BRUSH NECK COVE
AQUATIC ECOSYSTEM RESTORATION
WARWICK, RHODE ISLAND

FEASIBILITY REPORT AND ENVIRONMENTAL ASSESSMENT

US Army Corps
of Engineers®
New England District

Authority: WRDA Section 206
Date: November 2010

Cover Sheet

FEASIBILITY REPORT AND ENVIRONMENTAL ASSESSMENT

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Aquatic Ecosystem Restoration
Warwick, RI

The responsible lead Federal agency for this study is the U. S. Army Corps of Engineers New England District. The non-Federal sponsor for the study is the Rhode Island Coastal Resource Management Council. The Corps is also the lead Federal agency for National Environmental Policy Act compliance. This report is a combined feasibility report and environmental assessment complying with requirements of the U.S. Army Corps of Engineers (Corps) and the Council of Environmental Quality, and is intended to reduce duplication and paperwork.

Abstract:
The purpose of the Feasibility and Environmental Assessment was to document the aquatic restoration of Brush Neck Cove planning process. The sponsor, stakeholders and Corps believed that the perceived environmental degradation of Brush Neck and neighboring Buttonwoods Cove is related to reduced tidal flushing and tidal range caused by a restriction at the inlet and sedimentation. The group also believed that removing the soft sediment layer and exposing a coarser underlying material in the coves could improve benthic habitat. However, data collected during the feasibility study suggest that these coves are not tidally restricted and have no reduced water volume exchange; the coves receive the maximum tidal flushing and ranges available and the volume of water entering the coves has not changed with time. The sediment core data revealed minimal to no physical difference between the upper and lower sediment layers; the sediment cores did not contain a distinct coarse substrate layer. The Corps concluded from these data that dredging the inlet or the coves would not result in significant restoration benefits. Therefore, we do not recommend a Federal project at this time and recommend terminating the investigation. The City of Warwick should work together with other Federal, State and local agencies and groups to implement best management practices to minimize sediment, nutrient and bacteria loading and take steps to eradicate invasive species in the study area watershed.

The findings of this negative report have not gone through the formal Corps of Engineers review/quality assurance process. Information, other than the general conclusion that further consideration under the Section 206, Aquatic Ecosystem Restoration Program is not warranted, should be considered preliminary.

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Brush Neck Cove Aquatic Ecosystem Restoration
Executive Summary

This report presents the results of studies for aquatic ecosystem restoration in Brush Neck Cove, Warwick, Rhode Island under the authority contained in Section 206 of the Water Resources Development Act. The Rhode Island Coastal Resource Management Council (CRMC), the non-Federal sponsor, and the U.S. Army Corps of Engineers (Corps) initiated the feasibility phase in March 2005.

This summary is intended to describe the major factors that were considered in the investigation and those that influenced the decisions documented in this report.

MAJOR CONCLUSIONS AND FINDINGS

This study concludes that the dredging of the Brush Neck Cove inlet and basin would not provide sufficient environmental benefits to warrant Federal participation in the implementation of the restoration measures evaluated.

Problems and Opportunities.
Problems identified in Brush Neck and Buttonwoods Coves were:

- Degraded water quality (nutrients, bacteria, dissolved oxygen and turbidity) contributing to aquatic habitat degradation
- Shoaling, sediment loading and resuspension
- Loss of shellfish spawning habitats
- Loss of aesthetic value

Opportunities identified included:

- Restoration of waterfowl habitats
- Restoration of salt marsh habitats

The team considered the possibility that many of these problems were at least partially related to a restriction of tidal flow from the narrow inlet to Brush Neck Cove based on information provided by the sponsor, stakeholders and residents. The general perception was that the inlet had become shallower and narrower with time and that the cove had reduced depth due to sedimentation. Based on this information, the planning objectives were centered around restoring historic tidal flushing, depth and benthic substrate while improving water quality and habitat within the project area.

Planning Objectives
The investigation of problems and opportunities in the study area led to the establishment of the following planning objectives:

- Remove or reduce impacts from high nutrient/organic material sediments within the estuary
- Reduce the impact from stormwater runoff containing nutrients and sediment to the estuary
- Improve flushing and restore tidal range within the estuary
- Stabilize salt marshes and riparian areas to reduce erosion, sediment loading and suspension
- Restore buffer zones and riparian habitats.
- Restore and create salt marsh habitat
- Restore substrates that would support shellfish populations
- Improve water quality to levels sufficient to support high quality shellfish and benthic communities.

Alternatives
A wide range of restoration measures were evaluated to address the planning objectives. Measures are then combined to form alternative plans. However, during data acquisition and analysis, it was determined that the restoration measures would not accomplish the planning objectives and therefore no alternatives were formulated. The measures considered were:

- I. Inlet Channel Dredging
    - i. Width – 75 feet
    - ii. Lengths – 1,000, 4,000, 6,000 feet
    - iii. Depths – 4, 5, 6-foot
- II. Cove Dredging
    - a. Brush Neck Cove
        - i. Widths – 100, 200, 300 feet
        - ii. Lengths – 2,0000, 2,500, 3,000 feet
        - iii. Depths – 4, 5, 6-foot
    - b. Buttonwoods Cove
        - i. Widths – 100, 200, 300 feet
        - ii. Lengths – 250, 500, 750 feet
        - iii. Depths – 3, 4, 5-foot
- III. Beach Replenishment (dependant on I. or II. above)
    - a. Oakland Beach (Corps project)
    - b. City Park Beach (City-owned)
- IV. Habitat Restoration (dependant on I. or II. above)
    - a. Restoring Benthic/Shellfish Substrate (Brush Neck Cove)
    - b. Restoring Benthic/Shellfish Substrate (Buttonwood Cove)
    - c. Salt Marsh creation/restoration/stabilization (City Park)
    - d. Salt Marsh creation/restoration/stabilization (east of Sea View Drive)
    - e. Invasive Species Removal (*Phragmites*)
- V. Water Quality
    - a. Sedimentation Trap Structures
    - b. Natural Wetland Filtration Systems
    - c. Restore riparian buffer
- VI. Other
    - a. Rehabilitation of Groins (Oakland Beach)
    - b. Dredging at Boat Ramp (Warwick Cove)

During the data collection and evaluation process, it was determined that the entire volume of Brush Neck Cove is exchanged during normal tides and therefore inlet dredging to restore tidal flushing and range would not produce any significant change in the flushing rate. Inlet dredging measures were eliminated from further consideration.

The planning process continued to evaluate the remaining measures including cove dredging to reduce nutrient recycling, improve water quality and provide suitable substrate for shellfish. If coarser material were present below the existing upper organic sediment layers, exposing this material by dredging could improve conditions within the estuary. However, sediment sampling and testing indicated that there was no defined sand or coarse substrate layer within sediment cores, down to 7.0 – 15.9 feet, and that the physical characteristics of historic deeper substrate are not substantially different than the upper newer layers. In addition, nutrient concentrations were relatively low in the upper layer and exposing deeper sediment would not likely result in a substantial decrease in nutrient release or less resuspension of sediment nor is it expected to lessen the biological oxygen demand. Cove dredging was therefore eliminated as a restoration measure.

The beach replenishment and salt marsh restoration/creation measures were also eliminated since they required the reuse of dredged material removed during the inlet or cove dredging. The restoration of shellfish and other benthos was also dependant on dredging, with removal of material to expose an existing suitable substrate layer. The remaining measures (V and VI) are either not in the Corps authority or do not provide significant ecosystem restoration benefits. Other Federal, State and local agencies can address water quality and specific local needs under different authorities and programs.

The planning constraints of the project required suitable sediment for reuse on site and exposure of desirable sediment beneath the existing upper layers. These constraints limited the measures available to formulate alternative plans. Given this, no alternative plans were formulated and no alternatives are recommended. The CRMC was informed of these data and agree that limited benefit is expected. The sponsor does not wish to continue with the project as planned.

The Corps is not recommending any of the restoration measures evaluated since these measures are not expected to substantially restore structure and function of Brush Neck and Buttonwoods Coves.

This findings of this negative report have not gone through the formal Corps of Engineers review/quality assurance process. Information, other than the general conclusion that further consideration under the Section 206, Aquatic Ecosystem Restoration Program is not warranted, should be considered preliminary.

Table of Contents

Appendices

List of Tables

List of Figures

1.0 Introduction

This chapter provides basic background for the study. It also lists the steps in the U.S. Army Corps of Engineers (Corps) planning process and relates them to the organization of this report.

1.1 Study Authority

Authority to perform this investigation was provided under Section 206 of the Water Resources Development Act of 1996 (PL 104-303) entitled “Aquatic Ecosystem Restoration,” which states in part,

> *“The Secretary [of the Army] may carry out an aquatic ecosystem restoration and protection project if the secretary determines that the project – will restore the quality of the environment and is in the public interest; and is cost-effective.”*

Implementation of any alternative plan or combination of alternatives is subject to the recommendation and approval of the Corps, as well as approval of the Federal budgets on which its program funding depends.

1.2 Study Area

The study area consists of two adjacent coves, Brush Neck Cove and Buttonwoods Cove, located in the City of Warwick, Rhode Island (Figure 1). The City of Warwick is located in Kent County, Rhode Island and is approximately 12 miles south of Providence. Warwick is the second largest city in the state. Brush Neck and Buttonwoods Coves are located in the West Bay area of Warwick and drain to Greenwich Bay. Brush Neck Cove is approximately a mile in length and has an area of approximately 83 acres. Buttonwoods Cove is approximately ½ mile in length and has an area of about 46 acres.

1.3 Study Purpose and Scope

The purpose of this investigation is to quantify ecosystem restoration benefits and associated costs for various alternatives to restore aquatic habitat in Brush Neck and Buttonwoods Coves in Warwick, Rhode Island. The study scope is to identify a cost effective restoration plan that achieves the study goals and objectives while considering the interests of the sponsor. While stormwater management is not a direct component of this study, as part of its overall efforts to restore the coves, the City of Warwick is actively working to improve conditions through a combination of water quality improvement projects within the watershed.

This study investigates the extent of degradation of water quality, finfish, shellfish and benthic habitat within the coves and considers measures to restore benthic habitat, fish and shellfish resources. The Corps and the Rhode Island Coastal Resources Management Council (CRMC) consulted with other agencies and organizations to identify appropriate restoration measures. The measures investigated include: methods to reduce sediment accumulation, dredging and redistributing sediment to restore tidal flushing and appropriate substrates for shellfish and salt marshes, dredging and isolating nutrient rich or contaminated sediments, and restoring buffer zones. The study considers the contribution of activities in the watershed to habitat degradation.

1.4 History of the Investigation

The CRMC, the non-Federal sponsor, and the Corps initiated the feasibility study in March 2005 after completing a preliminary restoration plan in July 2004. This report presents the results the feasibility study.

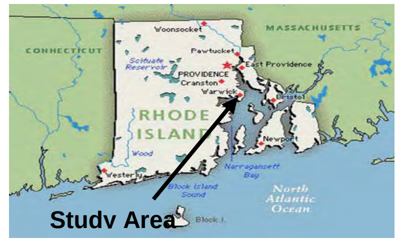


Figure 1. Site Location Map

1.5 Planning Process and Report Organization

The planning process consists of six major steps:

1. Specify water and related land resources problems and opportunities,
2. Inventory, forecast and analysis of water and related land resources conditions within the study area,
3. Formulate alternative plans,
4. Evaluate the effects of the alternative plans,
5. Compare the alternative plans, and
6. Select the recommended plan based upon the comparison of the alternative plans.

