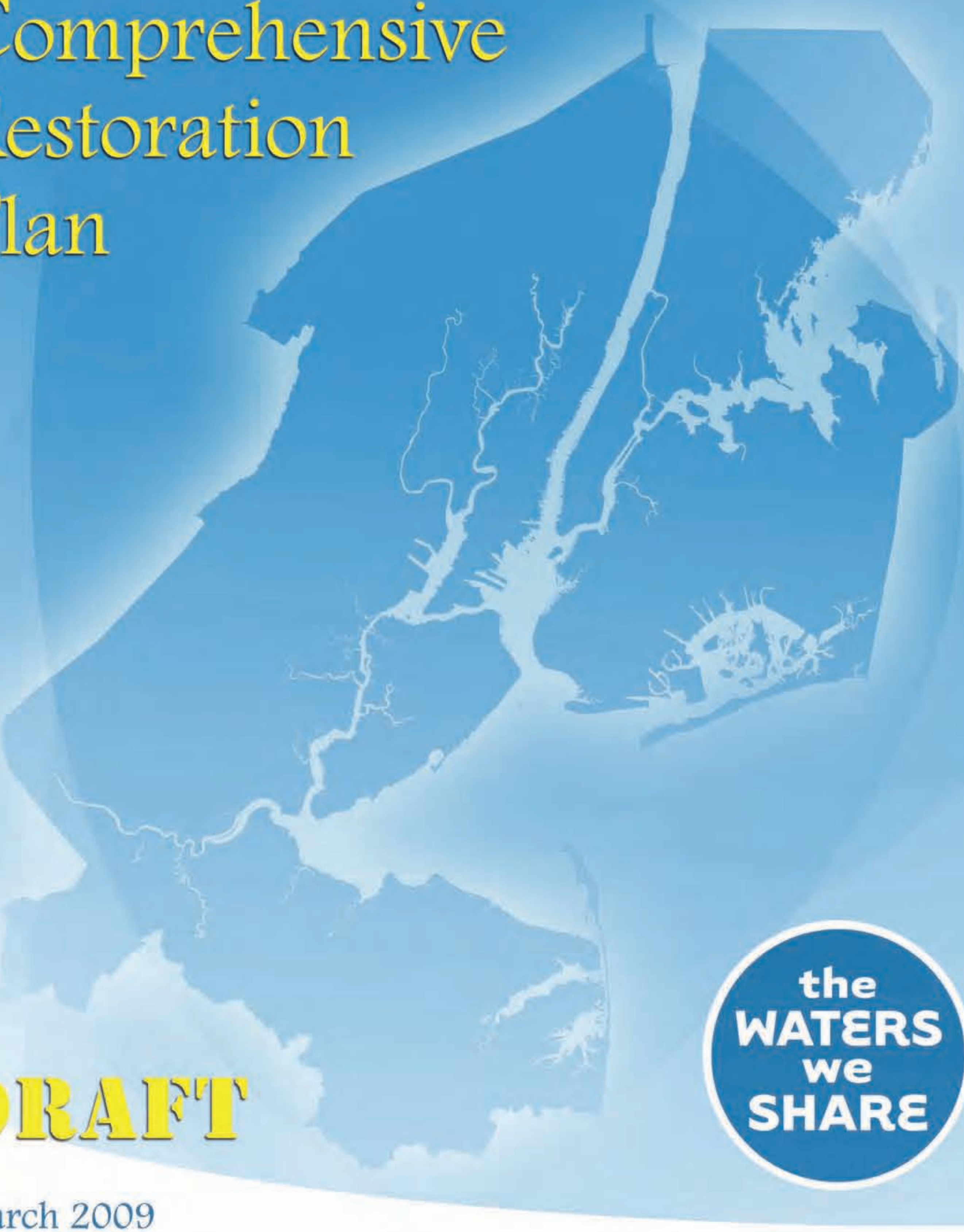
HUDSON-RARITAN ESTUARY Comprehensive Restoration Plan



DRAFT

the WATERS we SHARE

March 2009

Hudson-Raritan Estuary
Comprehensive Restoration Plan

DRAFT

Volume I

March 2009

the WATERS we SHARE

US Army Corps of Engineers®

and

THE PORT AUTHORITY OF NY & NJ

In partnership with

New York - New Jersey Harbor Estuary Program

Contributing Organizations

Government

- U.S. Army Corps of Engineers, New York District
- The Port Authority of New York & New Jersey
- National Oceanic and Atmospheric Administration
- U.S. Environmental Protection Agency
- U.S. Fish & Wildlife Service
- New Jersey Department of Environmental Protection Division of Fish and Wildlife
- New Jersey Department of Transportation
- New York State Department of Environmental Conservation
- New York State Department of State, Division of Coastal Resources
- New York City Mayor's Office
- New York City Department of Parks and Recreation
- New York City Department of Environmental Protection

Academia and Research Foundations

- Brooklyn College
- City University of New York
- Cornell University
- Hudson River Foundation
- Hunter College
- Cary Institute of Ecosystem Studies
- Manhattan College
- Montclair State University
- Queens College
- Rutgers University and Institute of Marine and Coastal Sciences
- Stevens Institute of Technology
- State University of New York at Stony Brook
- State University of New York – College of Environmental Science and Forestry
- Virginia Institute of Marine Science

Non-Profit Organizations

- American Littoral Society
- Brooklyn Botanical Gardens
- Downtown Boathouse
- Environmental Defense Fund
- Going Coastal
- Gowanus Canal Conservancy
- Hackensack Riverkeeper
- Hoboken Cove Community
- Hudson River Park
- Metropolitan Waterfront Alliance
- National Fish and Wildlife Federation
- National Parks Conservation Association
- New York/New Jersey Baykeeper
- New York City Audubon
- New York State Museum
- Passaic River Boat Club
- Passaic River Coalition
- Red Hook Boaters
- Regional Plan Association
- Rockaway Waterfront Alliance
- Sebago Canoe Club
- The Gaia Institute
- The Nature Conservancy
- Urban Divers Estuary Conservancy
- Wildlife Conservation
- Wildlife Trust
- Working Harbor

Others

- AKRF, Inc.
- Battelle
- HDR, Inc.
- Hydroqual, Inc.
- New York-New Jersey Harbor Estuary Program
- URS Corporation
- Weston

Table of Contents

List of Tables

List of Figures

List of Maps

List of Acronyms

°C	degrees Celsius
CAP	Continuing Authorities Program
CARP	Contamination Assessment and Reduction Program
CCMP	Comprehensive Conservation Management Plan
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CRP	Comprehensive Restoration Plan
CSO	Combined Sewer Outfall
CWA	Clean Water Act
CZMA	Coastal Zone Management Act
DDT	Dichloro-Diphenyl-Trichloroethane
DIN	Dissolved inorganic nitrogen
DIP	Dissolved inorganic phosphorus
ERM	Effects Range Medium
ERL	Effects Range Low
GI	General Investigations
GIS	Geographical Information System
HARS	Historic Area Remediation Site
HEP	New York/New Jersey Harbor Estuary Program
HRE	Hudson-Raritan Estuary
HRF	Hudson River Foundation
JEM	Jamaica Bay Eutrophication Model
MCY	Million Cubic Yards
MWA	Metropolitan Water Alliance
NEP	National Estuaries Program
NFWF	National Fish and Wildlife Foundation
NJDEP	New Jersey Department of Environmental Protection
NJDOT	New Jersey Department of Transportation
NJMC	New Jersey Meadowlands Commission
NOAA	National Oceanic and Atmospheric Administration
NRDA	Natural Resource Damage Assessment
NRG	Natural Resources Group of the New York City Department of Parks and Recreation
NYCDEP	New York City Department of Environmental Protection
NYCDPR	New York City Department of Parks and Recreation
NYC OASIS	New York City Open Accessible Space Information Systems
NWI	National Wetlands Inventory
NYSDOT	New York State Department of Transportation
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
NYSDOS	New York State Department of State
OMRR&R	Operation, maintenance, repair, replacement and rehabilitation
PAH	Polycyclic aromatic hydrocarbon

PANYNJ	Port Authority of New York and New Jersey
PCDF	Polychlorinated dibenzofurans
PeCDF	Pentachlorodibenzofuran
PEIS	Programmatic Environmental Impact Statement
PRPs	Potential Responsible Parties
PCB	Polychlorinated Biphenyl
RSM	Regional Sediment Management
SWEM	System-Wide Eutrophication Model
TEC	Target Ecosystem Characteristics
TCDD	Tetrachlorodibenzo-p-dioxin
TSS	Total suspended solids
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
WRDA	Water Resources Development Act

Executive Summary

The Comprehensive Restoration Plan (CRP) for the Hudson-Raritan Estuary (HRE) is a master plan to guide ecosystem restoration efforts throughout the estuary. It is intended to be used by all stakeholders (environmental and community groups, government agencies, and others), thus allowing the whole region to work towards a series of common restoration goals providing benefits to the estuary.

This effort was initiated in 1988, when Congress recognized the New York-New Jersey Harbor as an estuary of national importance and accepted it into the National Estuary Program (NEP). Following this designation, the Harbor Estuary Program (HEP) completed a Comprehensive Conservation and Management Plan (CCMP) in March of 1996. Included among the CCMP's recommendations was the development of a comprehensive strategy for habitat protection and restoration. The US Army Corps of Engineers (USACE), in partnership with their non-Federal sponsor, The Port Authority of New York & New Jersey, joined the process of developing the strategy in 1999 with the initiation of the HRE Ecosystem Restoration Feasibility Study.

To enhance the scientific credibility of the project, beginning in 2005 the Hudson River Foundation and Cornell University led a series of workshops to craft a strategy to develop a restoration plan for this highly urbanized estuary. From the beginning, the scientists agreed that the restoration program should be focused on creating and restoring a mosaic of habitats within the human-dominated landscape.

To achieve this goal, a team of estuarine scientists identified 11 measurable objectives for restoration, termed Target Ecosystem Characteristics (TECs), each of which defines specific goals for an important ecosystem property or feature that is of ecological and/or societal value. The TECs reflect the broad interest of HRE stakeholders and address habitat and degradation issues. Achieving the objectives in the TECs will increase the sustainability and resiliency of the HRE. Each TEC has established short- and long-term objectives for each of eight planning regions within the estuary. For example, the short-term objective for the Coastal Wetlands TEC is to create or restore 1,200 acres of wetlands by 2015, while the long-term objective is to create or restore a total of 15,200 acres by 2050.

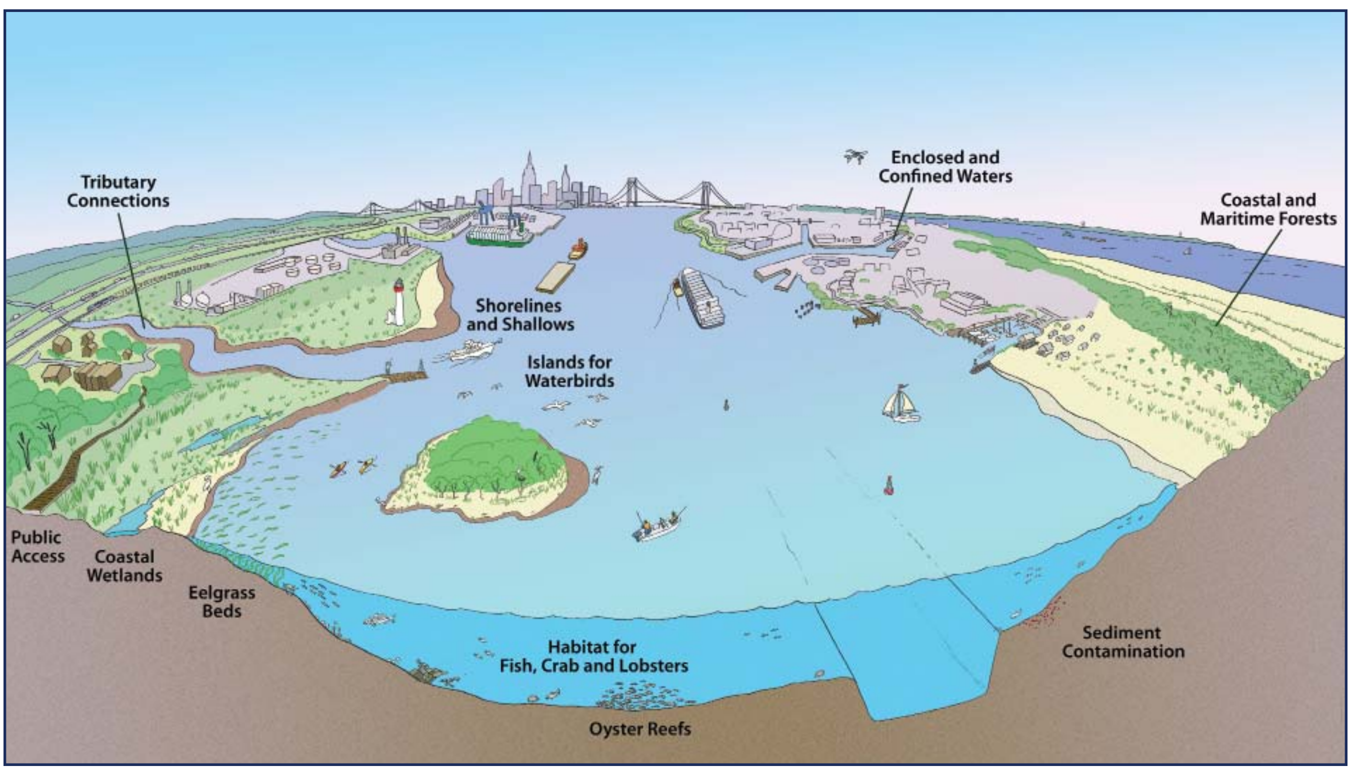
As a first step in the planning process, the HEP Habitat and Public Access Workgroups' acquisition and restoration site nomination process helped to catalog numerous restoration opportunities. Additional sites were identified during outreach efforts conducted as a part of USACE's Needs and Opportunities evaluation. Collectively, a total of 296 restoration and acquisition sites and 436 public access sites have been cataloged and included in HEP's New York City Open Accessible Space Information System (NYC OASIS). While many of these sites provide opportunities to conduct restoration activities, additional areas are needed to achieve the ambitious objectives of the program.

A series of Geographic Information Systems (GIS) analyses was conducted to identify additional restoration opportunities. These estuary-wide analyses helped to guide the planning efforts and to estimate whether the TEC objectives are achievable. For each target, existing datasets were used to identify habitat suitability (e.g., appropriate depth, water quality parameters, etc.) as well as potential constraints to ecological restoration. Preliminary findings indicate that sufficient habitat is available for achieving the TEC objectives throughout the eight planning regions.

There are many challenges to implementing the CRP. Restoration projects and their associated monitoring programs are costly. Therefore, achieving the objectives will require a substantial dedication of funds and creative funding strategies. Innovative local financing techniques, combined with State and Federal funding opportunities, will generate the support necessary to make these projects a reality. Mitigation and/or Natural Resources Damage Assessment funding should also be considered to support restoration projects. At this early stage of planning, accurately estimating project costs for all of the restoration opportunities would not be possible. The costs to conduct restoration vary greatly by project and by type of restoration (i.e., TEC). However, a rough estimate of the costs to achieve the Coastal Wetlands objectives range between $262 and $856 million (2008 dollars) for the short-term objective and $3.3 to $10.8 billion for the long-term objective, based on average costs per acre for this type of project. Considering that these are only the costs associated with one of the 11 TECs, funding to implement all the targets will be difficult to secure. The success of the CRP in improving the estuary's ecosystem is dependent upon successful partnering among stakeholders.

Multi-jurisdictional regulatory boundaries present another challenge to restoration planning within the HRE. Resource management agencies are tasked with balancing multiple, often conflicting goals of resource conservation while providing for compatible uses of the environment. Examples of policy issues that should be addressed include: 1) habitat exchange issues, 2) placement of fill in water, 3) beneficial use of dredged material for habitat restoration, 4) attractive nuisance issues, and 5) issues affecting management of contaminated sediments.

The CRP is considered a living document which is meant to be updated as projects are implemented so that lessons learned can be incorporated for the use and understanding of all stakeholders.



1.0 Introduction

The Hudson-Raritan Estuary (HRE) is located within one of the most urbanized regions in the United States. The waters and nearshore habitats of the HRE were once ecologically productive, but centuries of industrialization and urbanization have degraded the environmental conditions. This history has resulted in severe habitat loss and degradation, poor water quality, pervasive sediment contamination and lack of public access to the estuary. These actions have significantly impacted the ecological integrity and health of the estuary and consequently the societal values of the region. Due the severity of the impacts many programs have been initiated by various Federal, state, municipal, or non-governmental organizations that have implemented successful habitat restoration projects. However, there has been no explicit consensus regarding estuary-wide restoration goals and objectives and, therefore, no comprehensive system-wide plan to guide the process. Success is measured on a project-by-project basis, without consideration of the value of the project in the context of what is needed for the entire Estuary. Often, little consideration is given to past restoration efforts or alternate restoration opportunities.

The Draft Comprehensive Restoration Plan (CRP) has been prepared as a collaborative effort among many agencies and non-governmental organizations. It is intended to address the need for a comprehensive master plan for ecological restoration within the HRE study area, broadly defined as the area within 25 miles of the Statue of Liberty. It provides a framework for an estuary-wide ecological restoration program by presenting restoration targets that have been identified and developed in cooperation with the region's stakeholders. The CRP outlines a comprehensive strategy for restoration and presents the opportunity to coordinate separate restoration and habitat improvement projects into a well-defined program to efficiently and effectively address the estuary's needs. It also provides the opportunity to track the progress and challenges of individual projects to increase the likelihood for future successes. In addition, the CRP will serve as a central source document that can be drawn upon to foster and mobilize broad public support for diverse HRE restoration efforts.

The Draft Comprehensive Restoration Plan is comprised of two volumes: Volume I provides the broad framework of the plan by introducing the program goal and objectives, laying out a strategy for success, and identifying opportunities to meet those objectives. Volume II provides technical guidance to interested stakeholders for planning, evaluating, and conducting individual restoration projects for the Target Ecosystem Characteristics (TECs) habitats within the Estuary.

The following sections of Volume I provide background on the study and introduce the restoration philosophy, program goal, and objectives that are critical components of the CRP. Subsequent chapters provide additional information on the ecological conditions of the HRE study area, and detailed descriptions of the restoration targets and objectives, and identify opportunities for achieving these targets. Volume I of the Comprehensive Restoration Plan is organized in the following chapters:

- Chapter 1: Introduction
- Chapter 2: Existing Conditions
- Chapter 3: Target Ecosystem Characteristics
- Chapter 4: Restoration Opportunities
- Chapter 5: Comprehensive Restoration Plan Implementation
- Appendix A: Target Ecosystem Characteristics Development
- Appendix B: Geographic Information Systems Evaluation Methodology
- Appendix C: Sediment Contamination Target Ecosystem Characteristic
- Appendix D: Atlas of Restoration Opportunities

1.1 Study Background

The Comprehensive Restoration Plan is the culmination of decades of planning and outreach efforts among the region's stakeholders and scientists. Comprehensive restoration planning was initiated in 1988, when the U.S. Congress recognized the New York-New Jersey Harbor Estuary (i.e., the HRE study area) as an estuary of national importance and inducted the Estuary into the National Estuary Program (NEP) in response to a request by the governors of New York and New Jersey. In conjunction with this designation was the formation of the New York-New Jersey Harbor Estuary Program (HEP), which brought together Federal, State, local, and non-government organizations interested in improving the ecological conditions within the HRE. The HEP completed a Comprehensive Conservation and Management Plan (CCMP) in March 1996. The CCMP documented the condition of the environmental resources of the HRE and proposed a series of critical actions to address the environmental threats facing these ecosystems. Included among its recommendations was the development of a comprehensive regional plan to restore and protect habitat within the HRE (HEP 1996).

The CCMP's recommendation to restore the Hudson-Raritan Estuary received support from the region's stakeholder's, including state and municipal regulators and policy makers, Federal agencies, non-governmental organizations, environmental advocates as well as the public. In response to this broad support, the U.S. Congress authorized the U.S. Army Corps of Engineers (USACE) to investigate and identify opportunities to implement the CCMP's habitat goals within the estuary. The 2000 USACE Reconnaissance Study determined Federal interest in restoration (USACE 2000) and, in 2001, the HRE Ecosystem

What is the Harbor Estuary Program?

Incorporation of the Hudson-Raritan Estuary (the study area) into the National Estuary Program required the creation of an organizational structure, the New York-New Jersey Harbor Estuary Program (HEP), to provide program direction and help carry out key actions. HEP was established in 1988. HEP's primary program goals were to develop and implement a conservation plan that would curb the harmful effects of pollution and garner public awareness, appreciation, and support for the HRE. HEP's major accomplishments include preparing the initial conservation strategy for the estuary (CCMP); developing a community based process for nominating sites for acquisition and restoration; providing site information via an online interactive map; developing a contaminant assessment program that will be used to reduce contaminants (Contaminant Assessment and Reduction Program [CARP]); developing the first ever harbor-wide water quality survey; refining and using modeling tools to assess loading reductions for nutrients and pathogens; mapping public access sites and needs; and supporting numerous outreach and stewardship programs. Active participants in the HEP program include:

Federal Government
- National Oceanic & Atmospheric Administration (NOAA)
- National Park Service (NPS)
- U.S. Army Corps of Engineers (USACE)
- U.S. Department of the Interior
- U.S. Environmental Protection Agency (USEPA)

State and Local Governments
- Interstate Environmental Commission
- New Jersey Department of Environmental Protection (NJDEP)
- New Jersey Meadowlands Commission (NJMC)
- New York City Department of Environmental Protection (NYCDEP)
- New York State Department of Environmental Conservation (NYSDEC)
- New York State Department of State
- The Port Authority of New York/New Jersey (PANYNJ)
- State of New Jersey
- State of New York

Non-Government Organizations
- Citizens Advisory Committee
- Hudson River Foundation (HRF)
- National Parks Conservation Association
- New Jersey Harbor Dischargers Group
- Science and Technology Advisory Committee
- NY/NJ Baykeeper
- Metropolitan Waterfront Alliance
- So many more…

Restoration Feasibility Study was initiated by the USACE in partnership with The Port Authority of New York & New Jersey (PANYNJ) (Figure 1-1).

The USACE and the PANYNJ have worked with many partners to create a Comprehensive Restoration Plan that can achieve the objectives of the region's stakeholders first expressed in the CCMP. Throughout the planning process, the region's stakeholders emphasized the need for collaborative planning and a regional partnership, in which stakeholders look beyond political boundaries to focus on estuary-wide issues through research-based planning. The stakeholders emphasized the need for a plan that included the acquisition and preservation of ecologically valuable lands, as well as active restoration and enhancement of habitat.

Early on in the planning phase of the HRE Ecosystem Restoration Feasibility Study, the USACE and the PANYNJ conducted a "Needs and Opportunities" evaluation to identify local interests in ecosystem restoration. During the public outreach for this study, stakeholders representing local, State, and Federal agencies, scientists, citizens, and business interests emphasized the need for a collaborative, ecosystem-based restoration strategy that would tie local sites and specific needs to projects into a cohesive effort. The Needs and Opportunities Report identified potential restoration opportunities, and emphasized the importance of habitat acquisition to the future environmental health of the estuary (RPA 2003).

For several years, the HEP Habitat Workgroup has been nominating priority acquisition and restoration sites working with hundreds of organizations, elected officials and community proponents within the HRE since 1994. This program helps direct potential project sponsors to ecologically important lands that are privately owned and potentially vulnerable to development. Information about the priority sites is made available to the public and potential sponsors on the New York City Open Accessible Space Information System (NYC OASIS) website. In 2001, the PANYNJ initiated the Hudson-Raritan Estuary Resources Program, which established a $60 million fund to acquire and preserve ecologically valuable tracts of land around agency facilities in New York and New Jersey. The PANYNJ works closely with the HEP Habitat Workgroup to identify the most valuable sites for acquisition. The Needs and Opportunites Report added to the list of existing candidate sites developed through the HEP Habitat Workgroup.

Figure 1-1. Timeline of important events in the Hudson-Raritan Estuary study area.

In addition to the value placed on habitat acquisition and preservation, both the Needs and Opportunities Report and the CCMP emphasized the value of a coordinated and comprehensive plan for habitat restoration and preservation within the HRE study area. Since 2005, Cornell University and the Hudson River Foundation (HRF) have provided support to focus the development of the Comprehensive Restoration Plan by working with the region's stakeholders and scientists to establish broad-based, non-site specific goal and restoration targets (TECs). The TECs can be used to identify and design restoration projects and measure programmatic success. The Comprehensive Restoration Plan uses the TECs as the framework for an estuary-wide ecological restoration program, and outlines a strategy for ecological restoration within the Hudson-Raritan Estuary.

Development of the Target Ecosystem Characteristics

The Hudson River Foundation in cooperation with Cornell University guided the development of the restoration targets for the Hudson-Raritan Estuary, by defining the program goal, identifying candidate restoration objectives, and defining the 11 Target Ecosystem Characteristics (TECs).

The development of the TECs are documented in two reports:

Setting Targets for Restoration of the Hudson-Raritan Estuary: Report of an Interdisciplinary Workshop (2006)

Target Ecosystem Characteristics for the Hudson-Raritan Estuary: Technical Guidance for Developing a Comprehensive Ecosystem Restoration Plan (2007)

To learn more, please visit: www.hudsonriver.org

The CRP will establish a forum for all stakeholders in the HRE study area to coordinate, discuss, and plan restoration efforts. The HEP provides a structure that encourages open communication among the region's stakeholders, and the HEP structure can be built upon to facilitate restoration planning and to promote CRP programmatic success. Through collaboration with the HEP, the approach employed to prepare the CRP has already fostered broad consensus on harbor-wide restoration goals and targets as well as a shared vision of a restored future state. This collaborative framework recommends that all restoration and acquisition programs, regardless of the authority under which they are conducted, work toward shared estuary-wide goals.

1.2 Restoration Goals and Targets

The HRE has a long history of physical and chemical habitat degradation and unchecked industrial and residential development, along with vast navigation and infrastructure improvements. These alterations have resulted in ecosystem-level changes to the HRE causing dramatic shifts in the community structure, types of habitat and the population of organisms inhabiting the area. Ecological restoration, as defined by the Society of Ecological Restoration, is the process of assisting with the recovery of an ecosystem that has been degraded, damaged or destroyed. Developing a plan to assist with the recovery of such an altered ecosystem required extensive coordination with the region's stakeholders and scientists.

Scientists from various Federal, state, and local agencies, non-government organizations, and institutions gathered in a series of workshops and meetings to craft a strategy to develop an ecological restoration plan for such an urbanized estuary. From the beginning of the planning effort, they acknowledged that the estuary will remain a populous area with a landscape continuously re-shaped by humans, and that a "renaturing" approach to habitat restoration would be the most realistic for the HRE. This approach entails designing an ecosystem where nature and people co-exist, a system wherein environmental and societal needs are equivalent ecosystem elements (Bain et al. 2007).

Table 1-1. Target Ecosystem Characteristics (TECs) in the Hudson-Raritan Estuary study area.

TEC	Target Statement
Coastal Wetlands	Create and restore coastal wetlands, at a rate exceeding the annual loss or degradation of wetlands in the HRE study area, to produce a net gain in acreage.
Islands for Waterbirds	Restore and protect roosting, nesting, and foraging habitat for long-legged wading birds on islands in the HRE study area.
Coastal and Maritime Forests	Create a linkage of forests accessible to avian migrants and dependent plant communities from Rockaway Peninsula, NY to the coasts of New York and Raritan Bays to Sandy Hook, NJ.
Oyster Reefs	Establish oyster reefs at several locations in the HRE study area.
Eelgrass Beds	One eelgrass beds in each of the eight HRE planning regions that can support eelgrass.
Shorelines and Shallows	Create or restore shoreline and shallow sites that meet a 3-zone criterion specified for an integrated site with a vegetated riparian zone, an inter tidal zone with a stable slope, and illuminated shallow water.
Habitat for Fish, Crab, and Lobsters	Create functionally related habitats in each of the eight regions of the HRE.
Tributary Connections	Reconnect freshwater streams and inland habitats to the estuary to provide a range of quality habitats to aquatic organisms.
Enclosed and Confined Waters	Upgrade the water quality in enclosed waterways and tidal creeks within the estuary to match or surpass the designated use of their receiving waters.
Sediment Contamination	Isolate or remove one or more sediment zone(s) that is contaminated until such time as all HRE sediments are considered uncontaminated based on the all related water quality standards, related fishing / shelling bans or fish consumption advisories, and any newly-promulgated sediment quality standards, criteria or protocols.
Public Access	Improve direct access to the water and create linkages to other recreational areas, as well as provide increased opportunities for fishing, boating, swimming, hiking, education, or passive recreation

The scientists agreed that the restoration program should be focused on creating and restoring a variety of habitats with high ecological value and function interspersed within the human-dominated landscape, and to allow public access to the waterfront to appreciate the estuary. The CRP Program Goal is:

To develop a mosaic of habitats that provides society with renewed and increased benefits from the estuary environment.

