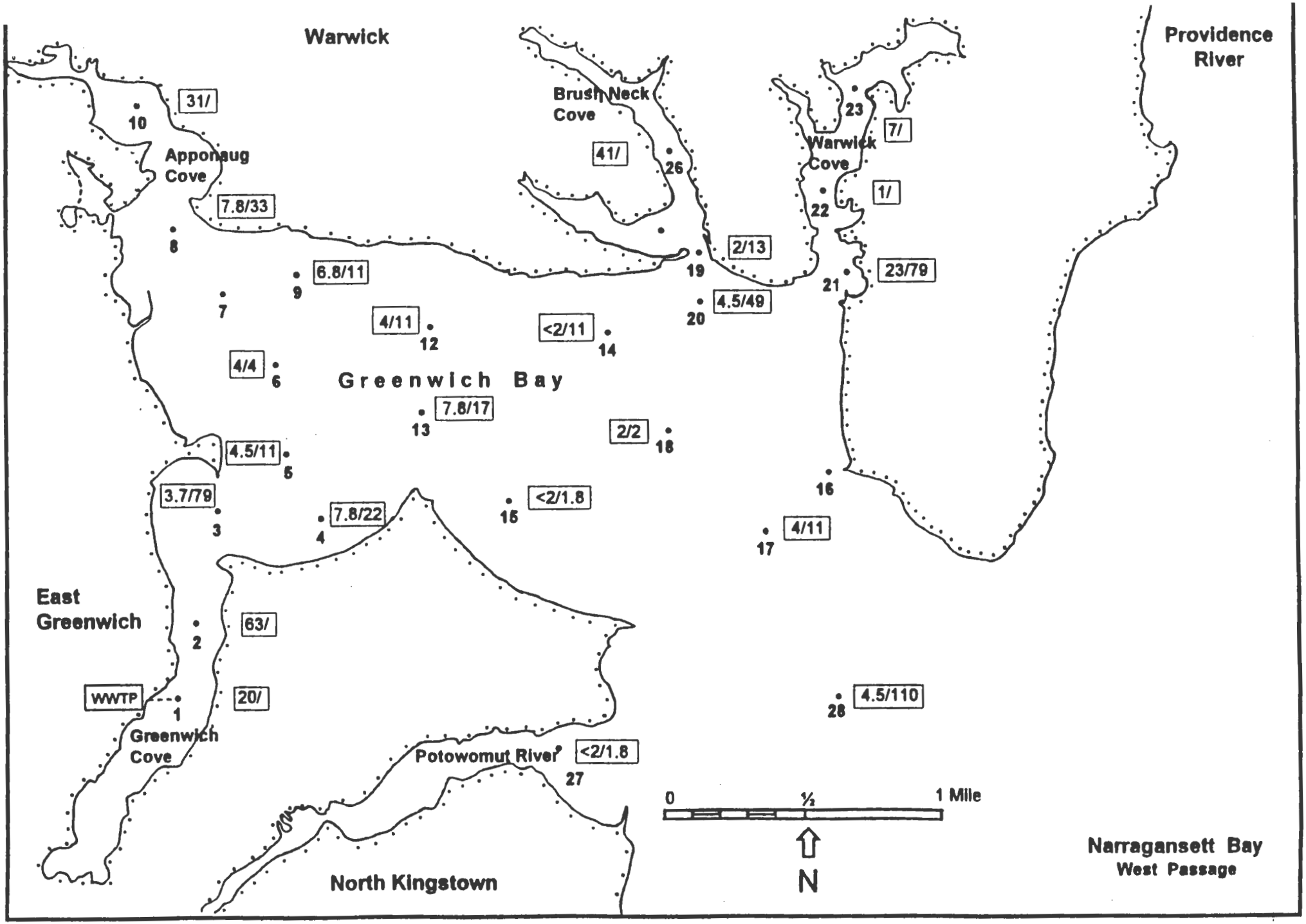
Source: Warwick Planning Department, 1994.




Surface fecal and total coliform MPNs (FC/TC) for April 12, 1993 a.m. low tide.
Source: Food and Drug Administration, 1994.

ISSC Maximum Fecal Coliform Standard = 14FC/100ml.

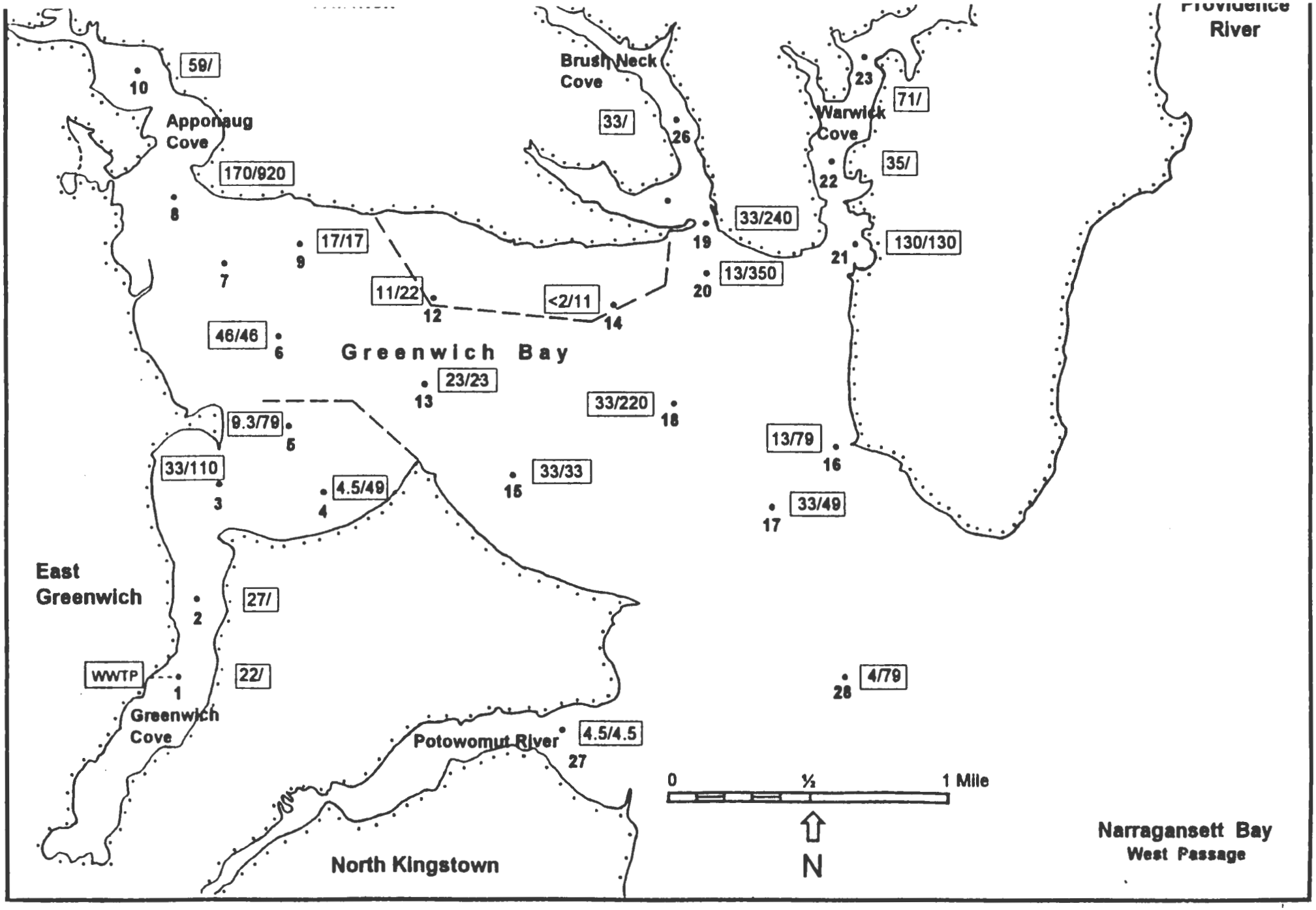
ISSC Maximum Total Coliform Standard = 70C/100ml.