Sections of the report relate to the six steps of the planning process as follows:

- Section 2 – Project Need and Objectives, covers the first step in the planning process (Specification of water and related land resources problems and opportunities).
- Section 3 – Initial Screening of Restoration Measures, covers the beginning portion of the third, fifth and sixth steps in the planning process. The Corps did not formulate alternative plans, evaluate plans or compare plans since the restoration measures are not expected to produce significant restoration benefits.
- Section 4 - Affected Environment, covers the second step of the planning process (Inventory, forecast and analysis of water and related land resources in the study area).

2.0 Project Need and Objectives

This section presents the results of the first step of the planning process, the specification of water and related land resources problems and opportunities in the study area. The section concludes with the establishment of planning objectives and planning constraints, which is the basis for the formulation of restoration measures and alternative plans.

2.1 National Objectives

The national or Federal objective of ecosystem restoration projects is to contribute to National Ecosystem Restoration (NER). This objective is to contribute to the nation's ecosystems through ecosystem restoration, with contributions measured by changes in the amounts and quality of habitat.

2.2 Public Concerns

A number of public concerns were identified during the course of the study. Input was received through coordination with the sponsor, coordination with other agencies, public review of draft and interim products, and through public meetings. A discussion of public involvement is included in Section 5, Public Involvement, Review and Consultation.

Public concerns center around the degradation of habitat and water quality over time. Historically, Brush Neck and Buttonwoods Coves supported healthy estuarine habitats and recreationally harvested soft-shell clams (*Mya arenaria*) and quahogs (*Mercenaria mercenaria*). As recently as the 1960s, the coves had a relatively healthy and diverse benthic (bottom) community and fish habitat. Currently, these resources are limited and the fishery is closed. Excessive nutrients and pollutants accumulate in the coves causing eutrophication, algal blooms, high bacteria concentrations, and episodic low dissolved oxygen concentrations that result in fish kills.

The discharge of combined-sewer-overflows and other non-point sources within the Greenwich Bay watershed has contributed to low dissolved oxygen concentrations and catastrophic fish kills, the most recent occurring during the summer of 2003. Various state and local agencies are working together to improve the water quality of the Bay and restore the estuarine habitat of Greenwich Bay and its tributaries.

2.3 Problems and Opportunities

The evaluation of public concerns reflects a range of needs perceived by the public. This section describes these needs in the context of problems and opportunities that can be addressed through improving ecosystem structure and function. This section identifies watershed problems and opportunities related to its capacity to support aquatic fish and wildlife. Figure 2 identifies areas where problems exist in Brush Neck and Buttonwoods Coves.

Restoration opportunities are generated by comparing existing, historic and potential future conditions, or by identifying areas that are functioning below their capacity. The Brush Neck Cove Special Area Management Plan (Ernst et al., 1999; referred to in this document as the SAM Plan), prepared by the CRMC summarized problems and opportunities in Brush Neck Cove and its watershed. The information provided in the SAM Plan, supplemented by meetings of the project team and knowledgeable agencies and individuals, provide the basis for defining the problems and opportunities addressed in this feasibility study.

Figure 2. Problems within the Brush Neck and Buttonwoods Cove Watershed.

Many of the problems identified in the SAM Plan for the Brush Neck Cove are beyond the scope of the authority provided by the Section 206 Aquatic Ecosystem Restoration Authority. The SAM Plan outlines strategies for remedying these problems. One problem identified in the SAM Plan that is beyond the Corps Authority is the density of Individual Sewage Disposal Systems (ISDS). The local communities are addressing this problem. Improvements in water quality that result from the upgrade to sewers will take time to fully develop but they may also be offset by increased development in the watershed. The SAM Plan indicates that, even with sewering the watershed, nitrogen inputs will continue to increase due to increased use of lawn fertilizers as more of the watershed is developed. However, the potential for future improvements in water quality, with the conscious effort of landowners to control fertilizer use, provides an opportunity for the Brush Neck Cove system to support higher quality fish and wildlife habitats.

The purpose of this project is to restore historic tidal flushing, depth and benthic substrate while improving water quality and habitat in Brush Neck and Buttonwoods Coves. Restoring benthic productivity would add a forage base to the system and encourage the use of the area by numerous fish and wildlife species. Restoring salt marsh to this estuarine system would serve as additional habitat for many estuarine dependent species. These functions are diminished when marshes are cut off from tidal flooding and become dominated by *Phragmites*. The targeted effect of this restoration project is to restore previously existing ecological functions and habitat quality to the estuarine system of the coves.

2.3.1 Problems

Degraded Water Quality Contributing to Aquatic Habitat Degradation

The SAM Plan indicates that there are two primary water pollutants of concern in Brush Neck and Buttonwoods Coves: coliform bacteria and nitrogen. The major sources of these pollutants are septic systems and commercial and residential fertilizer application. Internal recycling from sediment can also increase nutrient concentrations in overlying waters. The high coliform concentrations led to the permanent closure of both coves to shellfishing. High nitrogen concentrations lead to eutrophication. Eutrophication is a process whereby water bodies, such as lakes or estuaries receive excess nutrients that stimulate excessive plant growth (e.g. algae or nuisance plants), reducing dissolved oxygen when dead plant material decomposes. Eutrophication can lead to fish kills, shifts in plankton and benthic invertebrate communities, and loss of eelgrass. Elevated nutrient concentrations are believed to adversely affect eelgrass plants by stimulating algal competitors, which limit light transmission.

Most water quality problems can and should be addressed at the source, however, in some cases, water quality problems can be exacerbated by poor flushing. Water quality improvements may be attained by improving flushing.

Potential restoration/remedial measures:

- Remove high nutrient/organic material sediments using thin layer dredging to reduce nutrient flux to the overlying waters.
- Isolate high nutrient/organic material sediments by consolidating them in wetland restoration sites or capping to reduce nutrient flux to the overlying waters.
- Use Best Management Practices (BMPs) to collect nutrients and sediment from runoff and storm drains before they enter the estuary.
- Remove existing shoals near the mouth of the river to improve flushing.
- Restore riparian buffer zones to intercept nutrients before they enter the estuary.

Shoaling, Sediment Loading and Resuspension

Shoaling in the lower portion of the coves and high nutrient concentrations may contribute to a decline in bottom habitat quality for benthic organisms such as shellfish. Excessive sedimentation and resuspension of sediment are also detrimental to eelgrass beds and other benthic life. Excessive sediment accumulation can bury organisms and change the physical and chemical characteristics of benthic substrate. Continual resuspension of sediments can decrease light penetration degrading conditions for plant growth. Eelgrass beds and other submerged aquatic vegetation provide valuable spawning, nursery, cover, and foraging habitat for aquatic and semi-aquatic animals. For the last few decades, submerged aquatic vegetation has disappeared from Brush Neck and Buttonwoods Coves.

Potential restoration/remedial measures:

- Stabilize eroding salt marshes using biological engineering techniques to reduce sediment erosion and suspension.
- Stabilize eroding riparian areas using biological engineering techniques to reduce sediment erosion and suspension.
- Use Best Management Practices (BMPs) to collect sediment from runoff and storm drains before it can be deposited in eelgrass habitats.
- Plant or seed eelgrass.

Loss of Shellfish Spawning Habitats

Brush Neck and Buttonwoods Coves supported ecologically and commercially important species such as quahogs, mussels, razor clams, soft-shelled clams, oysters, and (historically) scallops. Restoration of shellfish and related habitats in the estuary along with improvements in water quality could contribute to the reestablishment of the State of Rhode Island Shellfish Management Area designation.

Potential restoration/remedial measures:

- Remove organic mud from the surface of coarser sediments to restore substrates that will support shellfish populations.
- Restore water quality to levels sufficient to support high quality shellfish and benthic communities.

Loss of Aesthetic Value

Degradation of habitats and water quality in Brush Neck and Buttonwoods Coves reduce their aesthetic values.

Potential restoration/remedial measures:

- Improve water quality.
- Restore buffer zones and riparian habitats.

2.3.2 Opportunities

Restoration of Waterfowl Habitats

The Brush Neck and Buttonwoods Coves are the Focus Area under the Atlantic Coast Joint Venture of the international North American Waterfowl Management Plan (NAWMP). Restoration of eelgrass beds, salt marsh, shellfish and benthic habitats in Brush Neck Cove under the Section 206 project could contribute to the restoration of important waterfowl populations, including migrating and wintering black ducks. Black ducks are themselves the focus of the Black Duck Joint Venture under the NAWMP, attesting to their National significance based on scientific considerations.

Potential restoration measures:

- Restore salt marshes by reducing erosion, restoring tidal elevations, and tidal flushing.
- Restore benthic, fishery, and wetland habitats to improve feeding opportunities for waterfowl.

Restoration of Salt Marsh Habitats

The creation of additional salt marsh habitat in Brush Neck Cove will improve the above described water quality problems:

- Salt marsh vegetation would remove nutrients, nitrogen and phosphate, from all inflows, reducing nutrient loads.
- Selective dredging would provide substrate for the planting of additional salt marsh in Brush Neck Cove.
- Salt marsh creation in conjunction with the conversion from ISDS to municipal sewage treatment in the watershed would improve water quality by reducing the fecal coliform levels in Brush Neck and Buttonwoods Coves.

2.4 Planning Objectives

The water and related land resource problems and opportunities identified in this study are restated as specific planning objectives to provide focus for the formulation of alternatives. These planning objectives reflect the problems and opportunities and represent desired positive changes while incorporating opportunities presented. The planning objectives are specified as follows:

- Remove or reduce impacts from high nutrient/organic material sediments within the estuary
- Reduce the impact from stormwater runoff containing nutrients and sediment to the estuary
- Improve flushing and restore tidal range within the estuary
- Stabilize salt marshes and riparian areas to reduce erosion, sediment loading and suspension
- Restore buffer zones and riparian habitats.
- Restore and create native plant salt marsh habitats
- Restore substrates that will support shellfish populations
- Improve water quality to levels sufficient to support high quality shellfish and benthic communities.

2.5 Planning Constraints

Unlike planning objectives that represent desired positive changes, planning constraints represent restrictions that may prevent the achievement of the objectives. The planning constraints identified in this study are as follows:

- Suitable substrate must be available beneath the upper undesirable organic layer of cove sediment
- Cove sediments must be suitable for reuse on site on beaches or for creation of salt marsh or benthic habitat
- The alternatives must not cause flooding or increase erosion on existing salt marsh habitat, beaches, residential areas or other shoreline properties

3.0 Initial Screening of Restoration Measures

This section describes the development and evaluation of restoration measures to address the planning objectives. It also describes the studies and data used to conclude that substantial ecosystem restoration benefits are not expected from the measures evaluated.

3.1 Plan Formulation Rationale

A wide variety of management measures were developed that would address one or more of the planning objectives. These measures were then evaluated and then screened. Alternative plans are typically developed by combining one or more of the management measures and compared. However, alternative plans were not formulated in this case since substantial ecosystem benefits are not anticipated from the measures evaluated.