To define a successful restoration program within the HRE, it was essential to identify specific restoration targets that are collectively critical to the estuary's ecological viability. For this purpose, a team of estuarine scientists identified a set of 11 TECs, each of which is an important ecosystem property or feature that is of ecological and/or societal value. The TECs identified in Table 1-1 are estuarine-dependant habitat types, habitat complexes, contamination issues, and societal values that have been selected to guide the HRE Ecosystem Restoration Study. The TECs reflect the interests of HRE stakeholders and incorporate the habitat and degradation issues repeatedly emphasized in the past two decades of HEP outreach efforts. By increasing the quantity of physical habitat value and species diversity, the HRE study area will become more sustainable and resilient.

Establishing measurable objectives was the next critical step in defining the restoration program. These objectives will allow the HRE stakeholders to prioritize actions and track progress in achieving the program goal over time. The estuarine scientists established short – and long-term objectives for each TEC, as are presented in Table 1-2. In the short-term (i.e. by 2015), the success of the restoration program will be measured against whether or not the short-term objectives for each TEC were met. Many of these short-term actions will be initial efforts to test the feasibility of restoring these habitat types, measure performance, or to provide opportunities for technical innovation. Evaluation of successes and challenges encountered while attempting to meet these short-term objectives will serve to feed an adaptive management strategy designed to refine and strengthen the long-term plan.

The HRE's stakeholders have been involved throughout the development of the program goal, the TECs, and their measurable objectives to ensure that the program is designed to meet the needs of the region's interested agencies and non-governmental organizations. The TECs have been refined through input received from these stakeholders, and they represent a consensus on the framework for the restoration master plan for the HRE (outlined in Appendix A).

Table 1-2. Short-Term and Long-Term Objectives for Target Ecosystem Characteristics (TECs) in the Hudson-Raritan Estuary (HRE) study area.

TEC	2015	2050
Coastal Wetlands	One new wetland that provides at least five primary functions in each HRE region (1,200 total acres)	Continue restoration at a rate of 400 acres per year for a total system gain of 15,200 acres
Islands for Waterbirds	Enhance at least one island in each of the four main island groups within the HRE study area	All islands in the four main island groups provide roosting and nesting sites
Coastal and Maritime Forests	Establish one new forest of at least 50 acres and rehabilitate at least 200 additional acres of existing forest.	Establish 500 acres of new forest among three sites, and rehabilitate another 500 acres of existing forest.
Oyster Reefs	500 acres of reef habitat across 10-20 sites	5,000 acres of established oyster reef habitat
Eelgrass Beds	Create one test bed in each HRE region	Three established beds in each HRE region capable of supporting eelgrass
Shorelines and Shallows	Establish new shorelines and shallows sites in three HRE regions	Restore all available shorelines and shallows sites in three HRE regions, and two sites in other planning regions
Habitat for Fish, Crab, and Lobsters	Complete a set of two functionally related habitats in each HRE region	Complete four sets of at least two functionally related habitats in each HRE region
Tributary Connections	One less barrier per year to passage between at least three different inland habitats	Continue reconnecting habitats at a rate of one project per year until all barriers within the HRE study area are removed or made passable
Enclosed and Confined Waters	Improve the water quality or environmental conditions of eight confined water bodies to meet their current designated use classification	Improve the water quality or environmental conditions of eight confined water bodies to meet the criteria of their receiving waters
Sediment Contamination	Isolate or remove at least 25 acres of contaminated sediment	Isolate or remove at least 25 acres every 2 years
Public Access	Create one access point and upgrade one access point in each of the HRE regions per year	All waters of the HRE are accessible within a short walk or public transit trip

2.0 Existing Conditions

2.1 Study Area

The Hudson-Raritan Estuary (HRE) study area is located within one of the largest estuaries on the east coast of the United States, comprising over 1,600 square miles (100 kilometers^2, USACE 2004a) and almost 1,000 linear miles (1,600 kilometers) of shoreline (RPA 2003, USACE 2006a). The HRE study area, as identified in the USACE study authorization is approximately defined by a 25-mile (40-kilometer) radius from the Statue of Liberty. The actual borders of the HRE study area and its planning regions were delineated based on a combination of watershed boundaries and physical landmarks, creating ecologically and historically distinct areas that are all tidally influenced (USACE 2004a). The HRE study area was delineated into eight planning regions to facilitate stakeholders' identification of restoration needs and opportunities specific to each region. The eight regions of the HRE study area include: (1) Jamaica Bay, (2) Lower Bay, (3) Lower Raritan River, (4) Arthur Kill/Kill Van Kull, (5) Newark Bay, Hackensack River, and Passaic River, (6) Lower Hudson River, (7) Harlem River, East River, and Western Long Island Sound, and (8) Upper Bay (Figure 2-1).

The HRE study area includes all tidally influenced portions of rivers flowing into New York and New Jersey Harbor including the Hudson, Raritan, Hackensack, Passaic, Shrewsbury, and Navesink rivers and the East River from the Battery to Hell Gate (USFWS 1997). The 320-mile (515-kilometer) Hudson River dominates the hydrology of this system, with a watershed of 13,400 miles^2 (34,705 kilometers^2), and an average flow of 21,000 feet^3/second (683 m^3/second). The Hackensack, Passaic, Raritan, Shrewsbury and Navesink rivers collectively account for about 13% of the flow into the Harbor (USFWS 1997).

The complex geological and glacial history of the HRE study area created this unique and diverse estuary. The estuary is the location of the convergence of three physiographic provinces: the sand, gravels, and clays of the Atlantic Coastal Plain; the sandstones, shales, and igneous intrusions of the Piedmont Province; and the metamorphic crystalline rock ridges of the New York – New Jersey Highlands and Manhattan Hills extensions of the New England Province (USFWS 1997). The HRE study area also includes the terminal or end moraine of the most recent (Wisconsin) glacial advance (USFWS 1997). This results in a great variety of sediments, landforms, bedrock types, which support diverse groups of ecological communities within the study area.

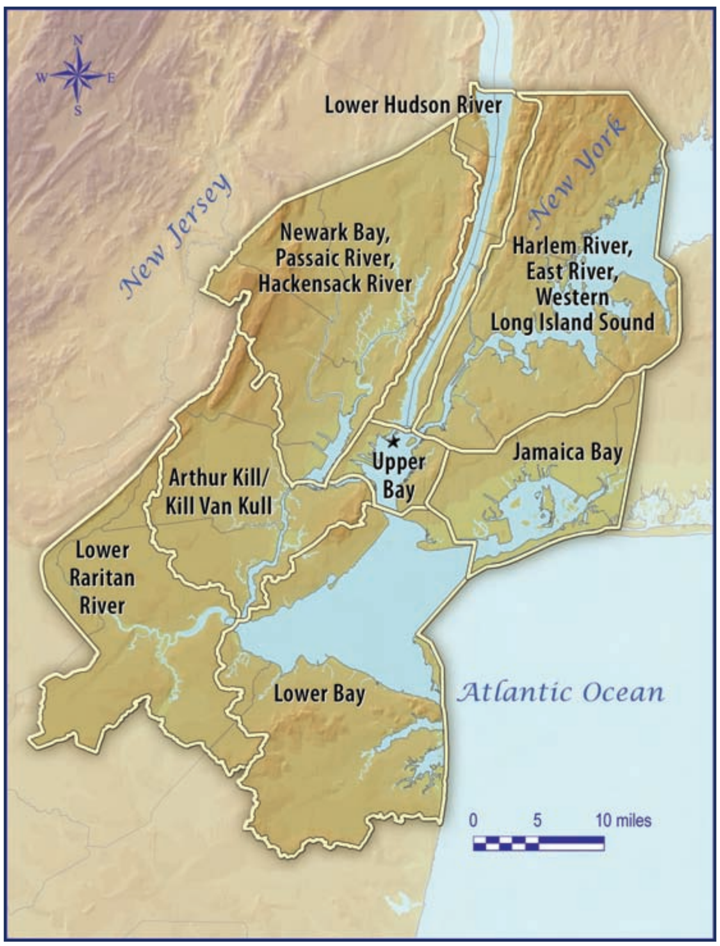


Figure 2-1. The eight Planning Regions of the Hudson-Raritan Estuary study area. The Statue of Liberty is represented by the star.

The HRE study area is also located where the east-west oriented shoreline of the New England and Long Island coasts meets the north-south oriented shorelines of the mid-Atlantic coast. This concentrates those species of birds, insects, and fish that seasonally migrate along the coastline and funnels them into the region leading to exceptional diversity and numbers (USFWS 1997). The U.S. Fish and Wildlife Service (USFWS) lists almost 400 plant, animal and fish species of special emphasis as occurring within the HRE study area (USFWS 1997). Additionally, the Atlantic Flyway, one of four major avian migratory routes in North America, passes directly over the HRE study area. This estuary supports residents and migrants of almost 300 species of birds; over 100 species of fishes; countless plant species; and many important terrestrial and aquatic invertebrates (Steinberg et al. 2004, USFWS 1997).

Jamaica Bay, the Hackensack Meadowlands, and Sandy Hook Bay are examples of invaluable open spaces with functional aquatic habitats in the HRE study area. The aquatic vegetation in these areas contributes to preserving the integrity and productivity of the nearshore zone (Bain et al. 2007). For decades the islands of the HRE study area have functioned as rookeries, supporting over a thousand breeding pairs of long-legged wading birds (Kerlinger 2004). Some of these areas scattered throughout the HRE study area have been preserved or restored. However, many of these remaining environmental assets represent isolated sites that are typically surrounded by industrialized or densely populated urban areas and are vulnerable to degradation from surrounding land uses. Although currently they support some fish and wildlife, many of these open areas are severely degraded and would benefit significantly from habitat improvements.

The HRE study area is the most densely populated estuary in the United States, with more than 20 million residents (USACE 2006a; Figure 2-2). In addition to residential land use, a large amount of the HRE study area is used for industry and commerce. Many industries are closely linked to the ports of the HRE study area. Therefore, shipping channels are maintained in most waterways and surface waters are used primarily for commercial boat traffic (USACE 2004a). There are also many power plants that withdraw water from the HRE study area and at least 27 major wastewater treatment plants that discharge treated and untreated effluent into the estuary through combined sewer outfalls (CSOs) (NYCDEP 2003).

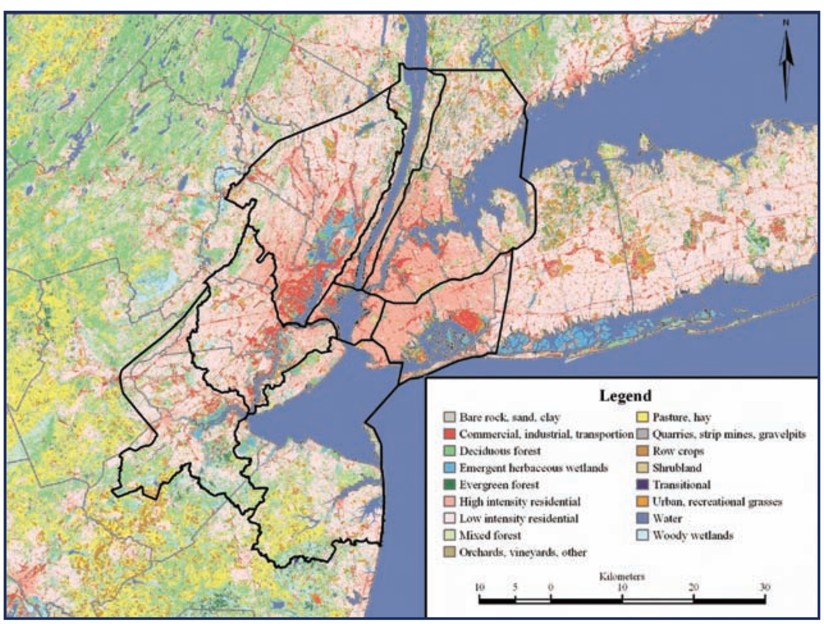


Figure 2-2. Land use in the Hudson-Raritan Estuary study area.
Source: 1992 USGS National Land Cover Dataset, North American Datum 1983, 30 m resolution

The HRE study area has suffered extensive losses in wetland habitat and aquatic vegetation communities such as eelgrass beds (USACE 2004b, Squires 1992). Approximately 300,000 acres (1,214 kilometers^2) of tidal wetlands and subtidal waters have been filled in the study area and only about 20% (15,500 acres [63 kilometers^2]) of historic tidal wetlands remain (USFWS 1997). Without aquatic vegetation, which functions as storage areas for flood runoff, most of the current overland runoff and leachate enters directly into open water (HEP 1996, Bain et al. 2007). The losses of shoreline aquatic vegetation have resulted in increased turbidity, shoreline erosion, and reductions in wildlife breeding and wintering grounds. Moreover, alterations in tidal exchange have transformed much of the remaining shallow water and salt marsh habitat from the originally diverse wetland plant assemblages to monocultures of invasive species (USACE 2004a). Almost all of the approximately 224,000 acres (906 kilometers^2) of freshwater wetlands that existed in New York City prior to the American Revolution have been filled or otherwise eliminated (USFWS 1997).

Figure 2-3. Historic presence of oysters in the Hudson-Raritan Estuary study area.
Source: Metropolitan Sewerage Commission 1911

Physical and chemical habitat alteration has led to changes in the populations of organisms that use the HRE study area. For example, the historically abundant eastern oyster has all but disappeared over their once expansive range. Sedimentation likely smothered some oyster beds, killing them directly and burying hard, benthic substrates on which oysters colonize, reducing available habitat (Coen and Luckenbach 2000, references therein). These high sedimentation rates were the combined effect of increased overland runoff, dredging, shoreline structure, and poor land management in the HRE study area. Overharvesting and poor water quality also contributed to the population decline of oysters. Other community changes resulted from the disappearance of oyster beds, which provide benthic structure over a range of depths and habitat for many aquatic species (MacKenzie 1992; Figure 2-3). This theme of interdependence is repeated often and magnifies the impact of past losses as well as potential value of any restoration.

In addition to eliminating much of the HRE study area's aquatic habitat, the construction of bulkheads, piers, and placement of shoreline fill have greatly reduced the physically diverse near-shore zone of shallow, soft-bottom habitats, rocky outcroppings, wetlands, and sand beaches (Sanderson 2005). The littoral zone historically found in the estuary was structurally complex with diverse physical characteristics, supporting resident fish populations as well as attracting large populations of migratory and transient fish for spawning and feeding (Levinton and Waldman 2006). These complex and productive waters were ideal nursery areas for young fish, particularly where benthic structure and/or plant communities existed. The construction of piers slowed near-shore waters and promoted extensive sediment accumulation, which in concert with other forms of shoreline hardening, contributed to the loss of physically complex habitat, greatly reducing quality of spawning and nursery areas.

2.2 History of Degradation and Historic Losses

Degradation to the historic habitats in the HRE study area has been the result of human modifications to natural systems. The types of degradation commonly identified in the HRE study area can be classified as bathymetric alterations, shoreline modifications, hydrodynamic and hydraulic changes, or changes to water and sediment quality.

2.2.1 Bathymetric Alterations

Before colonial settlement, the HRE study area was a relatively shallow system; with most of the waters less than 20 feet in depth at mean low water. Early efforts to improve navigation undertaken during the early 1800s, included removing obstructions, such as the rocks at Hell Gate in the East River, New York and in the Raritan River of New Jersey (Parkman 1983). Large-scale bathymetric alterations began with the inception of the suction dredge in the late 1800s, when the dredged material was initially used to supply landfill material (Bone 1997). As wooden boats were replaced with larger steel ships, a series of navigation improvement projects was initiated in New York Bay to accommodate these vessels. In 1891, a 30 feet (9 meters) deep passage was dredged through the Lower Bay, followed by an extensive 40 feet (12 meters) deepening completed in 1914 (Parkman 1983). During World War II, the network of channels and supporting berthing areas were deepened to almost 45 feet (14 meters) and expanded into the Upper New York, Raritan, and Newark bays (Parkman 1983). Since then, navigation channels have been maintained or deepened throughout the estuary's rivers and bays, resulting in over 250 miles (400 kilometers) of established channels and associated berthing areas. In 2000, Congress authorized the deepening of the main shipping channels of the HRE to 50 feet (15.2 meters) to meet shipping needs and ensure the Harbor's long-term economic viability (§101 (a) (2) of WRDA 2000, P.L. 106–541). The harbor deepening effort is currently being conducted and is scheduled for completion by 2015 (USACE 2008b).

2.2.2 Shoreline Modifications

Shortly after European settlement, colonists began developing the shoreline in the HRE study area. By filling and stabilizing nearshore habitat with soil, rocks, and refuse, colonists protected their homes and industries from flooding, erosion, and ice as well as creating fast lands. Most of Manhattan's southern shorelines were hardened and approximately 279 acres (1.12 kilometers^2) of new land was added onto the island in an effort to expand the city. Rip-rap revetments and bulkheads stabilized shorelines and allowed for larger vessels to navigate the bays and rivers, at the expense of the shoreline and shallow waters. By the early 1800s, ship traffic increased and solid-filled pier bases replaced the more basic stone embankment and timber piling designs. By 1853, there were 112 piers in the East and lower Hudson Rivers, some of them extending 600 feet (180 meters) into the river (Bone 1997).

Continued population growth and technological improvements raised the need for improved transportation infrastructure. Railroad causeways were built, fragmenting many wetlands in the Hackensack Meadowlands and surrounding areas. The present-day LaGuardia, John F. Kennedy, and Newark International Airports were constructed on filled wetlands, as was Floyd Bennett Field in Brooklyn. Decks were assembled into Flushing Bay to enlarge LaGuardia Airport by 50 acres (20 hectares; HEP 1990). Major shipping terminals were established in the HRE which currently occupy a total of 755 miles

(1,209 kilometers) of shoreline between New York and New Jersey, with 460 miles (736 kilometers) and 295 miles (473 kilometers), respectively (USFWS 1997).

Urban and industrial uses currently dominate nearshore areas in the HRE study area, and these uses have eliminated natural shoreline habitat from much of the estuary. These hardened and often deepened shorelines have replaced the gently sloping and vegetated natural shorelines. Remaining stretches of unhardened shorelines within the HRE study area are typically littered with debris, such as dilapidated piers or abandoned buildings, which obstruct aquatic and terrestrial growth.

2.2.3 Hydrodynamic and Hydraulic Changes

Within the estuary, the majority of streams and creeks have either been eliminated by filling, redirected through storm sewers, or have been altered by stormwater runoff or channelization. These modifications have nearly eliminated the natural salinity gradient that should occur near tidal streams. Wastewater treatment plants and combined sewer overflows (CSOs) increase freshwater inputs to localized areas. Stormwater runoff into the estuary also brings debris and sediment that can change nearshore areas by filling or scouring, depending on the magnitude of flow. Bridges, piers and roadways have constricted or restricted flow in many locations (USACE 2004a). Bathymetric changes that make the estuary more navigable have also influenced water circulation and flow patterns. The subsequent increase in ship traffic by more and larger vessels produces waves and wakes as well as scours areas that can result from deep drafted vessels navigating in shallower side channels.

In addition to factors within the HRE study area that caused hydrodynamic and hydraulic changes, there were also changes occurring outside of the study area that directly affected the estuary. One of the most substantial changes has been the decrease in freshwater flow to the estuary. The Hudson River, the primary source of freshwater to the HRE study area, has lower flow to the estuary due to dozens of reservoirs and impoundments and several water treatment facilities in its watershed. Impoundments alter stream flow patterns and encourage upstream siltation, which can change the channel structure, benthic substrate, and bank stability in downstream river reaches. This decrease in freshwater flow to the estuary is exacerbated during low flow periods, as flood tides bring a greater volume of saline water up the Hudson River, influencing community composition along the shoreline and habitat use of migratory and transient species.

2.2.4 Water Quality and Sediment Degradation

Throughout history, human impacts adversely affected water and sediment quality in the HRE study area. Unchecked and untreated discharges of human and industrial wastes and debris entered the estuary and its sediments from the time of European settlement to the establishment of environmental regulations in the 1970s. Although the establishment of water quality regulations such as the Clean Water Act (CWA) has led to gradual improvements to water quality, the surface waters are impaired in areas where bathymetry and/or shoreline alterations have affected the natural flows and flushing. In addition, during large rain events, untreated wastewater enters the estuary through the hundreds of CSOs remaining in the HRE. The wastewater contains floatable debris, pharmaceutical agents and nutrients. The nutrients released from the CSOs can indirectly impact dissolved oxygen concentrations, causing decreased fish production, less aquatic vegetation, and noxious odors (Steinberg et al. 2004).

Urbanization also causes less conspicuous impairments to water quality, such as decreased clarity and circulation. For example, excess sediment and contaminants in runoff caused by an increase in paved surfaces can reduce water clarity and quality and impact sensitive habitats, like oyster reefs and eelgrass beds (Steinberg et al. 2004). Reduced water clarity can also affect fish and aquatic invertebrates, such as zooplankton, by interfering with their ability to feed or by changing the composition of prey species and phytoplankton. In some bays and confined waterways with reduced or limited flushing, high organic loads reduce dissolved oxygen and can cause periods of poor water quality.

The presence of contaminated sediment from discharges or spills in portions of the HRE study area has decreased the quality of benthic habitat, and has led to increased contamination in many aquatic and terrestrial species. Sediment and mussel samples from the estuary rank the highest overall in heavy metal, Polyaromatic hydrocarbons (PAH), Polychlorinated biphenyls (PCBs), pesticide, and dioxin concentrations among the estuaries sampled by the National Status and Trends Program. Major sources of contaminated sediments include, but are not limited to, industrial discharges, wastewater treatment plant discharges, CSOs, stormwater runoff, non-point source discharges, atmospheric deposition, and chemical and oil spills (USFWS 1997). Other active sources of contamination to water and sediment quality include: leachate (i.e., water percolating through landfills), as well as persistent sediment contaminants that are vestiges from before the CWA (HEP 1996).

Other significant indirect economic impacts of sediment and surface water contamination are associated with fisheries resources. Although the HRE study area has supported significant fisheries resources, these benefits are unclaimed due to fish consumption advisories relating to high concentrations of mercury, PCB, Dioxin, and dichloro-diphenyl-trichloroethane (DDT) levels in fish and shellfish (Steinberg et al. 2004). Much of the harbor is closed to commercial fishing, and recreational fishing is primarily limited to anglers that practice catch-and-release techniques. Contamination issues have limited the economic benefits that could be achieved through a viable fishery that includes both commercial and recreational party boat fishing industries.

In addition, contamination in surface waters and sediments has also led to significant, indirect economic impacts to the region's population through increased costs of port operation. Maintaining the economic viability of the region requires navigational access to the Port of New York and New Jersey by container ships and vessels. Navigational channels require periodic maintenance and deepening, and placement of the dredged materials, and the costs associated with the placement of dredged materials vary with the concentration of contaminants. Dredged materials with low concentrations of contaminants can be transported by barge for placement at the Historic Area Remediation Site (HARS). However, fine grained, and often contaminated sediments tend to settle in the navigation channels and when dredged, appropriate placement sites must be identified. Expensive processes are often employed to bind or remove the contaminants prior to the overland transport and ultimate upland disposal or beneficial use. These processes can exponentially increase the costs associated with navigation channel maintenance and decrease the overall efficiency of navigation programs.

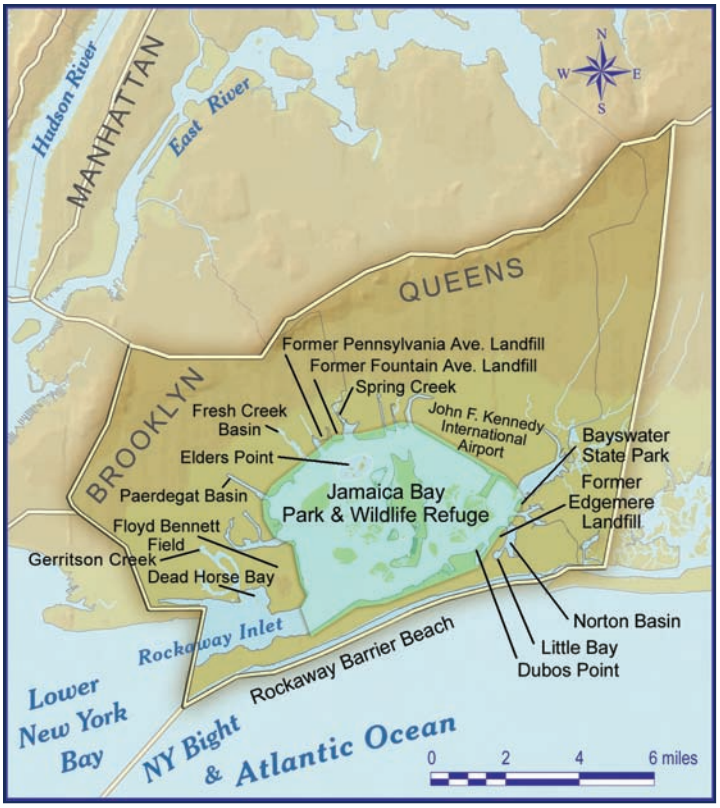


Figure 2-4. Jamaica Bay Planning Region.

2.3 HRE Planning Regions

Within the HRE study area, each of the eight planning regions consists of different habitats that contribute to the overall health of the ecosystem. The following sections describe the existing conditions of the HRE's planning regions.

2.3.1 Jamaica Bay

The Jamaica Bay planning region, located on the southwestern shore of Long Island, is enclosed by the Rockaway barrier beach (Figure 2-4). This region includes portions of Brooklyn, Queens, and Nassau Counties, New York, as well as the John F. Kennedy International Airport. On its western edge, Rockaway Inlet connects Jamaica Bay to Lower New York Bay. Most of the watershed is urbanized and the shorelines are flanked by heavily developed lands, including the Belt Parkway, John F. Kennedy International Airport, and several landfills dominating the shoreline.

This planning region contains one of the last great contiguous blocks of habitat in the HRE study area. The Jamaica Bay Wildlife Refuge, established as part of the Gateway National Recreation Area, was the country's first national urban park and remains an important feature of this region. The wildlife refuge is centered around an artificial impoundment created to replicate the historically common freshwater habitats all now but gone. The Jamaica Bay Park and Wildlife Refuge is dominated by an embayment of eroding tidal wetlands that serve as an island of habitat within the urbanized estuary. These wetlands are visited by over 300 bird species annually, and are home to shellfish, invertebrates, and 49 fish species (RPA 2003).

Islands scattered through the marshes and mudflats support important nesting habitat for colonial waterbirds (USACE 2004a). Upland meadows and shrublands provide habitat for terrestrial species and are important buffer areas. This planning region includes the Jamaica Bay and Breezy Point complex, which has been designated by the USFWS as a Significant Habitat Complex of the New York Bight Watershed. Breezy Point on the western tip of the Rockaway Barrier Beach sustains large populations of beach-nesting birds, and consistently supports one of the largest nesting colonies of piping plovers in the New York Bight coastal region (USFWS 1997). Although fish and wildlife species can use the remaining habitat within the planning region, the wetlands within Jamaica Bay are eroding rapidly and the surrounding land use further diminishes the quality of the habitat (NYSDEC 2001).

Jamaica Bay's Disappearing Wetlands

Since 1974, regulations preventing the dredging and filling of coastal wetlands in New York State helped curtail the rampant acreage losses observed in the early and middle part of the century. Despite this, since the 1990s severe losses of Jamaica Bay's interior wetlands have alarmed stakeholders in the HRE study area. Detailed research studies have investigated the potential causes for the losses, and these efforts continue today. Potential causes and contributing factors range from climate change and erosional losses to invasive species, increased nutrients, and an unbalanced sediment budget. In 2001, the New York State Department of Environmental Conservation (NYSDEC) estimated the annual rate of salt marsh losses in Jamaica Bay at about 44 acres/year between 1994 and 1999. In 2007, the Gateway National Recreation Area conducted a similar study and estimated average wetland losses between 1989 and 2003 at 33 acres/year. Because the reference material, analysis methods, and year evaluated differ, direct comparisons of these studies cannot be made. Despite this, both studies conclude that salt marshes in Jamaica Bay are disappearing and that the rate of this loss has increased in recent decades.

Several recommendations for future watershed protection have been proposed in the Jamaica Bay Watershed Protection Plan developed by the New York City Department of Environmental Protection to protect existing wetlands and curb continuing losses. The wetland-specific planning measures include:

- Prioritize the restoration of additional salt marsh islands (Black Wall, Ruler's Bar, Duck Point, etc.)
- Investigate existing literature and examine various technologies to protect salt marshes from erosive forces
- Evaluate the potential for acquisition and restoration of tidal wetlands and upland buffer areas.
- Reduce the extent of invasive vegetation to create wetlands and/or upland buffers
- Where applicable, implement freshwater habitat restoration plans along the periphery of Jamaica Bay and within the watershed.