Surface fecal and total coliform MPNs (FC/TC) for April 12, 1993 p.m. high tide.
Source: Food and Drug Administration, 1994.

ISSC Maximum Fecal Coliform Standard = 14FC/100ml.

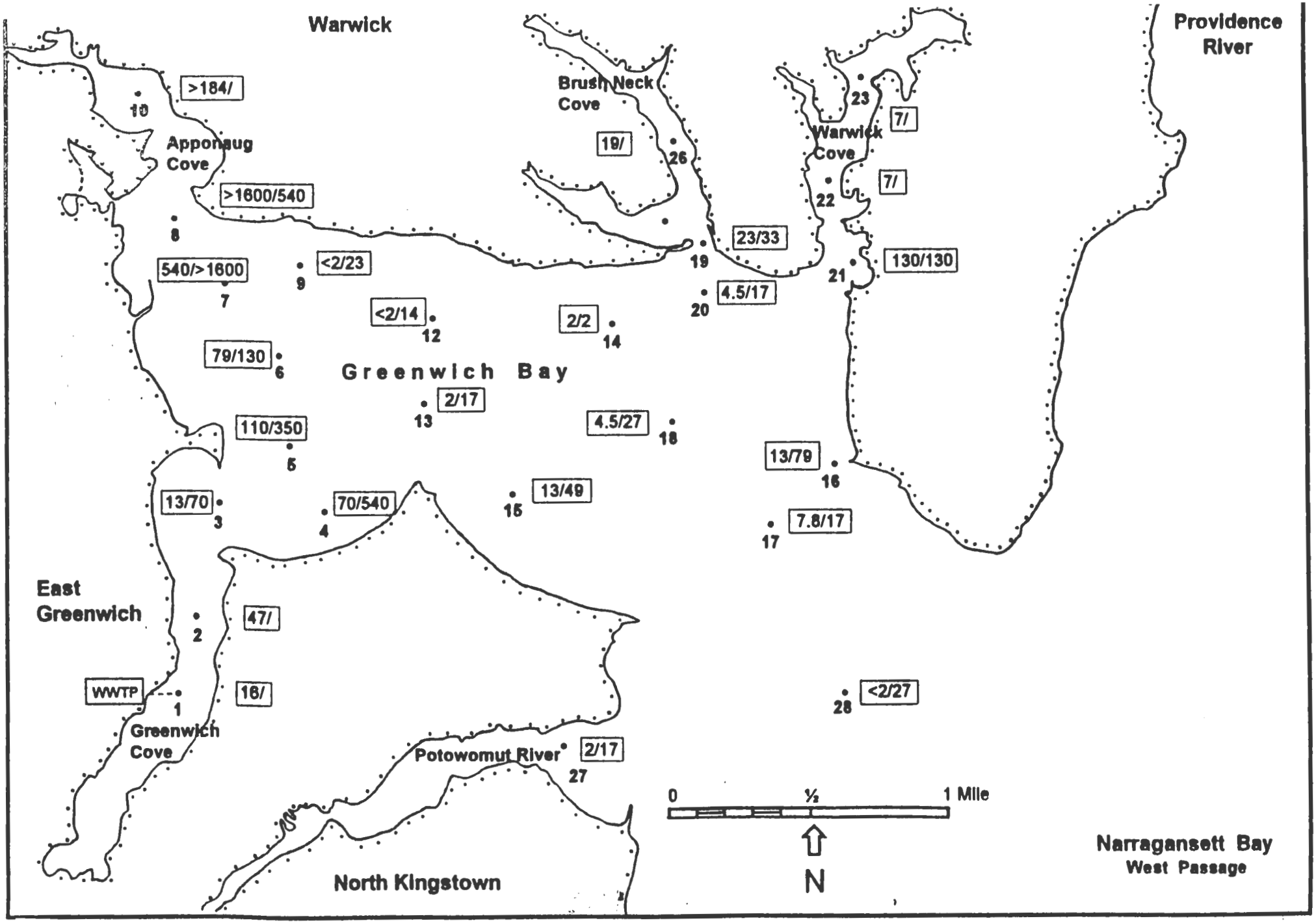
ISSC Maximum Total Coliform Standard = 70C/100ml.




Surface fecal and total coliform MPNs (FC/TC) for April 13, 1993 low tide.
Source: Food and Drug Administration, 1994.

ISSC Maximum Fecal Coliform Standard = 14FC/100ml.

ISSC Maximum Total Coliform Standard = 70C/100ml.




Surface fecal and total coliform MPNs (FC/TC) for April 14, 1993 low tide.
Source: Food and Drug Administration, 1994.

ISSC Maximum Fecal Coliform Standard = 14FC/100ml.

ISSC Maximum Total Coliform Standard = 70C/100ml.

## APPENDIX B

**Warwick Sewer Authority-Total Questionnaire Summary Sheet**

This questionnaire provided general information regarding the design, age, condition, and maintenance of ISDS's within Warwick. The questionnaire was distributed to Warwick residents and results were compiled at both the city and plat-scale. The following summary includes all plats within the Greenwich Bay Study Area.

Number of Questionnaires Found 1,644

1. Are there sewer lines in your street? Yes 14 No 1547 Don't Know 83
2. Over the past years have you witnessed any of the following:

| | Yes | No | Often | Seldom | Don't Know |
|---|---|---|---|---|---|
| A. Puddles of water in your yard. | 412 | 984 | 105 | 2067 | 15 |
| B. Toilet, sink and drain backups. | 475 | 889 | 110 | 229 | 8 |
| C. Periodic septic odors. | 463 | 841 | 108 | 209 | 17 |
| D. Septic odors from neighbors. | 616 | 675 | 149 | 210 | 52 |
| E. Problems w/ neighbor's septic. | 484 | 722 | 107 | 152 | 233 |

3. What seasons do problems occur with your system?

Spring 702 Summer 313 Fall 305 Winter 341 None 729

4. Do you ever have to restrict water use due to system backup?

   Yes 512 No 1063

5. What type of system do you have?

   Cesspool 804 Septic tank 824 Don't know 47

6. Has your septic system ever been repaired, replaced, or altered in the past ten years?

   Yes 412 No 1126

   If yes, what type of repair or alteration was done?