3.2 Management Measures

A management measure is a feature or activity at a site, which addresses one or more of the planning objectives. A wide variety of measures were considered. Each measure was assessed and a determination made regarding whether it should be retained in the formulation of alternative plans. The descriptions and results of the evaluations of the measures considered in this study are presented below:

- I. Inlet Channel Dredging
    - i. Width – 75 feet
    - ii. Lengths – 1,000, 4,000, 6,000 feet
    - iii. Depths – 4, 5, 6-foot
- II. Cove Dredging
    - a. Brush Neck Cove
        - i. Widths – 100, 200, 300 feet
        - ii. Lengths – 2,0000, 2,500, 3,000 feet
        - iii. Depths – 4, 5, 6-foot
    - b. Buttonwoods Cove
        - i. Widths – 100, 200, 300 feet
        - ii. Lengths – 250, 500, 750 feet
        - iii. Depths – 3, 4, 5-foot
- III. Beach Replenishment (dependant on I. or II. above)
    - a. Oakland Beach (Corps project)
    - b. City Park Beach (City-owned)
- IV. Habitat Restoration (dependant on I. or II. above)
    - a. Restoring Benthic/Shellfish Substrate (Brush Neck Cove)
    - b. Restoring Benthic/Shellfish Substrate (Buttonwood Cove)
    - c. Salt Marsh creation/restoration/stabilization (City Park)
    - d. Salt Marsh creation/restoration/stabilization (east of Sea View Drive)
    - e. Invasive Species Removal (*Phragmites*)
- V. Water Quality
    - a. Sedimentation Trap Structures
    - b. Natural Wetland Filtration Systems
    - c. Restore riparian buffer
- VI. Other
    - a. Rehabilitation of Groins (Oakland Beach)
    - b. Dredging at Boat Ramp (Warwick Cove)

Restoration measures are combined to develop restoration alternative plans. Alternative plans are formulated to achieve planning objectives within the defined constraints and capitalize on identified opportunities. An alternative plan consists of a system of structural and/or nonstructural measures, strategies, or programs formulated to meet, fully or partially, the identified study planning objectives subject to the planning constraints. The alternative plan formulation is an ongoing process, as new data and ideas emerge, plans are added, modified or removed from further consideration. Alternative plans are not limited to those the Corps could implement directly under current authorities.

The Corps collected and evaluated data to determine if the measures proposed, singly or combined, would provide substantial ecosystem benefits. Based on these data, the Corps concluded that the proposed measures (identified above) would not provide substantial benefit. Therefore alternative plans were not formulated. The section below describes the rationale used to draw this conclusion.

3.2.1 Inlet Dredging for Improving Tidal Range and Flushing

One of the perceived problems in the Brush Neck/Buttonwoods Cove system was poor tidal flushing, loss of tidal range and water depth resulting in reduced water quality and bottom habitat. Shoaling in the inlet was thought to restrict incoming tide water. Excessive sedimentation was believed to result in reduced cove water depth.

To quantify changes in bathymetry over time and to determine the tidal flushing, two study efforts were undertaken. The first was mapping the system bathymetry and inlet shoreline. This evaluation provided direct information pertaining to the sedimentation of the system and changes to the inlet. The bathymetric change study was completed using a 1975 Corps survey of Brush Neck Cove and survey data from 2005/2006. The digital terrain model maps for each survey are provided in Figures 3 & 4 with side by side comparisons. Elevation data from the 1975 survey were subtracted from the 2005/2006 survey to yield the change over time. A map was generated using these data and is presented in Figure 5. Areas shown in yellow and red indicate bottom elevation has risen since 1978 (accretion), areas in light blue and green remained similar (within a few tenths of a foot), and areas in darker blue and purple indicate a reduction in bottom elevation (erosion). These data show that most of the changes in the Brush Neck Cove bathymetry are small with the most significant change being slight channel migration. Overall the changes are on the order of tenths of a foot (both erosion and accretion). The inlet did not shoal significantly in this time period and only minor accretion is evident from 1975 to 2005/2006.

Other data support this conclusion. Accretion rates for the Greenwich Bay are low and suggest very little accumulation of sediment within the Bay. The rate of accretion for the Greenwich Bay area is 0.55 cm/yr in marsh sediments and 0.23 cm/yr in subtidal areas (Bricker 1996). Assuming the same rate for Brush Neck/Buttonwoods Coves, the average of these two values (0.39 cm/yr or 0.013 ft/yr) suggests that it would take over 75 years to accumulate one foot of sediment.

As an additional evaluation on shoaling of the inlet, aerial photographs from 1939 and 2007 were compared (Figure 6). The shoreline from these photos was coarsely mapped and should not be used for other uses outside this study. The shoreline mapping data suggests that the inlet has widened with time. Although the inlet has widened since 1939 it has also become shallower and thus supports claims that the inlet was historically deeper and narrower. However, the combination of these changes has not likely changed the overall volume of water allowed to pass through the inlet; although the inlet is shallower, the inlet encompasses a larger area. The findings of this mapping effort show that significant bathymetric changes have not occurred in the system, and that the minor changes were likely not enough to impact tidal flushing.

Tidal flushing within the study area was evaluated using a tidal survey conducted on August 25, 2006. Tide elevations were measured at three locations in the Brush Neck Cove/Buttonwoods Cove system. The locations are provided in Figure 7.

Tide elevation data were manually recorded approximately every 15 minutes. These data are plotted in Figure 8, with the predicted tide data for East Greenwich, RI provided on the plot as well. These data show that there is no reduction in tide range from Narragansett Bay into the Cove system. All three measurement points are almost identical with regards to tide range and phase (no lag between high and low tides). This tide elevation survey further demonstrates that there is no tidal restriction in the system, and that the Cove system experiences 100% of the possible tidal flushing possible.

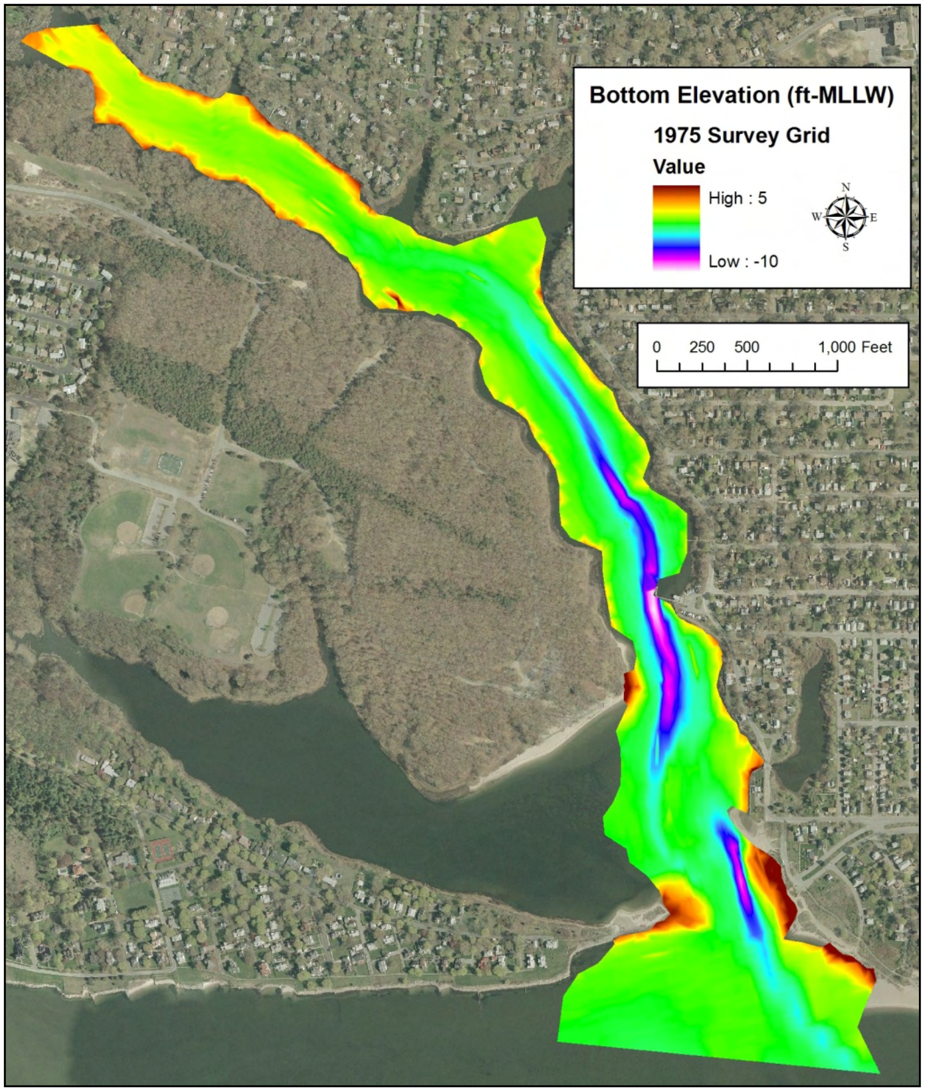


Figure 3. 1975 Survey Digital Terrain Model.

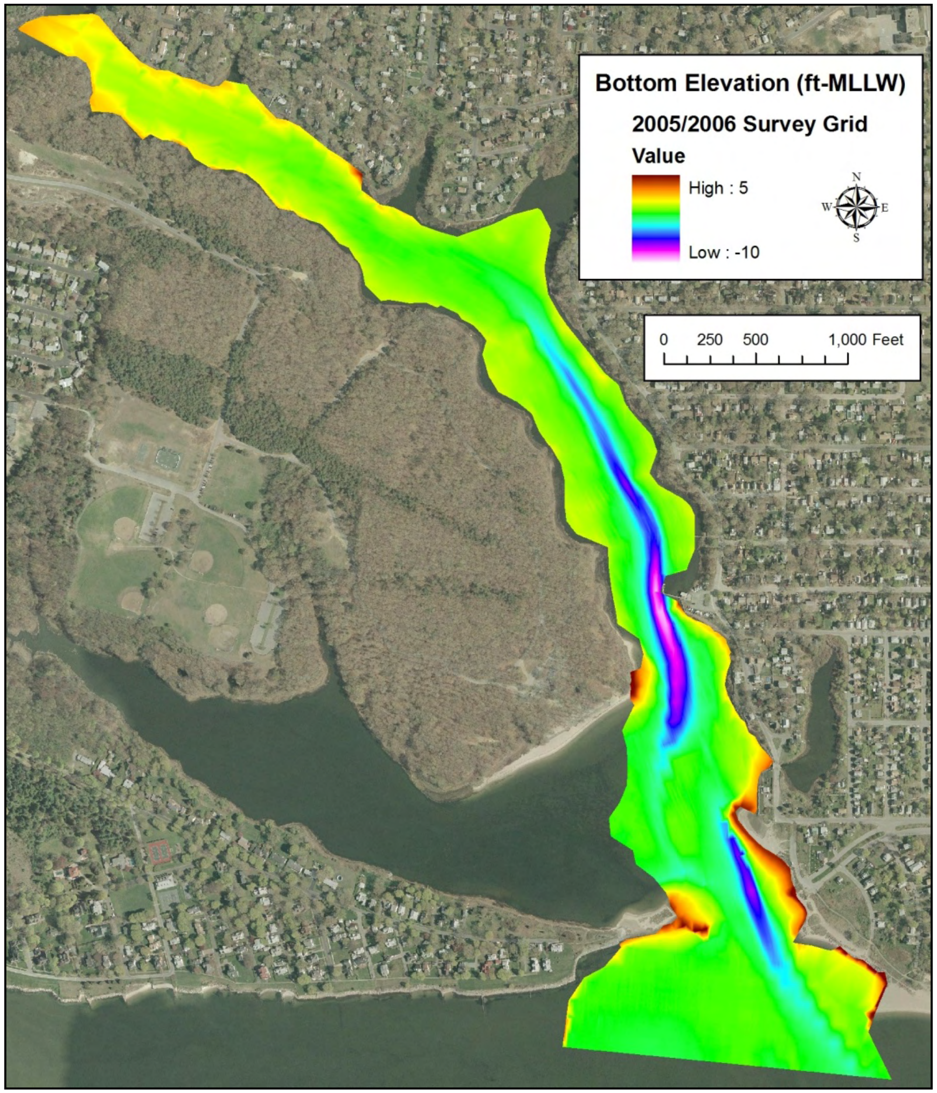


Figure 4. 2005/2006 Survey Digital Terrain Model.