GNRA 2007 Study				
Total Vegetated Marsh	**1951**	**1974**	**1989**	**2003**
Vegetated Marsh (acres)	2,347	1,610	1,333	876
Rate of Marsh Loss	**1951-1974**	**1974-1989**	**1989-2003**	
Average Rate of Loss (acres/yr)	17	18	33	
NYSDEC 2001 Study				
Rate of Marsh Loss	**1924-1974**	**1974-1994**	**1994-1999**	
Average Rate of Loss (acres/yr)	~10*	26	44	

*Loss not attributed to direct dredging and fill activities

Sources:

Gateway National Recreation Area and Jamaica Bay Watershed Protection Plan Advisory Committee. 2007. An update on the disappearing salt marshes of Jamaica Bay, New York.

New York City Department of Environmental Protection. 2007. Jamaica Bay Watershed Protection Plan.

New York State Department of Environmental Conservation. 2008. Jamaica Bay Wetland Loss Analysis. Available at http://www.dec.ny.gov/lands/5489.html. Accessed July 30, 2008.

Jamaica Bay is threatened by poor water and sediment quality, and habitat losses. Millions of gallons of urban inputs from combined sewer overflows, landfill leaching, municipal waste discharge, and runoff from the roads and developed areas diminish water quality (USFWS 1997). Chronic erosion in the bay has sloughed off shorelines and deteriorated the interior islands. About 4,000 acres (16 kilometers^2) of the historic wetland habitat remains, a reduction of almost 75% (RPA 2003). Dredging and filling of the wetlands resulted in much of the historic habitat losses in this region. Remnant borrow pits and channels in the Bay, some as deep as 60 feet (18 meters), are sometimes oxygen-poor and do not provide functional habitat for fish and wildlife. These depressions may act as sediment sinks, trapping fine, organic sediment that may have otherwise been deposited on the surrounding wetlands, and may also alter the hydrodynamics of Jamaica Bay by increasing the residency time of water as much as three-fold (RPA 2003, USFWS 1997).

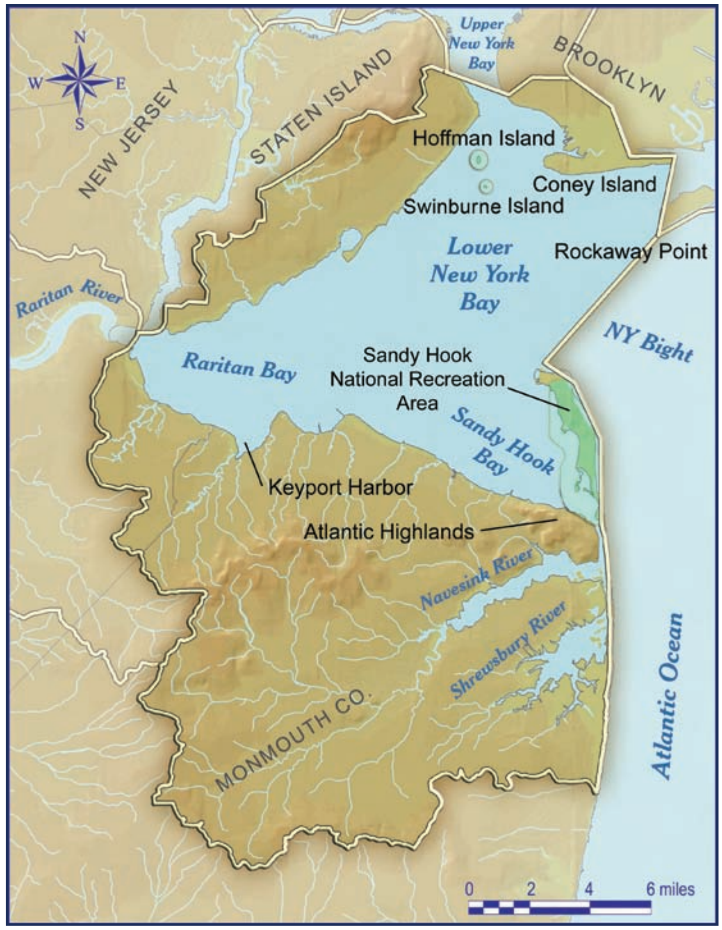


Figure 2-5. Lower Bay Planning Region.

2.3.2 Lower Bay

The Lower Bay planning region contains an expanse of both deep and shallow open water, including Lower New York Bay, Raritan Bay, and Sandy Hook Bay (Figure 2-5). The planning region is bounded on the north by Staten Island and Brooklyn and on the south by Monmouth County, New Jersey, and on the ocean side by a transect between Sandy Hook, NJ and Rockaway Point, NY. This line separates Lower Bay from the New York Bight. The Lower Bay planning region is predominantly developed with industrial, commercial and residential land uses. Sandy Hook peninsula, and Hoffman and Swinburne Islands just off Staten Island are part of the Gateway National Recreation Area. Sandy Hook's shoreline is interspersed with public and private marinas, sandy beaches, and riprap shorelines (USACE 1999). Private and public beaches are scattered throughout the region, located in Monmouth County, New Jersey, and on Coney Island and Staten Island, New York. The surface waters in this planning region are used for commercial shipping and recreation, and support a large recreational fishery and commercial shellfishing (USACE 2004a).

Figure 2-6. A great egret in marsh grasses.

Major waterbodies in this planning region provide a combination of marine, estuarine, and terrestrial habitats that support diverse ecological communities (USACE 2004a). Of the major waterbodies within the planning region, Lower New York Bay generally provides deeper, marine habitat, while the Raritan Bay – Sandy Hook Bay complex provides shallower waters, with much of the bays' 69,188 acre-area (280 kilometers^2) less than 20 feet (6 meters) deep (USFWS 1997). The Lower New York Bay is influenced by Jamaica Bay, Upper New York Bay, the Atlantic Ocean, and dozens of freshwater tributaries. The Raritan Bay receives inputs from the Raritan River and Newark Bay and its tributaries via the Arthur Kill. Sandy Hook Bay receives inputs from the Navesink and Shrewsbury Rivers, which are divided from the Atlantic Ocean by a barrier beach.

When compared to other planning regions in the HRE study area, the Lower Bay has more remaining natural shoreline (USFWS 1997). The relatively long stretches of natural shoreline provide shallow water habitat for many fish and wildlife species (USACE 2004a, USFWS 1997; Figure 2-6). The Raritan – Sandy Hook Bay complex is one of the USFWS Significant Habitats and Habitat Complexes of the New York Bight Watershed (USFWS 1997). Raritan and Sandy Hook bays are characterized by salt marshes, extensive mudflats, and sandy beaches with valuable fish and shellfish habitat (RPA 2003). The National Wetlands Inventory mapped over 4,800 acres (19 kilometers^2) of intertidal and subtidal sand flats and mudflats off the shorelines of the bays and western Staten Island (USFWS 1997). Sandy Hook is a 9-mile (15-kilometer) narrow sand spit that has a fairly extensive vegetated dune system and two distinct maritime forest communities that encompass 285 acres (1 kilometers^2).

Hoffman and Swinburne Islands

In the 19th century, people with contagious diseases were placed in quarantine hospitals around the city, particularly on Staten Island. Public disapproval and unrest over their proximity led quarantine commissioners to construct islands off the coast of Staten Island (Seitz and Miller 2001). Construction of Hoffman and Swinburne Islands began in the mid-1860s using dredged sand from New York Harbor. Both islands were completed nearly a decade later. For almost 50 years, facilities on these islands housed thousands of immigrants, residents, and soldiers infected with contagious diseases like yellow fever and cholera. After the quarantine facilities closed in the 1920s, several uses of the islands were proposed, like creating parkland, waste disposal facilities, or rehabilitation centers. In 1972, the islands were deeded to the Federal government to become a part of the Gateway National Recreational Area. Although there are currently no formal plans for the islands, they remain important, protected nesting habitat for waterbirds in the HRE.

Soft shoreline habitat also exists around Coney Island, and is primarily sandy bank with occasional riprap and seawalls (USACE 1999). The beach habitat provides foraging areas for waterfowl and shorebirds (RPA 2003). Riparian forests of the Atlantic Highlands line the freshwater tributaries that feed into Sandy Hook Bay, the Navesink and Shrewsbury Rivers (RPA 2003, USACE 2004a, USACE 1999). Raritan Bay and Sandy Hook Bay also support the greatest variety of State – and Federally-listed threatened and endangered species in the HRE study area (USFWS 1997).

2.3.3 Lower Raritan River

Primarily located in Middlesex County, New Jersey, the Lower Raritan River is the western-most planning region of the HRE study area (Figure 2-7). This region contains the lower six miles (10 kilometers) of the Raritan River before its confluence with the Raritan Bay (USACE 2004a). Portions of the region stretch into Union, Somerset, and Monmouth Counties, New Jersey.

The shoreline of the Lower Raritan River is flanked with residential or industrial development. Land use changes from predominantly industrial development with bulkheaded shorelines and piers at the river's mouth to a mix of industrial, commercial, and residential development further upstream, which are supported through maintained navigation channels (USACE 2004a, USACE 1999). Agricultural lands are located along the upstream boundary of the planning region (USACE 2004a). Isolated pockets of tidal wetlands occur along the shore (USACE 2004a, USACE 1999). Shoreline industry includes an unremediated landfill, the former Raritan Arsenal, and the Sayreville and Werner generating stations that withdraw water from the river (Figure 2-7). Although there are no public bathing areas in the region, waterbodies are used for recreational navigation and secondary contact recreation including water/jet skiing and fishing (USACE 2004a).

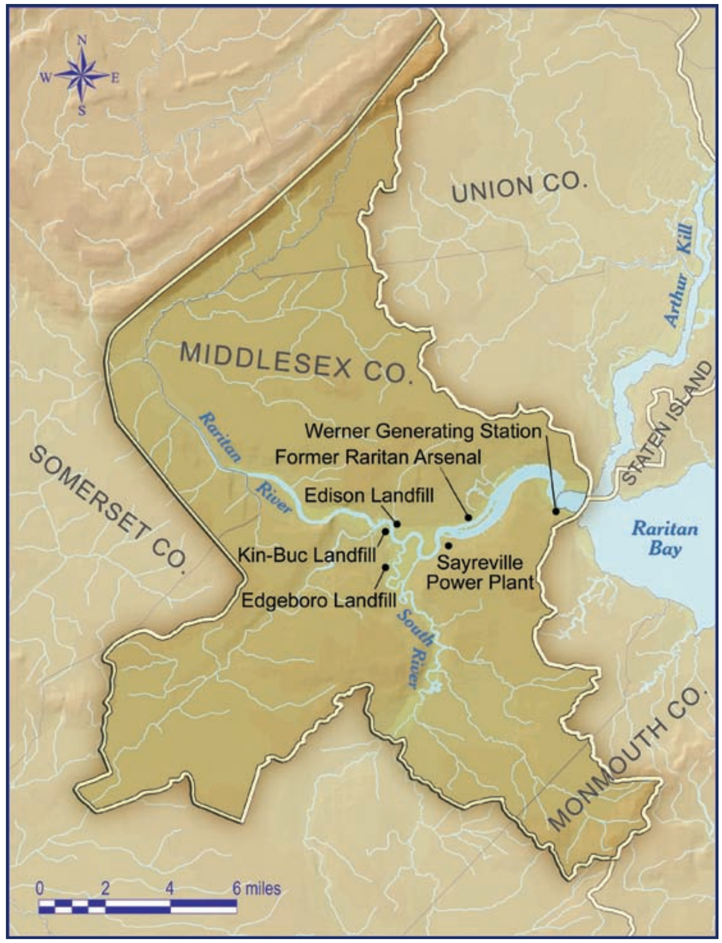


Figure 2-7. Lower Raritan River Planning Region.

This tidally influenced river features some regionally important floral and faunal assemblages (RPA 2003, USACE 2004a). A large wetland complex of 1,000 acres (4 kilometers^2), located in Edison Township provides habitat for waterfowl, wading birds, mammals, and fish (USACE 2004a). Saltwater intrusion occurs throughout the length of the Lower Raritan River, with sensitive estuarine resources such as tidal wetlands, submerged aquatic vegetation, and intertidal mud flats occurring in shallow, near-shore areas (USACE 1999). Some fallow or abandoned agricultural lands afford open spaces for upland wildlife (USACE 2004a). However, these habitats are isolated and somewhat degraded due to the industrial land uses in the region.

The landscape of the Lower Raritan River planning region has changed tremendously over the past few centuries. Wetland losses due to filling have been estimated at 93% of their former area, and remaining wetlands are generally a degraded mix of non-native or invasive plants (USACE 2004a). In addition, 12 dams are located on the Lower Raritan River and its tributaries, and these dams impede the movement of diadromous fish that travel upriver or downriver to spawn.

2.3.4 Arthur Kill and Kill Van Kull

HRE planning region is joined to Upper New York Bay via the Kill Van Kull (another tidal straight) and mixes waters with Newark Bay. The Arthur Kill is also the water body connecting Newark Bay with Raritan Bay. Important freshwater tributaries of this region include the Rahway and Elizabeth Rivers and Fresh Kills Creek (USACE 2004a). The Arthur Kill/Kill Van Kull planning region has a dynamic hydrology due to the variation in tidal velocity, amount of freshwater flow, and bathymetry among the three connecting bays (i.e., Upper New York, Newark, and Raritan bays; USACE 1999).

These waterways exist within a heavily industrialized and developed corridor, with an average population density of almost 5,000 people per square mile (2,000/kilometers^2). The New Jersey side of the Arthur Kill is industrialized, while in New York, large areas of wetlands are intermingled with facilities. On Staten Island wetlands are located adjacent to the largest landfill in the region (Fresh Kills) and a coal fired power generating plant. In the southern section, many abandoned industrial facilities exist along the shoreline (USACE 2004a). The industries of the Arthur Kill and Kill Van Kull waterways process petroleum and non-petrol chemicals along their shorelines, and occasional oil spills occur (Yozzo et al. 2001, Steinberg et al. 2004). Scattered among the refineries are four area landfills, three power plants that withdraw water from the Arthur Kill, and three sewage treatment plants that discharge effluent in the Arthur Kill (USACE 2004a, Yozzo et al. 2001). At least 30 closed landfills and dozens of contaminated brownfields discharged leachate into the groundwater. Although leachate collection systems are now in place on most of the closed landfills, many of these chemicals are persistent in the sediment (USACE 2004a). The Arthur Kill and Kill Van Kull also have deepwater navigation channels that allow transport of cargo into and out of the ports of New York and New Jersey. Abandoned industrial areas are also common, which are typically littered with debris.

The Arthur Kill/Kill Van Kull complex has been designated as a Significant Habitat Complex of the New York Bight Watershed by the USFWS (USFWS 1997). The extensive tributary system of Arthur Kill provides major blocks of tidal and freshwater wetlands, marshlands, mudflats, and intact riparian habitat. With 16 tributaries, nine in New Jersey and seven in New York, this region offers much needed backwater habitat for important marine and estuarine fish species, such as winter flounder, black sea bass, and red hake (RPA 2003). This region also contains deepwater habitats in which over 60 migratory and resident fish species have been collected (USACE 2004a).

Three islands are located in the Arthur Kill/Kill Van Kull planning region. Pralls Island and the Isle of Meadows are located adjacent to the western shoreline of Staten Island on the Arthur Kill, and Shooters Island is located on the Kill Van Kull. Large breeding populations of herons, egrets, and ibises have used these uninhabited islands as nesting sites, and the nearby marshlands and mudflats as foraging areas. Between the late 1970s through to the early 1990s, the islands supported the largest heron rookery in New York State. It was

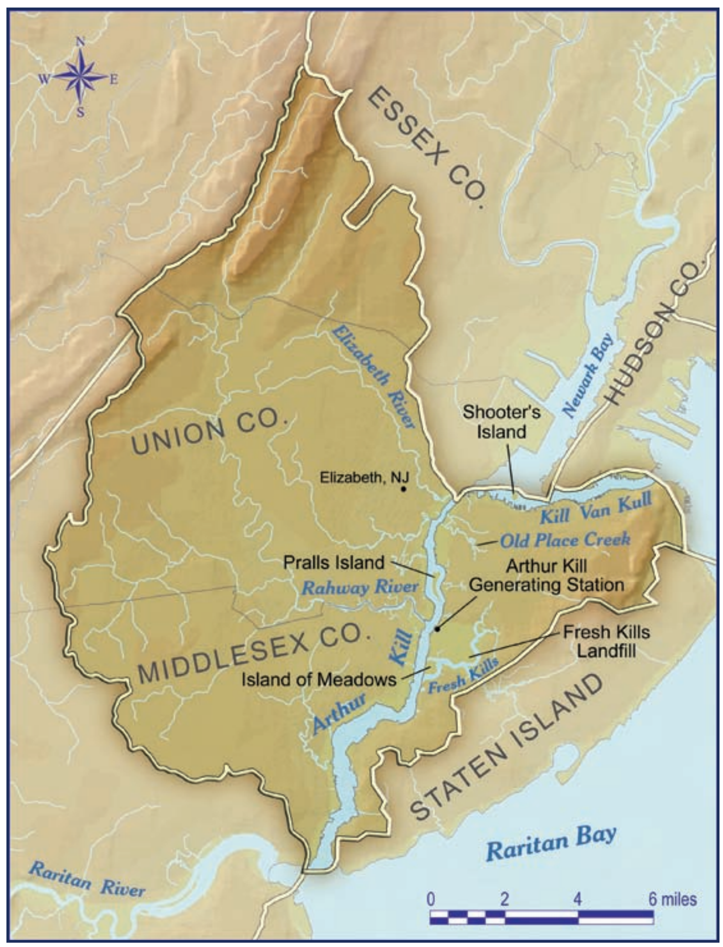


Figure 2-8. Arthur Kill and Kill Van Kull Planning Region.

estimated that the entire rookery in the HRE study area accounted for almost 25% of the wading birds that nested in coastal waters within New York, New Jersey, and Connecticut (USFWS 1997). Although currently none of the islands in the Arthur Kill region support active wading bird rookeries, these islands provide habitat for other bird species and may be recolonized by wading birds in the future, especially if restored (Bernick 2006).

Many of the coastal sections in this planning region are fragmented or degraded, and monotypic stands of the common reed (*Phragmites* australis) dominate blocks of wetlands (USACE 2000). Several spillways and cement riverbeds exist on tributaries on both sides of the Arthur Kill, creating ponds for urban parks (Durkas 1992). Unfortunately, these structures often deter movement of anadromous fish (USACE 2000, Durkas 1993, Durkas 1992, USFWS 1997). This region has had long-term issues with poor water quality and high contaminant levels (USACE 1999). However, because this HRE planning region contains over 30,000 acres (>120 kilometers^2) of open space, these sites have the potential of being important for future habitat restoration programs (RPA 2003).

2.3.5 Newark Bay, Hackensack River, and Passaic River

The Hackensack and Passaic River basins create the upper boundary of this HRE planning region, with the lower boundary encompassing Newark Bay and its ports (Figure 2-9). This watershed is indirectly connected to Upper New York Bay and Lower New York Bay through Kill Van Kull and Arthur Kill, respectively. The Hackensack and Passaic Rivers drain portions of the densely populated Bergen, Passaic, Hudson, Essex, and Union Counties, New Jersey, in which the cities of Newark and Paterson are located. A small portion of Rockland County, New York is also included in this planning region.

Predominant land uses in this planning region include commercial, industrial, and residential development. Surface waters are withdrawn from the Hackensack and Passaic Rivers and used as cooling water at three power plants. Three sewage treatment plants are also located in this region (USACE 2004b). Along the western shoreline of Newark Bay are Port Newark and the Elizabeth-Port Authority Marine Terminal. Collectively, these ports are the largest maritime cargo handling facilities on the East Coast of North America, and operate primarily as a container ship facility. The Hackensack Meadowlands District is a dominant feature within this region, measuring approximately 19,730 acres (80 kilometers^2). The lower 1.7 miles of the Lower Passaic River is dominated by petroleum commercial facilities currently utilizing the river. The upstream

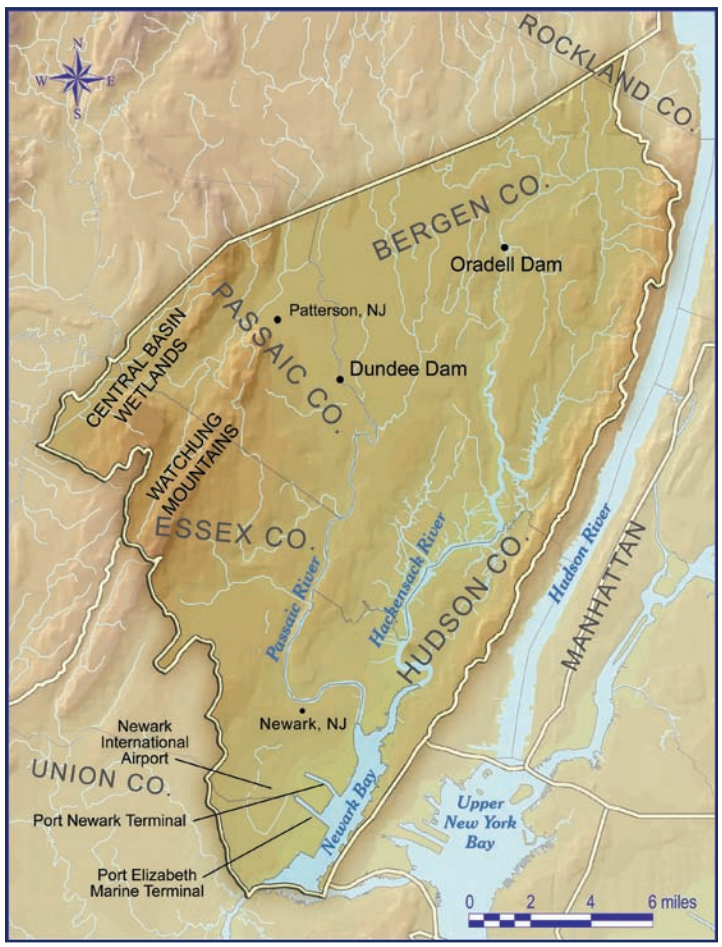


Figure 2-9. Newark Bay, Hackensack River, and Passaic River Planning Region.

reaches of the Lower Passaic predominantly support recreational uses (USACE 2008a). The District contains residential, commercial, industrial, and landfill areas, as well as tidal wetlands and large areas of open space.

Two large habitat complexes of regional importance and ecological value in this region are the New Jersey Hackensack Meadowlands and a portion of the Central Basin Wetlands. Within the Hackensack Meadowlands District exists the largest remaining brackish wetland complex in the HRE study area measuring approximately 8,400 acres (34 kilometers^2; USACE 2004b). Originally a large, 21,000 acres (85 kilometers^2) marshland complex, the Meadowlands have diverse habitat types and over 100 species of nesting birds, fish and shellfish, many of which are State – or Federally-protected (RPA 2003). Near the Watchung Mountains, the Central Basin Wetlands support large swamp areas and forested wetlands that are fed by several important tributaries.

Lower stretches of the Passaic and Hackensack Rivers provide habitat for marine and estuarine fish and invertebrates, while further upstream, the rivers support a mix of estuarine and freshwater species (USACE 2004b). Newark Bay's open water is used by many fish and invertebrate species as nursery habitat, although its shorelines and river channels have been greatly modified by bulkheads and riprap. Unfortunately, the hydrology of open river areas has been altered by numerous flood risk management structures, dams and debris, which reduce connectivity and freshwater flow to Newark Bay, and block upstream passage by fishes (USFWS 1997). Anadromous fishes make annual spawning runs up the 17-mile (27-kilometer) tidal stretch of the Passaic River to the Dundee Dam, but are blocked from going further. The Oradell Reservoir Dam, on the Hackensack River, blocks passage of American shad, alewife, and blueback herring from reaching upstream segments of the watershed (USACE 2004b). Other smaller dams and inoperable tide gates in the planning region degrade habitat and impair passage for anadromous species (Durkas 1993). Catadromous species, like American eel, may also be negatively affected by these impediments.

Development in this region has contributed to extensive habitat losses. Historic wetland losses have transformed the Hackensack Meadowlands from a rich combination of fresh and saltwater marshland into a less diverse, brackish tidal marsh with a 60% loss in area (RPA 2003, USACE 2004b). Even at this reduced size, the Meadowlands still represents, after Jamaica Bay, the largest remaining tracts of habitat in HRE study area. Many streams feeding into the Hackensack and Passaic have been converted to storm sewer drainages. Surrounding wetlands were either filled, or mosquito ditches were dug, in order to control mosquito populations. The destruction of shallow water habitats have led to poor water quality and have altered the floral and faunal species assemblages (USACE 2004b, Yozzo et al. 2001). Shorelines and river channels have been greatly modified by bulkheads and riprap. Dams and debris reduce connectivity and freshwater flow to Newark Bay, and block upstream and downstream passage by fishes.

The level of contamination in this region is of great concern to stakeholders. The lower Hackensack River and Passaic River basins and Newark Bay have been a center of industry since the Industrial Revolution. As a result, hundreds of chemical, herbicide, paint and pigment manufacturing plants, petroleum refineries, and other large industrial facilities have been located along their banks. Effluent from these facilities has caused severe contamination of sediments in the rivers. Although several petroleum refineries and chemical manufacturing plants continue to operate, the majority of the industrial facilities in the planning region have been shut down, but their legacy of contaminants still remains in the sediments. Primary contaminants of concern in the study area include dioxins (2,3,7,8-tetrachlordibenzo-p-dioxin [TCDD]), mercury, lead, polychlorinated dibenzofurans (PCDF), PCBs, PAHs, and DDT. Many of these contaminants pose risks to human and ecological health. Several U.S. Environmental Protection Agency (USEPA) Superfund sites exist within this planning region, including the 17-mile tidal portion of the Lower Passaic River, Newark Bay and portions of the Hackensack River. Pathogenic microbial contamination, floatable debris, excessive levels of waterborne nutrients, and non-point source discharges further impair water quality. There are strict consumption advisories for fish and crab caught from this region.

Newark Bay is heavily trafficked by container vessels, with the ports of New York-New Jersey bringing in billions of dollars in commerce annually. Channel deepening, maintenance dredging and port expansion to ensure the economic viability of the ports also increases the risk of environmental degradation to valuable habitat (USFWS 1997). While degraded, the Meadowlands and surrounding areas in this region represent significant open spaces that continue to function as flood storage and habitat and offer much in the way of restoration potential (USFWS 1997).

2.3.6 Lower Hudson River

The Lower Hudson River planning region extends from the Upper New York Bay to the Tappan Zee Bridge, and includes the ports and riparian lands in Bergen and Hudson Counties, New Jersey and New York City, Rockland, and Westchester Counties, New York (Figure 2-10). The area along lower Westchester County (i.e., Yonkers) and into western Manhattan is densely populated. Areas in north-eastern New Jersey along the Hudson River coastline, such as Jersey City with a population of approximately 240,000, are among the most populated in the state (USACE 2006a). Palisades Park runs along the western shoreline of the Lower Hudson River from Bergen County, New Jersey to Rockland County, New York.

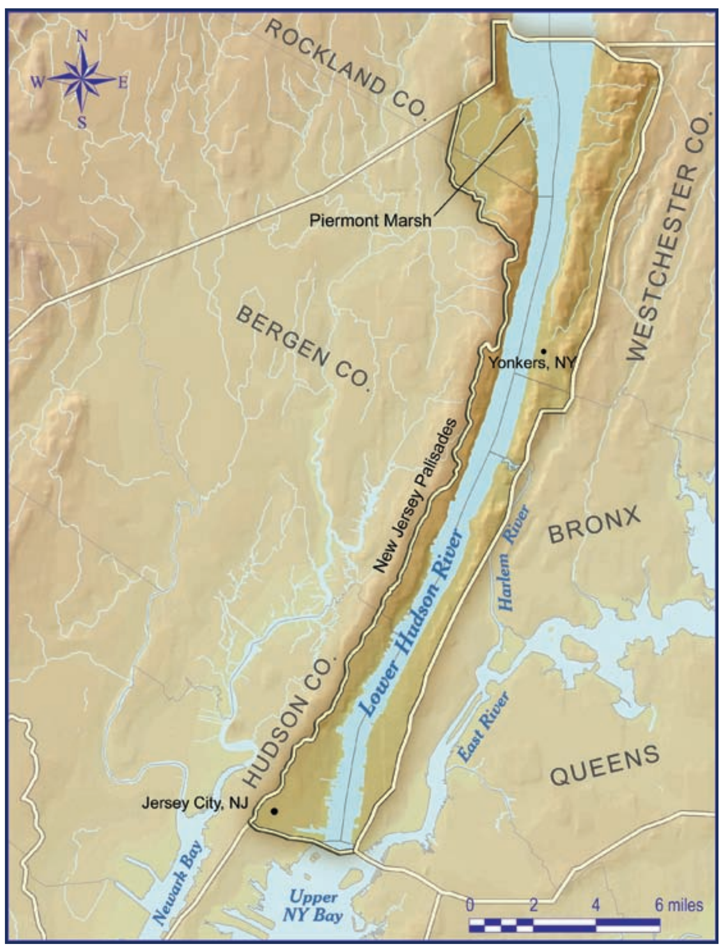


Figure 2-10. Lower Hudson River Planning Region.