   Replaced leaching field. 64 Additional leaching field 168

   Total system replacement 112 Other 110

7. Do you have your septic system pumped on a regular basis?

   Yes 829 No 610

   If yes, how often?

   Every 3 months 49 Every 6 months 136 Once a year 402

   Every 2 years 306 Other 176

8. Have you taken any of the following measures in an attempt to improve the performance of your septic system?

   Add yeast 314 Add acid 631 Other 226

9. What is the age of the house?

   1-10 years 45 11-20 years 82 21-30 years 136

   31-40 years 201 41-50 years 78 50+ years 219

10. How long have you owned this property?

    1-10 years 503  11-20 years 398  21-30 years 324

    31-40 years 216  41-50 years 64  50+ years 50

11. What type of dwelling unit is it?

    Single family 1596  Two family 32  Other 7

12. How many people reside in the structure?

    (1-4) 1467  (5-10) 162  (11-15) 2  16+ 0

* The number of lots considered to have significant problems is: 777 (47.3%)

Source: Beta Engineering, 1992.

## APPENDIX C

### Municipal Authority to exceed RIDEM's ISDS Regulations

The Department of Environmental Management's Individual Sewage Disposal System (ISDS) regulations have been established as minimum criteria for the location, design, and construction, of ISDSs. The Rhode Island Supreme Court ruled that "clearly the intent of chapter 131 was to grant municipalities the option of providing additional restrictions concerning the construction of individual wastewater facilities". This decision was rendered in the case of Gara Realty, Inc. versus the Town of South Kingstown's Zoning Board of Review in April, 1987.

Source: Department of Administration Division of Planning, 1987.

# APPENDIX D

# MODEL ORDINANCE

## Wastewater Management District

## SECTION 1.0 PURPOSE

The city or town council hereby finds that, without proper operation and maintenance, Individual Sewage Disposal Systems (ISDS) or septic systems are prone to failure. ISDS failure poses a risk to public health and a potential contamination source to the surface and ground waters of the State. The purpose of this ordinance is to establish a Wastewater Management District (WWMD), in accordance with the provisions of Chapter 45-24.5 of the Rhode Island General Laws, to ensure that ISDS are properly operated, regularly inspected, and routinely maintained to prevent malfunctioning systems and to operate as an alternative to municipal sewer systems.

## SECTION 2.0 DEFINITIONS

### 2.1 Alteration

An alteration is any change in size or type of system, or installation of a replacement system.

## 2.2 Failed System

Any sewage disposal system that does not adequately treat and dispose of sewage so as to create a nuisance or threat to public health and/or environmental quality, as evidenced by, but not limited to, the following conditions:

a. Failure of a system to accept wastewater discharge or backup of wastewater into the building sewer.

b. Discharge of wastewater directly or indirectly to a subsurface drain, surface drain, or surface water.

c. Effluent rising to the surface of the ground over or near any part of the septic system or downgrade from the absorption area at any change in grade, bank, or road cut.

d. Discharge of improperly treated effluent to groundwater including but not limited to inadequate separation from the bottom of the leaching system to groundwater or impervious layer and resulting in contamination of ground or surface water.

e. Condition of deterioration, damage, or improper design, to any ISDS that would preclude adequate treatment and disposal of wastewater.

f. Pumping records that indicate very frequent maintenance. A system shall be considered in need of repair or alteration if the system has been pumped, or in need of pumping, four or more times in a period of one year.

### 2.3 Individual Sewage Disposal System (ISDS)

An individual sewage disposal system shall be a system installed to provide sanitary sewage disposal by means other than discharge into a public sewer system.

### 2.4 Leachfield

A subsurface area from which septic tank effluent or waste containing little or no solids is leached into the soil.

### 2.5 Maintenance

The inspection on a regular basis of the ISDS and as necessary the cleaning out or pumping of accumulated scum and sludge from any septic tank, building sewer, or any other component of an ISDS that can be cleaned or pumped.

### 2.6 Owner

Owner is any person who alone, or jointly, or severally with others (a) has a legal title to any premises, or (b) has control of any premises, such as agreement of purchase, agent, executor, executrix, administrator, administratrix, trustee, lessee or guardian of the estate of a holder of a legal title. Each such person is bound to comply with the provision of this ordinance.

### 2.7 Person

The term person shall include any individual, group of individuals, firm, corporation, association, partnership or private entity, including a district, city, town or other government unit or agent thereof, and in the case of corporation, any individual having active and general supervision of the properties of such a corporation.

### 2.8 Repair

To mend, remedy, renovate, or restore to a sound state after injury, deterioration, partial destruction or, to replace a septic tank, distribution box, leachfields, or pipes connecting any of these, with no change in type of material, location, or area of an ISDS.

### 2.9 Sanitary Sewage

Any human or animal excremental liquid or substance, any putrescible animal or vegetable matter, garbage and filth, including the discharge of water closets, laundry tubs, washing machines, sinks, dishwashers and the contents of septic tanks, cesspools or privies.

### 2.10 Septage

Septage is the solid or liquid materials which are pumped from an ISDS.

### 2.11 Septic System

For the purpose of this ordinance a septic system is analogous to an individual sewage disposal system. Refer to section 2.3.

### 2.12 Septic Tank

A septic tank is a water tight receptacle which receives the discharge of sanitary sewage and is designed and constructed to permit the deposition of settled solids, the digestion of the matter deposited, and the discharge of the liquid portion into the leaching system.

### 2.13 Wastewater

Wastewater is analogous to sanitary sewage. Refer to section 2.9.

### 2.14 Wastewater Management District

A Wastewater Management District (WWMD) is all or a portion of one or more cities or towns where the proper operation and maintenance of an ISDS will be required in accordance with the provisions of an adopted ordinance, which defines the district.

## SECTION 3.0 APPLICABILITY

This ordinance shall be applicable to every owner of the premises that has an Individual Sewage Disposal System located within the designated boundaries of the Wastewater Management District.

## SECTION 4.0 WASTEWATER MANAGEMENT DISTRICT BOUNDARIES

The Wastewater Management District will regulate the operation and maintenance of all ISDS within - (specify the entire municipality, portion thereof, or regional district including all or portions of two or more municipalities).

## SECTION 5.0 REGULATIONS FOR ISDS OPERATION AND MAINTENANCE

### 5.1 Pumping of Individual Sewage Disposal Systems

The contents of all ISDS within the WWMD shall be inspected and as necessary pumped out (within 2 years of the effective date of these regulations and every three years thereafter or as required). Such pumping shall be performed by municipal employees or private operators duly authorized by the WWMD.

Additional pumpings may be required as deemed necessary by the WWMD for the proper operation of an ISDS.

### 5.6 Garbage Disposals

Garbage disposal discharges to an ISDS shall be discouraged, since they add unnecessary solids to an ISDS.

### 5.7 Trees and Shrubs

The owner shall keep trees and shrubs at a minimum of 10 feet from the leaching area to keep roots from clogging or disrupting the ISDS.