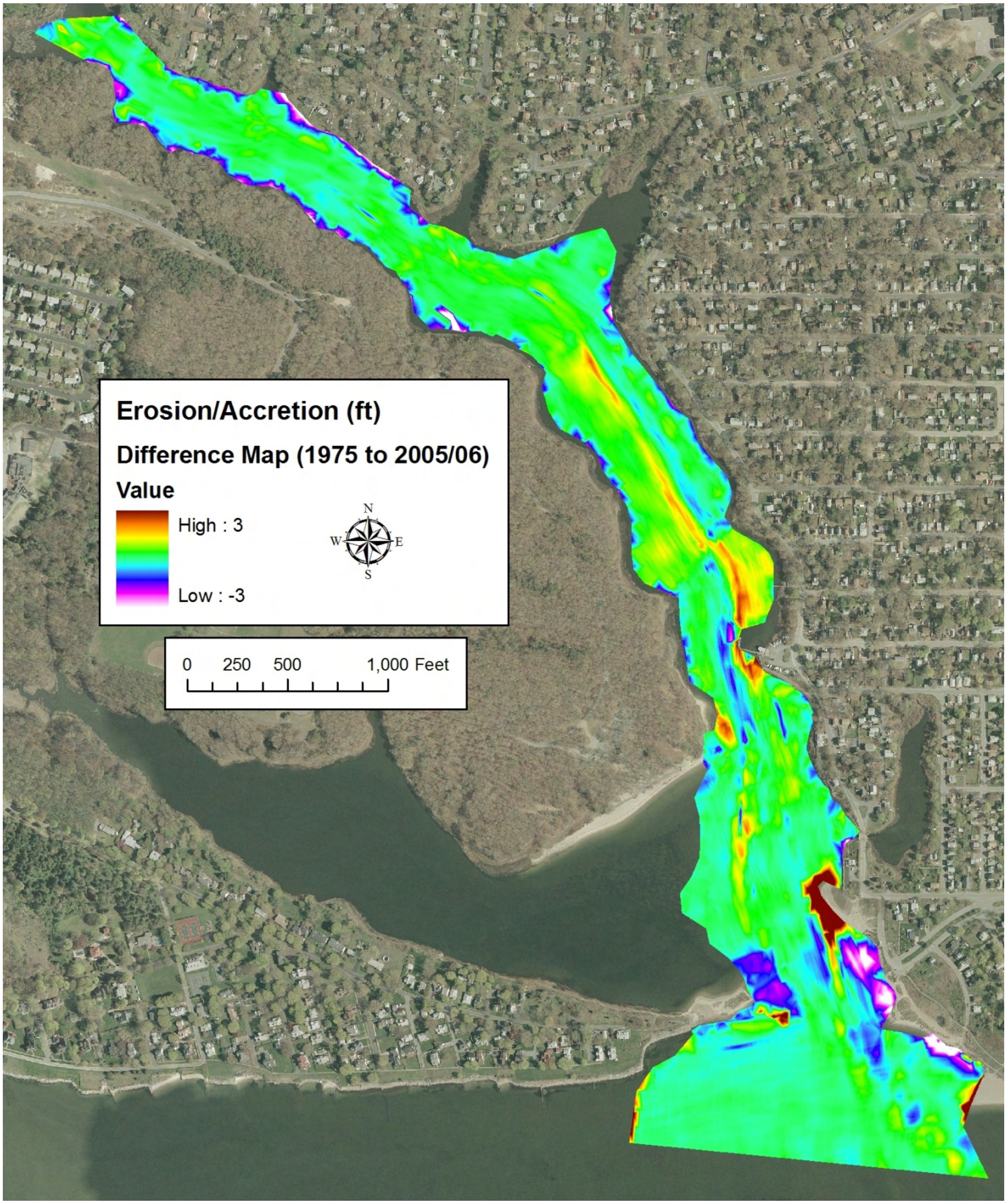


Figure 5. Difference Map of 1975 and 2005/2006 Surveys (difference of Figures 3 & 4)

Figure 6. Inlet Comparison, 1939 versus 2007

Figure 7. Tide Survey Data Collection Locations

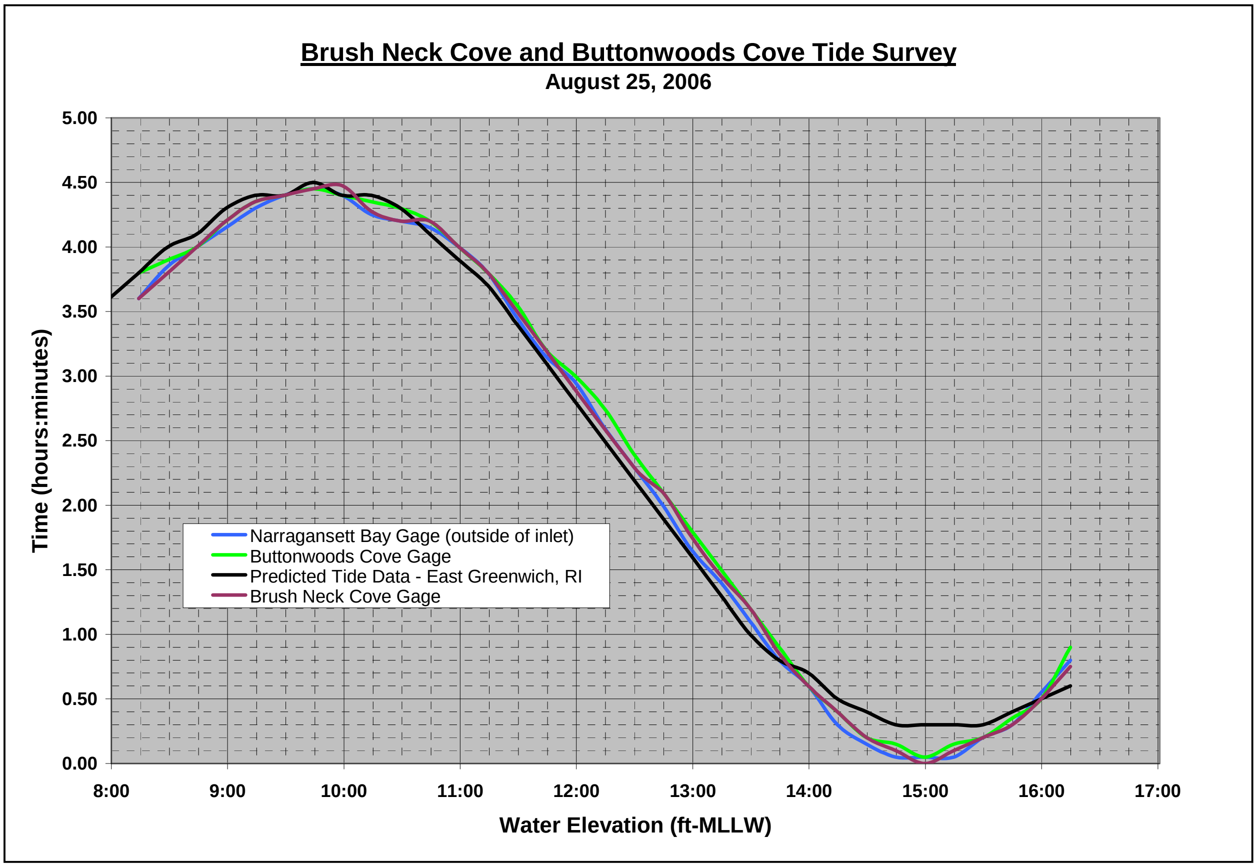


Figure 8. Tide Survey Data Plot

The results of the mapping and the tidal elevation investigations indicate that the existing shoaling condition at the entrance does not restrict the tidal exchange within the coves. These data suggest that dredging the inlet for the single purpose of increasing cove flushing would not provide significant ecosystem restoration benefit. After consultation with the design team and the sponsor, the study efforts were redirected to improve habitat and water quality by removing accumulated sediment/organic material within the coves.

3.2.2 Cove Dredging

Three surveys were conducted (2006, 2007 and 2009) within the Brush Neck and Buttonwoods Cove estuaries to characterize the material for disposal, identify the optimal dredge depth to expose coarse substrate and provide the justification of sediment removal for improved water quality. The surveys are summarized below with results of each study presented by sediment characteristic.

- 2006 Survey - The Corps collected sediment samples from 22 stations in Brush Neck Cove, Buttonwoods Cove and a portion of Greenwich Bay in 2006 to assess grain size (Figure 9). The 22 stations were sampled with a 2-inch diameter push-core sampler to a depth of approximately 1.5 feet. The grain size distribution graphs are presented in Appendix A.

- 2007 Survey – Battelle collected a total of 11 sediment cores within Brush Neck and Buttonwoods Coves in 2007 to characterize the physical and chemical nature of the sediment for disposal. Penetration into the sediment for each of the sampling locations was 10.0 feet and core recovery ranged from 7.0 to 9.3 ft with an average of 8.4 ft. Results of the physical and chemical analysis are provided in Appendix A of this report. Physical features included grain size analysis and visual observation of cores. Identification of coarse substrate within the cores would serve as an indicator of the historic elevation of the cove and would provide the optimal dredge depth to