Land use along the shoreline consists of residents, marinas, marine parks, some vacant disturbed lands, and scattered commercial and industrial facilities, especially in areas below the George Washington Bridge. Recreational and commercial boating are prevalent. Power plants draw cooling water from the Lower Hudson River (although most of these plants are upstream of the HRE), and nine wastewater treatment plants are located in this region (USACE 2004a).

Strong semi-diurnal tides make the Lower Hudson River one of the few major tidal rivers of the North Atlantic coast (USFWS 1997). This stretch of river is naturally turbid, with limited primary productivity and moderate to high salinity levels. The Lower Hudson River includes a wide range of riverine and estuarine habitats that function as overwintering habitat and significant nursery areas for many fish and invertebrate species (USACE 2004a, USFWS 1997, USACE 2000). This planning area is located within a USFWS designated Significant Habitat Complex of the New York Bight Watershed. The Lower Hudson River is the primary nursery and overwintering area for striped bass in the Hudson River estuary (USFWS 1997). The Federally-listed endangered species, shortnose sturgeon (Acipenser brevirostrum) and the Atlantic sturgeon (A. oxyrhynchus) also spawn in the Lower Hudson River (NYSDEC 2008, USFWS 1997). At the northern reach of the region, Piermont Marsh provides intertidal wetlands and emergent vegetation for aquatic and terrestrial species. Other shallow-water habitat, like shoal and inter-pier areas, may be important foraging sites for young fish before they move into deeper Harbor waters (USACE 2004a).

Like most major rivers of the U.S., the Lower Hudson River is maintained for navigation and has been affected by centuries of human use. Consumptive uses of freshwater impact the Lower Hudson River two-fold; by potentially causing the salt-front to migrate upstream and by discharging the used water into a higher salinity zone (USFWS 1997). Artificially changing the natural salinity range has secondary effects on species diversity and habitat function, particularly of wetlands like the Piermont Marsh, which are currently dominated by monotypic *Phragmites* stands (USFWS 1997; Figure 2-11). Maintenance of the shipping channel and bulkhead construction have progressively narrowed and deepened the river. Because the western shore runs along the New Jersey Palisades (a geologic feature dominated by steep, rocky shorelines) littoral (e.g., shallow water) habitat is naturally sparse. Hardened shorelines from bulkhead and pier areas on the eastern shore eliminated any remaining natural shoreline and littoral habitats (USACE 2000).

Figure 2-11. Piermont Marsh located south of the Tappan Zee Bridge.

The Lower Hudson River is also contaminated with persistent chemicals. Between 1946 and 1977, nearly 500,000 pounds of PCBs were discharged from two General Electric Company plants located in the upper Hudson River, upstream from this HRE region (Yozzo et al. 2001). Because of this contamination, the USEPA designated a 200-mile stretch of the Hudson River, from Hudson Falls to the Battery in New York City, as a Superfund site. The resulting contamination of benthic habitat and fish tissue led New York State to close the commercial striped bass fishery throughout the river in 1976 and to issue consumption warnings for many other important species of the Hudson River (USEPA 2008, NYSDOH 2008). The New York State Department of Health recommends consuming no more than one meal per month of striped bass collected from the Lower Hudson. The General Electric Company is working with the USEPA to develop a dredging program to safely clean the river and a project to install alternate drinking water lines to area residents.

2.3.7 Harlem River, East River, and Western Long Island Sound

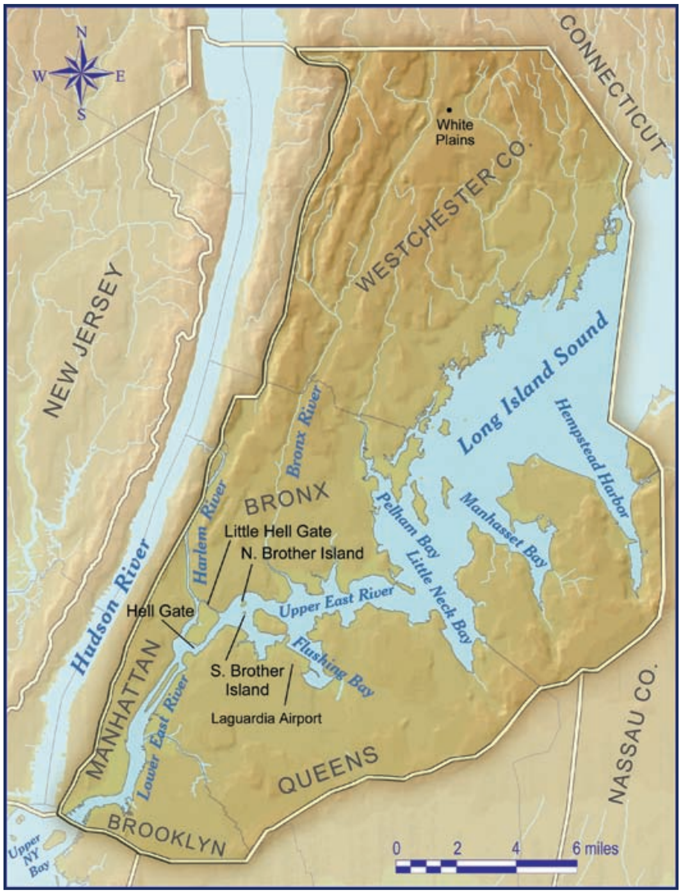


Figure 2-12. Harlem River, East River, and Western Long Island Sound Planning Region.

This HRE planning region contains sections of Manhattan and the Bronx to the north, and Brooklyn and Queens to the south (Figure 2-12). It extends east to include part of the Long Island Sound and portions of Westchester and Nassau Counties, New York. The East River is an important tidal strait connecting Long Island Sound and Upper New York Bay. The brackish Lower Hudson River connects to this system via the Harlem River.

It is the most densely populated of the eight HRE regions. Shorelines along the Harlem and East rivers are lined with urban residential, commercial, and industrial development. Commercial ferry terminals, marinas, and parkland are also found along the shorelines of this planning region. The waterways are used for commercial navigation as well as recreation boating, fishing, and water/jet skiing. Public and private beaches, found in the Upper East River and Western Long Island Sound, are open for bathing except when total coliform concentrations exceed water quality criteria. This planning region receives treated effluent from six sewage treatment plants, and water is withdrawn from the East River by four power plants (USACE 2004a).

Complex tidal flow patterns prevail in this region. The tidal influences in the East River from Upper Bay and Long Island Sound interact with the generally southern movement of water from the Hudson River through the Harlem River (USACE 1999). The result is a region influenced by the tidal patterns of three estuarine bodies that serves as a significant route for migratory fishes (RPA 2003, USACE 2004a). However, many of these fish populations, like American eel, winter flounder, and especially the Atlantic and shortnose sturgeons, are fractions of their historic population levels, likely due to historic harvest, impoundments, and/or habitat degradation within this planning region as well as the entire HRE study area (Mayo et al. 2006).

Many tributaries of the East and Harlem Rivers have been channelized and re-directed through culverts. The upper East River still has bays and creek mouths but with sparse remnants of tidal wetland and upland habitats (RPA 2003, USACE 2004a). Several islands in this region support large populations of wading birds, most notably South Brother Island, which was recently estimated to support almost 500 breeding pairs of wading birds and over 300 cormorant nests (Bernick 2006, Blanchard et al. 2001). Further east into Long Island Sound, the southern shore contains some of the most significant waterfowl wintering areas in the HRE, Little Neck Bay, Manhasset Bay, and Hempstead Harbor (USACE 2000, USACE 2004a). Many marine and estuarine finfish species, like bluefish, scup, striped bass, and winter flounder, also seek out these bays as nursery and foraging areas (USACE 2004a). Pelham Bay is regionally distinct, pairing rocky outcroppings of the New England rocky coast with intertidal mudflats that are exposed during low tide.

These areas are stressed by numerous factors that threaten water quality and habitat integrity (Yozzo et al. 2001), such as shoreline development, persistent contamination, and pollutant discharges (USFWS 1997). Like all areas in the HRE study area, the shores are heavily urbanized, lessening much of the ecological benefit provided by its beaches, decreasing transitional littoral habitat, and fragmenting important shorebird feeding and waterfowl wintering areas. Water and sediment quality are degraded due to numerous point sources: leachate from landfills and many CSO outfalls (USACE 2000).

Water quality in the tributaries of this planning region has been severely degraded by industrial and CSO inputs, such as in Newtown Creek, limiting the waterways to primarily transportation-related uses. With the exception of Tibbets Brook and Little Hell Gate, the Harlem River's tributaries are completely enclosed in culverts and are often redirected several city blocks from their historic route to allow for building or road construction. In the lower East River, most of its shorelines have been bulkheaded and filled, creating a deep, narrow passage. River obstructions that created topographic relief, like reefs, shallows, and rocks, were dredged or blasted to create a continuous, navigable channel through Hell Gate (USACE 1999).

2.3.8 Upper Bay

The Upper Bay planning region is centrally located within the HRE study area, connecting five other HRE regions (Figure 2-13). The Upper Bay begins at the mouth of the Hudson River as it empties into the Lower New York Bay, is connected to the Newark Bay and Arthur Kill via the Kill Van Kull, and exchanges water with the East River and Long Island Sound. The Upper Bay, surrounding the Statue of Liberty, Ellis and Governor's Islands, is closely tied to portions of Manhattan, Brooklyn, and Staten Island, New York as well as Hudson County, New Jersey.

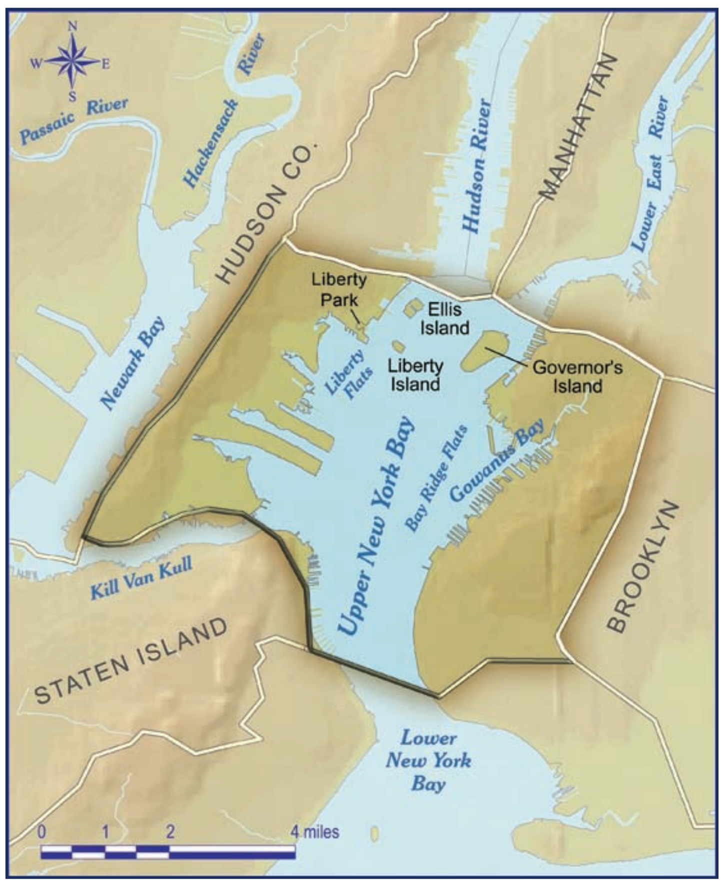


Figure 2-13. Upper Bay Planning Region.

Development along the shoreline of the Upper Bay planning region is primarily commercial and industrial, with few non-industrial uses. Industrial and CSO inputs in Upper Bay tributaries has severely degraded their water quality, such as in Gowanus Canal, limiting the waterways to primarily transportation-related uses. Scattered among the shipping terminals and marinas are parklands or public promenades, some vacant disturbed land, and small residential areas. Existing parks, like

Liberty State Park provide some recreational areas and open spaces, but are mostly lined by bulkheaded shorelines. Two sewage treatment plants discharge effluent into the Upper Bay (USACE 2004a).

Unhardened shoreline habitat and valuable aquatic habitat in the Upper Bay are limited. Shoreline habitat can be found in the form of wetlands on the west side of Liberty Island. Remnant mudflats are located along the New Jersey coastline (USACE 2000, USACE 1999). Sandy shallows within the Bay Ridge Flats that have been significantly reduced in size over time by dredging are located along the eastern edge of the Bay. These flats provide some habitat to many species of young fishes. The Upper Bay is still a critical component of the HRE study area because it serves as a migratory pathway for many fish species, providing access to important feeding, overwintering, and nursery areas (USACE 2004a).

In the HRE study area, the Upper Bay is a vital link among the other regions; both influencing them and being influenced by their hydrology, biology, and impairments. This region is heavily urbanized along its perimeter, made possible through shoreline filling and hardening. Even the open water is crowded with ship traffic and large channels that must be maintained. Sediment contaminants occur in several waterfront areas of the Upper Bay due in part to historic industrial uses, local runoff, and CSO inputs. Shallow sheltered areas and littoral habitats are almost non-existent, and heavy commercial boat traffic erodes unprotected shorelines (USACE 2004a).

2.4 Restoration Efforts

Ecosystem restoration and conservation programs have existed in the HRE study area for decades, and many of these efforts have been successful. Prior to 1990, restoration programs coordinated by state governments and local organizations focused on habitat protection, in which pre-existing natural lands were acquired and public lands were protected from development. Land acquisition of wetlands and other valuable open spaces still regularly occur in New York City, Long Island, and northeastern New Jersey, and are supported through public funding and legal settlements from parties responsible for discharges and spills (NYSDEC 2008, NJDEP 2008). An example is the PANYNJ's Hudson-Raritan Estuary Resources Program. This publicly-funded acquisition program has protected approximately 295 acres of habitat from development since its inception in 2001. Land acquisition remains an important component of any restoration plan and one that directly goes to the point of preventing habitat losses from reaching a critical point, as well as providing a location to implement restoration.

For the past two decades, HRE stakeholders have adopted a proactive approach toward conservation. Current programs often consist of physically altering

Jamaica Bay Ecosystem Restoration Project

The Jamaica Bay Ecosystem Restoration Project (JBERP) is the result of an interagency collaboration among the USACE – New York District, the NYCDEP, NYSDEC, NYCDPR, and the NPS, among other agencies. These agencies are working to protect this 9,155-acre area (37 kilometers^2), one of the nation's most important urban wildlife refuges. The USACE began investigating restoration opportunities in 1992, and since then have narrowed the scope of the program to focus on several areas along the region's perimeter. The recommended sites for restoration include Bayswater, Dead Horse Bay, Dubos Point, Elder's Point, Fresh Creek, Paerdegat Basin, and Spring Creek. The JBERP plans to increase the habitat diversity and overall connectivity among adjacent habitat types to create a full functioning, integrated estuarine system. Water quality improvements will facilitate increases in intertidal and subtidal habitat function, increases in prominent benthic and shellfish populations, and subsequent increases in resident and migratory fish species.

Liberty State Park Restoration Project

Liberty State Park is one of the first restoration studies conducted under the HRE study authority. The 30-year old park, located on a 1,122-acre (4.5 kilometers^2) plot by the water's edge in Jersey City, New Jersey, is in the Upper Bay HRE Planning Region (USACE 2004c). It offers spectacular views of the Manhattan skyline, the Statue of Liberty, and Ellis Island, as well as a green oasis amidst dense development. An estimated 4.3 million visitors a year enjoy its man-made walkways, open spaces, and educational centers (USACE 2004c).

Human-induced disturbances have re-shaped the ecological community and conditions within the park. This site was originally an intertidal mud flat and salt marsh that was filled and stabilized, then used by the Central Railroad of New Jersey Terminal for freight and passenger services (USACE 2004c). Once rail operations ended and the terminal facilities were removed, natural succession resulted in ecological communities dominated by invasive species and low animal diversity, which is indicative of a highly disturbed area that is isolated from surrounding natural areas. Currently, a large undeveloped section located at the center of the park (approximately 250 acres) is inaccessible to the public due to high concentrations of sediment-borne toxins (USACE 2004c).

Restoration plans will complement the existing parkland by offering natural spaces. A tidal marsh is planned in the park's center, along with enhancements to the uplands and freshwater wetlands within the undeveloped area. A narrow channel will connect the tidal marsh to the North Cove. Nuisance plant species will be controlled and native grasslands, shrublands, and forests will be planted. The salt marsh will add an entirely new host of functions and values that are not present in the park, particularly aquatic habitat for fish and waterfowl. A system of walkways and observation platforms are planned, which will add educational and aesthetic value to the inherent ecological value of Liberty State Park.

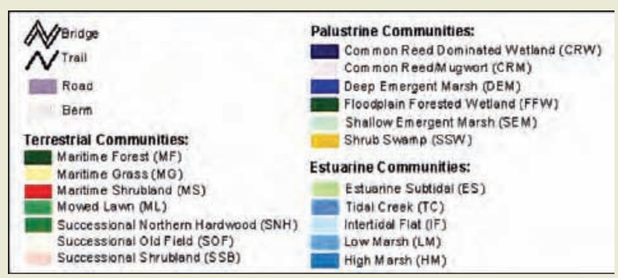


Table 2-1. Examples of Current Restoration Programs and Studies in the Hudson-Raritan Estuary Study Area.

Lower Passaic River Restoration Project, NJ

USACE, USEPA, NJDOT, NJDEP, NOAA, USFWS

Status: Feasibility Study

Website: www.ourpassaic.org

Develop a comprehensive watershed-based plan for the remediation and restoration of the Lower Passaic River Basin. Habitat losses of floodplains, wetlands waterfowl nesting areas, and valuable fish spawning and benthic habitats will be remedied through restoration of specific habitats, vegetative buffer creation, shoreline stabilization, and aquatic habitat improvements. The remedy will include long-term, effective reduction of toxicity, mobility, and volume of sediment contamination to improve habitat and reduce potential effects to human health and the environment.

Hudson River Estuary Program

NYSDEC

Status: Implementation

Website: www.dec.ny.gov/lands/4920.html

Based on 1996 Action Plan; comprehensive restoration of intertidal and subtidal freshwater and oligohaline habitats, conservation of natural resources, promote full public use and enjoyment of the river.

Harbor Estuary Program

USEPA, USACE, PANYNJ, NY, NJ, Local Government, NGOs.

Status: Planning

Website: www.harborestuary.org

Established as part of the National Estuary Program, the HEP manages a multi-year effort to develop and implement a plan to protect, conserve, and restore the HRE.

Hackensack Meadowlands Restoration Program, NJ

USACE, New Jersey Meadowlands Commission

Status: Feasibility Study

Website: www.nan.usace.army.mil/harbor/envt.htm

Develop a comprehensive watershed-based restoration plan. Initiated to acquire and enhance significant wetland habitat, this program also plans to improve tidal flow and manage connectivity, monitor water quality, and develop a hydrodynamic model to address flood control and water quality improvement. Opportunities also exist for cleanup of sediments that have been contaminated by numerous non-point sources.

Gowanus Canal and Bay Restoration Study, NY

USACE, NYCDEP, Gowanus Canal Community Development Corporation, Urban Divers, Friends and Residents of Greater Gowanus

Status: Feasibility Study

Website: www.nan.usace.army.mil/harbor/envt.htm

Restoration opportunities include selective dredging or capping to reduce sediment contaminants, wetland creation, and water quality improvements in confined waterways.

Long Island Sound Study

Save the Sound, NOAA, USEPA, USFWS, CTDEP, NYSDEC, NYCDEP

Status: On-Going

Website: www.longislandsoundstudy.net

Part of the National Estuary Program, this program is a collaborative effort to protect and restore degraded fish and wetland habitat. Particular focus is given to hypoxia, habitat restoration, public involvement and education, and water quality monitoring.

New York City Pier Restoration, NY

Hudson River Park Trust, HEP, Patagonia Soho, NYU, Harbor Estuary Stewardship Program

Status: Planning

Website: www.fohrp.org

The dilapidated piers are being reconstructed into public spaces for mixed uses, including lawn/garden areas, scenic overlooks, playgrounds, athletic fields, event space, community docks, historic resources, and educational and research facilities.

Bridge Creek Wetland Restoration Project, NY

NOAA and NYSDEC

Status: Planning

This project on Staten Island is part of a larger effort to restore degraded wetland habitat, remove invasive species, and preserve existing wetlands and uplands using NRDA funds from the 1990 oil spill in the Arthur Kill. The project will restore 18 acres (0.07 km^2) of wetlands near the Arthur Kill.

Metropolitan Waterfront Alliance

Status: On-Going

Website: www.waterwire.net

Comprised of hundreds of civic organizations, public agencies, companies, utilities, and community groups, the MWA is working to transform the waterways of the HRE to make the waters of NYC cleaner and more accessible. Coordination with diverse stakeholders has resulted in creating a clear agenda of action.

Flushing Bay and Creek Restoration Study, NY

USACE, NYCDEP, PANYNJ

Status: Feasibility Study

Flushing Bay's ecosystem has been degraded through filling, shoreline hardening, and effluent from CSOs and landfills. Potential restoration measures for the area include: tidal and freshwater wetland restoration, complete removal of an earthen dike that restricts tidal flow, stabilizing shoreline, and debris removal.

Contamination Assessment and Reduction Project (CARP)

HRF, PANYNJ, NJDOT, NYSDEC, NJDEP, USACE, USEPA, USGS, Environmental Defense, multiple universities and research groups

Status: On-Going

Website: www.carpweb.org/main.html

The CARP began in the 1990s to identify and quantify sources of contamination in the HRE and reduce levels of contaminants in sediments, water, and organisms (e.g., fish tissue). This data collection and modeling effort revealed the extent to which persistent, legacy chemicals continue to contaminate the HRE study area and recommends sediment remediation as the most significant method of contaminant control. The CARP products can provide new and important information on managing contaminants and insight into their fate and transport, but the models still require additional data collection and refinement to answer most project-specific questions.

Woodbridge Creek Restoration & Mitigation Project, NJ

USACE, PANYNJ, NOAA, and NJDEP

Status: Construction

This project includes tidal wetland restoration and preservation to reconnect nearly 70 acres (0.28 km^2) of healthy existing and newly created wetlands to the Arthur Kill and provide public access and educational nature trails.

Bronx River Restoration, NY

USACE, NYCDEP, Westchester County Dept. Of Planning

Status: On-Going

This study is developing a watershed restoration plan for the Bronx River Basin.. The findings of the plan will both identify potential restoration opportunities and aid in informing the site selection prioritization process. This plan will also identify key non-structural components of environmental restoration and maintenance operations and actions that would complement the proposed restoration actions.

Liberty State Park, NJ

USACE and NJDEP

Status: Pre-construction

Website: www.nan.usace.army.mil/harbor/envt.htm

This is one of the first restoration studies conducted under the HRE study authority, and will include the reintroduction of tidal wetland habitat, protection and enhancement of freshwater wetlands, native grasslands and maritime forests, and creation of public access trails for the approximately 4.3 million visitors a year.

Jamaica Bay Ecosystem Restoration Project NY

USACE, NYCDEP, NPS

Status: Feasibility Study

Website: http://www.nan.usace.army.mil/project/newyork/factsh/pdf/jamaica.pdf

Investigate chronic loss of perimeter wetlands and the benefits of restoring the underwater borrow pits in Norton Basin and Little Bay.

Other projects work to promote better water circulation and restore tidal flow, maritime forests, and benthic habitat.

Office of Natural Resource Restoration, NJDEP

Status: On-Going

Website: www.nj.gov/dep/nrr/

Similar to Federal Trustees like NOAA and USFWS, the NJDEP's Office of Natural Resource Restoration (ONRR) assesses damages to natural resources and works to accurately identify instances where environmental injuries are caused by specific releases. If a responsible party is identified, restoration and/or compensation for damages will be reached through a settlement, which will specify an adequate dollar amount for compensation and a proposed use of the funds. Settlements cover initial assessment and litigation costs, as well as fund restoration projects or habitat acquisitions.

Passaic River Coalition, NJ

Status: On-Going

Website: www.passaicriver.org

The Passaic River Coalition has been working since 1969 to improve the Passaic River watershed by gathering and using pertinent data to protect drinking water, preserve sensitive wildlife habitat, improve water quality, create new open space, and promote natural flood control management. This organization has led or participated in many initiatives including: Lower Passaic River Restoration Initiative, New Jersey's watershed management area (WMA) programs, Blue Acres Program to reduce flood conditions, and a Land Trust to acquire properties of ecological significance and unique landscape character for water resource protection.

Natural Resources Group, NY

NYCDPR

Status: On-Going

Website: www.nycgovparks.org/

The NRG, which is a division of the Parks Department, has pioneered the field of urban ecological restoration and acquired natural lands, stabilized eroding shorelines, and conducted restoration programs throughout NYC. Several programs are specifically focused on coastal restoration, and when complete, will add approximately 200 acres (0.8 km2) of critical estuarine habitat. Many larger programs include salt marsh restoration components, like Turtle Cove in the Bronx, Spring Creek in Brooklyn (with USACE), and Alley Park in Queens, New York.

Harbor Herons Project, NY/NJ

New York City Audubon Society

Status: On-Going

Website:www.nycaudubon.org/projects/harborherons/

The Harbor Herons Project, led by the New York city Audubon Society, conducts annual breeding bird surveys of heron, egret, and ibis colonies in NYC, providing valuable information on their population status and breeding habits. The program has recently been expanded to include monitoring of shoreline areas to gain information on foraging areas.

Oyster Reef Restoration

NY/NJ Baykeeper

Status: On-Going

Website: www.nynjbaykeeper.org

The NY/NJ Baykeeper's Oyster Restoration Program has been possible due to the dedicated support of hundreds of volunteers. Several studies have been initiated including the Oyster Gardening Program, the Keyport Harbor and Navesink River oyster plantings, and the proposed benthic habitat restoration at Jamaica Bay. They have also partnered with Rutgers University, NY Meadowlands Commission, and Hackensack Riverkeeper to implement oyster research in the Hackensack River.

Bronx River Alliance

Status: On-Going

Website: www.bronxriver.org

The Alliance, comprised of Federal, state, and local organizations, serves as a coordinated voice to protect, improve, and restore the river. They prepared an Ecological Restoration and Management Plan and the Bronx River Greenway Plan that offers a comprehensive view of the restoration of the Bronx River and the parks along its banks. They also coordinate outreach, education, and recreation programs.

Jamaica Bay Marsh Islands, NY

USACE, NYSDEC, NYCDEP, NPS

Status: Continuing Authorities Program (CAP)

Website: http://www.nan.usace.army.mil/project/newyork/factsh/pdf/jammarsh.pdf

Investigate chronic loss of marsh island wetlands and its potentially deleterious effects on the ecosystem if the trend were to continue.

Elders Point East Marsh Island Restoration - Beneficial Use of Dredged Material

USACE, PANYNJ, NPS, NYSDEC, NYCDEP

Status: Constructed

Website: http://www.nan.usace.army.mil/project/newyork/factsh/pdf/elders.pdf

Restoration of Elder's Point Marsh in Jamaica Bay involves using dredged material to restore island elevation and replanting salt marsh vegetation.

New York City Department of Environmental Protection (NYCDEP)

Status: On-going

Website: www.nyc.gov/dep

The NYCDEP leads many restoration efforts to protect and improve water quality and the NYC water supply. Related efforts include creating a mosaic of salt marsh and upland habitat at Alley Creek in Queens, NY and helping to implement the Jamaica Bay Watershed Protection Plan (2007).

PANYNJ Hudson Raritan Estuary Resources Program

Status: On-Going

In 2001, the PANYNJ established a $60 million fund to acquire and preserve ecologically valuable tracts of land around agency facilities in New York and New Jersey. The program is designed to help the Port Authority balance its redevelopment plans with the need to preserve critical habitats and waterfront areas for public use. Properties considered for the program are sites that environmental groups identified as candidates for preservation and provide public access to waterfront areas, buffer areas around existing Port Authority facilities, or preserve key natural resource areas.