### 5.8 Accessibility

The owner shall maintain ISDS so that it is accessible for inspection and maintenance.

## SECTION 6.0 ISDS INSPECTIONS

This ordinance authorizes the passage of City, Town, or WWMD officials or their designees and septage haulers onto private property when necessary for the periodic inspection, maintenance and repair of ISDS.

### 6.1 Inspection Frequency

All ISDS shall be subject to an on-site inspection by the WWMD or its designee on an annual basis. More frequent inspections may be conducted if deemed necessary by the WWMD. All ISDS owners shall be sent a written notice of inspection schedules.

## 6.2 Inspection Records

The WWMD shall maintain a record of each ISDS inspected including:

- Owner's name
- Street address or utility pole number
- Telephone number
- ISDS location (NOTE: A rough sketch map will assist in locating the system in subsequent years)
- Date(s) of previous maintenance
- Notes on ISDS condition

## 6.3 Inspection Reports

A written report detailing the results of the inspection shall be kept on the file with the WWMD. If the inspection reveals a malfunctioning ISDS, the owner shall be given a written notice indicating the probable cause and recommended corrective actions. A copy of said report shall also be sent to the DEM Division of Land Resources. The owner shall be given (30 days) to contact the DEM and apply for a permit to repair or replace the system, if necessary. A time limit to complete any needed repairs shall be established on a case by case basis.

If a system has not failed but requires pumping, the owner shall be required to show proof that the ISDS has been pumped within (30) days of the inspection. A receipt from the pumper shall constitute adequate proof.

## SECTION 7.0 ADMINISTRATION

Upon the adoption of this ordinance the (city/town council) shall establish an administrative framework necessary to implement the provisions of Chapter 45-24.5 and this ordinance. Refer to *Wastewater Management Districts...A Starting Point* for administrative options.

## SECTION 8.0 EDUCATION

It shall be the responsibility of the WWMD to establish a public education program to make ISDS owners aware of the proper operation and maintenance of these systems.

## SECTION 9.0 FINANCING

### 9.1 Fee Structure

The WWMD shall have the authority to raise funds for the administration, operation, contractual obligations and services of the WWMD. (An annual service fee of ____ dollars will be assessed to each owner of an ISDS based on the number of these systems owned in the WWMD).

### 9.2 Grant or Loan Program

The WWMD shall have the authority to issue bonds or notes of the (city or town) and received grants for the purpose of establishing a revolving fund to make low interest loans or grants available to qualified property owners for the improvement, correction,

or replacement of failed ISDS. The WWMD shall establish specific criteria that shall be subject to comments from a public hearing prior to implementing a loan or grant program. (NOTE: The criteria for the DEM sewer and water failure fund program could serve as a guide).

## SECTION 10.0 ENFORCEMENT

### 10.1 Enforcement Responsibility

The WWMD shall be responsible for enforcing the provisions of this ordinance.

### 10.2 Notice of Violations

Any owner of an ISDS determined to be in violation of these regulations will be issued a written notice explaining the nature of the violation, required actions, a reasonable time frame for compliance, and the possible consequences for non-compliance.

### 10.3 Hearing

Any owner receiving a written notice of violation shall be given an opportunity, within a reasonable time frame, for a hearing before the WWMD to state their case. If the evidence indicates that a violation has not occurred, the WWMD shall revoke the notice of violation.

### 10.4 Penalties

Any person neglecting or refusing to comply with a written notice of violation issued under the provisions of this ordinance shall be fined not more than $500 per violation. Each day of a continuing violation shall constitute a separate and distinct violation.

(NOTE: A WWMD could correct a serious violation of this ordinance and place a lien on the violators property to recover the costs for any necessary pumping, repairs, and/or the replacement of an ISDS determined to be in violation following the procedures of Section 10.2 and 10.3).

## SECTION 11.0 SEVERABILITY

If any provision of this ordinance or any rule or determination made hereunder, or application hereof to any person, agency, or circumstances is held invalid by a court of competent jurisdiction, the remainder of this ordinance and its application to any person, agency, or circumstance shall not be affected thereby. The invalidity of any section or sections of this ordinance shall not affect the validity of the remainder of the ordinance.

Source: Department of Administration Division of Planning, 1987.

## APPENDIX E

### Federal Laws Affecting Narragansett (Greenwich) Bay

Congress' passage of the Clean Water Act of 1972 firmly established the federal commitment to controlling pollution in coastal waters, and this legislation has controlled subsequent efforts by federal, state, and local agencies. EPA has the primary responsibility for the National Estuary Program, established by Congress in 1985, and formalized the amendments to the Clean Water Act in 1987.

Also in 1972, Congress enacted the Coastal Zone Management Act (CZMA) to preserve, protect, develop, and enhance coastal resources. Activities conducted under this act are administered by NOAA and Coastal Zone Management (CZM) programs. The CZMA was amended in 1991 to include much broader state responsibility for controlling nonpoint source pollution in the coastal zone.

Other federal laws include:

* National Environmental Policy Act of 1965, which requires that any project involving federal legislation, funds, or activities that could significantly alter the quality of the human environment must be the subject of an environmental impact statement.

* Coastal Barrier Resource Act of 1982, which protects barrier beaches, wetlands, and nearshore waters and provides funds for maintenance, research, and public safety.

* Estuarine Areas Act of 1968, which provides for the preservation, protection, and restoration of valuable estuaries.

* Shoreline Protection Act of 1988, which protects coastal waters from litter and pollution by providing for permits to transport municipal and commercial wastes in coastal waters and regulates waste handling.

* Marine Protection, Research and Sanctuaries Act of 1972, which regulates ocean dumping of industrial and municipal wastes and dredged materials.

* Submerged Lands Act of 1986, which allows states to manage, administer, lease, develop, and use submerged land and natural resources beneath navigable waters.

* Land and Water Conservation Fund Act of 1965, which provides funds for and authorizes federal assistance to states in planning, acquisition, and development of needed land and other areas and facilities.

* River and Harbors and Flood Control Act of 1970, which requires that all civil projects undertaken by the Army Corps of Engineers consider environmental, social, and economic effects.

* National Flood Insurance Act of 1968, which encourages state and local governments to make appropriate land use adjustments to constrict the development of land that is exposed to flooding.

* Endangered Species Act of 1973, which identifies, lists, and protects endangered and threatened species and requires that all federal actions avoid destroying or modifying critical habitats.

* Fish and wildlife Coordination Act of 1958, which requires that wildlife conservation receive equal consideration and be coordinated with other features of water resources programs through planning, development, maintenance, and coordination of wildlife conservation and rehabilitation.

* Fish and wildlife Conservation Act of 1980, which provides funds and technical assistance to states for the development, revision, implementation, and monitoring of conservation plans and programs for nongame fish and wildlife.

* Migratory Bird and Conservation Act of 1962, which provides funds and authorization for the acquisition of areas for protection and management of migratory birds.

* Wild and Scenic Rivers Act of 1968, which provides for preservation of selected rivers.

* Magnuson Fishery Conservation and Management Act of 1976, which promotes domestic commercial and recreational fishing through sound conservation and management principles.