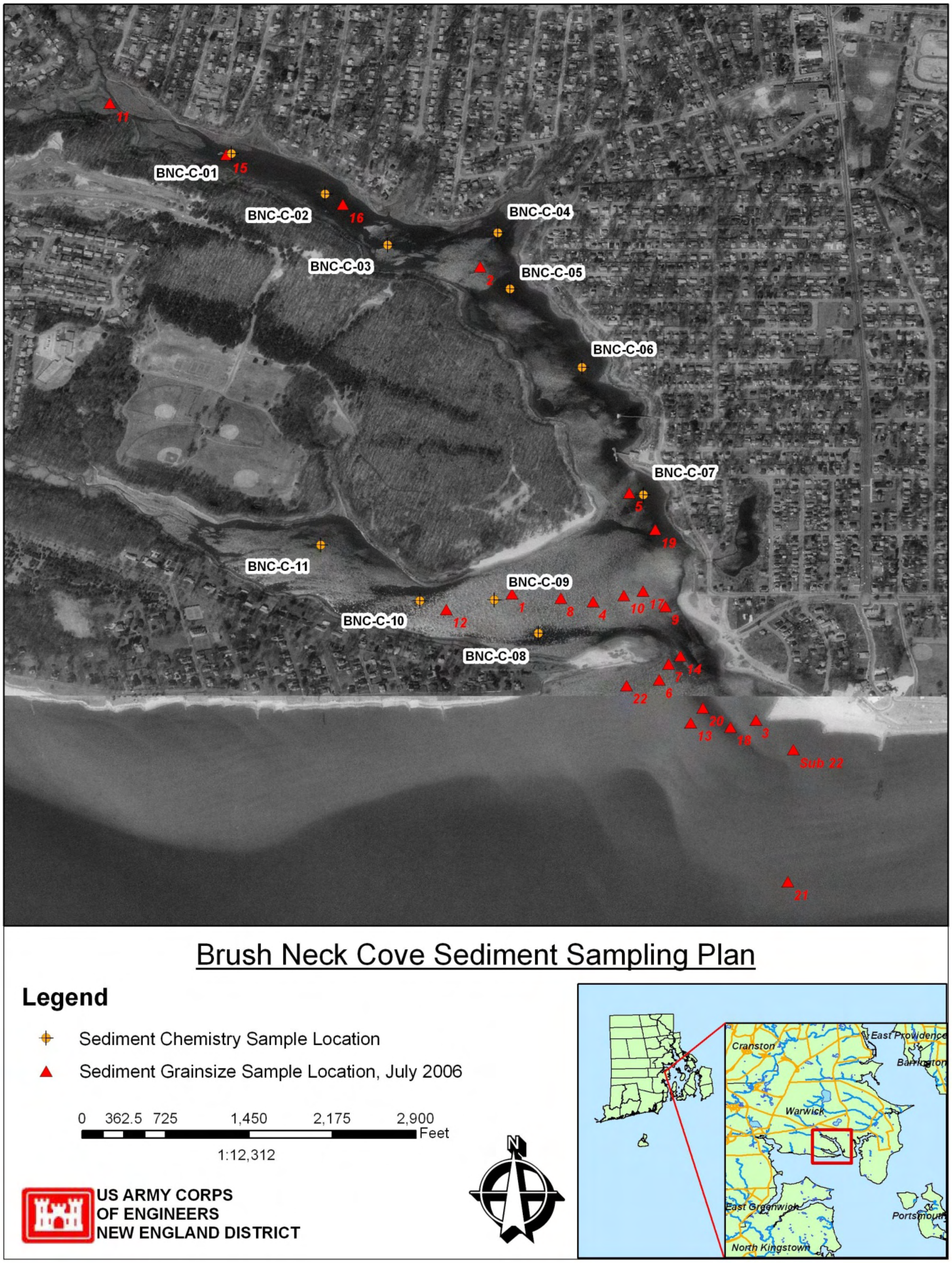


Figure 9. Sediment Sample Locations in Brush Neck Cove and Buttonwoods Cove

expose desirable shellfish and benthic substrate. Chemical data were used to determine the possible reuse of the material for salt marsh creation and beach replenishment. Chemical analysis included total organic carbon (TOC), percent water, percent solids, polychlorinated biphenyl congeners (PCBs), pesticides, metals and polynuclear aromatic hydrocarbons (PAHs).

- 2009 Survey - Scientists collected cores at four locations within Brush Neck Cove to determine if dredging would result in water quality improvement within the coves. All four cores were described and photographed by a trained sedimentologist. Maximum recovery of these cores was 15.9 ft. The top layer (approximately one foot) of three cores was analyzed for TOC, grain size, and nutrients (total phosphorus, ammonium, nitrate and total Kjeldahl nitrogen). The fourth core was not analyzed by the analytical lab because the core recovery was well short of the penetration depth.

Sediment Physical Characteristics
In general, the sediments at the inlet of the project area were dominated by sands while the sediments in upper sections of Brush Neck and Buttonwoods Cove were dominated by silts and clays. There was no obvious substrate layering present in the cores that would be useful to suggest a proposed dredge depth. Only one sample had a noticeable transition zone, BCN-C-09 located near the confluence of Brush Neck and Buttonwoods Coves, from fine sand to coarse sand with some fine gravel and a distinct horizon from 1.8 to 2.5 ft. Laboratory grain size analysis of the 2007 samples confirmed the general description of the cores, with silts and clays comprising the greatest percent (56-89%), except at BCN-C-09 where fine sand comprised much of the core (68%). All cores contained silt and clay percentages above the Rhode Island Rules and Regulations for Dredging and the Management of Dredged Material criteria for beach nourishment (silt/clay criteria is <10%). Most cores contained shell hash at depths varying from 0 to 2.5'. All cores had penetration to ten feet with a recovery of at least seven feet. These data are consistent with the previous sampling in 2006.

Sediment Chemical Characteristics
Total organic carbon (TOC) percentages were low to moderate throughout Brush Neck and Buttonwoods coves. Average values (average of two results per sample) ranged from <0.1% to 2.8%. TOC generally increased with increased distance from Greenwich Bay. Samples with lower silt and clay generally had lower TOC. BCN-C-09 contained the lowest TOC and silt and clay percentages. This location was also the only core that did not emit a distinct sulfur odor. Hyland et al. (2005) suggests that the risk of reduced benthic species diversity is low at TOC concentrations less than 1% and high at 3.5%. These data suggest that TOC concentrations in Brush Neck and Buttonwood Coves are low to moderate and are not at a high risk for species diversity reduction.

Sediment within the coves contain low levels of polychlorinated biphenyl congeners (PCBs), pesticides and metals. Concentrations of PCBs ranged from 3 to 20 ug/g (ppb) and concentration of pesticide were at or below the detection limit of 1 ng/g (ppb). Target metals were detected in all samples and concentrations were relatively similar across samples. Concentrations were below the Rhode Island Rules and Regulations for Dredging and the Management of Dredged Material criteria for beach nourishment.

Polynuclear aromatic hydrocarbons (PAHs) were detected in all samples. Total PAHs ranged from 51 to 638 ng/g (ppb) with the highest concentrations observed at the upstream portion of Brush Neck Cove (BNC-C-01 and BNC-C-02). The highest PAHs were generally fluoranthene and pyrene, and other high molecular weight PAHs. This pattern suggests pyrogenic PAH sources indicative of combusted petroleum products and is similar to what is often observed in urban run-off and would not be applicable for beach nourishment.

Inorganic nitrogen (ammonia and nitrate) concentrations were typical of estuarine environments. Ammonia ranged from 21-81 mg/kg, which is slightly elevated but not uncharacteristic under low to no oxygen conditions. Only one sample contained nitrate nitrogen above the detection limit (2.5 mg/kg;

detection limits ranged from 2.0 to 2.6 mg/kg). Total Kjeldahl nitrogen (TKN) ranged from 1,800 to 2,500 mg/kg, including the duplicate sample. TP ranged from 440 to 580 mg/kg.

Finer materials such as clay and silts generally contain higher concentrations of nutrients and organics and increase the potential for flux from sediment. However, the proportion of the overall nutrient load to these coves from the sediments is not expected to be large given that they flush relatively quickly; the mean residence time for Brush Neck and Buttonwoods Coves is 0.9 days (approximately 22 hours; CRMC 2005). Any benefits from dredging the sediments to reduce internal recycling would be short lived given the high nutrient loading from the watershed.

Although material dredged from these coves could be reused onsite for salt marsh creation, there is no desirable coarse substrate within the core depth that could be exposed by dredging (average core depth 8.4 ft, maximum 15.9 ft). In addition, dredging will not improve nutrient loading, biological oxygen demand or resuspension of sediment since there is no coarse, less nutrient rich layer to expose.

3.2.3 Salt Marsh Restoration

Creation of salt marsh, if large enough, could reduce nitrogen concentrations within the estuary. The Corps considered creating a five-acre (2 hectare) salt marsh in the project area using material provided from dredging the inlet or coves. We estimated the expected nutrient removal capacity of the created marsh in terms of dissolved inorganic nitrogen (DIN) using gain and loss rates in scientific literature (Estuarine Nitrogen Loading Model from Valiela et al., 2004). Based on the expected DIN losses (nitrogen burial and denitrification) and gains (nitrogen fixation and regeneration), the created salt marsh area is likely to reduce annual DIN loading by approximately 42 kg/ha/yr. Multiple loading methods estimate the overall annual DIN loading to Brush Neck Cove at around 9,000 to 15,000 kg/yr (See Affected Environment). In order to reduce this load by as little as 5% (450-750 DIN kg/yr) approximately 11 to 18 ha, or 26 to 44 acres, of salt marsh is required. Creation of five acres of salt marsh would not have measurable impact on nitrogen concentrations.

As previously stated, creation of new marsh would incorporate dredged material from Brush Neck Cove. Sediment core analysis indicates that, with the exception of a few cores taken adjacent to the south end of City Park and Oakland beach that have more sand, most of the sediment is homogeneous with the low levels of PAH contamination and could be used for salt marsh creation. However, increasing existing salt marsh habitat by only two hectares is expected to decrease DIN loading by <0.1% of the existing load (or 84 kg/yr). Although significant reduction in nitrogen is not expected, creation of salt marsh will reduce turbidity directly by the facilitation of sedimentation and potentially improve conditions for eelgrass and juvenile fish habitat, but these benefits alone do not justify dredging.

3.3 Conclusion from Preliminary Screening

The Corps, together with CRMC, concluded that dredging would not provide significant ecosystem benefits in Brush Neck and Buttonwoods Coves. Before conducting the detailed tidal study, inlet dredging was expected to increase tidal flushing and tidal range which would improve water quality, reduce invasive species colonization (*Phragmites* and *Ulva*) and help restore, create and stabilize salt marsh habitat. Once the tidal survey data were analyzed, the Corps concluded that inlet dredging would not provide significant changes to the tidal range or flushing of Brush Neck Cove. The Corps also concluded that dredging of the coves would not provide substantial benthic substrate or water quality benefits based on core analysis.

The proposed beach replenishment and salt marsh restoration/creation measures require the reuse of dredged material removed during the inlet or cove dredging. The restoration of shellfish and other benthos was also dependant on dredging, with removal of material to expose an existing suitable substrate layer. We therefore eliminated the beach replenishment and habitat restoration measures from the alternative plan formulation. The remaining measures evaluated without the aforementioned dredging measures, are either not in the Corps authority or do not provide significant NER benefits. Other Federal, State and local agencies can address these water quality measures under different authorities and programs.

The planning constraints of the project required suitable sediment for reuse on site and exposure of desirable sediment beneath the existing upper layers. These constraints limit the measures available to formulate alternative plans. Given this, no alternative plans were formulated and no alternatives are recommended.

4.0 Affected Environment

This section contains a baseline description of environmental resources of the study area. Information was obtained from sampling, previous studies, and discussions with resource agencies, State and local officials, and stakeholders. The major characteristics of the study area's natural and human resources are provided to promote a general understanding of the area.

4.1 Environmental Setting of the Study Area

Brush Neck and Buttonwoods Coves are located in the City of Warwick, Rhode Island (Figure 1). The City of Warwick is located in Kent County, Rhode Island and is approximately 12 miles south of Providence. Brush Neck and Buttonwoods Coves are part of the Greenwich Bay watershed (Figure 10) and are located in the northern portion of the Bay. Brush Neck Cove is approximately a mile in length and has an area of approximately 86 acres. Buttonwoods Cove is approximately ½ mile in length and has an area of about 54 acres. Both coves are shallow (mean and maximum depth 1.6 and 7.9 ft respectively; CRMC 2005). Oakland Beach is located on the eastern shore of Brush Neck Cove.

The Brush Neck and Buttonwoods Coves watershed is approximately three square miles and is primarily medium to high density residential (61%) (RIDEM 2005). Brush Neck Cove receives water from two main tributaries, Tusctucket Brook and Southern Creek, also known as Carpenter Brook. The TF Green Airport drainage area is partially within the Brush Neck Cove watershed. The major tributary to Buttonwoods Cove is an unnamed tributary.