Joseph P. Medwick Park Restoration Project, NJ

USACE, PANYNJ, Middlesex County, NJ, Department of Parks and Recreation

Status: Constructed

The site is located in the northern portion of Joseph P. Medwick Park along the southern shore of the Rahway River, Rahway, N.J. The $3,300,000 project was constructed to mitigate for potential shallow water impacts resulting from the deepening of the Arthur Kill Channel. Approximately 14 acres of tidal wetlands were restored by removing Phargmites and approximately 30,000 cubic yards of soil, re-contouring the site to elevations suitable for native plants, and planting 270,000 plugs of native wetland plants. Water flow to the area has been reestablished, improving the water and soil quality and promoting the return of native fish and wildlife.

USACE Aquatic Ecosystem Restoration Programs

USACE's traditional programs of flood risk management and navigation were broadened in the 1990's when Congress requested the Corps to also pursue ecological restoration as a mission area. Increasing scientific and public interest in the restoration of aquatic ecosystems offers an opportunity to broaden USACE's restoration mission. USACE is currently involved in a variety of activities focused on restoring hydrologic and geomorphic processes within the aquatic ecosystem. This should, in turn, help other Federal and state agencies with whom the USACE cooperates in restoration projects and programs, focus on other important restoration program elements such as habitat preservation, reintroduction of native species, and pollution control.

Salt Marsh Restoration & Monitoring, NY

NYSDOS Division of Coastal Resources

Status: On-Going

Website: www.dec.ny.gov/lands/5116.html

Program provides guidance for developing and monitoring salt marsh restoration programs to standardize methodology and ensure successful results.

KeySpan Corporation in Staten Island, NY

USACE, PANYNJ

Status: Constructed

This site is located adjacent to the Keyspan corporation facility in Staten Island, NY. The $5,400,000 project was constructed to mitigate from potential shallow water impacts resulting from the deepening of the Arthur Kill Channel. restored nine acres of tidal marsh by removing Phragmites, 36,200 cubic yards of soil, re-contouring the site to elevations suitable for native plants and planting 107,000 native plants.

Old Place Creek Tidal Wetlands Restoration, NY

USACE, NYSDEC

Status: On-Going

The site is part of the larger Old Place Creek Wetland, Staten Island, NY and a tributary to the Arthur Kill. Restoration will reinstate tidal flow to a 25-acre remnant salt marsh that is currently isolated from the creek by a berm and overrun by non-native vegetation (Phragmites).

Soundview Park Ecosystem Restoration Study, NY

USACE, NYCDPR, NRG

Status: On-Going

Study will restore aquatic ecosystem resources and adjacent upland habitat in southern Soundview Park, located along the estuarine/tidal section of the Bronx River. Restoration will contribute to improved water quality by increasing functional salt marsh acreage.

Gerritsen Creek Ecosystem Restoration Project, NY

USACE, NYCDPR, NRG

Status: On-Going

Project's goal is to improve the aquatic and coastal grassland habitats by improving tidal connectivity and removing invasive species near the junction of Gerritsen Creek and Mill Creek, immediately west of Floyd Bennett Field in Jamaica Bay. The proposed project will restore approximately 20 acres of salt marsh and 15 acres of rare coastal grassland.

Elders Point West Marsh Island Restoration, NY

USACE, PANYNJ, NYSDEC, NPS

Status: On-Going

Restoration at Elders Point West in Jamaica Bay has been proposed through beneficial use of dredged material from the NY/NJ Harbor. Approximately 34 acres of salt marsh habitat would be restored via the placement of approximately 200,000 cubic yards of dredged material. Existing salt marsh plant hummocks will be re-planted within the new, elevated substrate.

areas and re-creating upland, wetland, and aquatic habitat to bring the habitat closer to its original condition, thereby moving to an approach of preventing the habitat loss to also restoring what was lost. Several factors led to the increasing trend of restoration programs in the HRE study area, such as funding availability, incorporating restoration considerations into resource management programs, the expansion of restoration ecology and scientific information, and increased stakeholder awareness.

Many large-scale aquatic restoration programs coordinated by state and Federal agencies and non-government organizations in the HRE study area are in the planning phases. Several USACE feasibility studies have evolved from the HRE Ecosystem Restoration Study authority (1999), including the Lower Passaic River, Hackensack Meadowlands, Gowanus Canal and Liberty State Park. The USACE is moving these studies forward with their local sponsors including the New Jersey Department of Transportation (NJDOT), the New Jersey Meadowlands Commission (NJMC), the New York City Department of Environmental Protection (NYCDEP), and the New Jersey Department of Environmental Protection (NJDEP). Some work proposed by the USACE has focused on creating habitat from beneficial use of dredged material such as oyster reefs, artificial reefs, seagrass beds, intertidal mud flats, salt marshes, upland habitats and wetlands (Yozzo et al. 2004). Restoration at Elders Point Marsh Island is an example of a successful use of dredged material to counter the extensive habitat losses the bay has suffered.

There are also many encouraging examples of local and regional ecological restoration. For example, the New York City Department of Parks & Recreation's (NYCDPR) Natural Resources Group (NRG) has several acquisition and restoration sites that throughout the HRE study area total over 1,000 acres (4 $kilometers^2$) of protected land (NYCDPR 2008). The NYCDEP Office of Ecological Services looks for opportunities to maximize the habitat value of reclaimed lands and mitigation projects. The office has created diverse upland habitats over former landfill sites and has restored more than the required acreage of compensatory mitigation projects to increase the success of the restoration efforts. The NY/NJ Baykeeper offers many programs ranging from habitat restoration to conservation and advocacy programs that protect or save lands (NY/NJ Baykeeper 2007). The decades of data collected by the New York City Audubon have been essential to protecting heron species and their rookeries in the HRE study area (Kerlinger 2004, Bernick 2006). Some examples of Federal, state and local restoration programs within the HRE study area are highlighted in Table 2-1.

Although there are many on-going programs in the HRE study area, they are typically conducted independent of one another or in isolation from the rest of the estuary. These organizations tend to compete against each other for funding and participants. Implementation of a comprehensive restoration plan will promote cost effectiveness and efficiency, and will help prioritize the process and maximize the value of restoration efforts by reducing overlap and redundancy in programs. It will also help to ensure that future restoration efforts are working towards common goals that were agreed upon by the region's stakeholders.

2.5 Trends in Environmental Quality

Although the HRE study area has lost a substantial amount of habitat and ecological function, and legacy contaminants remain in the sediments, policies and programs instituted in the past century have resulted in improved water quality and a decrease in the rate of habitat destruction. Public concern over drinking water in the 1940s resulted in the Federal Water Pollution Control Act and programs to assist states in constructing wastewater treatment facilities. Unfortunately, the limited scope, awkward enforcement policies, and state-enforced standards generally rendered this legislation ineffective. With the passing of the CWA in 1972 and its amendments, Congress set national goals to address water quality issues. This legislation regulates pollutant dischargers, sets water quality standards, specifies effluent limitations for wastewater treatment facilities, protects wetlands, and addresses issues of nonpoint source pollution.

During the last 30 years since the CWA was implemented, concentrations of contaminants, bacteria, and nutrients have started to decrease and the levels of dissolved oxygen in the waters have started to increase (HEP 1996, Steinberg et al. 2004). These water quality improvements have been substantial, but there is significant room for improvement. In most HRE planning regions, legacy chemicals in the sediments, including mercury, PCBs, DDT, and dioxin, still exceed acceptable levels (Steinberg et al. 2004). Many of these chemicals, which are readily absorbed in the fat cells of animals, can accumulate to dangerous levels. Currently, all regions of the HRE study area have consumption advisories in some fish and shellfish species (NYSDOH 2008, NJDEP 2008). Moreover, the recent rates of decline in contaminants will be difficult to match in the future since current non-point sources of these chemicals and metals (e.g., overland runoff, atmospheric deposition) will not be as easy to control as point sources (Steinberg et al. 2004).

Water quality programs initiated following the CWA have reduced, treated, and prevented many sources of pollution and immediate human health threats. Sewage treatment plants in New York and New Jersey have been upgraded and additional plants were constructed. Further improvements since the late 1980's are the result of improved maintenance and operation of sewage collection systems, wastewater treatment facilities and year-round water quality surveillance programs. Regulation of industrial and treated sewage discharges have reduced concentrations of heavy metals (i.e., mercury, cadmium) dissolved in the water column up to 90% since the 1970's (Steinberg et al. 2004).

In addition to habitat restoration programs, regulatory programs and government initiatives are also helping to improve the habitat within the HRE study area by restricting habitat disturbance and the spread of contamination. The USACE, National Oceanic and Atmospheric Administration (NOAA), the New York State Department of Environmental Conservation (NYSDEC) and NJDEP regulations are, in most cases, restricting losses of valuable habitats. These agencie' mitigation programs are requiring the restoration of increased acreages of habitats to restore the functions of lost habitats. Solid waste programs at the local, state, and Federal levels have created strict guidelines to protect and preserve public health and the environment through the introduction of clay and geotextile landfill liners to contain potential contaminants, and leachate collection, treatment, and disposal systems (NYCDCP 2008). Many capped landfills in the HRE study area are being transformed into recreational areas or natural upland sites, like the Elizabeth Landfill in New Jersey or the former Pennsylvania and Fountain Avenue Landfills in Jamaica Bay.

Given the momentum to improve environmental quality through legislation and habitat restoration programs, it is an opportune time to coordinate and accelerate the implementation of restoration projects in the HDR study area.

Figure 2-14. Harbor Seals on Swinburne Island in the Lower Bay Planning Region.

3.0 Target Ecosystem Characteristics

As discussed in Section 1.1, the purpose of the CRP is to provide a master plan for ecosystem restoration in the HRE. This is achieved through use of Target Ecosystem Characteristics to focus restoration goals on distinct actions with measurable objectives (Table 3-1). The TECs were initially developed by a team of estuarine scientists in consultation with agency representatives and other stakeholders. The TECs represent a consensus of what is desired and achievable; with short and long-term goals as a basis for gauging overall progress.

The process began with a two-day workshop in October 2005, led by the Hudson River Foundation and Cornell University to review existing restoration plans and solicit candidate restoration goals and actions (Bain et al. 2006). The multidisciplinary group was comprised of approximately 45 people from various Federal, state, and local agencies, non-government organizations, national and regional estuarine scientists. The group proposed 23 habitats and restoration actions for the HRE study area.

In early 2006, the group's efforts were synthesized to be consistent with the HEP CCMP. Candidate restoration actions that had common elements were merged while actions that would be met indirectly or were being actively addressed by other programs were removed. The final 11 TECs were chosen based upon technical merit, management relevance, and feasibility. Once these TECs were developed, documented and justified by the team, the targets were reviewed by independent scientists and resource/regulatory agency managers. The resulting products were presented at a series of workshops designed to concentrate on further refinement of each individual TEC. The process successfully demonstrated the effectiveness of the TEC process as a framework for building consensus and defining broad restoration objectives.

The 11 TECs define specific habitat types, complexes, contamination issues or societal values that together contribute to the overall program goal of restoring the HRE through the establishment of a mosaic of habitats that provide society with new and increased benefits from the estuary environment. Each TEC was assigned both short-term and long-term quantitative objectives (Table 3-1). Each TEC provides its own unique range of ecological services that together define the critical habitat and societal needs for the HRE and promote increased biotic diversity, sustainable ecosystem functions and public access. The TECs provide the basis for a decisive environmental agenda for the estuary as well as a long-term strategy capable of changing with environmental conditions and human needs (Bain et al. 2007). Detailed information about the development of the TECs can be found in Appendix A (including workshops, transcripts, presentations and technical memoranda).

Once the major objectives were defined, the team searched for potential opportunities to achieve each TEC objective. Coarse geographical information system (GIS) data layers related to each TEC goal were identified and applied in a map overlay procedure to identify broad zones of opportunties that meet the characteristics of each TEC. The data layers included physical parameters, such as bathymetry, fetch distance and total suspended solids in the water. Water quality and sediment quality were used for some of the TECs, and land use constraints were also considered.

It is important to note that the data sets that were used represent the best available spatial data spanning the HRE study area. Data sets that only include a portion of the HRE study area were not incorporated into this analysis. Many of the datasets used in the analysis were developed from satellite imagery and aerial photography of varying age and current

Table 3-1. *Short-Term and Long-Term Objectives for Target Ecosystem Characteristics (TECs) in the Hudson-Raritan Estuary (HRE) study area, including a list of ecosytem services offered by each TEC.*

TEC	2015	2050	Ecosystem Services
Coastal Wetlands	One new wetland that provides at least five primary functions in each HRE region (1,200 total acres)	Continue restoration at a rate of 400 acres per year for a total system gain of 15,200 acres	Climate regulation, Disturbance regulation, Water supply, Erosion control and sediment retention, Nutrient cycling, Waste treatment, Refugia, Food Production, Recreation
Habitat for Waterbirds	Enhance at least one island in each of the four main island groups within the HRE study area	All islands in the four main island groups provide roosting and nesting sites	Biological control, Recreation, Cultural
Coastal and Maritime Communities	Establish one new forest of at least 50 acres and rehabilitate at least 200 additional acres of existing forest.	Establish 500 acres of new forest among three sites, and rehabilitate another 500 acres of existing forest.	Gas regulation, Climate regulation, Disturbance regulation, Erosion control and sediment retention, Refugia, Cultural
Oyster Reefs	500 acres of reef habitat across 10-20 sites	5,000 acres of established oyster reef habitat	Refugia, Cultural
Eelgrass Beds	Create one test bed in each HRE region	Three established beds in each HRE region capable of supporting eelgrass	Nutrient cycling, Refugia, Cultural
Shorelines and Shallows	Establish new shorelines and shallows sites in three HRE regions	Restore all available shorelines and shallows sites in three HRE regions, and two sites in other planning regions	Disturbance regulation, Water supply, Erosion control and sediment retention, Nutrient cycling, Waste treatment
Fish, Crab, and Lobster Habitat	Complete a set of two functionally related habitats in each HRE region	Complete four sets of at least two functionally related habitats in each HRE region	Biological control, Refugia, Food Production, Recreation, Cultural
Tributary Connections	One less barrier per year to passage between at least three different inland habitats	Continue reconnecting habitats at a rate of one project per year until all barriers within the HRE study area are removed or made passable	Gas regulation, Climate regulation, Disturbance regulation, Erosion control and sediment retention, Biological control, Refugia, Recreation, Cultural
Enclosed and Confined Waters	Improve the water quality or environmental conditions of eight confined water bodies to meet their current designated use classification	Improve the water quality or environmental conditions of eight confined water bodies to meet the criteria of their receiving waters	Water regulation, erosion control & sediment retention, nutrient cycling, waste treatment, food production, recreation, refugia.
Sediment Quality	Isolate or remove at least 25 acres of contaminated sediment	Isolate or remove at least 25 acres every 2 years	Nutrient cycling, Refugia, Cultural
Public Access	Create one access point and upgrade one access point in each of the HRE regions per year	All waters of the HRE are accessible within a short walk or public transit trip	Recreation, Cultural

accuracy. For example, the existing coastal wetlands layer was developed from the USFWS National Wetlands Inventory. Although some portions of the existing coastal wetlands layer were identified as recently as 2001, some areas have not been updated for several decades. For this reason, the analyses are intended to be applicable at the watershed and regional levels, rather than the site-specific level. These preliminary analyses should be used to narrow the potential opportunities and focus attention on the most likely areas for restoring habitat. In many cases, field verification and feasibility investigations will be necessary before proceeding with site-specific project planning. Additional information on the methods of the GIS analysis is provided in Appendix B .

The following sections describe the current status, present the target statements, restoration objectives, and identify potential opportunities for restoration of the TECs in the HRE study area. A detailed discussion of each TEC, including current research needs, recommendations for implementation restoration projects and conducting post-construction monitoring is provided in Volume II of the CRP.

3.1 Habitats

Five of the TECs represent habitat types that were historically abundant, but have either been eliminated or significantly reduced in size in the HRE study area. These habitats were deemed essential to the ecology of the HRE, and the purpose of these TECs is to restore acreage of these valuable habitats in the HRE study area.

3.1.1 Coastal Wetlands

Coastal wetlands, defined as tidally influenced wetlands connected to the open waters, are among the most productive ecosystems on Earth, with measured production rates exceeding those of tropical rain forests and freshwater wetlands (Good et al. 1982). They are characterized by a distinctive vegetation community. Smooth cordgrass (*Spartina alterniflora*) dominates intertidal salt marsh communities in the HRE study area. This species generally occurs between mean high water and mean sea level and may vary in growth form (i.e., tall, medium, and short), depending on tidal flooding frequency and duration. Above the mean high water (high marsh) the floral composition of salt marshes increases in diversity, with several plant species typically present, including saltmeadow hay (*S. patens*) and salt grass (*Distichlis spicata*). The structure and function of many coastal wetlands in the HRE study area have been altered in recent decades by the proliferation of an aggressive European genotype *Phragmites* that forms monoculture stands.

Coastal wetlands perform a variety of functions including sediment retention, which is important for chemical detoxification, nutrient retention and recycling, and decomposition processes (Seneca and Broome 1992). The ability of coastal wetlands to retain high levels of nitrogen has important implications for eutrophication and nitrogen-loading to the HRE study area. Coastal wetlands also provide valuable habitat for a variety of organisms. Juvenile fish and crustaceans gain refuge from predators and benefit from abundant prey resources in salt marshes. Wading birds prey upon resident fishes and invertebrates in salt marshes. Migratory waterfowl use salt marshes as stopovers during their winter and summer migrations. A variety of mammals use salt marshes for foraging, breeding, and refuge. Northern diamondback terrapins (*Malaclemys terrapin terrapin*) forage and breed in salt marshes. Coastal wetlands can also be important areas for recreational boating and fishing, and offer numerous educational opportunities.

Historically, coastal wetlands represented a significant habitat complex in the HRE study area. However, a large portion of the coastal wetland habitat in the HRE study area has been degraded or destroyed by human activities. The most devastating losses occurred between World War II and the implementation of the CWA when large expanses of wetlands were filled, drained or diked (Bone 1997). In the last 30 years, cumulative wetland losses have slowed due to the implementation of protective legislation and mitigation (Steinberg et al. 2004). Yet, acres of wetlands still disappear and are degraded annually in the HRE study area. Many factors have been suggested as possible contributors to current wetland habitat loss: sea level rise; alterations in the estuary's sediment budget; erosion due to changes in wave energy; effects of contaminants; changes in hydrologic connectivity; or excessive consumption of marsh grasses by waterfowl (Steinberg et al. 2004). Excess nutrients leading to eutrophication have also been hypothesized as a major contributor to wetland losses, particularly in Jamaica Bay. Other threats arise through changes in soil chemistry and moisture (e.g., during droughts), such as soil oxidation, soil acidification, and metal toxicity which can cause sudden losses of acres of wetlands. Stressed wetlands may be more susceptible to fungal pathogens and elevated salinities (Lindstedt and Swenson 2006). Wetland loss is complex and is likely a function of many factors, each of which varies in intensity and exposure among regions of the HRE study area.

Target Statement

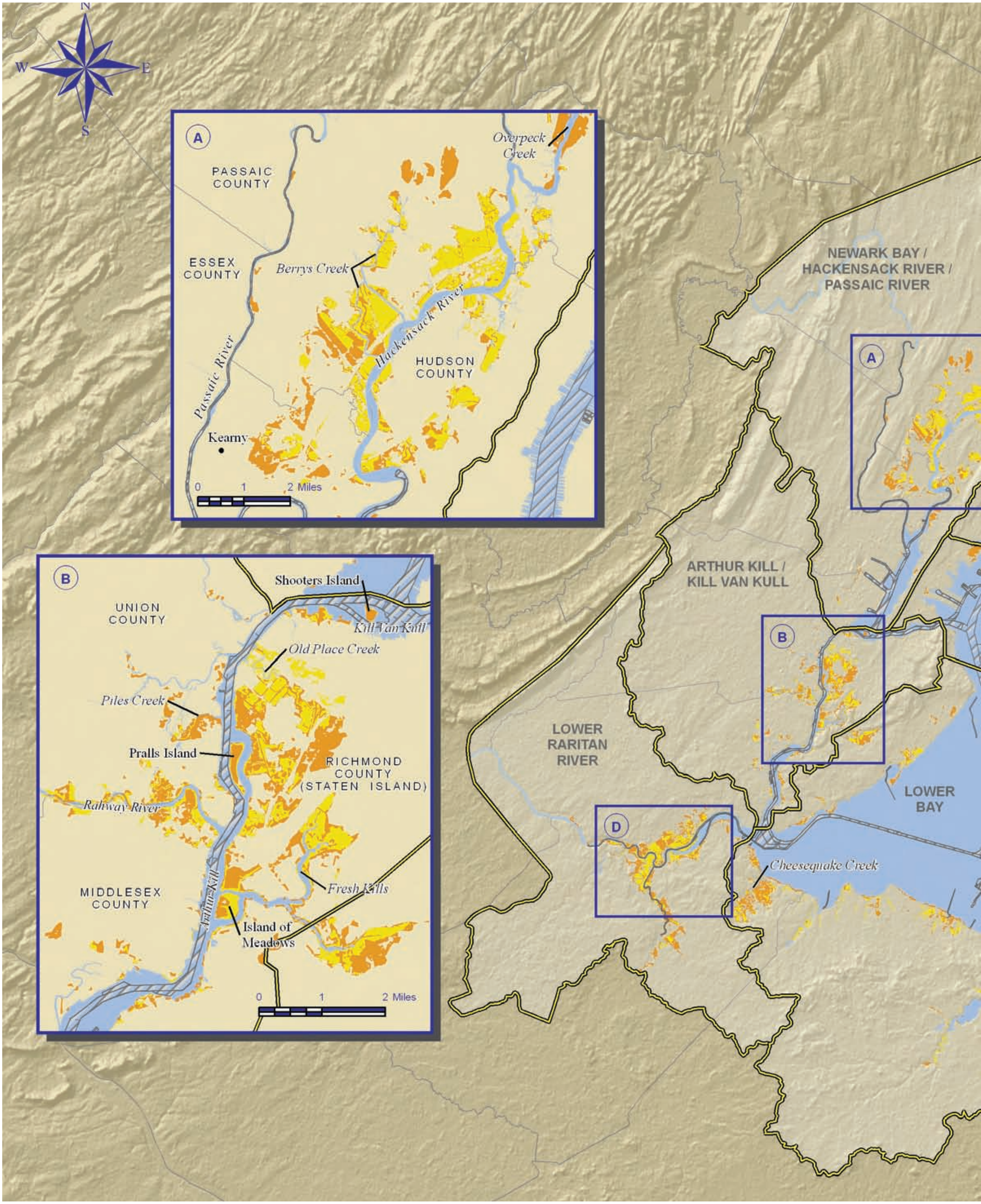
The Coastal Wetlands TEC aims to create and restore coastal wetlands, at a rate exceeding the annual loss or degradation of wetlands in the HRE planning region, to produce a net gain in acreage. The target statements for the Coastal Wetlands TEC address acreage and ecosystem function, unlike many other TECs. The short-term objective is to restore one coastal wetland that provides five or more primary functions in each of 8 planning regions for a total increase in the HRE planning region of 1,200 acres by 2015. By 2050, the objective is to continue restoring an average of 400 acres of coastal wetland per year for a total HRE gain of 15,200 acres.

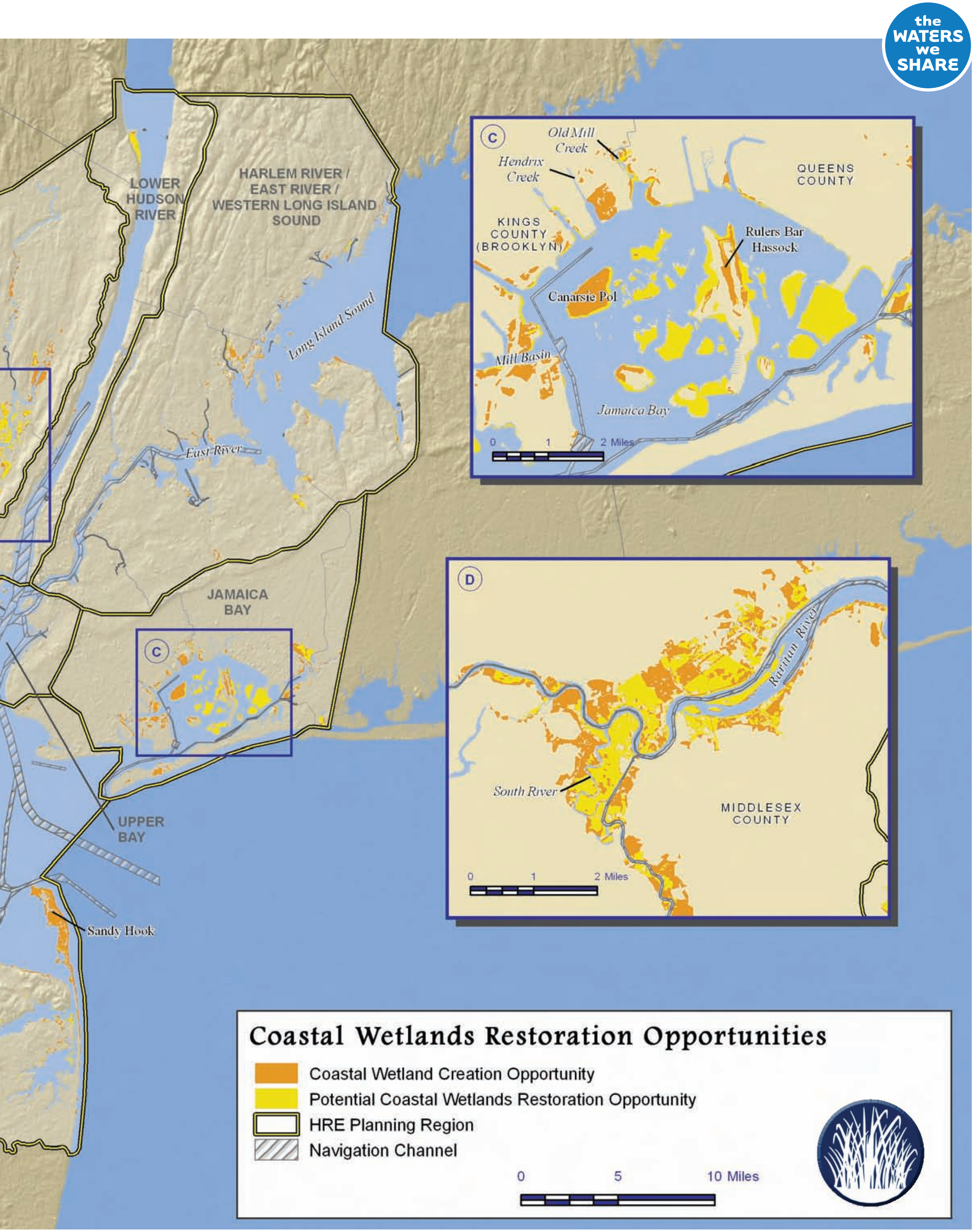
Restoration Opportunities (Map 3-1)

Identification of restoration opportunities was based upon major physical requirements of coastal wetlands (land elevation, bathymetry, and fetch distance) and land use constraints in the estuary (Map 3-1). Two layers are displayed on the map, coastal wetland creation opportunities and existing coastal wetlands. No distinction is made between the quality of existing wetland habitat (i.e., this layer represents both degraded and non-degraded wetlands), but it can be assumed that many polygons represent existing degraded coastal wetlands that are dominated by dense stands of *Phragmites*. Degraded wetlands represent potential wetland restoration opportunities (as opposed to wetland creation opportunities).

In the HRE study area, there are approximately 12,500 acres (50 kilometers^2) of existing coastal wetland habitat. The largest acreages occur along the Hackensack River (Inset A), along the Arthur Kill and its tributaries (Inset B), in Jamaica Bay (Inset C), and along the Raritan River and its tributaries (Inset D). Additional large expanses exist along Staten Island and the southern shore of the Lower Bay planning region (i.e., Middlesex and Monmouth County, New Jersey shorelines). The NWI map indicates that about 50% of the existing wetlands classified as "estuarine" in the HRE study area are impaired in some way (e.g. diked or impounded, drained or ditched, excavated, or have modified substrate). This suggests that wetland restoration opportunities could contribute significantly to the quality of coastal wetland habitat in the HRE.

Map 3~1.