* Anadromous Fish Conservation Act of 1965, which provides for the conservation, development, and enhancement of fishes that spawn in freshwater and live as adults in saltwater.

* Department of Transportation Act of 1966, which establishes a policy that special efforts should be made to preserve the natural beauty of the countryside and public park and recreation lands, wildlife and waterfowl refuges, and historic sites.

* Water Bank Act of 1970, which implements a continuous program to prevent the serious loss of wetlands and preserves, and restores and improves wetlands.

* Safe Drinking Water Act, as amended in 1986, which authorizes the adoption of national standards and treatment technologies for public drinking water.

* Resource Conservation and Recovery Act, the 1976 amendment to the Solid Waste Disposal Act, which provides standards for treatment, storage, and disposal facilities for hazardous wastes, aimed at preventing contamination of surface and groundwater.

* Comprehensive Environmental Response, Compensation, and Liability Act of 1980, which established the Superfund program to clean up existing or closed hazardous waste sites.

Federal Agencies that influence pollution control and resource management control and resource management issues include not only EPA and NOAA, but also FDA, which sets allowable levels of contaminants in fish and shellfish consumed by humans; U.S. ACE, which regulates dredged material disposal and the wetland permit program; the Coast Gaurd, which is responsible for response to spills; the Navy; and the U.S. Fish and Wildlife Service (RIDEM Water Resources 1992).

## State Laws Affecting Narragansett (Greenwich) Bay

The State of Rhode Island enacted legislation as early as 1920 to "prohibit and regulate the pollution of waters of the state". RIDEM, formed in 1977, now has jurisdiction over water quality policy and management. RIDEM has also produced the Non-Point Source Management Plan and the State Clean Water Strategy. Non-Point Source Management Plan specifies management approaches to decrease nonpoint sources of contaminants to the Bay. The State Clean Water Strategy will integrate assessment and management plans for point and nonpoint source contaminants.

Another R.I. state agency, CRMC, was established in 1981 as a planning and management authority. CRMC has the authority to develop and enforce plans related to the use of land and water in coastal areas.

Other programs administered by the state include the following:

* ISDS permit process, which ensures that the siting, design, and operation of septic systems is protective of public health and environmental quality.

* Freshwater wetlands permit process, which protects water quality, groundwater recharge abilities, wildlife habitat, recreational values, and unique wetland characteristics.

* Water quality classification process, which classifies Rhode Island waters and sets forth policies for their use.

* Natural Heritage Program, which identifies habitats for rare or threatened species.

* Endangered Species of Plants and Animals Act, a state law that prohibits the sale of federal endangered or threatened species.

* Erosion and sediment Control Act, which enables communities to require developers to submit erosion and sediment control plans.

* Groundwater protection Act, which establishes state policies for groundwater protection.

* Wellhead Protection Program, which delineates wellhead areas in need of protection, identifies contaminant sources, develops management strategies and ordinances, guides siting of new wells, and provides contingency plans for events of well contamination.

* Underground Storage Tank Regulation, which implements a registration system and establishes design requirements, testing schedules and procedures, and measures for siting underground tanks.

* Hazardous Waste Regulation, which governs the storage, transport, treatment, and disposal of hazardous wastes.

* Hazardous Waste Management Facilities, which establishes a process for siting hazardous waste management facilities.

* Solid Waste Regulation, which authorizes prohibition of disposal of solid waste in groundwater aquifer areas.

* Underground Injection Control Program, which is intended to preserve the quality of the groundwaters of the state by assuring the proper location, design, construction, maintenance, and operation of injection wells and other subsurface disposal systems.

* Pesticide Control, which authorizes regulation of registration, sale, storage, transport, use, application, and disposal of pesticides.

* Public Drinking Water Protection Act, which allows public water supply authorities to impose a charge on water use.

One recent Rhode Island law affects land use issues in the watershed and consequently will affect the water quality of the Bay. The Comprehensive Planning and Land Use Regulation Act, passed in 1988, requires all cities and towns to produce a comprehensive plan to guide development. The Zoning Enabling Act, enacted in 1991, expands local authority to enforce the plans developed under the Comprehensive Planning and Land Use Regulation Act.

Because environmental regulation often produces conflicts between public and private rights and expectations, the federal and state courts also play an important role in governance of the Bay. Also, although they have no official regulatory capacity, environmental groups, trade organizations, other special interest groups and the local universities also influence resource management and pollution control policies.

Each of these groups--federal, state, and local governments, environmental groups, marine trade organizations, other special interest groups and the universities--

have the best intentions for proper management and preservation of the Bay's resources. However, the number of organizations and laws that affect the Bay is complex. It is difficult to coordinate all interested parties and applicable laws and programs.

Source: RIDEM Water Resources, 1992.

## APPENDIX F

### Municipal Stormwater Pollution Control Tips

- Prevent the release into the storm sewer of hazardous substances such as used oil or household or yard chemicals.
- Make sure new commercial and residential developments include stormwater management controls, such as reducing areas of paved surfaces to allow stormwater to seep into the ground.
- Promote practices such as street sweeping, limiting use of road salt, picking up litter, and disposing of leaves and yard wastes quickly.
- Collect samples of stormwater from industrial sites to see whether pollutants are being released. If so, identify the type and quantity of pollutants being released.
- Design and institute flood control projects in a way that does not impair water quality.
- Prevent runoff of excess pesticides, fertilizers, and herbicides by using them properly and efficiently. (Commercial, institutional, and residential landscapes can be designed to prevent pollution, conserve water, and look beautiful at the same time).
- Make sure that construction sites control the amount of soil that is washed off by rain into waterways.

- Promote citizen participation and public group activities to increase awareness and education at all levels. Encourage local collection pick-up days and recycling of household hazardous waste materials to prevent their disposal into storm drains.

  Source: Environmental Protection Agency Office of Water, 1993.

## APPENDIX G

## EDUCATION STRATEGIES

Water quality education has, in general, enjoyed little emphasis. Government agencies have gravitated toward the brochure strategy, which by itself, is no strategy at all. Effective education is a form of marketing audiences, messages, targeting, media, and saturation: these key concepts are integral to designing a program to modify people's behavior. Effective education is also an essential component of maintaining public support for water quality programs.

Education programs can and do miss the mark. The most helpful and accurate brochure will have no effect if the target audience: 1) doesn't get it, 2) doesn't read it, or 3) isn't motivated by it. An in-person training program for technical people in an industry will be a waste of time if: 1) the person presenting the information is not credible to the audience; 2) the information isn't tailored to the specific real world of the particular business; or 3) the purpose of the education is to change the policies of management, rather than to change the behavior of the people in the room. Academic programs can exacerbate fragmentation in solving water quality programs by emphasizing information and omitting learning strategies that might broaden context and assist in integration.

On the other hand, education can be extremely effective. Good information, presented at the right time in the right form, can change behavior, avoid battles, empower people, and prevent pollution. Encouraging peer-to-peer education can

overcome the credibility problems invariably encountered when government tries to educate business people. Funding citizen involvement programs such as labeling storm drains can do double duty-addressing a specific water-quality problem while building a more general environmental ethic. Education can also overcome the confines of compartmentalized regulatory programs by integrating environmental responsibility and technical competence in a "real world" context.