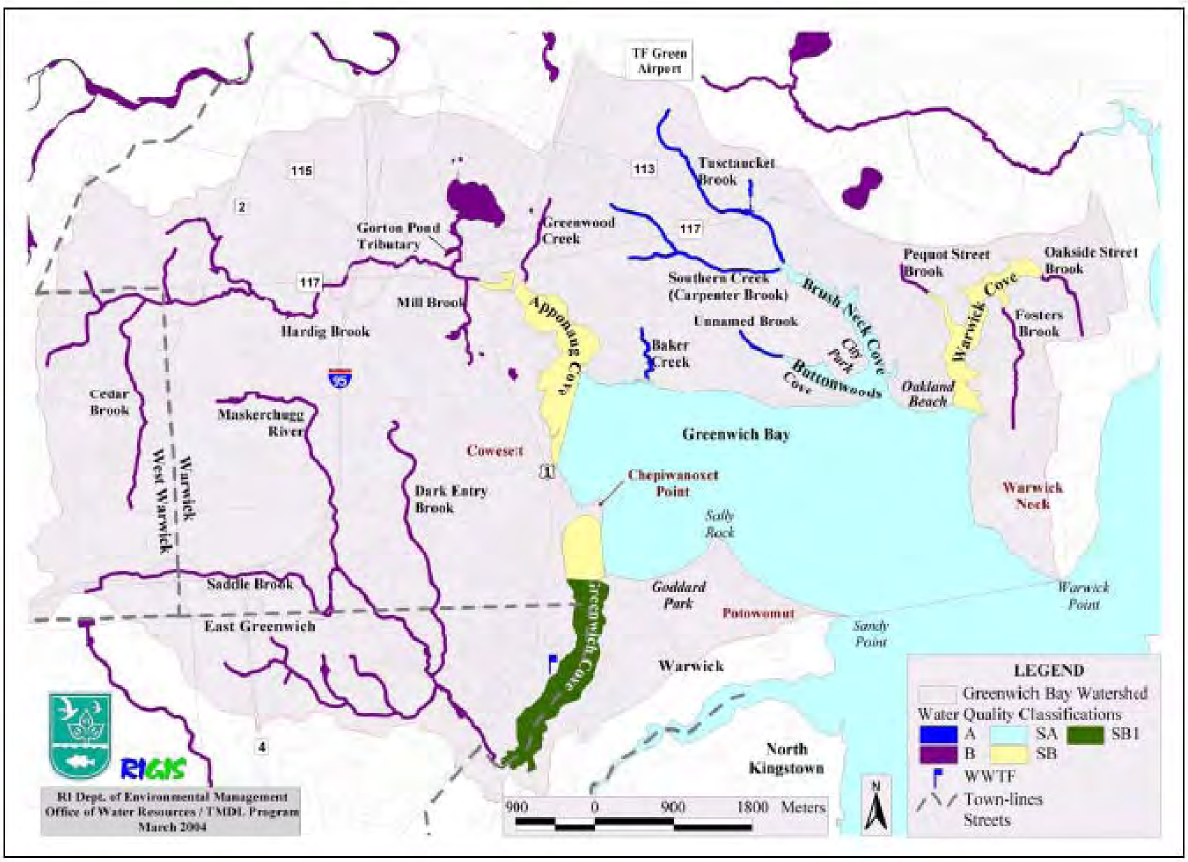


Figure 10. Greenwich Bay Watershed (from RIDEM 2005).

4.2 Water Quality

Review of the existing water quality data for the coves is complicated by three factors:

1. There are limited water quality data specifically for Brush Neck Cove.
2. Most of the water quality data was collected when about 30% of the heavily populated watershed surrounding Brush Neck Cove had Individual Sewage Disposal Systems (ISDS). A recent communication (conversation with Ms Lynn Owen from the Warwick Sewer Department) indicates that in excess of 90% of the watershed surrounding Brush Neck Cove is now connected to municipal sewers and there are no recent data to reflect this change.
3. A significant portion of the nutrient data and nutrient budgets were calculated for Greenwich Bay, of which the coves comprises only about 2% of the surface area and 0.05% of the volume (Greenwich Bay Special Area Management Plan, CRMC 2005)

Brush Neck Cove and its two major inflows, Tuscatucket Brook and Southern Creek are in violation of Environmental Protection Agency (EPA) and the State of Rhode Island Water Quality Standards (WQS). Brush Neck Cove, Greenwich Bay proper and Buttonwoods Cove are assigned the Water Quality Classification SA. Class SA is a designation for seawaters "…that produce shellfish for direct human consumption, are able to be used for primary and secondary recreation, fish and wildlife habitat and have good aesthetic value." Brush Neck Cove is often in violation of these standards with regard to pathogens, nutrients and dissolved oxygen concentration (CRMC 2005).

Sources of nutrients, suspended sediments and other contaminants to the coves are:

1. Dry weather freshwater surface flow from stream (Tuscatucket Brook and Southern Creek and other unnamed inflows),
2. Wet weather flow from storm drains, surface runoff and small unnamed streams,
3. Tidal input from Greenwich Bay and Narragansett Bay, and
4. Groundwater inflow.

4.2.1 Bacteria

In response to consistent elevated pathogen indicators (fecal coliform bacteria), the Rhode Island Department of Environmental Management (RI DEM) developed a Total Maximum Data Load (TMDL) for Greenwich Bay. The TMDL documents the WQS exceedences for 16 distinct waters and includes Brush Neck Cove, Buttonwoods Cove, Southern Creek (Carpenter Brook) and Tuscatucket Brook. The report provides recommended implementation activities focusing on stormwater and wastewater management to bring these waters into compliance. One of the largest sources of bacteria to Greenwich Bay is Brush Neck Cove.

Beach and shellfish closures are common within in the bay, particularly following wet weather. Because of the consistent high levels of fecal coliform, the shellfish beds in Brush Neck and Buttonwoods Coves are permanently closed. Bacteria values exceed the shellfish WQS even under dry weather conditions. Table 1 below summarizes fecal coliform data collected from shellfish sampling locations to evaluate compliance with WQS.

Bacteria concentrations were also assessed at Oakland and City Park Beaches. Samples collected by the Rhode Island Department of Health at Oakland Beach during 2000 and 2001 were evaluated as part of the TMDL. The Department of Health sampled these beaches three times per week. Results are summarized in Table 2. Although these data appear to comply with the beach Department of Health standards, multiple closures did occur. Data presented in the table below are a seasonal summary and closure is based on individual samplings. In 2000 and 2001 there were 10 and 12 days of closure at Oakland Beach and 0 and 19 closures at City Park Beach.

Table 1. Dry (October 2000 – December 2001) and Wet Weather (2001 and 2002) Shellfish Fecal Coliform Data Summary (modified from RIDEM 2005).

Station	Location	Number Samples		Geometric Mean (fc/100 ml) Observed			90th Percentile (fc/100 ml) Observed		
		Dry	Wet	Target	Dry	Wet	Target	Dry	Wet
25	Buttonwoods Cove	15	5	14	8	**116**	49	**93**	**354**
26	Brush Neck Cove	15	6	14	14	**228**	49	**73**	**8758**

Bold values exceed WQS

Table 2. Oakland and City Park Beach 2000-2001 Fecal Coliform Data Summary (modified from RIDEM 2005).

Station	Location	Number of Samples		Geometric Mean (fc/100 ml) Observed			90th Percentile (fc/100 ml) Observed		
		Dry	Wet	Target	Dry	Wet	Target	Dry	Wet
East	Oakland Beach	33	23	50	34	44	500	460	240
Middle		23	19		34	42		232	440
West		33	20		17	31		262	155
	City Park Beach	35	22	50	28	29	500	444	240

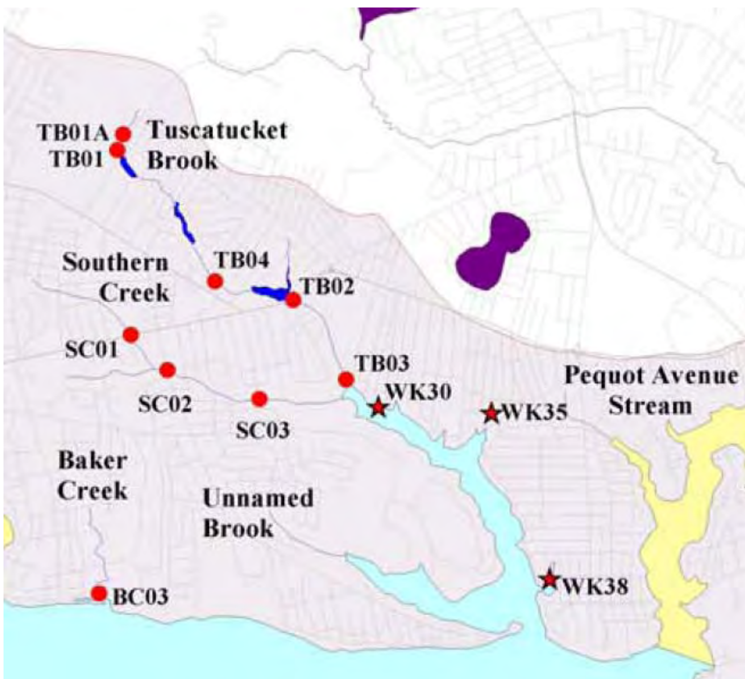
The Middle station was only sampled in 2000.

Extensive sampling of Greenwich Bay tributaries was conducted to characterize conditions of incoming water by State RIDEM. For Brush Neck Cove tributaries, Tuscatucket Brook and Southern Creek were sampled. Southern Creek contained the highest fecal coliform load in the study assessing Greenwich Bay's Northern Watershed conducted by researchers from the University of Rhode Island's Department of Civil and Environmental Engineering (Wright and Viator 1999). Prior to this study the DEM conducted surveys on these streams and demonstrated impacts from failing septic systems, including a 126-unit condominium complex. O'Rourke (1995) documented that 16% of the 598 septic system inspections within the Brush Neck Cove watershed were in violation.

The recent connections to municipal sewers should improve fecal coliform levels in Brush Neck Cove. Data from 1994, 1995, and 2000 did not show elevated dry weather concentrations in Southern Creek. Data summarized and used in the TMDL assessment for Southern Creek and Tuscatucket Brook is provided in Table 3. Figure 11. shows the sampling location within each of these tributaries. A 100% reduction in bacteria levels is required to meet WQS.

Table 3. Bacteria Data Summary for Brush Neck Cove Tributaries Used in the TMDL Analysis (modified from RIDEM 2005).

		Number of Samples Used for Assessment		Geometric Mean (fc/100 ml)			90th Percentile (fc/100 ml)		
					Observed			Observed	
Station	Location	Dry	Wet	Target	Dry	Wet	Target	Dry	Wet
SC01	Southern Creek	8	28	20	3	**1875**	200	166	**25000**
SC02	Southern Creek	8	30	20	2	**876**	200	148	**17100**
SC03	Southern Creek	10	30	14	11	**1928**	49	**471**	**19200**
TB01	Tuscatucket Brook	8	28	20	9	**157**	200	41	**6240**
TB01A	Tuscatucket Brook	8	28	20	6	**723**	200	87	**4860**
TB04	Tuscatucket Brook		2	20		**1406**	200		**3472**
TB02	Tuscatucket Brook	10	30	14	**19**	**1881**	49	**84**	**14200**
TB03	Tuscatucket Brook	7	8	14	**39**	**448**	49	**257**	**1470**



Data for stations not provided in Table above is available in the Final TMDL available at http://www.dem.ri.gov/programs/benviron/water/quality/rest/pdfs/gbtmdl.pdf

Figure 11. Bacteria Sampling Stations for Brush Neck Cove Tributaries Used in the TMDL Analysis (modified from RIDEM 2005).

4.2.2 Dissolved Oxygen

Brush Neck Cove also suffers from low dissolved oxygen (DO), although cove DO is not as low as some areas within Greenwich Bay. A series of surveys completed between August 1995 and May 1997 determined that of the various portions of Greenwich Bay sampled, Brush Neck Cove had the lowest percentage of dissolved oxygen values below 2 milligrams per liter (mg/L) and no values below 1 mg/L (Granger et al. 2000). The shallow morphometry of the cove is suspected to contribute to low DO.