N
S
E
W
A
PASSAIC COUNTY
ESSEX COUNTY
HUDSON COUNTY
Overpeck Creek
Berrys Creek
Hackensack River
Passaic River
Kearny
0
1
2 Miles
B
UNION COUNTY
Shooters Island
Kill Van Kull
Old Place Creek
Piles Creek
Pralls Island
RICHMOND COUNTY (STATEN ISLAND)
Rahway River
MIDDLESEX COUNTY
Arthur Kill
Fresh Kills
Island of Meadows
0
1
2 Miles
NEWARK BAY / HACKENSACK RIVER / PASSAIC RIVER
ARTHUR KILL / KILL VAN KULL
LOWER RARITAN RIVER
LOWER BAY
Cheesequake Creek
A
B
D


the WATERS we SHARE
LOWER HUDSON RIVER
HARLEM RIVER / EAST RIVER / WESTERN LONG ISLAND SOUND
Long Island Sound
East River
JAMAICA BAY
UPPER BAY
Sandy Hook
C
Old Mill Creek
Hendrix Creek
QUEENS COUNTY
KINGS COUNTY (BROOKLYN)
Rulers Bar Hassock
Canarsie Pol
Mill Basin
Jamaica Bay
0 1 2 Miles
D
Raritan River
South River
MIDDLESEX COUNTY
0 1 2 Miles
Coastal Wetlands Restoration Opportunities
Coastal Wetland Creation Opportunity
Potential Coastal Wetlands Restoration Opportunity
HRE Planning Region
Navigation Channel
0 5 10 Miles

Areas adjacent to existing wetlands tend to represent the largest areas for coastal wetland creation opportunities in the HRE study area. According to the analysis, coastal wetland creation opportunities total 14,044 acres (56.8 kilometers^2) in the HRE study area. Because this analysis excluded all existing developed lands and parklands, the actual coastal wetland creation acreage may be higher if partnerships with land owners and parks are made.

When looking at the restoration opportunities map, several inset maps draw attention to locations where substantial wetland creation and wetland restoration opportunities may exist.

- *Inset A* – Sizeable plots of land occur between the Hackensack and Passaic rivers, particularly east of Kearny and along Berrys Creek. Overpeck Creek, a tributary of the Hackensack River, may also represent large wetland creation opportunities. In addition, this planning region has one of the largest expanses of existing estuarine wetlands and according to the NWI maps, about 80% of these wetlands are impaired. Many of these wetlands have been degraded and are currently dominated by *Phragmites*. These wetlands provide an opportunity for restoration.
- *Inset B* – Opportunities may exist on the islands of the Arthur Kill, including Shooters Island, Pralls Island, and the Island of Meadows. Other areas of interest are on Staten Island, south and west of Old Place Creek and branches of the Fresh Kills. On the New Jersey side of the Arthur Kill, opportunities may exist along Piles Creek and the Rahway River.
- *Inset C* – In Jamaica Bay, the largest wetland creation opportunity was identified on the island, Canarsie Pol. Other opportunities may exist between Hendrix and Old Mill creeks, along Mill Basin, and west of the Cross Bay Boulevard on Rulers Bar Hassock.
- *Inset D* – Wetland creation opportunities exist adjacent to existing coastal wetland habitat along the Raritan River and its main tributary, the South River.

Other wetland creation opportunities may exist along the southeastern coast of Staten Island, throughout Sandy Hook, and along Cheesequake Creek, a tributary of the Raritan Bay. Scattered opportunities may exist in other planning regions, Lower Hudson River, Upper Bay, and Harlem River, East River, and Western Long Island Sound.

3.1.2 Islands for Waterbirds

Waterbirds function as important keystone species in estuarine systems, are indicators of ecosystem integrity, and are intrinsically valuable to the public (Bain et al. 2007). Aquatic birds (or "waterbirds") include a variety of birds adapted to life in and around coastal habitats. Waterbird groups include seabirds (e.g. cormorants, gulls and terns), shorebirds, (e.g., plovers and sandpipers), waterfowl (e.g., ducks, geese), and long-legged wading birds (e.g., herons, egrets, and ibis). Within the HRE study area, a particular subset of waterbirds, the long-legged wading birds, are the focus of this TEC. Nine species of egrets, ibises and herons are collectively known as the "Harbor Herons," and this assemblage has been monitored annually in the HRE by New York City Audubon and its agency and institutional partners for over two decades (Bernick 2007).

As top predators in coastal wetlands, waterbirds consume fish and crustaceans within coastal wetlands and other littoral areas, thereby playing an important role in energy transfer and controlling population dynamics in these communities. Waterbirds in their natural setting are sought after by members of the birding community, members of which are often active supporters of ecological restoration initiatives, especially in urban locales. In addition to the important ecological role and the recreational opportunities waterbirds offer, they also function as indicators of ecological health. Through bioaccumulation of contaminants in the food web, bird reproduction can be impaired, leading to diminished or extirpated populations.

Long-legged wading birds have experienced a dramatic comeback in the HRE study area since the 1960s, when populations were nearly extirpated by centuries of hunting, pollution, and habitat loss. With improved water and habitat quality, herons began populating the uninhabited islands of the Arthur Kill, Kill Van Kull, East River, and Jamaica Bay during the late 1970s (Steinberg et al. 2004). Ten islands in the HRE study area currently function as nesting rookeries for resident and transient waterbirds (Table 3-2).

Target Statement

The Islands for Waterbirds TEC focuses on restoring and protecting roosting, nesting, and foraging habitat (i.e., inland trees) for long-legged wading birds on islands in the HRE study area (Bain et al. 2007). The short-term objective for this TEC is to enhance at least one island within each of four island groups, western Long Island Sound, the East River region, along Staten Island area and in Jamaica Bay to provide roosting and nesting sites for waterbirds by 2015. The long-term goal of the Islands for Waterbirds TEC is to enhance all islands in these island groups to provide improved waterbird roosting and nesting habitat by 2050.

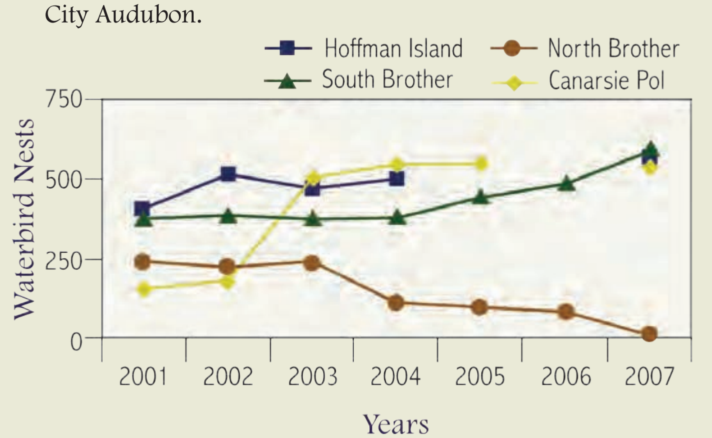
Restoration Opportunities (Map 3-2)

Opportunities for restoring island habitat exist in most planning regions of the HRE study area (Map 3-2). The Islands for Waterbirds restoration opportunities map displays areas where existing islands could be restored to provide more nesting and feeding habitat for target species. The map includes 68 existing islands over 0.25 acres (0.001 kilometers^2) in size, which are represented as color-coded dots, symbolizing the number of waterbird nests observed (excluding cormorant nests) during the 2007 Harbor Herons Nesting Survey (Bernick 2007). Because shallow wetlands are important foraging areas for waterbirds in the HRE study area, islands are symbolized in the inset maps to represent the distance to the nearest wetland habitat. Percent tree canopy cover is also displayed on the inset maps to identify islands where trees and large shrubs currently exist.

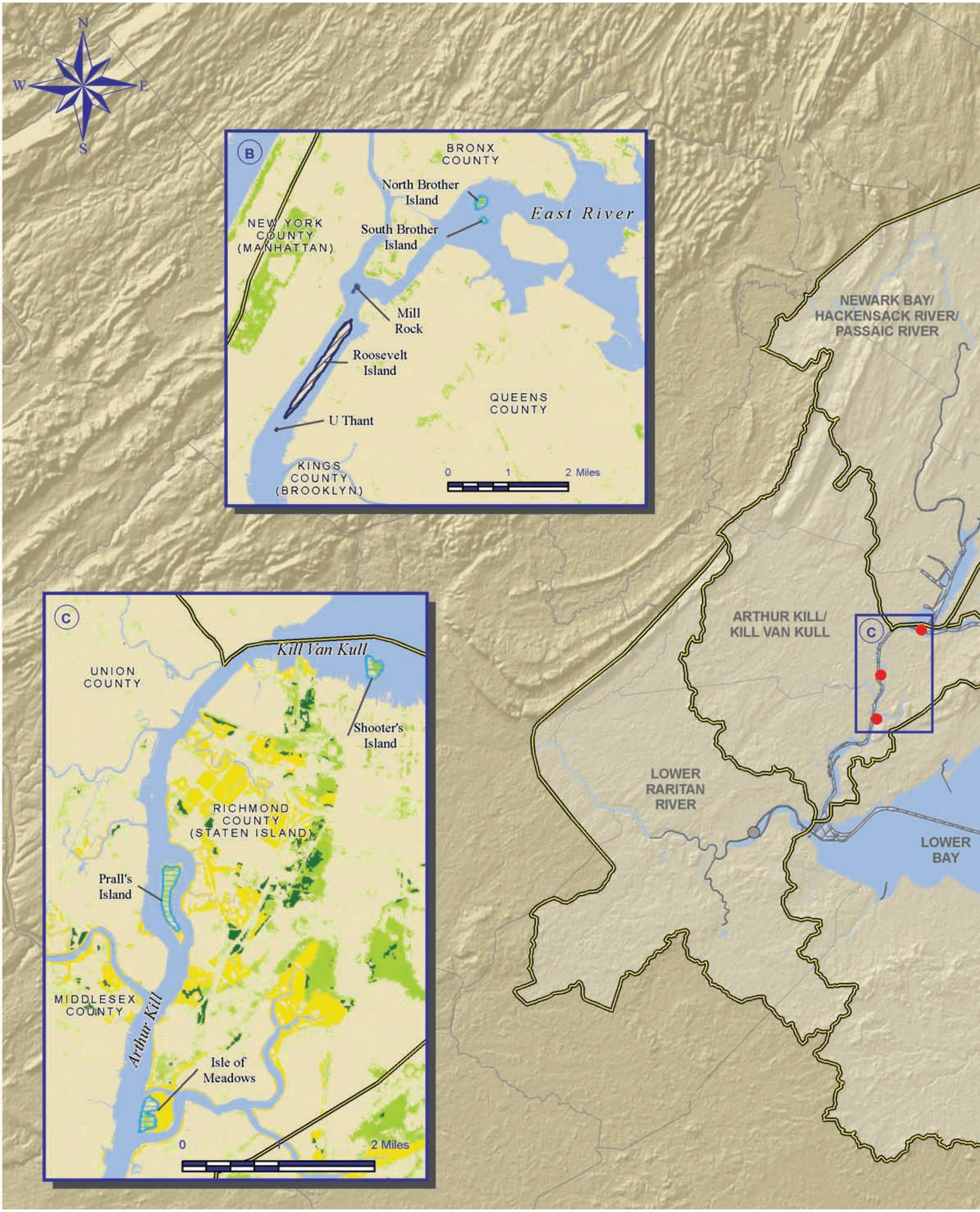
For all 64 islands, the average area was approximately 26 acres (0.1 kilometers^2). On average, the islands were almost 500 feet from the nearest wetland habitat, ranging from adjacent to 1.1 miles (1.8 kilometers^2) away from the islands. Three surveyed islands in the estuary

Harbor Herons Survey

The Harbor Herons program conducts annual surveys of important waterbird nesting islands in the HRE study area. The observed nests from four islands are depicted above (no data were available for Hoffman Island during 2005 and 2006, or for Canarsie Pol during 2006). Harbor Herons Monitoring Program, New York City Audubon.



Map 3~2.



N
W
E
S
B
BRONX COUNTY
North Brother Island
East River
NEW YORK COUNTY (MANHATTAN)
South Brother Island
Mill Rock
Roosevelt Island
QUEENS COUNTY
U Thant
KINGS COUNTY (BROOKLYN)
0
1
2 Miles
NEWARK BAY/ HACKENSACK RIVER/ PASSAIC RIVER
C
UNION COUNTY
Kill Van Kull
Shooter's Island
RICHMOND COUNTY (STATEN ISLAND)
Prall's Island
MIDDLESEX COUNTY
Arthur Kill
Isle of Meadows
0
1
2 Miles
ARTHUR KILL/ KILL VAN KULL
C
LOWER RARITAN RIVER
LOWER BAY

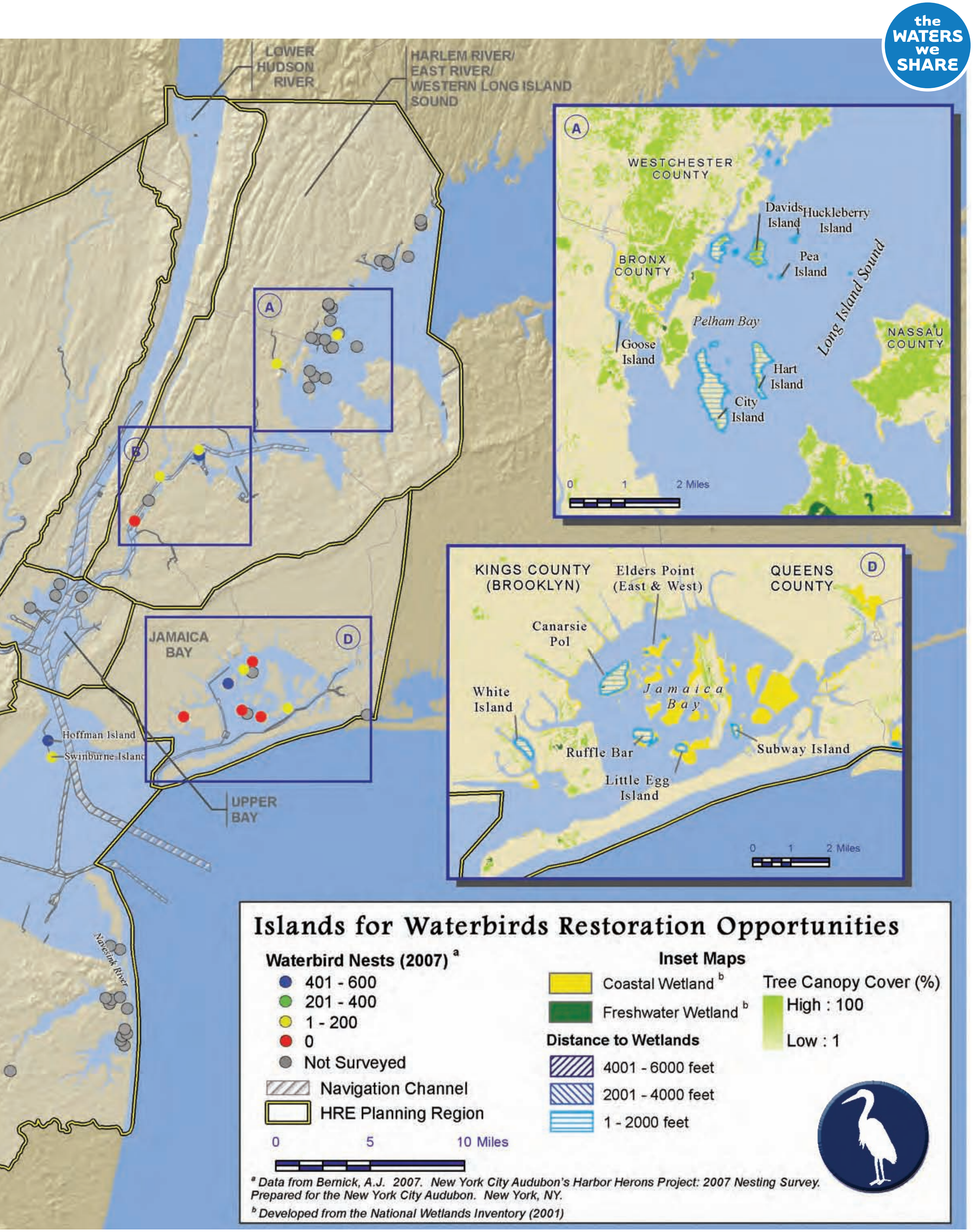

the WATERS we SHARE
LOWER HUDSON RIVER
HARLEM RIVER/ EAST RIVER/ WESTERN LONG ISLAND SOUND
A
B
JAMAICA BAY
D
Hoffman Island
Swinburne Island
UPPER BAY
Navesink River
WESTCHESTER COUNTY
BRONX COUNTY
Davids Island
Huckleberry Island
Pea Island
Long Island Sound
Pelham Bay
Goose Island
Hart Island
City Island
NASSAU COUNTY
0 1 2 Miles
KINGS COUNTY (BROOKLYN)
Elders Point (East & West)
QUEENS COUNTY
Canarsie Pol
White Island
Jamaica Bay
Ruffle Bar
Subway Island
Little Egg Island
0 1 2 Miles
Islands for Waterbirds Restoration Opportunities
Waterbird Nests (2007) a
401 - 600
201 - 400
1 - 200
0
Not Surveyed
Navigation Channel
HRE Planning Region
0 5 10 Miles
Inset Maps
Coastal Wetland b
Freshwater Wetland b
Tree Canopy Cover (%)
High : 100
Low : 1
Distance to Wetlands
4001 - 6000 feet
2001 - 4000 feet
1 - 2000 feet
a Data from Bernick, A.J. 2007. New York City Audubon's Harbor Herons Project: 2007 Nesting Survey. Prepared for the New York City Audubon. New York, NY.
b Developed from the National Wetlands Inventory (2001)

Table 3-2. Islands of the HRE study area that are surveyed as part of the Harbor Herons program, including acreage, distance to either freshwater or coastal wetland habitat, and the number of nests identified during the 2007 Harbor Herons Nesting Survey. Acreages represent terrestrial land and do not include adjacent wetland habitat on these islands.

Surveyed Island	Acres	Distance to Wetlands (feet)	Nest Counts						
			2001	2002	2003	2004	2005	2006	2007
Canarsie Pol	244.0	364.1	156	180	504	544	--	192	533
Elders Point Marsh - East	2.7	30.7	--	--	--	--	--	--	0
Elders Point Marsh - West	1.3	24.1	--	--	--	--	--	--	1
Goose Island	0.8	173.2	75	104	123	127	95	108	86
Hoffman Island	11.2	1,386.9	403	513	472	500	--	164	567
Huckleberry Island	5.3	25.3	140	99	118	28	50	20	6
Isle of Meadows	28.4	107.5	--	--	--	--	0	0	0
Little Egg Island	27.4	137.7	--	--	--	--	--	--	0
Mill Rock	2.7	2,983.6	--	--	--	--	43	62	43
North Brother	19.1	1,849.6	244	225	239	116	99	87	15
Pralls Island	43.5	46.3	--	--	--	--	5	0	0
Ruffle Bar	87.7	213.7	--	--	--	--	--	--	0
Shooter's Island	18.8	100.7	--	--	--	--	0	0	0
South Brother	5.2	1,566.0	377	384	379	381	444	485	592
Subway Island	31.8	74.2	--	--	--	--	--	--	2
Swinburne Island	2.7	2,496.6	--	--	--	--	--	1	1
U Thant Island	0.3	5,943.0	--	--	--	--	--	21	0
White Island	81.5	294.1	--	--	--	--	--	--	0
TOTAL	614.4		1395	1505	1835	1696	736	1140	1846

had more than 400 nests identified during 2007; South Brother Island, Canarsie Pol, and Hoffman Island. South Brother and Hoffman islands were the only surveyed islands that had increased nest counts since the last major survey. No waterbird nests were observed on eight islands, although two of these islands had cormorant nests during 2007. Seven of the surveyed islands experienced decreases in nest counts, and eight showed either no change in nest counts or were surveyed for the first time during 2007.

When looking at the Islands for Waterbirds restoration opportunities map, four inset maps draw attention to surveyed islands. These insets indicate the presence of canopy cover on these islands, and their proximity to wetland habitat.

- *Inset A* – There are 16 islands in the western Long Island Sound near Pelham Bay, two of which are currently surveyed through the Harbor Herons program: Goose and Huckleberry islands. Wading bird populations on Goose and Huckleberry islands have decreased over the past several years. The number of nests on Goose Island ranged between 75 and 127 between 2001 and 2007, with the lowest numbers found in 2001 (Good et al. 1982) and 2007 (Gibson et al. 2005). Huckleberry Island has experienced a dramatic decline in the nesting population. The peak number of 140 nests was found in 2001, while only 6 nests were found in 2007. All 16 islands are within 2,000 feet (0.6 kilometers) of a coastal or freshwater wetland. Several islands in this area are developed and have low canopy cover, making them less suitable locations for waterbird habitat restoration (i.e., City Island and Hart Island). Many of the smaller islands, like Huckleberry, Pea, and possibly Davids islands, are not inhabited by people and have coastal wetlands on their periphery or on nearby mainland areas. These smaller islands seem to have low canopy cover and may be candidates for tree plantings.

- *Inset B* – The East River contains surveyed islands with the highest number of nests in the HRE study area. The nesting population on South Brother Island has been increasing over the past six years, and in 2007 had the largest waterbird nesting colony, 592 nests (Bernick 2007). The nesting populations on North Brother Island have declined steadily in the past six years, decreasing from 244 nests in 2001 to 15 nests in 2007. U Thant Island has only been surveyed for the last two years, and 21 nests were discovered in 2006 and none were found in 2007. The nests on Mill Rock have been surveyed for the past three years, and the greatest number of nests, 62, was found in 2006. Although North and South Brother islands are relatively close to existing wetland habitat, U Thant Island is almost 6,000 feet (1.8 kilometers) from the nearest wetlands and Mill Rock is almost 3,000 feet (0.9 kilometers) from the nearest wetlands. U Thant and Mill Rock islands have few trees. The NYCDPR planted native trees and shrubs on North Brother Island during 2005 and 2006, and is considering additional vegetation management to reduce prevalent invasive vine species on the island (Bernick 2007). A similar program could be initiated for South Brother Island to remove vines, remove host tree species used by the Asian longhorned beetle, and plant native trees for waterbird nesting.
- *Inset C* – The peak of waterbird nesting occurred on the islands of the Arthur Kill and Kill Van Kull during the 1970's through the 1990's (Bernick 2007). However, no successful nesting has been observed on these islands since the 1990s (Kerlinger 2004). There are substantial coastal and freshwater wetlands near these islands. Baseline monitoring could identify causes of waterbird abandonment on these islands and potential measures to restore nesting. Pralls Island, recently deforested to eliminate an Asian longhorned beetle infestation, is a likely area on which to restore preferred trees and shrubs for nesting waterbirds.
- *Inset D* – Ten islands were identified within Jamaica Bay, all within 2,000 feet (0.6 kilometers) of wetland habitat. Carnasie Pol has been surveyed regularly by the New York City Audubon Society. The number of nests found on Carnasie Pol has ranged between 156 and 544 over the past six years, and 533 were found on the island in 2007. Many of Jamaica Bay's islands have little canopy cover, but this does not seem to deter nesting activity. Canarsie Pol, which is the largest island surveyed, supported the most diverse assemblage of nesting waterbirds and some of the highest nest counts during 2007 (Bernick 2007). The other surveyed islands of Jamaica Bay, Ruffle Bar, White Island, Subway Island, Little Egg Marsh, and Elders Point (East and West), typically have not supported large nesting populations of waterbirds, although they are thought to have suitable habitat for the target species (Kerlinger 2004). Although substantial coastal wetland acreage appears in the inset, many of these areas are degraded and could represent wetland restoration or creation opportunities.

Other Islands for Waterbirds restoration opportunities may exist on islands in Lower Bay. There are at least 12 islands along the Navesink River, although none have been surveyed as part of the Harbor Herons program. Hoffman Island had some of the highest nest numbers in recent years, increasing since 2004. During nesting season, Swinburne Island is typically dominated by cormorants, but there may be opportunities to improve this island for roosting and nesting waterbirds.

Future baseline studies should evaluate the specific attributes of each island in terms of soils/substrate, vegetation cover, predators, and human disturbance (including contamination of soils and biota). In the face of potentially significant increases in sea level rise within the HRE study area in coming years, island habitats should be restored with long-term sustainability in mind; this may entail raising the elevations of low-lying areas with clean fill (e.g., dredged sand from ongoing channel maintenance projects) prior to the restoration of native vegetation communities.

In order to gain a better understanding of the spatial relationships between existing nesting areas and available foraging habitat, it is recommended that radio-telemetry and banding studies be conducted on groups of several birds from each of the active colonies to determine where they are feeding and the direction/distance they travel. This should be implemented as a baseline monitoring component at existing rookeries, and incorporated into a long-term monitoring program at restored islands, following recolonization by waders.

An important baseline data component will be to identify the presence of contaminated soils or biota on the islands, evaluate body burdens for the populations, and determine the effect of contaminants on behavior and reproductive health of waterbird populations. Beyond the initial baseline characterization, it will be important to monitor contaminants in soils and biota at restored sites on a long-term basis (years to decades) to be able to evaluate this factor on the integrity of waterbird populations in the HRE study area, relative to improvements in nesting/foraging habitat.

3.1.3 Coastal and Maritime Forests

The Coastal and Maritime Forests TEC addresses ecologically rare and unusual systems that have become vulnerable to extirpation, within the HRE study area and globally. These plant communities are important ecological corridors, providing habitat and food resources to support many wildlife species (Table 3-3). Coastal and Maritime forest communities provide a variety of valuable functions, including: habitat for rare species, nesting habitat, food sources, seed sources, corridors for wildlife, stormwater reclamation, shoreline/land stabilization, aesthetic value, and protection from climate change.

Maritime plant communities are dynamic systems that occur across a range of fringe seacoast habitats in narrow, discontinuous bands (National Biological Service 1995). These forests, often described as "strand forests", are influenced by strong salt spray, high winds, unstable substrates (e.g., dune deposition/shifting), and have characteristically stunted and contorted trees (National Biological Service 1995, Yozzo et al. 2003, Edinger et al. 2002). Maritime communities are perpetually shifting complexes that interchange in response to the dynamics of the substrate. Beach and dune habitats are the most dynamic of the maritime vegetative communities, being modified by winds and waves and stabilized by vegetation. When the dunes are altered, this changes the inland shrub and forested lands, bringing them closer to shore, pushing them further inland, or even periodically eliminating them. Herbaceous and shrub layers thrive on the outskirts of the forest and in bog areas, behind the dune and swale communities (Bain et al. 2007). Both evergreen and deciduous trees, such as

Table 3-3. Coastal and maritime communities that may be possible to create in the HRE study area (adapted from Edinger et al. [2002] and Reschke [1990]). Species status, rare [R], threatened [T], and endangered [E], are detailed.

Community	Landscape/Hydrology	Soil	Characteristic Plant Species	Wildlife Species
PALUSTRINE				
Maritime freshwater interdunal swale	Between dunes	Sand or peaty sand	**Sedges and herbs** Beakrush (*Rhynchospora spp.*) Cyperus (*Cyperus spp.*) Twig rush (*Cladium mariscoides*)	No available information
TERRESTRIAL OPEN UPLANDS				
Maritime beach	Above mean high tide/modified by storm waves and wind erosion.	Sand, gravel, or cobble ocean shores	**Sparse vegetation** Beachgrass (*Ammophila breviligulata*) Sea-rocket (*Cakile edentula*) Seaside atriplex (*Atriplex*) Seabeach amaranth (*Amaranthus pumila*) [E] Seabeach knotweed (*Polygonum glaucum*) [R] Dune sandspur (*Cenchrus tribulides*) [T]	Piping plover Least tern Common tern Roseate tern
Maritime dunes	Active and stabilized dunes (depends on stability of the dune, amounts of sand deposition and erosion and distance from ocean)	Sand	**Grasses and low shrubs** Active: Beachgrass, Dusty miller, Beach pea Stabilized: Beach heather, Seabeach amaranth	No available information
Maritime shrubland	Dry seaside bluffs and headlands that are exposed to offshore winds and salt spray	Sand	**Tall shrubland** Shadbush (*Amelancier canadensis*)	Black crowned night heron Fish crow
Maritime heathland	Rolling outwash plains and moraine of glaciated areas, near the ocean and within the influence of offshore winds and salt spray	Sand	**Dwarf shrubland; low heath or heath-like shrubs** Bearberry (*Archtostaphylos*) Heather (*Hudsonia spp.*)	No available information
Maritime grassland	Rolling outwash plains of glaciated areas near the ocean and within the influence of offshore winds and salt spray	Sand	**Grasses** Little bluestem(*Schizachyrium scoparium*) Common hairgrass (*Deschampsia flexuosa*)	No available information
TERRESTRIAL BARRENS AND WOODLANDS				
Dwarf pine plains	Woodlands on nearly level outwash sand and gravel plains. Excessively well-drained soils.	Coarse-textured sand	Dwarf individuals of pitch pine (*Pinus rigida*) and a handful of other woody species. Low shrub canopy exists beneath the trees.	Warblers Thrashers Ovenbird
Pitch pine mixed woodlands	Well drained, nutrient poor	Sandy soils	Pitch pine and various oaks (scrub oak, oak-heath, post oak-blackjack, oak barrens). Adapted to periodic fires. Occasionally stunted individuals.	Warblers Eastern towhee Sparrows

Table 3-3. Continued

Community	Landscape/Hydrology	Soil	Characteristic Plant Species	Wildlife Species
TERRESTRIAL FORESTED UPLANDS				
Maritime forest	Proximity to marine communities. Influenced by strong salt spray, high winds and dune deposition, shifting and overwash processes. (Occur in narrow bands; "strand forest")	Sand	Stunted "salt pruned" trees with contorted branches and wilted leaves and a dense vine layer.	No available information
Maritime post oak forest	Borders salt marshes or occurs on exposed bluffs and sand spits within 200 meters of the seacoast	Sand	**Stunted trees** Post oak (*Q. stellata*) Black oak (*Q. velutina*) Scarlet oak (*Q. coccinea*) Dense shrub thicket and vines	Eastern towhee White tailed deer Gray catbird Common yellowthroat Ovenbird Black and white warbler
Maritime beech forest	North facing exposed bluffs and back portion of rolling dunes; wind and salt spray	Well-drained fine sand	**Hardwood forest** Beech (*Fagus grandifolia*)	No available information
Maritime holly forest	Low areas on the back portion of maritime dunes, which protect the area from overwash and salt spray enough to allow forest formation.	Sand	**Broadleaf evergreen maritime strand forest; stunted trees** Holly (*Ilex opaca*) Sassafras (*Sassafras albidum*) Post oak (*Q. stellata*)	More data needed
Maritime red cedar forest	Dry sites near the ocean	More data needed	**Conifer forest** Eastern red cedar (*Juniperus virginiana*) Post oak	More data needed
Pitch pine-oak forest	Glacial outwash plains or moraines	Sandy or rocky soils	**Mixed forest** Pitch pine and oak (scarlet, white, red, or black)	Rufous-sided towhee Common yellowthroat Field sparrow Warblers Whip-poor-will
Coastal forest	Non-maritime areas within the Coastal Plain; not in immediate proximity to marine communities.; (at most)Lightly Influenced by coastal processes inc. minor salt spray associated with extreme storms (e.g., hurricanes), and lacking dune deposition, shifting and overwash processes.	Dry low nutrient	**Normal stature trees** Oak-heath, oak-hickory, oak-beech, oak-laurel, and oak-holly mixed forests	Eastern towhee White tailed deer Red-eyed vireo

American holly (*Ilex opaca*), oaks (*Quercus spp.*), sassafras (*Sassafras albidum*), shadbush (*Amelanchier canadensis*), black tupelo (*Nyssa sylvatica*), beech (*Fagus grandifolia*), red cedar (*Juniperus virginiana*), northern bayberry (*Myrica pensylvanica*), and beach plum (*Prunus maritima*), commonly dominate the forest community (Bain et al. 2007). The species composition can depend upon how connected these communities are to nearby forests on the coastal plain (Bain et al. 2007).