A comprehensive water-quality education strategy would include at least the following:

**Technical assistance and technical training** - Working through industry and technical/professional associations is especially effective in conveying technical information to targeted audiences. Regulatory programs have generally not proven to be sufficient conduits of technical training.

**Technology transfer** - This term refers to methods and approaches as well as to hardware and treatment or manufacturing processes. Most technology transfers occur informally but can be hastened by conferences and well-thought-out dissemination of information.

**Targeted audiences** - This concept starts by thinking about the audience rather than the government agency and its program. It asks, "If I owned a dry cleaning establishment or if I were a resident in this watershed or if I were a mayor in this region, what would I need to know to protect water quality or the environment more generally? And how would I learn it? With this perspective, effective and efficient education

strategies can be developed, but only if the educator is up to the challenge of cutting across bureaucratic lines.

**General audience** - Messages to general audiences require effective use of mass communication methods, including sufficient saturation to ensure that the messages have an impact. General awareness information (for example the value of marine ecosystems) and information applicable to virtually everyone (what to do with waste oil or paint thinner) require such methods.

**Water quality education in schools** - Excellent water quality and other environmental curricula exist for use in schools. They are most effective when adapted to specific local places and issues and teachers are trained in their use. Both of these needs require resources. Basic environmental water quality curricula tend to be good for this goal, given the over-arching nature of the question "what affects water quality and how can we protect the water"?

**Technical and scientific training in higher education** - Integration rather than compartmentalization of technical/scientific education is crucial for the next generation of environmental professionals. Academia needs to address the companion (yet often competing) objectives of producing both "big thinkers" and competent specialists.

**Public involvement linked to education** - "Hands-on" projects for volunteers, such as storm drain stenciling projects, beach clean-ups, restoring streams, and replanting anadromous fish, can educate while simultaneously accomplishing a direct environmental purpose. Such projects are very low cost, and will flourish with some governmental or private seed money.

**Pollution prevention programs** - Agencies and business associations are increasingly emphasizing "pollution prevention pays" and the technical information to encourage source reduction. Because most regulatory programs focus on the end of the pipe, prevention has largely stayed in the province of education, although, ideally, regulatory pressure and education would work together to achieve prevention.

Source: National Research Council 1993

## APPENDIX H

## Greenwich Bay Task Force Meeting

## December 9, 1993

## City of Warwick Council Chambers

## Summary

The meeting was called to order at 1:30 p.m. In attendance were representatives from: the City of Warwick Planning Department, Warwick Public Works, and Sewer Authority; Department of Environmental Management's Water Resources, Division of ISDS, and Narragansett Bay Project; the Coastal Resources Management Council; and the East Greenwich Wastewater Facilities.

The purpose of the meeting was to bring institutional stakeholders together to discuss the initiatives set forth by the Greenwich Bay Reclamation Plan, gather professional opinion, and gain consensus regarding the most effective ways in which to fulfill the goals of the study. From the meeting a number of important issues were raised. The following is a summary of those issues.

* Further investigation into the source of high fecal coliform counts in the Potowomut River was recommended.

* It was generally felt that sewers would be more appropriate for addressing the issue of failing septic systems because, while alternative or innovative systems are effective at treating nutrients they are not always effective in treating bacterial

contaminants. However, communal or innovative ISDSs may be more appropriate in areas that would be too costly to sewer such as places far removed (like Potowomut) from wastewater facilities.

* The Warwick Sewer Authority said the Warwick Wastewater Facilities is currently being run at 65-75% capacity.

* Water conservation measures were brought up as a means of lessening the volume of wastewater to be received by the facilities.

* The Sewer Authority expressed an interest in focusing its attention on the Greenwich Bay study area. It was mentioned that impending construction along Post Road would provide an excellent opportunity for extending sewers in the Apponaug/Chepiwanoxet area.

* The Sewer Authority believed that mandatory tie-ins should be required city-wide; not exclusively to the Oakland Beach area. Although not mentioned at the meeting, it is the Planning Department's contention that the City of Warwick had also targeted the Apponaug/Cowesett Hills area as a place where mandatory tie-ins should be considered.

* A representative of the CRMC mentioned that it may be a better idea to concentrate on coastal regions within the study area, which are the largest contributors to Greenwich Bay's problems, rather than more distal inland sources.

* The issue of public outcry over requirements to replace or upgrade septic systems as being a potential obstacle in reaching the goals of the Greenwich Bay Reclamation Plan was brought to the attention of the task force.

* Regarding the Food and Drug Administration's recent efforts in monitoring fecal coliform levels, DEM's Department of Water Resources essentially said: the measurements are generally incomplete or inconclusive at this time. However, it appears some areas of interest may include: Apponaug Cove, Hardig Brook, and the mouth of the Potowomut River. Winter wet-weather levels are the highest. The Bay cannot be justifiably re-opened at this time.

* It was mentioned that boating within Greenwich Bay is an important source of bacterial contamination to the Bay and that marine pump-outs and no-discharge zones may be a couple "quick and dirty" solutions for addressing the pollution problem.

* There was a general consensus that more attention should be placed on stormwater runoff and that further analysis is essential.

* The CRMC expressed a concern regarding the construction of homes on land having very high water table levels.

* The Director of Planning for the City of Warwick mentioned that the City will soon be making changes to its zoning ordinance and that this will provide an ideal opportunity for ensuring proper land use in environmentally sensitive areas such as land contiguous to the Bay. In addition, a policy of requiring retrofitting to ensure adequate wastewater treatment during land transactions would be explored.

* The Narragansett Bay Project mentioned that they would soon be working in cooperation with the Army Corps of Engineers on a stormwater runoff study.

* RIDEM's Department of ISDS confirmed that sub-standard ISDS', French drains, etc., were a major contributor of pollution to the Bay.

* Sources of funding were discussed. Grants through the Clean Water Act's 319 program and some limited funding for further stormwater studies under 6217 may be available. RIDEM's Division of ISDS mentioned the potential for using 319 money for retrofitting or rerouting stormwater drainage. A retrofit of stormwater drainage has already occurred around Gorton's Pond in Apponaug. It was also mentioned that the Department of Transportation will likely be having a more environmental focus than in past years.

* There seemed to be a general consensus regarding the need for maintenance of existing stormwater devices.

* CRMC expressed a concern about the effects of the introduction of freshwater stormwater to brackish or salt waters.

* A discussion of Special Area Management Plans (SAMP's) and CRMC's role in SAMP's were discussed.

* It was suggested that the next meeting should be held in approximately six weeks (near the end of January). It was recommended that a number of other stakeholders be added to the Greenwich Bay Task Force including: Peter Schaeffer (Fiance Director of Warwick), Art Ganz (state shellfish expert), a member of the City of Warwick's Building Department and a representative of the City of North Kingston.

## REFERENCES


Beta Engineering Inc. 1992. *Advanced Wastewater Treatment Facilities-Plan.* Lincoln,R.I.: Beta Engineering Inc.