4.2.3 Nutrients

Both dry weather and wet weather provide significant nitrogen loading to Brush Neck Cove. The SAMP provides an estimate of dissolved inorganic nitrogen (DIN) loading to Greenwich Bay from multiple sources. According to the SAMP, dry weather loading from Southern Creek from two separate studies was 8.4 and 22.1 kilograms per day (kg/d); dry weather loading from Tuscatucket Brook was 4.8 and 10.8 kg/d. The Southern Creek represents the highest dry weather load to Greenwich Bay for the years evaluated 1994 and 1995. Wet weather loading from these tributaries is estimated at 21.2 and 13.8 kg/stormwater event for Southern Creek and Tuscatucket Brook respectively and are the highest of the tributaries and point sources measured under wet conditions. The water column average DIN concentration in Brush Neck/Buttonwoods Cove in Aug/Sept 2000 was 22 micrograms per liter (ug/L) (CRMC 2005).

To obtain a rough estimate of watershed loading to Brush Neck Cove from these main tributaries, the Corps multiplied the wet weather and dry weather loading estimates by the average number of days of dry weather and number of days of rainy weather reported in Providence, RI over a 40 year period (available at http://www.weatherbase.com/weather/weather.php3?s=070527&refer). Using 124 rainy days, loading from these two tributaries is estimated at 4,300 kilograms per hectare per yr (kg/ha/yr). Using 241 dry days and the average from the two studies, loading is estimated at 5,600 kg/yr for a total watershed DIN load of 9,900 kg/yr. Atmospheric deposition would add an additional 230 kg/yr (6.7 DIN kg/ha/yr according to Valiela et al., 2004) for a total of just over 10,000 kg/yr. Approximately 30% of the DIN to Greenwich Bay is attributable to unsewered lands, prior to the relatively recent connection to sewers (Granger et al. 2000).

The total dissolved nitrogen (TDN) load was estimated in a study determining the relationships of nitrogen loadings and other variables with plant structure in New England salt marshes (Wigand et al., 2003). TDN includes DIN and dissolved organic nitrogen (DON). The authors used a nitrogen loading model (NLM) developed and verified for Cape Cod, Massachusetts (Valiela et al., 1997 & 2000) to calculate the annual TDN load. NLM uses wet and dry atmospheric deposition, fertilizer, and wastewater disposal. The model takes into account losses from each of these sources as nitrogen moves through vegetation, soil, vadose zone, and aquifer. The TDN load to Brush Neck Cove and Buttonwoods Cove was calculated at 22,344 kg/yr. Assuming that 40% of the TDN is DIN (average percentage of atmospheric deposition, soils, aquifers and river reported by Valiela et al. 1997), the DIN load to Brush Neck Cove is approximately 8,900 kg/yr. This estimate is similar to the loading derived from the two main tributaries described above. Both of these estimates do not include the nitrogen that is transported from the Bay during incoming tides.

Using a range of literature derived values provided in the most recent SAM Plan (CRMC 2005), a DIN budget was estimated by the Corps for the Brush Neck Cove based on ISDS, atmospheric deposition and fertilizers. The DIN load using these data range from 12,000 to 15,000 kg/yr to Brush Neck Cove. Based on these three methods, loading to Brush Neck Cove is estimated between 9,000 to 15,000 kg/yr.

Water transported from the upper West Passage of Narragansett Bay that flows into Greenwich Bay as a result of wind, tidal currents, gravitational and estuarine circulation may also be a significant source of nutrients to the coves (Granger et al. 2000). The exact contribution to Brush Neck and Buttonwoods Coves from this source on incoming tides is undetermined. It is estimated, however, that the input of nitrogen and phosphorus from Narragansett Bay to Greenwich Bay may be twice as much as the amount from the watershed (Granger et al. 2000). Incoming nitrogen is estimated at 50 to 130 metric tons per year.

4.2.4 Sediment

Data specifically quantifying sediment transport to Brush Neck Cove were not available during the time of this review. However with the large amount of surface runoff from an urban setting being directed into Brush Neck Cove, it is likely large amounts of sediment are transported into the cove. Each rainfall event has the potential to increase turbidity in Brush Neck Cove. This increased turbidity is, at least partially, responsible the disappearance of eelgrass beds that were historically present in Brush Neck Cove. There were at least two attempts to reestablish eelgrass beds in Brush Neck Cove in areas that have historically supported eelgrass. Both of these attempts failed and it is hypothesized that elevated turbidities caused the failure. Granger et al. (2000) concluded that eelgrass will not be supported in conditions where greater than 80% of incident surface radiation (sunlight) is extinguished. Physical and chemical characteristic of cove and inlet substrate was described in the previous section.

4.3 Biota

4.3.1 Vegetation

The Corps examined aerial photographs and wetland maps to identify existing salt marsh habitat and locate areas for potential salt marsh creation. Figure 12 shows the existing salt marsh habitat. The salt marsh areas depicted are a hybrid of salt marsh delineated in 1996 and brackish marsh delineated in 1988.

The locations of the existing salt marsh in Brush Neck Cove are:

1. At the inflows of Southern Creek and Tuscatucket Brook. At their confluence, the salt marsh extends a short distance into Brush Neck Cove with a small isolated portion along the west shore approximately 200 feet downstream.
2. At the two small coves on the east shore of Brush Neck Cove flanking Canfield Ave.
3. Along the southwest shore of Brush Neck Cove within the City Park.

RICRMC considers all salt marsh in Brush Neck Cove to be high quality with the exception of a small area in Area 2 described above (Figure 12). This small area, less than an acre, is designated for restoration.

Wigand et al. (2003) estimates that Brush Neck and Buttonwoods Coves contains 9.1 ha (22 acres) of salt marsh habitat. These marshes contained typical wetland plant species and are dominated by *Spartina patens* (saltmeadow cordgrass) and *Spartina alterniflora* (smooth cordgrass or saltmarsh cordgrass). Five other species were identified in these marsh areas:

- *Distichlis spicata* – saltgrass
- *Limonium nashii* – sea lavander
- *Phragmites australis* – common reed
- *Salicornia europaea* – glasswort
- *Solidago sempervirens* – seaside goldenrod

No submerged aquatic vegetation (SAV) was observed in the project area during various sampling events conducted by the Corps. Additionally, the Rhode Island Geographic Information Systems (GIS) eelgrass data layer (http://www.edc.uri.edu/rigis/data/biota.aspx) does not show any current or historical eelgrass in the project area.

Figure 12. Brush Neck Cove Salt Marsh

4.3.2 Fish

The fish communities in the Brush Neck system were characterized using existing literature and information from Federal and State resource agencies. RI CRMC (2005) reported that the species found in Greenwich Bay (and the project area by extension) are both local populations and migratory species. The abundance and diversity of fish vary seasonally and annually, and depend on the life history of individual species as well as changing environmental conditions. Typical resident fish species in the project area consist of small estuarine fish such as silversides, mummichugs, killifish, and sticklebacks. Larger estuarine migrant and anadromous fish species that have the potential to occur in the project area include winter flounder, striped bass, menhaden, white perch, American eel, herring (alewives and blueback herring), shad, and bluefish.

4.3.3 Benthic Invertebrates and Shellfish

A quantitative survey was performed to document the benthic invertebrate assemblages in the project area. Seven (7) stations were established and at each station, a single 0.04 m^2 VanVeen grab sample was collected. The contents of the grab were screened through a 0.5 mm screen and preserved. Benthic organisms retained on the 0.5 mm screen were identified and enumerated. These data are provided in Appendix B.

Within the study area, macrobenthic communities varied by substrate-type. Typical dominant organisms found in the fine and medium sandy substrates included the polychaetes *Clymenella torquata*, a tube-welling, “head down” deposit feeder; *Leitoscloplos fragilis*, a burrow-dwelling, head down deposit feeder and the tube-dwelling deposit-feeding spionid polychaete *Polydora cornuta*. These species are typically found on stable fine sand substrates in good quality environments.

According the Greenwich Bay Special Area Management Plan (CRMC 2005), shellfish resources within Greenwich Bay include northern quahog (*Mercenaria mercenaria*), soft-shelled clam (*Mya arenaria*), oyster (*Crassostrea virginica*), and mussel (*Mytilus edulis*). No significant populations of shellfish were encountered in Brush Neck Cove or Buttonwoods Cove during this study. Minimal amounts of juvenile soft-shelled clams were documented in the benthic community analysis in stations near the inlet to the coves. A layer of shell hash in the cores indicates that shellfish do inhabit or have historically inhabited the coves. A sparse distribution of oysters was also noted in the intertidal areas near the stone jetties on Oakland Beach.

Horseshoe crabs (*Limulus polyphemus*) utilize Greenwich Bay beaches for spawning. Two areas of Buttonwoods Cove are popular breeding sites: City Park Beach and the opposite shore to the south. These areas are monitored by RIDEM and Save the Bay volunteers. These data are provided in Figure 13.

4.3.4 Birds

The bird population of Brushneck Cove is represented by typical coastal resident and migrant species found in New England. Common coastal species include herring gulls, common terns, great black-backed gulls, semipalmated sandpipers, double-crested cormorants, laughing gulls, and sanderlings. The presence of ospreys was noted during field work in the project area.

In a study conducted by McKinney et al. published in 2006, 321 waterfowl were observed wintering in Brush Neck Cove in 2001-2003. Table 4 shows bird abundance (number of birds ± standard error) reported by McKinney et al. (2006) for Brush Neck Cove by species category. Marsh ducks were the most abundant group. Brush Neck Cove had the second highest species richness (10.3 ± 3.3) of the 32 sites within Narragansett Bay included in the study.

The US EPA Atlantic Ecology Division in Narragansett has been conducting annual surveys since the 2001-2003 surveys conducted by McKinney et al. (2006). Annual data on species abundance from the EPA (2009) is provided in Table 5. Brant, wild geese of the genus *Brant,* are the most abundant overwintering waterfowl in Brush Neck Cove. Survey data are available at http://www.epa.gov/aed/html/research/fowl/data.html.