Coastal forests are non-maritime communities found within the coastal plain, but are not exposed to the same intensity of salt spray, wind, and substrate shifting as maritime communities. Because of this, trees are of normal stature and not contorted or "salt-pruned", despite the minor salt spray from severe storms like hurricanes (Eddinger et al. 2002). Coastal forests occur on dry, well-drained, low-nutrient soils, do not have dense, viney undergrowth, and have low species diversity typically dominated by one or two tree species. These communities include oak, hickory (*Carya spp.*), beech, holly, red maple (*Acer rubrum*), and pitch pine (*Pinus rigida*) forests (Eddinger et al. 2002).

Barrens (i.e., pine barrens) occur on shallow, low-nutrient soils, comprised of stunted or dwarfed trees. These communities occur on stabilized dunes, glacial till, outwash plains, and rocky soils and include species such as pitch pine, scrub oak (*Quercus ilicifolia*), post oak (*Quercus stellata*), and blueberry (*Vaccinium corymbosum*) and huckleberry (*Gaylussacia baccata*) shrubs. Pine-dominated forests blend with pine-oak forests as soil composition changes, but species composition generally stays the same, with only abundance changing. Parts of Long Island, mostly outside of the HRE study area, have remnant pine barrens that are similar to the New Jersey Pinelands. However, these forests are highly disturbed and cover a much smaller area than those of New Jersey (Olsvig et al. 1998).

Most coastal and maritime forests in the HRE study area have been degraded or eliminated by timber harvest and development. Recent encroaching development has increasingly impacted and fragmented these communities. Although there have been few attempts to restore these forests, many species in these habitat types are opportunistic and can rapidly colonize protected areas, making restoration of these forest communities in the HRE study area potentially feasible (Yozzo et al. 2003).

Target Statement

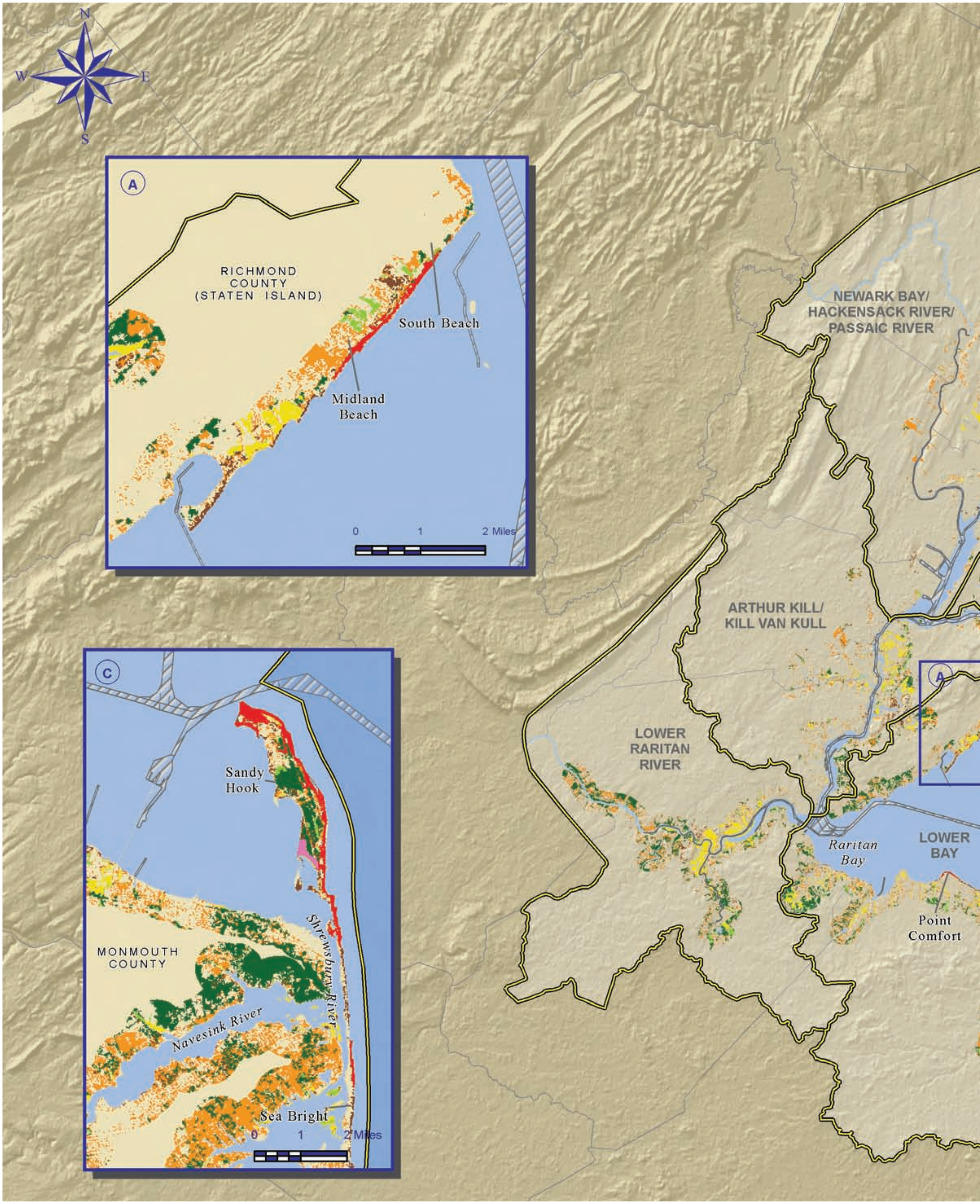
The Coastal and Maritime Forests TEC was initially designed to create a linkage of forests accessible to avian migrants and dependent plant communities from Rockaway Peninsula, New York to the coasts of New York and Raritan Bays to Sandy Hook, New Jersey. The short-term objective of the Coastal and Maritime Forests TEC is to establish one new maritime forest of at least 50 acres (0.2 kilometers^2) and rehabilitate at least 200 additional acres (0.8 kilometers^2) among several coastal forest types by 2015. By 2050, the objective is to have a total of 500 acres (2 kilometers^2) of maritime forest community among three sites, potentially at Sandy Hook, Kings/Queens counties, and/or Staten Island (Bain et al. 2007). In addition, 500 acres (2 kilometers^2) of various coastal forests should be rehabilitated within the HRE study area by 2050.

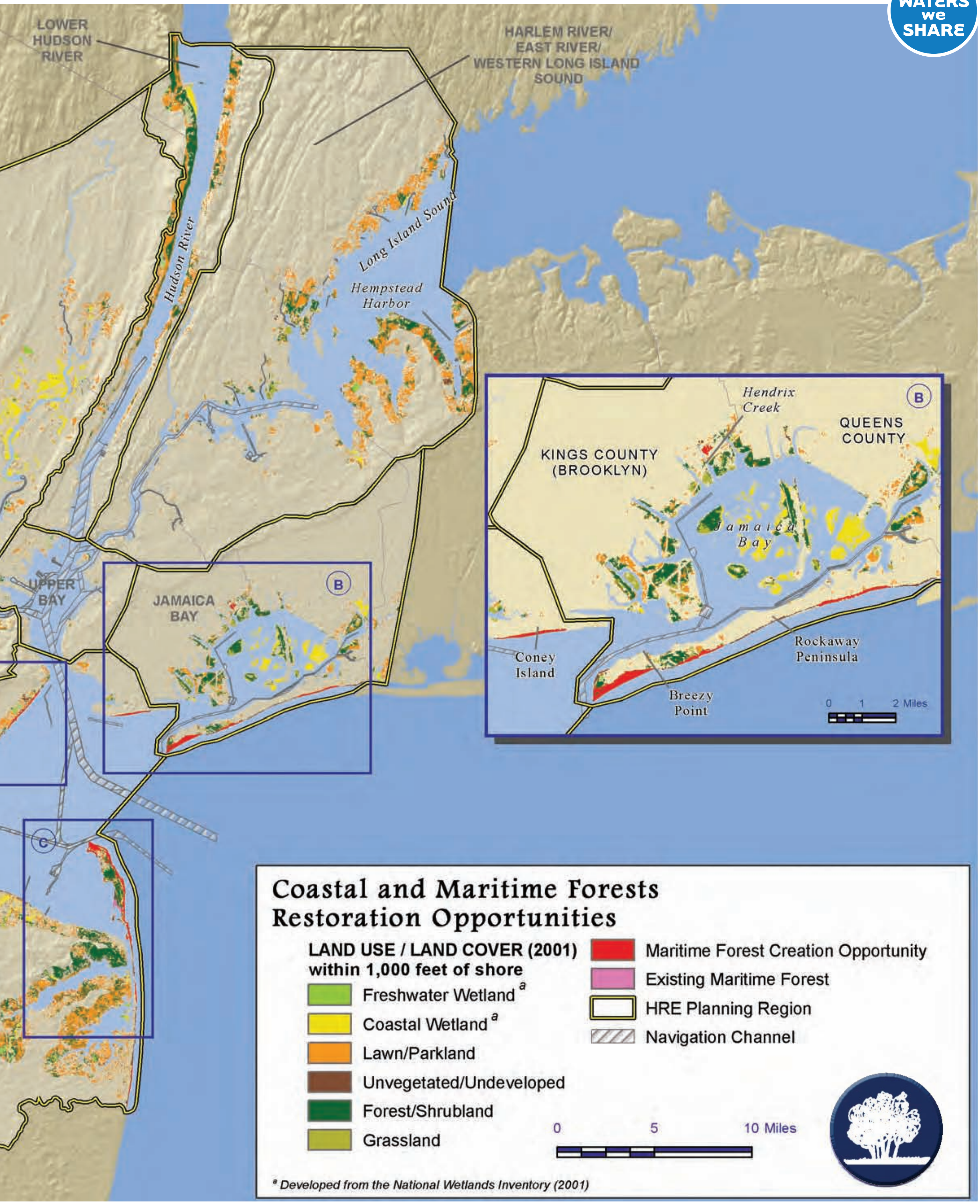
Adjacent habitats, such as dunes and maritime grasslands, or similarly rare communities, such as barrens, should also be created or enhanced when appropriate land exists. Because maritime communities represent critically rare habitat types, they should be targeted for restoration under this TEC.

Restoration Opportunities (Map 3-3)

Opportunities for restoring coastal and maritime forest habitat exist in relatively few planning regions of the HRE study area because of the strict physical requirements of these habitat types (Map 3-3). Several areas within these regions could be appropriate for creating these forest habitats. For instance, brownfields could be a potential restoration opportunity, where clean fill material could be placed over a degraded site to make it suitable.

Map 3~3.


N
W
E
S
A
RICHMOND COUNTY (STATEN ISLAND)
South Beach
Midland Beach
0 1 2 Miles
C
Sandy Hook
MONMOUTH COUNTY
Navesink River
Shrewsbury River
Sea Bright
0 1 2 Miles
NEWARK BAY/ HACKENSACK RIVER/ PASSAIC RIVER
ARTHUR KILL/ KILL VAN KULL
LOWER RARITAN RIVER
Raritan Bay
LOWER BAY
Point Comfort


LOWER HUDSON RIVER
HARLEM RIVER/ EAST RIVER/ WESTERN LONG ISLAND SOUND
Hudson River
Long Island Sound
Hempstead Harbor
UPPER BAY
JAMAICA BAY
B
C
Hendrix Creek
QUEENS COUNTY
KINGS COUNTY (BROOKLYN)
Jamaica Bay
Coney Island
Breezy Point
Rockaway Peninsula
0 1 2 Miles
Coastal and Maritime Forests Restoration Opportunities
LAND USE / LAND COVER (2001) within 1,000 feet of shore
Freshwater Wetland a
Coastal Wetland a
Lawn/Parkland
Unvegetated/Undeveloped
Forest/Shrubland
Grassland
Maritime Forest Creation Opportunity
Existing Maritime Forest
HRE Planning Region
Navigation Channel
0 5 10 Miles
a Developed from the National Wetlands Inventory (2001)

Maritime forest creation opportunities represent areas where new maritime forests could be created without affecting existing maritime forest habitat. For this reason, the Maritime Forest opportunity map displays existing maritime forest communities along with maritime forest creation opportunities. Maritime forest creation opportunities represent undeveloped land (excludes lawns and parks) within 1,000 yards (914 meters) of the shore, that can be expected to subject to salt spray due to surrounding high winds and salinity. Surrounding undeveloped land may provide much needed buffer from human influences, and for this reason, land use is presented on the map.

A single 64-acre (0.3-kilometers^2) plot of existing maritime forest is mapped in the HRE study area, on the Sandy Hook peninsula. There were 1,283 acres (5.2 kilometers^2) where maritime forests could potentially be created in the HRE study area, occurring in the Jamaica Bay and Lower Bay planning regions, and a small section in the Harlem River, East River, and Western Long Island Sound planning region. The largest areas occurred on exposed shorelines, typically not within coves or bays, like the Sandy Hook peninsula, the southern coast of Staten Island, and Rockaway Peninsula. Forested lands make up 7.3% of the land within 1,000 yards of shore (17,205 acres; 69.6 kilometers^2) in the HRE study area. These lands may be suitable for restoring coastal forest communities to create linkages among shoreline habitats.

When looking at the restoration opportunities map, three inset maps draw attention to locations where the GIS layering analysis identified maritime forest creation opportunities.

- *Inset A* – A small strip of Staten Island (near the communities of Midland Beach and South Beach) was identified as a maritime forest creation opportunity by the GIS analysis. Adjacent to this section of beach are inland parklands and unvegetated/undeveloped areas that could be appropriate for creating coastal or maritime forest communities. These areas will have to be field verified to ensure there are not conflicting land uses.
- *Inset B* – A large maritime forest creation opportunity exists on the Rockaway Peninsula, particularly west of Breezy Point along a relatively undeveloped stretch of coastline. Some of the existing forested land adjacent to these areas could be restored to form larger plots of forested habitat. A small plot of land within Jamaica Bay, along Hendrix Creek, was identified as a maritime forest creation opportunity although it may not receive substantial salt spray. A maritime forest creation opportunity was also identified on Coney Island. However, Coney Island has a popular public beach with dense inland development and it would probably not be possible to create a maritime forest here due to conflicting land uses. Coney Island Beach could benefit from re-establishing dunes, grasses, and shrubland near the boardwalk.
- *Inset C* – Sandy Hook has the only documented plot of existing maritime forest in the HRE study area. The existing maritime forest is flanked by forest/shrubland to the east, where it may be possible to restore the existing forest or create new, adjacent maritime forest habitat. Most of Sandy Hook peninsula's eastern shoreline has been identified as a maritime forest creation opportunity. This land is not densely populated, and there may be a sufficient area inland to establish the necessary beach and dune communities to protect any created maritime forest habitat. However, further south on the Sandy Hook peninsula, near the community of Sea Bright, substantial shoreline development and publicly used beaches may exclude these areas from further consideration as maritime forest creation opportunities. The existing forest/shrubland near the confluence of the Navesink and Shrewsbury rivers may be an opportunity for coastal forest restoration.

Few other opportunities for maritime forest creation appear to exist in the HRE study area. A narrow section of land along Point Comfort in Monmouth County, New Jersey was identified, but there may not be enough inland area to support the necessary beach and dunes for a maritime forest to be created. A small section of land was identified in Hempstead Harbor, off Long Island Sound, that is adjacent to existing forested land and may be appropriate for a maritime forest community. This western shore of Hempstead Harbor is well forested and may represent a coastal forest restoration opportunity. Other coastal forest restoration opportunities may exist in the Raritan Bay and the western Hudson River shoreline.

3.1.4 Oyster Reefs

Oyster reefs provide spatially-complex substrate and benthic structure that is important for many estuarine organisms. A well-developed reef will typically consist of intricately layered formations of live oysters on the exterior and layers of old oyster shell forming the base and reef interior. Deep crevices created by the oyster shell provide refuge for numerous species of small aquatic organisms. Oyster reefs are also feeding, breeding, and nursery grounds for finfish and large crustaceans, where multi-species congregations occur (Harding and Mann 1999). Oyster reefs provide attachment sites for the eggs of many small fishes, such as gobies and blennies, as well as the oyster toadfish (*Opsanus tau*). Juvenile and adult oysters are important prey for gastropods, whelks, sea stars, crabs, and boring sponges. Intertidal oyster reefs provide rich feeding grounds for many shorebird species.

Oysters are valuable organisms that can actually promote the growth and viability of other habitats. By filtering particulate material from the water column, oysters form an important link between the pelagic (i.e., open water) and benthic food webs (Yozzo et al. 2001). Through water clarity improvements, oysters can enhance other subtidal habitats like eelgrass by increasing the amount of light that can penetrate the water (Cerco and Noel 2007). In some geographic areas, oyster reefs may develop substantial vertical relief off the sea floor, altering patterns of current flow and possibly creating or expanding shallow water habitat by trapping sediments. Oyster reefs can encourage the growth and expansion of salt marshes located inshore of the reefs by functioning as natural breakwaters (Coen and Luckenbach 2000).

Historical accounts from Colonial times document flourishing oyster populations in the estuary. Large expanses of oysters in upper Raritan Bay stretched a mile in diameter and were referred to as the “Great Beds”. Populations also existed in the Hudson River and tributaries of Staten Island, although the upstream extent to which they occurred is uncertain (MacKenzie 1992). Historically, oysters were a keystone species in the HRE study area, providing both ecological functions and an economic role in the region. The oyster fishing industry in the estuary thrived in the mid-late 19th century and was estimated to cover approximately 200,000 acres (810 kilometers^2; Kennish 2002, Bain et al. 2007). However, by the early 20th Century, poor water quality conditions and incidence of human-transferable diseases resulted in declining harvest and, by 1925, the oyster industry in the estuary was abandoned (MacKenzie 1992). The loss of historic oyster beds permanently altered the structure and function of the estuary’s benthic ecosystem, and eliminated a significant habitat resource for estuarine fish and invertebrate species which rely on spatially-complex submerged structures.

Today, no known oyster reefs exist in the HRE study area. However, scattered live oysters can be found in certain areas, indicating the presence of isolated populations. Oyster restoration programs, such as the NY/NJ Baykeeper's Oyster Restoration Program oyster gardening and seeding program have become increasingly popular through enthusiastic grassroots participation. Research initiatives to identify suitable locations for restoration of oyster reefs have been planned and initiated. For example, the Rutgers Environmental Research Clinic is working with the NY/NJ Baykeeper, Hackensack Riverkeeper, and the New Jersey Meadowlands Commission to determine locations able to support sustainable long-term development of oyster reef habitat within the NY/NJ harbor estuary complex (RERC 2008). The research will provide data on survivability, growth, disease, and structural substrate. The Oyster Reefs TEC addresses important biological and physical contributions to the estuary and emphasizes the unique role oysters have played in the culture and history of the HRE.

Project Example: The Bronx River Oyster Restoration Pilot Study

Recent recognition of the ecological value oysters and their structurally complex reefs provide has resulted in an estuary-wide effort to restore the Eastern oyster to the HRE study area. In 2006, the Natural Resource Group of the New York City Department of Parks and Recreation, Rocking the Boat, and the Bronx River Alliance initiated an oyster restoration pilot study at the mouth of the Bronx River.

At this site, students and community groups constructed two artificial reefs offshore of Soundview Park on a soft-bottomed shoal. The groups have performed three years of post-construction monitoring to evaluate use of the reefs by estuarine organisms, including oysters. The monitoring programs investigated oyster spat settlement, sedimentation patterns in the project area, and fish, benthos, and epibenthos use of the reefs. Another main goal of the pilot study was to increase ecological monitoring, education, and stewardship opportunities for local environmental programs. The lessons learned from the Bronx River Oyster Restoration Pilot Study will be valuable when scaling oyster reef restoration to larger projects in the HRE study area.

The NYSDEC has requested that restoration practitioners and project sponsors consider the following when preparing an oyster restoration proposal in New York waters:

1. Pilot scale projects provide the benefit of community involvement.
2. Proposals for large-scale projects need to discuss habitat exchange issues.
3. Risk management strategies should be discussed.
4. Shells should be from New York. Out-of-State shells may require treatment prior to use in New York waters.
5. Spat should only be from New York and northern states because of disease concerns.
6. Protection of Waters and Coastal Zone Consistency permits will be required for oyster restoration projects.
7. Suggest coordination with the Food and Drug Administration and the Interstate Shellfish Sanitation Conference.

Although the NJDEP has not provided a formal set of guidelines to be followed when planning oyster restoration projects in New Jersey waters, they do not recommend restoration projects for commercially harvested shellfish in prohibited or special restricted waters (i.e. closed to shellfishing). Because they are concerned with illegal harvest of oysters and associated health risks, the NJDEP and NYSDEC recommend considering the restoration of shellfish species that have no commercial value in these waters. Presently efforts are being made to coordinate oyster reef restoration activities within the existing States' permitting framework. While the goals of the regulations are quite defensible (i.e., avoiding public harm with respect to navigation or the environment, protecting public health, etc.), alternative mechanisms for achieving them are being considered.

Because the success of oyster reef restoration has not been demonstrated in the HRE study area, and oysters can be considered an "attractive nuisance" for illegal harvest, it may be prudent to consider restoring shellfish species other than oysters that provide similar ecosystem services, such as hard clams, softshell clams, blue mussels and ribbed mussels. Although the ecological benefits of these species are not as substantial as those of oyster reefs, the risks associated with restoration may make these projects more attractive to regulators. Another possibility is the construction of reefs or other in-water structures without live oysters to provide structural complexity to the benthic environment.

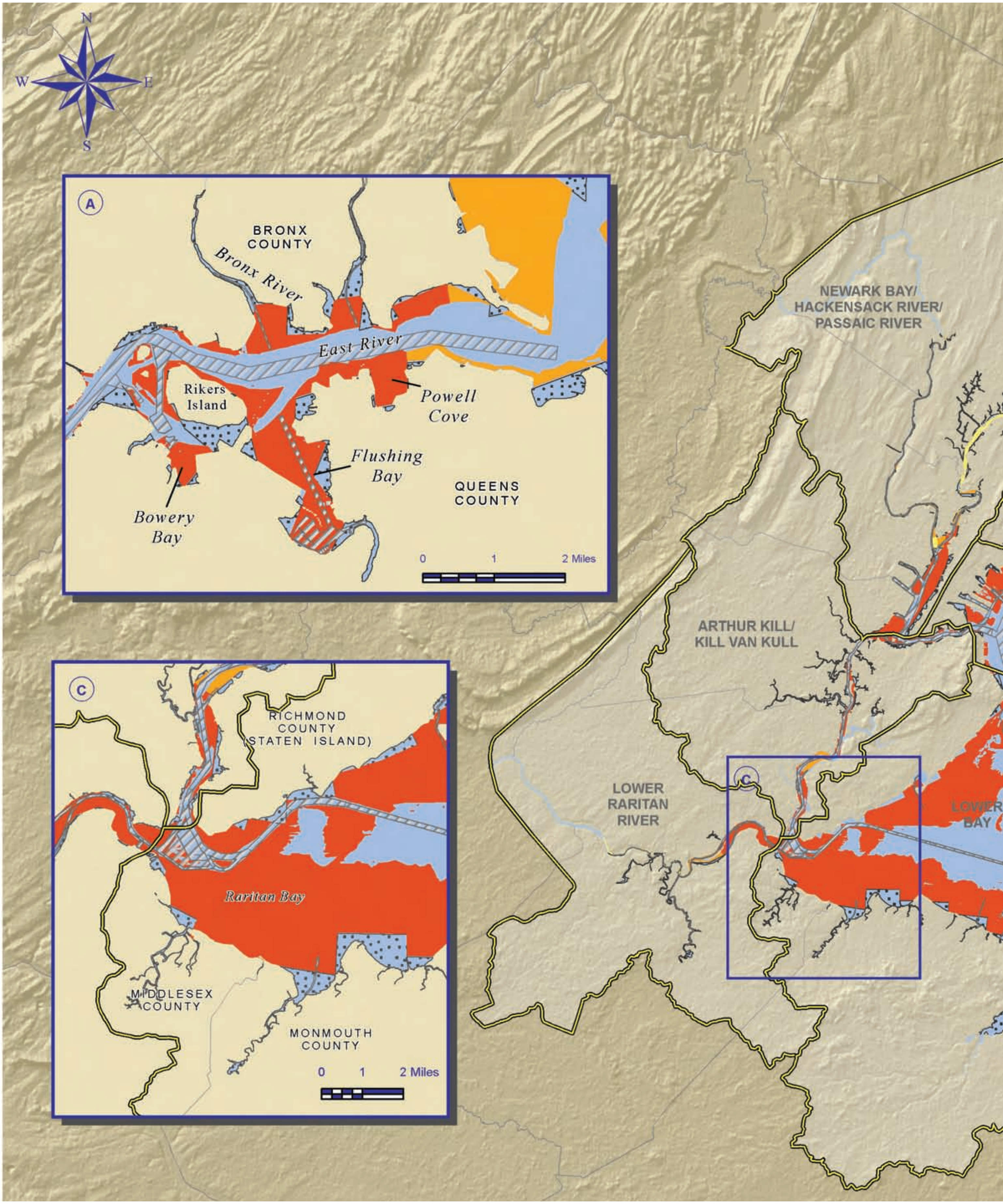
Target Statement

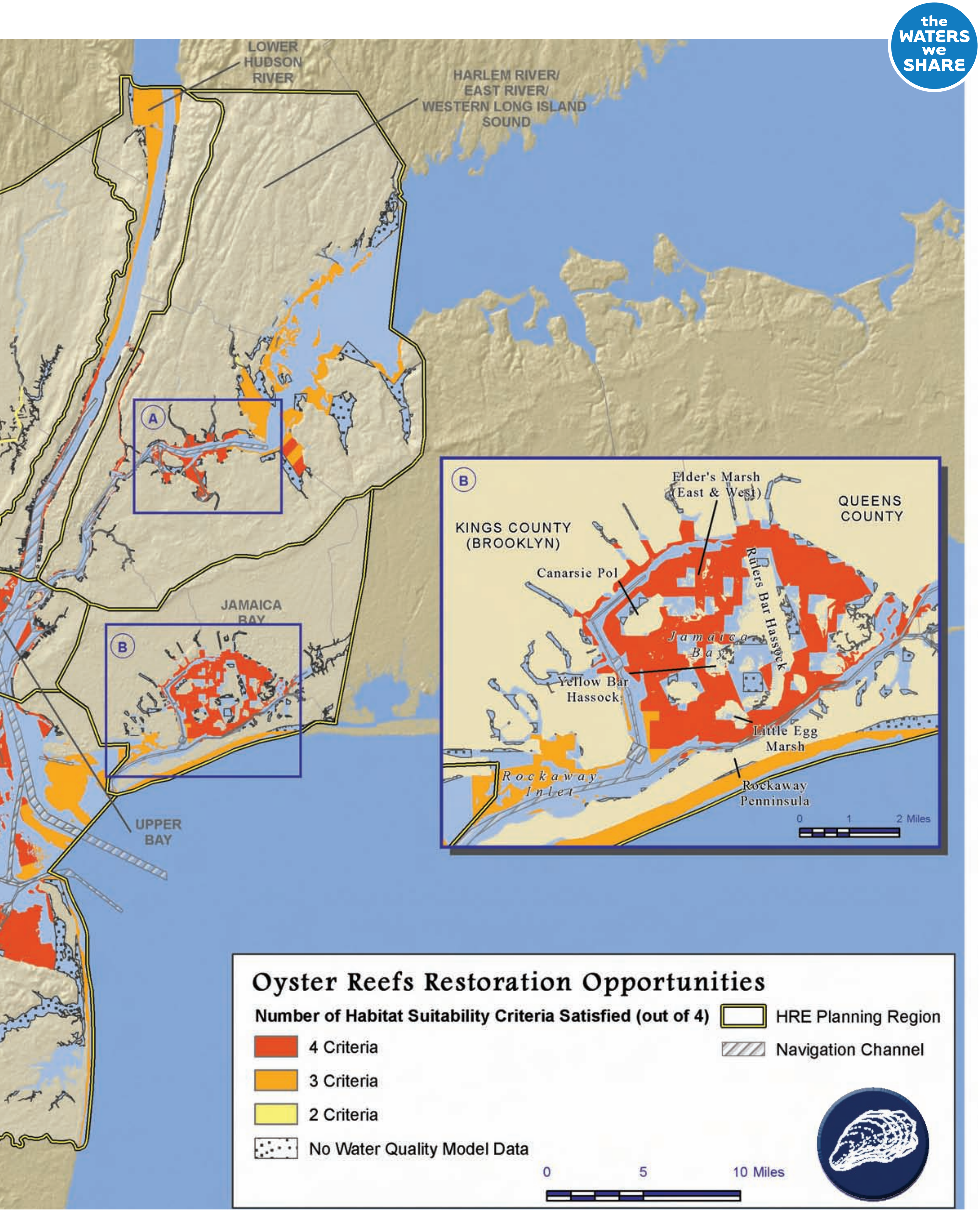
The Oyster Reefs TEC aims to establish oyster reefs at several locations in the HRE study area (Bain et al. 2007). The short-term objective for the oyster reefs TEC is to create 500 acres (2 kilometers^2) of self-sustaining and naturally expanding oyster reef habitat in the HRE study area across 10 to 20 sites by 2015. By 2050, the objective is to have 5,000 acres (20 kilometers^2) of established oyster reef habitat.