Bicki, Thomas J. and Brown, Randall B. 1991. On-site sewage disposal: the influence of system density on water quality. *Journal of Environmental Health.* (March/April). Vol. 53, No. 5.

City of Warwick Department of Planning. 1987. *Land Use Plan: 1986-1991.* Warwick, R.I.: City of Warwick.

City of Warwick Departments of Planning and Development and Economic Development. 1993. *City of Warwick Monograph.* Warwick, R.I.

City of Warwick Department of Public Works. Stormwater data and location map. Warwick, R.I.: DPW.

City of Warwick. 1993. *Zoning Ordinance.* Tallahassee: Municipal Code Corporation.

Coastal Resources Council. 1983. *The State of Rhode Island Coastal Resources Management Program.* Narragansett, R.I.: University of Rhode Island, CRC.

Coastal Resources Council. 1985. *Rhode Island's Salt Pond Region: A Special Management Plan.* Narragansett, R.I.: University of Rhode Island, CRC.

Committee on Wastewater Management for Coastal Urban Areas; Water Science and Technology Board Commission on Engineering; and Technical Systems National Research Council. 1993. *Managing Wastewater in Coastal Urban Areas.* Washington, D.C.: National Academy Press.

Environmental Protection Agency and Rhode Island Department of Environmental Management. 1992. *The Rhode Island Citizens' Volunteer Monitoring Programs.* Providence, R.I.: EPA.

Environmental Protection Agency. 1993. *Region I U.S. Environmental Protection Agency Clean Water Act, Section 319 Nonpoint Source Pollution Control Management Program and Work Plan Guidance for Fiscal Year 1994 State and Tribal Grants.* Boston, MA: EPA.

Environmental Protection Agency; National Oceanic and Atmospheric Administration; Coastal Resources Management Council; and Rhode Island Department of Environmental Management. 1993. *State of Rhode Island Stormwater Design and Installation Standards Manual.* Providence, R.I.: EPA.

Environmental Protection Agency Office of Water. 1993. *When it Rains, it Drains.* Public Information pamphlet. Boston, MA: (August).

Geldreich, E.E.; Best, L.C.; Kenner, B.A.; and Van Donsel, D.J. 1968. The bacteriological aspects of stormwater pollution. *Journal Water Pollution Control Federation.* Vol. 40, No. 11.

Gomez, Anthony; Taylor, Marilou; and Nicola, Ray M. 1992. Development of effective on-site sewage disposal surveys in King County, Washington. *Journal of Environmental Health.* (March/April). Vol. 54, No. 5.

GZA Geoenvironmental, Inc. 1994. *Hunt Aquifer Wellhead Protection Plan.* (Draft). Providence, R.I.: GZA.

MaGuire, C.E. Inc. 1978. *Wastewater Facilities Plan-Warwick, Rhode Island* (Draft). Providence, R.I.: MaGuire Group Inc.

MaGuire, C.E. Inc. 1982a. *On-site Sewage Disposal Systems Failure Manual.* Providence, R.I.: MaGuire Group Inc.

MaGuire, C.E. Inc. 1982b. *On-site Sewage Disposal Systems Management Plan for the City of Warwick.* Providence, R.I.: MaGuire Group Inc.

Marsh, William, M. 1991. *Landscape Planning: Environmental Applications.* New York: John Wiley and Sons Inc.

Massachusetts Bay Program. 1990. *The Massachusetts Bay Program: Progress 1990.* Boston, MA: MBP.

Nowiciki, Barbara L. and Mckenna, James H. Marine Ecosystems Research Laboratory. 1990. *A Preliminary Assessment of Environmental Quality in Greenwich Bay, Rhode Island.* Narragansett, R.I.: University of Rhode Island Graduate School of Oceanography.

On-Site Sewage Disposal Task Force of the New England Interstate Water Pollution Control Commission. 1992. *Criteria for Regulation of On-Site Sewage Treatment and Disposal Systems.* Boston, MA: New England Interstate Water Pollution Control Commission.

Peterson, Thomas C. and Ward, Robert C. 1989. Bacterial retention in soils: new perspectives, new recommendations. *Journal of Environmental Health.* (March/April). Vol. 51, No. 4.

Portney, Paul R.; Dower, Roger C; Freeman, A. Myrick III; Russell, Clifford S.; and, Shapiro, Michael. 1992. *Public Policies for Environmental Protection.* Washington, D.C.: Resources for the Future.

Rhode Island Department of Administration Division of Planning. 1987. *Wastewater Management Districts...A Starting Point.* Providence, R.I.: Rhode Island Department of Administration. Report Number 62.

Rhode Island Department of Administration Division of Planning. 1990. *Scituate Reservoir Watershed Management Plan.* Providence, R.I.: Rhode Island Department of Administration. Report Number 70.

Rhode Island Department of Administration Division of Planning. 1992. *State Enabling Acts Relating to Land Use and Planning.* Providence, R.I.: Rhode Island Department of Administration. Handbook Number 7.

Rhode Island Department of Environmental Management and Environmental Protection Agency. 1990. *Narragansett Bay Project Report.* Providence, R.I.: RIDEM.

Rhode Island Department of Environmental Management Division of Groundwater and ISDS. 1974-1992. Physical characteristics of selected properties gathered during on-site inspections. Providence, R.I.: RIDEM.

Rhode Island Department of Environmental Management Division of Groundwater and ISDS. 1992. *Rules and Regulations Establishing Minimum Standards Relating to Location, Design, Construction and Maintenance of Individual Sewage Disposal Systems.* Providence, R.I.:RIDEM.

Rhode Island Department of Environmental Management Division of Groundwater and ISDS. 1993. *List of ISDS Complaints.* Providence, R.I.: RIDEM.

Rhode Island Department of Environmental Management Division of Water Resources. 1990. *The State of the State's Waters.* Providence, R.I.: RIDEM.

Rhode Island Department of Environmental Management Division of Water Resources. 1991. *Shoreline Reappraisal Report: Greenwich Bay.* Providence, R.I.: RIDEM.

Rhode Island Department of Environmental Management Division of Water Resources. 1992. *The State of the State's Waters-Rhode Island. A Report to Congress.* Providence, R.I.: RIDEM.

Rhode Island Department of Environmental Management Division of Water Resources/Narragansett Bay Project. 1993. *Marina Pump-out Management Plan.* Providence, R.I.: RIDEM.

Rhode Island Department of Environmental Management Office of Environmental Coordination. 1988. *Recommendations of the Stormwater Management and Erosion Control Committee Regarding the Development and Implementation of Technical Guidelines for Stormwater Management.* Providence, R.I.: RIDEM.

Rhode Island Marine Trade Association. 1990. Greenwich Bay Boat Counts.

Rice, Michael A.; Grady, Mary; Schwartz, Malia L.; and O' Niel, Donna Palumbo. 1990. *Proceedings of the First Rhode Island Shellfisheries Conference.* Narragansett, R.I.: Rhode Island Sea Grant. August 27.

Rice, Michael A. and Garber, Deborah Grossman. 1992. *Proceedings of the Second Rhode Island Shellfish Industry Conference.* Narragansett, R.I.: Rhode Island Sea Grant.