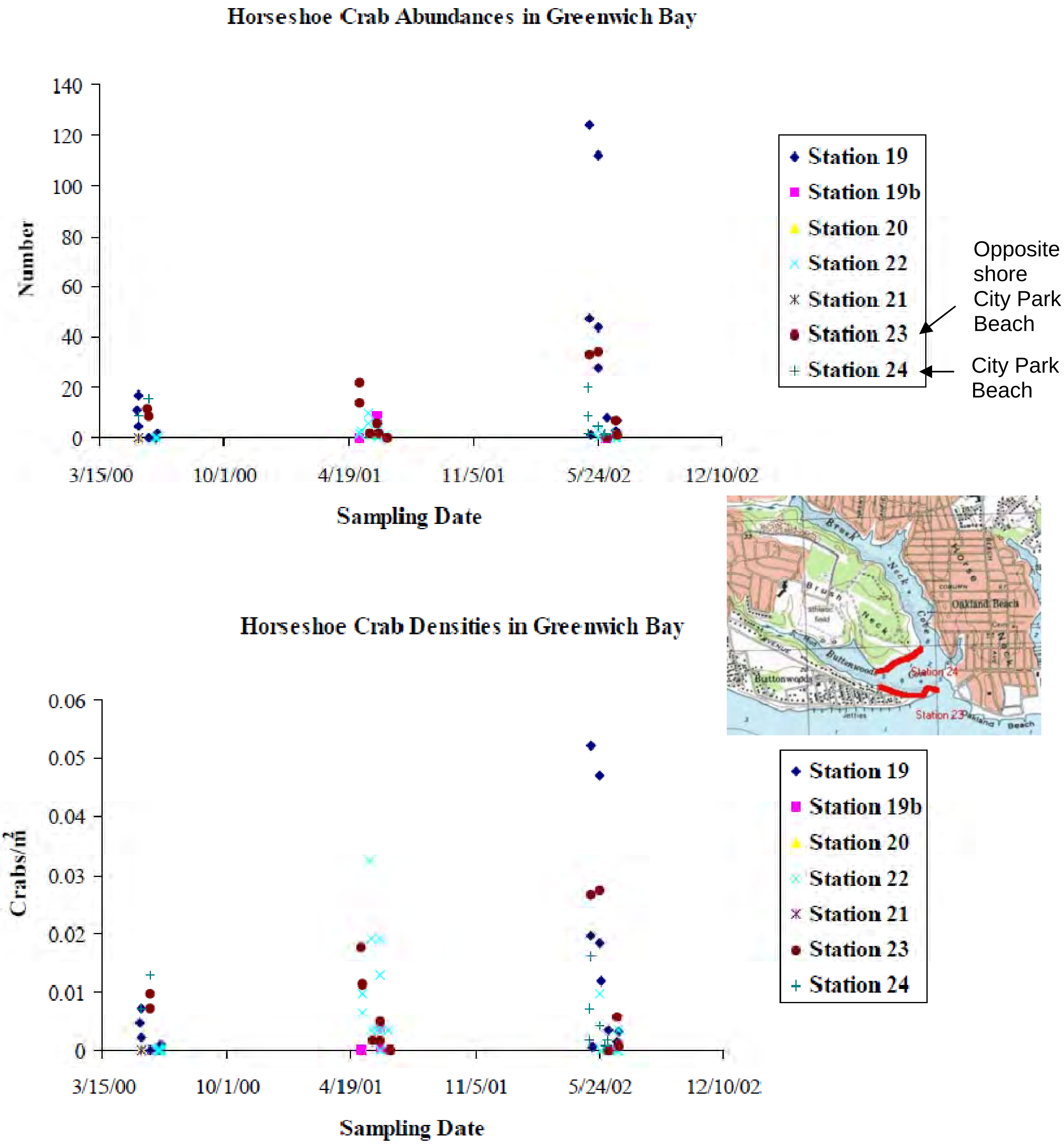


Figure 13. Horseshoe Crab Abundance and Density in Greenwich Bay (modified from CRMC 2005; originally from RIDEM)

Table 4. Wintering Waterfowl Abundance by Species Category in Brush Neck Cove 2001-2003.

Abundance (# ± SE)	Species Category	Species included in category
96.8 ± 56.6	Marsh Ducks	*Anas rubripes* (American black duck), *A. platyrhynchos* (mallard), *A. americana* (American wigeon) and *A. strepera* (gadwall)
30.3 ± 19.2	Open Water	*Bucephala clangula* (common goldeneye), *B. islandica* (Barrow's goldeneye), *Melanitta spp.* (Scoter spp.), *Clangula hyemalis* (long-tailed duck), *Mergus serrator* (red-breasted merganser) and *Aythya spp*. (Scaup spp)
24.4 ± 3.6	Shallow Cove Species	*B. albeola* (bufflehead), *Aythya valisinera* (canvasback) and *M. cucullatus* (hooded merganser)
320.9 ± 177.1	All	All species combined including geese and swans not mentioned above

Table 5. Wintering Waterfowl Abundance in Brush Neck Cove 2004-2009.

SPECIES	COMMON NAME	2004	2005	2006	2007	2008	2009
Bucephala clangula americana	Common Goldeneye	0	0	0	0	2	0
Bucephala albeola	Bufflehead	56	32	69	39	15	0
Mergus cucullatus	Hooded Merganser	6	2	10	7	3	0
Mergus serrator	Red-breasted Merganser	0	0	3	92	1	0
Aythya marila mariloides	Greater Scaup	0	0	1	0	0	0
Anas rubripes	American Black Duck	84	0	240	110	64	0
Anas platyrhynchos	Mallard	580	192	16	24	0	0
Anas americana	American Wigeon	518	8	123	73	33	0
Branta canadensis	Canada Geese	313	141	393	41	71	21
	Gulls	26	0	0	0	0	0
	Swans	0	0	0	2	0	7
	Brant	274	0	950	0	0	0
Total		**1857**	**375**	**1805**	**388**	**189**	**28**

4.3.5 Threatened and Endangered Species

There were no Federal or State threatened or endangered species listed for this area.

4.4 Air Quality

The entire state of Rhode Island is in nonattainment status for the Federal National Ambient Air Quality Standard (NAAQS) for ozone (FHWA 2005). Under provisions of the Federal Clean Air Act, Rhode Island must attain and maintain the Federal ozone NAAQS by 1999. As of 1 December 2006, Warwick, RI is in attainment status for carbon monoxide and all other NAAQS's.

4.5 Recreation and Aesthetics

Brush Neck and Buttonwoods Cove are valuable ecological resources that are utilized by the public for recreational fishing, bird watching, canoeing, kayaking, beach combing, hiking, and swimming. The aesthetic coastal scenery of Rhode Island not only benefits the residents of the coastal communities, but attracts tourists from around the world. There are multiple public access points to the coves including canoe and kayak launches, a state owned boat launch (in Warwick Cove), and access by way of Oakland Beach. There is moderate recreational power boat traffic in the coves during the summer months.

4.6 Sewer Connections

The city of Warwick through the Sewer Authority has implemented a mandatory sewer connection program that will require developed parcels with access to the collection system to tie-in within one year of the notification. As of November 30, 2007, approximately 78% of the parcels within the Brush Neck and Buttonwoods Coves are connected to the city's sewer system.

4.7 Historic and Archaeological Resources

The Corps did not initiate coordination with Rhode Island's State Historic Preservation Office due to the lack of justifiable restoration alternatives. However, the Corps obtained historical summaries from various websites which are presented in Appendix C.

5.0 Public Involvement, Review and Consultation

At the commencement of the feasibility phase, a notice was issued to residents, Federal, State and local agencies and interested groups. The recipients were invited to provide input to the feasibility study, including the scoping of the environmental issues that should be addressed throughout the study.

A coordinated site visit was conducted on March 21, 2006. Participants included individuals from CRMC, RI DEM, Mayor of Warwick, Conservation Commission members, Environmental Protection Agency, Fish and Wildlife Service, and citizens devoted to the protection and improvement of Narragansett Bay and watershed. The Corps' 6-step process, problems and opportunities, measures to be evaluated and the Corps' upcoming data collection activities were explained. Input from the attendees was encouraged.

A stakeholders meeting was held on April 12, 2007. This meeting also summarized the Corps process, results of the data collection to date and restoration measures that are considered, but was an open meeting designed to educate any interested party including residents and agencies.

Several meetings were held with the project sponsor with the most recent meeting describing the Corps' recommendation to discontinue plan formulation since the data analysis suggest that significant restoration benefits are not likely achievable with the measures identified. An email notifying stakeholders of the Corps and CRMC's decision not to proceed with any restoration alternatives at this time.

6.0 Recommendations

The data collected during the feasibility study did not support the presumption that inlet shoaling was restricting tidal flow and degrading habitat within the Brush Neck and Buttonwoods Coves. Sediment coring data did not reveal coarse substrate, suggesting that either current sediment conditions are not substantially different than historical conditions or that a suitable substrate layer is deeper than 16 feet. There is no substantial restoration benefits expected by dredging, therefore the Corps does not recommend proceeding with further evaluation at this time. CRMC should reevaluate these measures if new data demonstrate substantial benefits. The CRMC and the city of Warwick should work together with other Federal, State and local agencies and groups to implement best management practices to minimize further sediment, nutrient and bacteria loading and take steps to eradicate invasive species.

This findings of this negative report have not gone through the formal Corps of Engineers review/quality assurance process. Information, other than the general conclusion that further consideration under the Section 206, Aquatic Ecosystem Restoration Program is not warranted, should be considered preliminary.

7.0 References

Bricker, S.B. 1996. Retention of Sediment and Metals by Narragansett Bay Subtidal and Marsh Environments: An Update. The Science of the Total Environment 179: 27-46

CRMC 2005. Greenwich Bay Special Area Management Plan. Rhode Island Coastal Resources Management Council.

EPA 2009. Narragansett Bay Winter Waterfowl Survey Data. Available at http://www.epa.gov/aed/html/research/fowl/data.html

Ernst, L.M., L.K. Miguel, and J. Willis. 1999. Rhode Island's Salt Pond Region: A Special Area Management Plan (Maschaug to Point Judith Ponds). Rhode Island Coastal Resources Management Council.

FHWA 2005. Federal Highway Administration Transportation Conformity Reference Guide. 1-hour and 8-hour Ozone Nonattainment Area Maps. Available at http://www.fhwa.dot.gov/environment/conformity/nonattain/8hrozonepages/index.htm

Granger, S., M. Brush, B. Buckley, M. Traber, M. Richardson, and S.W. Nixon. 2000. An Assessment of Eutrophication in Greenwich Bay. Paper No. 1 in: M. Schwartz (ed.) Restoring Water Quality in Greenwich Bay: A Whitepaper Series. Rhode Island Sea Grant, Narragansett, R.I. 20pp.

Hyland, J, L. Balthis, I. Karakassis, P. Magni, A. Petrov, J. Shine, O Vestergaard and R. Warwick. 2005. Organic Carbon Content of Sediments as an Indicator of Stress in the Marine Benthos. Marine Ecology-Progress Series, 295: 91-103

McKinney, R.A., S.R. McWilliams and M.A. Charpentier. 2006. Waterfowl-Habitat Associations during Winter in an Urban North Atlantic Estuary. Biological Conservation 132: 239-249.

O'Rourke, P. 1995. Reducing the Pollution Potential in the Greenwich Bay and Green Hill Pond through Septic System Compliance Activity, Rhode Island Department of Environmental Management, Office of Water Resources, Providence, RI.

RIDEM 2005. Total Maximum Daily Load Analysis for Greenwich Bay Waters Pathogen/Bacteria Impairments. Rhode Island Department of Environmental Management Office of Water Resources.

Valiela, I., G Collins, J. Kremer, K. Lajtha, M. Geist, B. Seely, J. Brawley, and C.H. Sham. 1997. Nitrogen Loading from Coastal Watersheds to Receiving Estuaries: New Method and Application. Ecological Applications 7: 358-380.

Valiela, I., M. Geist, J. McClelland, and G. Tomasky. 2000. Nitrogen Loading from Qatersheds to Estuaries: Verification of the Waquoit Bay Nitrogen Loading Model. Biogeochemistry 49: 277-293.

Valiela, I., S. Mazzilli, J. L.Bowen, K. D. Kroeger, M. L. Cole, G. Tomasky, and T. Isaji. 2004. ELM, an Estuarine Nitrogen Loading Model: Formulation and Verification of Predicted Concentrations of Dissolved Inorganic Nitrogen. Water Air Soil Pollution 157:365–391.

Wigand, C., R. McKinney, M. Charpentier, M. Chintala, and G. Thursby. 2003. Relationships of Nitrogen Loadings, Residential Development, and Physical Characteristics with Plant Structures in New England Salt Marshes. Estuaries 26:1494–1504.

Wright, R. M. and O. J. Viator. 1999. Greenwich Bay Initiative – Northern Watersheds Loading Estimates to Greenwich Bay. Final Report Submitted to the City of Warwick, by the Department of Civil and Environmental Engineering, University of Rhode Island, Kingston, RI.