Rogers and Golden Inc. and Alan Mallach/Associates. 1977. *Environmental Assessment Handbook: A Maryland Coastal Zone Management Program Publication.* Philadelphia, Pa: Volume 4.

Saccoccio, Kristin. 1993. *City of Warwick Planning Intern.* Warwick, R.I.: (summer).

Save the Bay. 1990. *Septic Systems: A Homeowner's Manual.* Providence, R.I.: Save the Bay.

Schaeffer, Pedar. 1994. *City of Warwick Special Capital Development Program of 1994.* In-house memorandum. Warwick City Hall: January.

Seidman, Ethan; Geist, Al; Kourik, Robert; and Tenenbaum, David. 1993. Septics by the Sea. *Garbage.* V, 1. (February/March): 30-37.

Town of Hopkinton. 1991. *Town of Hopkinton Comprehensive Plan.* Hopkinton, R.I.

Town of Hopkinton. 1993. *Wastewater Management Ordinance.* Hopkinton, R.I.: Town of Hopkinton. Chapter 121.

United States Bureau of the Census. 1990. *United States Census of Population and Housing*. Washington, D.C.: U.S. Government Printing Office.

United States Department of Agriculture Soil Conservation Service. 1981. *Soil Survey of Rhode Island*. Rhode Island. National Cooperative Soil Survey.

United States Department of the Interior Geological Survey. 1955. *Surficial Geology Map of the Bristol, R.I. Quadrangle*. Reston, Virginia. United States Department of the Interior.

United States Department of the Interior Geological Survey. 1955. *Surficial Geology Map of the Crompton, R.I. Quadrangle*. Reston, Virginia. United States Department of the Interior.

United States Department of the Interior Geological Survey. 1955. *Surficial Geology Map of the East Greenwich Quadrangle*. Reston, Virginia. United States Department of the Interior.

United States Department of the Interior Geological Survey. 1955. *Surficial Geology Map of the Providence Quadrangle*. Reston, Virginia. United States Department of the Interior.

United States Department of the Interior Geological Survey. 1956. *Geologic Bulletin*. Reston, Virginia. United States Department of the Interior.

United States Department of the Interior Geological Survey. 1975. *Topographic Map of the Bristol, R.I. Quadrangle*. Reston, Virginia. United States Department of the Interior.

United States Department of the Interior Geological Survey. 1975. *Topographic Map of the Crompton, R.I. Quadrangle*. Reston, Virginia. United States Department of the Interior.

United States Department of the Interior Geological Survey. 1975. *Topographic Map of the East Greenwich, R.I. Quadrangle*. Reston, Virginia. United States Department of the Interior.

United States Department of the Interior Geological Survey. 1975. *Topographic Map of the Providence, R.I. Quadrangle*. Reston, Virginia. United States Department of the Interior.

United States Environmental Protection Agency and Rhode Island Department of Environmental Management. 1992. *Rhode Island Citizen Volunteer Water Quality Monitoring Programs*. Providence, R.I.: RIDEM.

United States Public Health Service Food and Drug Administration. 1994. *Greenwich Bay, R.I. Shellfish Grounds Area Survey and Classification Considerations: April and June, 1993.* Davisville, R.I.: USFDA.

University of Rhode Island College of Resource Development Department of Natural Resources Science. 1991a. *Homeowner's Guide to Managing Your Lawn to Protect Water Quality.* University of Rhode Island, Kingston, R.I.: Fact Sheet No. 88-1. (July).

University of Rhode Island College of Resource Development Department of Natural Resources Science. 1991b. *Natural Resources Facts: Maintaining Your Septic System.* University of Rhode Island, Kingston, R.I.: Fact Sheet No. 88-2. (July).

University of Rhode Island College of Resource Development Department of Natural Resources Science. 1991c. *Water Conservation In and Around the Home.* University of Rhode Island, Kingston, R.I.: Fact Sheet No. 91-2. (December).

University of Rhode Island College of Resource Development Department of Natural Resources Science. 1993. *The Narragansett Bay Watershed Project.* University of Rhode Island, Kingston, R.I.: Fact Sheet No. 93-6. (September).

University of Rhode Island Community Planning and Area Development. Advanced Planning Studio. 1990. *The Hidden River: A Land Use and Environmental Study for the Runnins River Watershed. Kingstown, R.I. :* Community Planning and Development, University of Rhode Island.

University of Rhode Island Division of Marine Resources. 1986. *Recreational Boating Facilities Warwick's Marinas, Boat Yards and Yacht Clubs.* Narragansett, R.I.: University of Rhode Island.

## MEETINGS, INTERVIEWS, AND TELEPHONE CONVERSATIONS


Brown, Timothy. 1993. *Executive Director of the Kent County Water Authority.* Telephone conversation. West Warwick, Rhode Island: December.

City of Warwick Harbor Commission. October 1993 - April 1994. *Bi-weekly Meetings.* Warwick City Hall Annex.

City of Warwick Planning Department. May 1993-April 1994. *Conversations, interviews, and meetings.* Warwick, R.I.

City of Warwick Sewer Authority. 1993. Meeting. Warwick, R.I.: May.

East Greenwich Wastewater Facility. 1994. *Telephone conversation.* East Greenwich, Rhode Island: January.

Ganz, Arthur R. 1993. *Principal Marine Biologist for Rhode Island Department of Environmental Management Division of Fish and Wildlife.* Telephone conversation. Providence, Rhode Island: August 12.

Greenwich Bay Task Force. 1993. *Meeting.* City Hall Council Chambers. Warwick, R.I.: December 8.

Greenwich Bay Task Force. 1994. *Meeting.* City Hall Council Chambers. Warwick, R.I.: January 27.

Migliore, Joseph. 1993. *Senior Environmental Scientist. Department of Environmental Management Division of Water Resources.* Meeting. Providence, Rhode Island: August 10.

Moore, Brian. 1994. *Rhode Island Department of Environmental Management Division of ISDS.* Personal Interview. Providence, R.I. March 25.

Palumbo, Vincent. 1994. *Rhode Island Department of Transportation.* Telephone conversation. Providence, Rhode Island: January.

Rhode Island Department of Environmental Management Office of Permitting. 1993. *Telephone conversation.* Providence, R.I.: September.

Rhode Island Marine Trades Association. 1994. *Telephone conversation.* East Greenwich: January.

Ribb, Richard. 1993. *Rhode Island Department of Environmental Management Narragansett Bay Project.* Conversation. RIDEM Providence, R.I. September.

Rice, Michael. 1993. *Assistant Professor of Fish, Animal and Veterinary Science.* Telephone interview. June.

Save the Bay and Narragansett Bay Project. 1993. *Meeting.* RIDEM Providence, R.I.: December.

Soil Conservation Service. 1993. *Telephone conversation.* East Greenwich, Rhode Island: July.

United States Food and Drug Administration. 1993. *Meeting.* Davisville, R.I.: September.

Venitahro, Dennis. 1993. *Warwick Sewer Authority.* Telephone conversation. Warwick, Rhode Island: December.