Restoration Opportunities (Map 3-4)

Oysters were prevalent throughout the estuary, and opportunities for restoration exist in every HRE planning region. Data used to identify restoration opportunities were seasonally – and spatially-variable water quality parameters developed using calibrated, peer-reviewed models: the System-Wide Eutrophication Model (SWEM) and the Jamaica Bay Eutrophication Model

Map 3~4.


N
W
E
S
A
BRONX
COUNTY
Bronx River
East River
Rikers
Island
Powell
Cove
Flushing
Bay
QUEENS
COUNTY
Bowery
Bay
0 1 2 Miles
C
RICHMOND
COUNTY
(STATEN ISLAND)
Raritan Bay
MIDDLESEX
COUNTY
MONMOUTH
COUNTY
0 1 2 Miles
NEWARK BAY/
HACKENSACK RIVER/
PASSAIC RIVER
ARTHUR KILL/
KILL VAN KULL
LOWER
RARITAN
RIVER
C



Habitat Suitability Layers from the System-Wide Eutrophication Model/Jamaica Bay Eutrophication Model (2008 model output): Bathymetry, Salinity, Dissolved oxygen, Total suspended solids

(JEM) that were developed by the NYCDEP and used for the Contamination Assessment and Reduction Program (CARP). As the name suggests, the SWEM covers a large spatial extent that fully encompasses the HRE study area, from the inland rivers of New York and New Jersey into the New York Bight, extending to Cape May, New Jersey and Nantucket Shoals, Connecticut. The JEM was developed using a higher resolution grid for Jamaica Bay.

The Oyster Reefs Restoration Opportunities map (Map 3-4) displays the results from the analysis. All sub-tidal waters of the HRE study area were evaluated for their potential to serve as oyster reef sites using environmental parameters critical for oyster egg and larval survival. Restoration opportunities were identified by layering the modeled parameter values for June through September and creating polygons where multiple criteria were satisfied. Locations where the most criteria were satisfied represent areas that appear to be the most suitable locations for establishing oyster reefs (based on available estuary-wide data sets). The four environmental parameters used to identify suitable locations for oyster restoration sites were based on oyster habitat requirements and feasibility. These parameters are: salinity range, dissolved oxygen, total suspended solids and bathymetry. Large areas of the HRE study area satisfied the four criteria, of which selection seemed to be driven by minimum salinity. Of the areas that met the bathymetry criterion, all of these met at least two other criteria. There were over 50,000 acres (202 kilometers^2) of subtidal habitat that met four criteria, occurring mostly in the Lower Bay and Jamaica Bay. Other areas that may be suitable include along the East River in Flushing Bay, Newark Bay, the Upper Bay, and the East River.

When looking at the restoration opportunities map, several inset maps draw attention to locations that might be suitable for oyster beds.

- *Inset A* – Sizeable areas that could provide habitat for oyster reefs exist along the East River in Flushing Bay, Westchester Cove and in the Bronx River.
- *Inset B* – A large portion of Jamaica Bay satisfies the water quality and depth habitat preferences for oyster reefs.
- *Inset C* – The Lower Bay, including Sandy Hook Bay and the Lower Raritan River, appear to have the potential for the greatest expanses of oysters in the HRE study area.

3.1.5 Eelgrass Beds

Eelgrass (*Zostera marina*), a true grass and not a seaweed is one of the few plants that occurs almost exclusively in subtidal waters with marine salinities, utilizing the water column for vertical support (Fonseca 1992). The Eelgrass Beds TEC represents a habitat that is vertically and horizontally complex, attracting dense and diverse communities of macroinvertebrates, shellfish, and fishes, as well as providing critical nursery habitat for important fishery species. Eelgrass beds support all trophic levels and provide many ecosystem services to the estuary.

Eelgrass can grow rapidly, producing large quantities of organic matter. This primary production supports a complex food web that cycles nutrients between sediments and surface waters (Fonseca 1992). Eelgrass plants produce oxygen and can filter nutrients and contaminants, improving the surrounding water quality (Bain et al. 2007). Eelgrass beds also provide physical benefits to the ecosystem. Wave and current energy is dissipated through the beds, reducing erosion and sediment resuspension, and preserving sediment-dwelling bacteria and fungi (Bain et al. 2007, Fonseca 1992). Enhanced sediment stability increases the accumulation of organic and inorganic materials (Fonseca 1992). The improved conditions surrounding eelgrass beds enhance their self-sustainability by providing stable sediment and optimal water quality for eelgrass bed expansion.

In the HRE study area, eelgrass beds were historically abundant along the Raritan Bay shore in north-central New Jersey. A wide-ranging infestation of the marine slime mold (*Labryinthula zosterae*) along with declining water quality in many coastal areas, virtually eliminated eelgrass from the HRE and other Atlantic coast estuaries during the 1930s (Bain et al. 2007). Today, eelgrass has been virtually eliminated from the HRE study area and only a few small beds remain.

Target Statement

Restoration of eelgrass beds should initially focus on choosing suitable sites for planting test beds and gaining an understanding of habitat criteria and feasibility of restoration. The short-term objective is to attempt test beds in each of the eight planning regions in the HRE study area by 2015. The long-term objective for the Eelgrass Beds TEC is to have at least three established, self-sustaining, and expanding eelgrass beds in each planning region by 2050. It must be emphasized that there may be entire planning regions that do not meet the physical requirements (e.g., low wave energy, high salinity) necessary to sustain healthy eelgrass populations. Test beds should be attempted in areas when there is a high probability for success and should not be "forced" in unsuitable areas.

Pilot eelgrass restoration projects and their associated monitoring will help to determine whether the creation of larger eelgrass beds may be possible and will help to increase the likelihood for success of future restoration efforts.

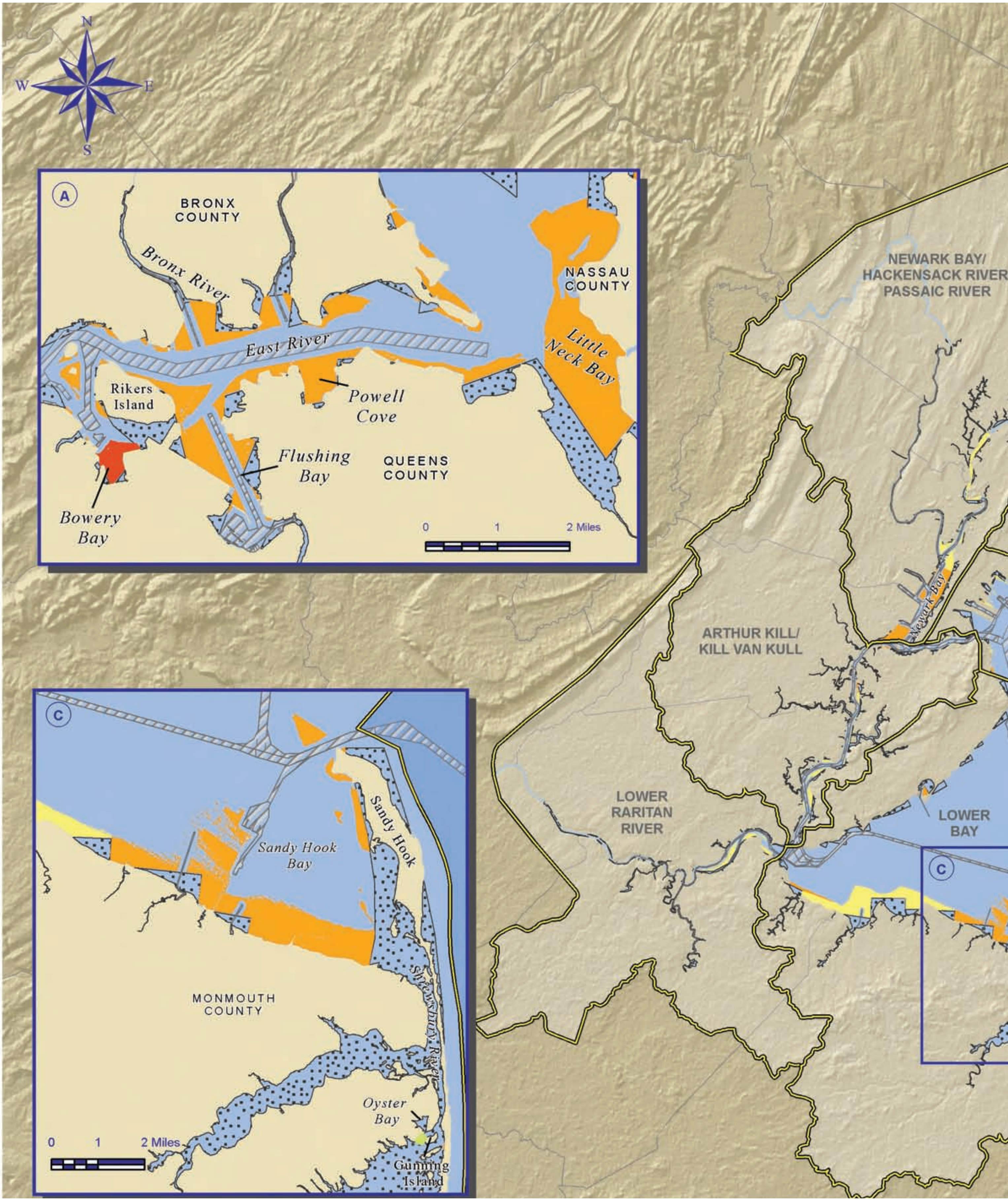
The future of eelgrass restoration in the HRE study area may be advanced through the implementation of the following near-term actions.

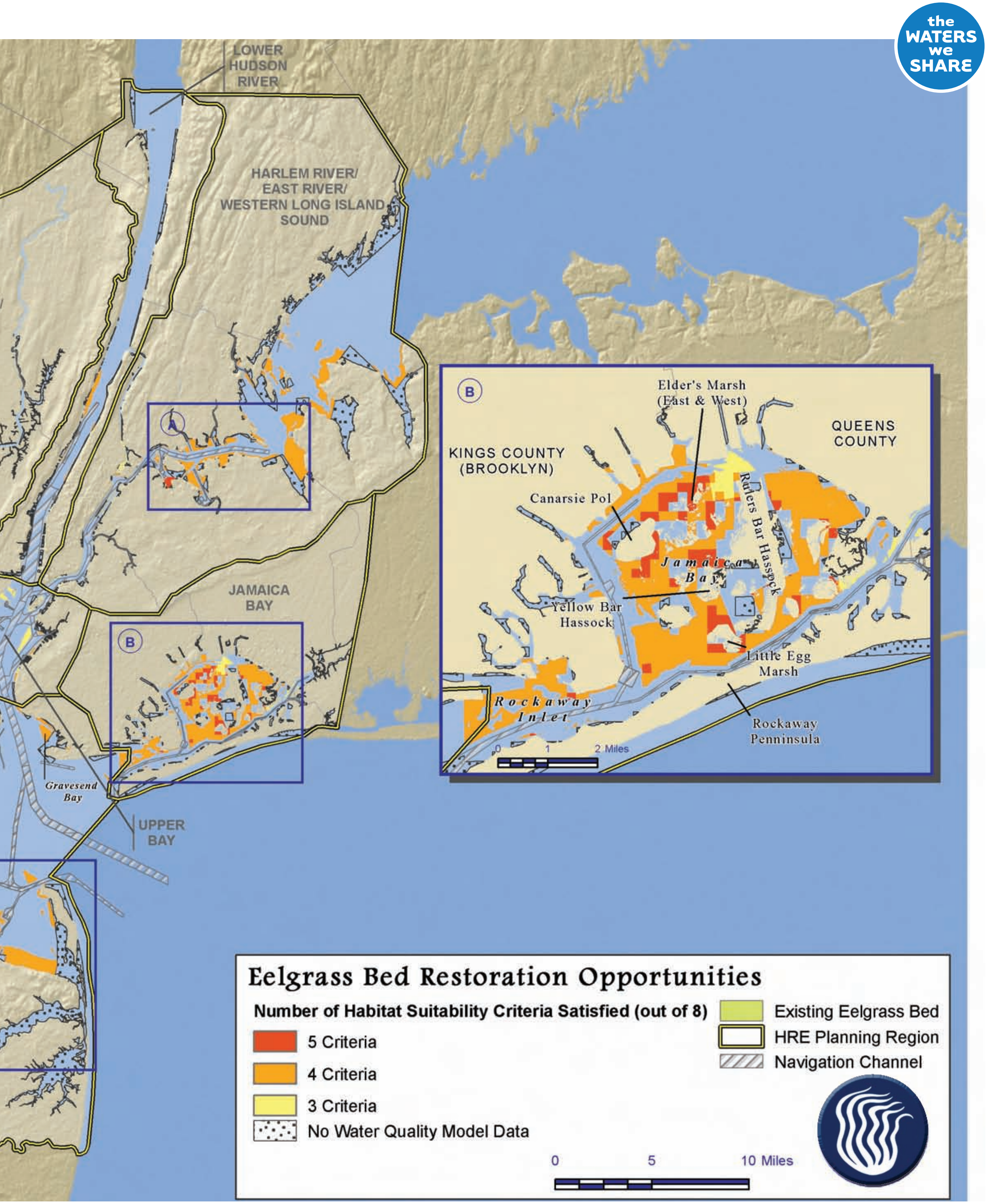
1. Pilot-scale projects should be conducted before any large-scale restoration programs are initiated. These projects should span discrete abiotic conditions (depths, sediment types, wave energy regimes) and incorporate a variety of seeding/planting techniques. In many cases, several techniques can be employed for a single site, where for instance, adult plants are transplanted then supplemented by a seed-based program.
2. Managers need to be involved in the research/restoration process so they better understand and support eelgrass research and monitoring.
3. The importance of post-restoration monitoring and sharing/implementing lessons learned should be emphasized. Monitoring will refine the suitability criteria and improve subsequent restoration programs.
4. It is necessary to develop a restoration plan for eelgrass that shifts away from opportunistic restoration and moves toward developing a strategic plan that focuses on restoration in suitable locations throughout the estuary. This plan should set achievable targets. It may be beneficial to use structural versus functional targets when evaluating restoration success.
5. Proponents for eelgrass restoration among the agencies and environmental groups should be identified.

Restoration Opportunities (Map 3-5)

Because eelgrass has specific habitat requirements, opportunities for restoration exist in only a few HRE planning regions. Data used to identify eelgrass pilot projects were seasonally – and spatially-variable parameters developed using calibrated, peer-reviewed models: the SWEM and the JEM. Eight parameters were used in the analysis, some with overlapping roles in

Map 3~5.


N
S
E
W
A
BRONX COUNTY
Bronx River
East River
NASSAU COUNTY
Little Neck Bay
Rikers Island
Powell Cove
Flushing Bay
QUEENS COUNTY
Bowery Bay
0 1 2 Miles
C
Sandy Hook Bay
Sandy Hook
MONMOUTH COUNTY
Shrewsbury River
Oyster Bay
Gunning Island
0 1 2 Miles
NEWARK BAY/ HACKENSACK RIVER PASSAIC RIVER
Newark Bay
ARTHUR KILL/ KILL VAN KULL
LOWER RARITAN RIVER
LOWER BAY
C



Habitat Suitability Layers from the System-Wide Eutrophication Model/Jamaica Bay Eutrophication Model (2008 model output): Bathymetry, Salinity, Fetch, Chlorophyll a, Dissolved inorganic nitrogen, Dissolved inorganic phosphorus, Light penetration, Total suspended solids restricting water clarity. The parameters represent habitat requirements, such as nutrient levels (dissolved inorganic nitrogen [DIN] and phosphorus [DIP]), phytoplankton levels (as *Chlorophyll a*), light penetration and total suspended solids, salinity, fetch distance, and bathymetry.

Two layers are displayed on the Eelgrass Opportunity Map (Map 3-5), existing eelgrass beds and restoration opportunities for eelgrass test beds. The restoration opportunities represent areas where multiple habitat requirements were met, indicating the potential for the area to support eelgrass beds.

The only mapped existing eelgrass bed, 8.7 acres (0.04 kilometers^2) in the HRE study area is in the Shrewsbury River between Gunning Island and Oyster Bay (Inset C). No locations satisfied the criteria for more than five parameters, and no waters of the HRE study area met the DIN or DIP criteria. Light also limited the suitable areas, with only Jamaica Bay having areas with optimal light penetration. There were 1,040 acres (4.2 kilometers^2) of subtidal habitat that met four criteria, occurring mostly in Jamaica Bay. Of the suitable areas identified, most satisfied three criteria, totaling 15,695 acres (63.5 kilometers^2), whereas 5,284 acres (21.4 kilometers^2) met two criteria. When looking at the restoration opportunities map, several inset maps draw attention to locations that might be suitable for eelgrass test beds.

- *Inset A* – Most of the areas identified in the East River satisfied four criteria: bathymetry, salinity, Total Suspended Solids (TSS), and fetch. Bowery Bay satisfied five criteria and could be an appropriate location for an eelgrass test bed; meeting the chlorophyll a preferences (did not meet DIN, DIP, or light criteria). Other promising locations for test beds appear to occur in the Bronx River and Westchester Creek estuaries, portions of Flushing Bay, Powell Cove, and Little Neck Bay. Subtidal areas surrounding Rikers Island satisfied four criteria, though eelgrass test beds are not recommended for these high velocity areas.
- *Inset B* – The suitability results suggest Jamaica Bay to be one of the most promising locations for eelgrass test beds. Sizeable areas that satisfied five criteria were identified in Jamaica Bay, most surrounding islands west of Rulers Bar Hassock. These typically occurred on the tidal flats, such as those to the south of Canarsie Pol, surrounding Elder's Marsh (east and west), to the north of Yellow Bar Hassock, and surrounding Little Egg Marsh. Small areas of high suitability occurred off the bay side of the Rockaway Peninsula. The five criteria satisfied in portions of Jamaica Bay were light penetration, salinity, TSS, bathymetry, and fetch. Large portions of the Rockaway Inlet satisfied four criteria, though only the most protected of these areas should be considered.
- *Inset C* – Portions of Sandy Hook Bay, along Monmouth County and the Sandy Hook Peninsula, met the fetch, bathymetry, salinity, and TSS criteria. Although modeled data did not exist for the Shrewsbury and Navesink rivers, the only mapped location of an existing eelgrass bed occurs in this region. Therefore, it is strongly recommended that these water bodies be further evaluated to determine their suitability as test bed locations.

Other opportunities – Similar to Shrewsbury and Navesink rivers, many of the inland bays of Long Island Sound were not included in the SWEM, and therefore could not be evaluated for this analysis. It is strongly recommended that the suitability of these bays be investigated. Other areas of the HRE study area that satisfied four criteria are Newark Bay, the coasts of the Lower Hudson River, and Gravesend Bay, off Brooklyn. These locations may not be the most appropriate for the initial test beds as light penetration may not be sufficient for eelgrass survival.

3.2 Habitat Complexes

Three of the TECs focus on ensuring the connectivity of different habitat types to provide habitat complexes for species that require more than one habitat during their life cycle. These habitat complexes are important for organisms that move between habitats to forage or spawn. Loss of the connectivity of these habitats can have serious consequences, especially when there are blockages that prevent migration to spawning areas. Many of the TEC habitats described above could be connected to form these habitat complexes. The following sections describe these habitat complexes, the objectives for the TECs, and potential restoration opportunities within the HRE study area.

3.2.1 Shorelines and Shallows

The Shorelines and Shallows TEC addresses important physical, chemical, and biological services to the nearshore habitats of estuaries by creating natural sloping shorelines with three contiguous habitat types. These habitat types are generally comprised of (1) littoral zones that remain inundated with shallow water, (2) intertidal areas that are regularly submerged during high tides, and (3) riparian zones that are important transitional habitats between land and water (Steinberg et al. 2004). This TEC targets habitats of four meters or less mean low water, based upon the USEPA's working definition of shallow waters, where "critical functions such as biological productivity and ecological balance must be reconciled with human activities" (Reilly et al. 1996).

Subtidal littoral zones typically support high densities of organisms and high species diversity, particularly when vegetated. Because of the high densities of invertebrates, slower current velocities, and available refuge, littoral zones support resident populations of small fish and crustaceans and provide critical nursery habitat areas for transient species. Larger fish tend to remain in deeper water habitat, on the outskirts of littoral areas, where they feed on macroinvertebrates and small fishes that may be carried outward by tidal currents (Findlay, Wigand and Nieder 2006). In addition, some plants and animals have evolved adaptations to life in intertidal environments that are alternately flooded and drained twice daily in the HRE study area.

In the HRE study area, many natural shorelines have been replaced with bulkheads, revetments, riprap, and dock/pier infrastructure. These shoreline structures have eliminated transitional intertidal and littoral areas. Hardened shorelines amplify wave energy, which can increase erosion and deepen nearshore waters, affecting water quality/clarity and habitat availability. Pier construction can reduce channel width, reduce current velocities, and increase sedimentation. Increased sedimentation reduces available water column habitat and buries existing, natural hard substrates. Shading impacts of shoreline structures on aquatic flora and fauna are increasingly being recognized in aquatic resource assessments, and recent research conducted within the HRE study area has documented fewer species, lower abundances, and fewer feeding opportunities underneath large over-water structures in comparison to open water, pile fields, or edge habitat (Able and Duffy-Anderson 2006).

Target Statement

Today, approximately 36% of shoreline in the HRE study area has been hardened, according to the 2006 NOAA National Geodetic Survey (Bain et al. 2007). Three HRE planning regions with the highest percentage of hardened shorelines are the Harlem River/East River/Western Long Island Sound (46%), Lower Hudson River (66%), and Upper Bay (87%). Although shoreline restoration opportunities exist in all planning regions, these three planning regions should be targeted for restoration under this TEC.

The short-term objective is to establish a new Shoreline and Shallow site in three of the planning regions by 2015, while the long-term objective aims to restore all available shoreline and shallows sites in the following priority planning regions (Lower Hudson, Upper Bay, and Harlem-East Rivers-Long Island Sound) and at least two sites in the others planning regions by 2050. Restoration should focus on removing hardened shorelines to create gently sloping areas with three zones: vegetated riparian, stable intertidal, and illuminated littoral zones. Although restoration of natural shorelines is ideal, other methods of shoreline softening should be considered in achieving the target conditions.

Structural elements can provide general habitat enhancement or target individual species by varying the size of crevices and structural materials (e.g., filling hollow areas with oyster shell, and/or creating structures with OysterKrete – biologically enhanced material to stimulate oyster growth). Examples of habitat features that can be incorporated into new waterfront features or reconstructed shorelines include:

- Underwater baffles or training walls to redirect flows and maintain desirable depths and exposed substrates,
- Increasing light transmission through piers by increasing the height or decreasing the width of piers (Able and Duffy-Anderson 2006), and
- Adding physical complexity through the use of texturized bulkheads or the addition of individual reef elements, like reef balls or stacked hollow cubes along a shoreline (Figure 3-1).

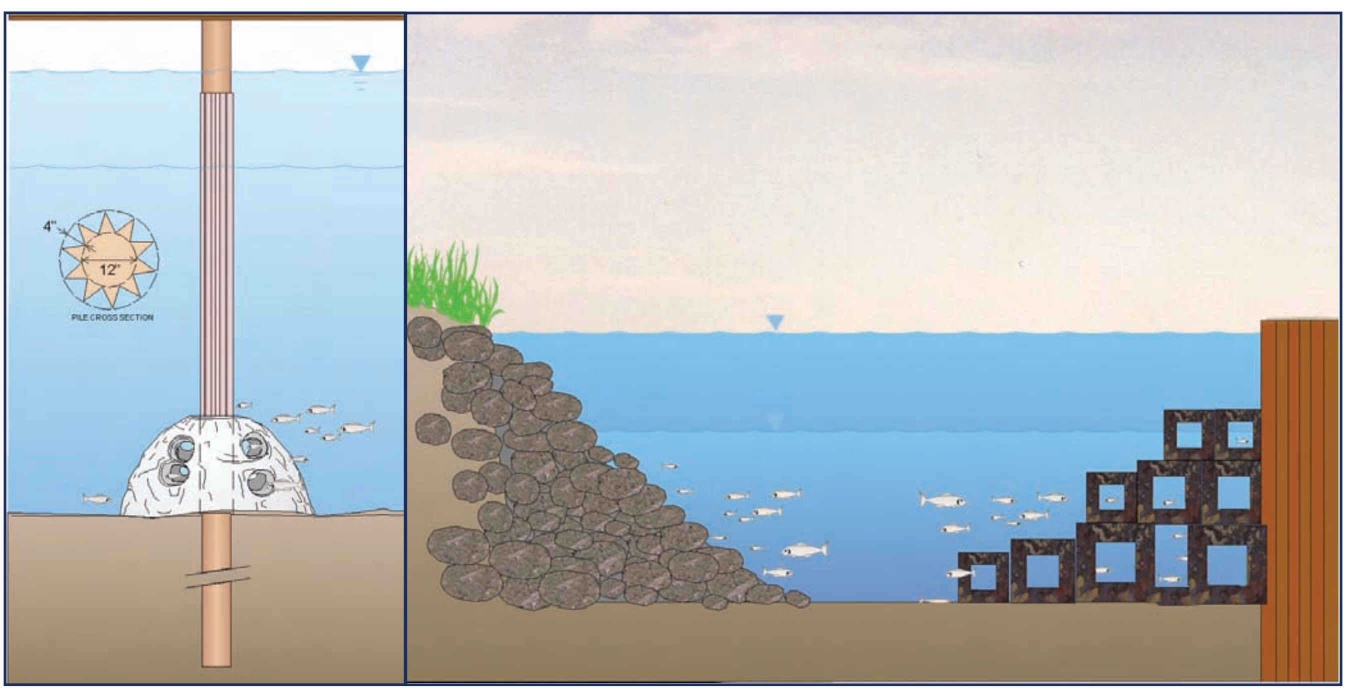


Figure 3~1. Examples of in-water structures that increase habitat value.

Restoration Opportunities (Map 3-6)

Opportunities for improving Shorelines and Shallows exist in each planning region of the HRE study area. Map 3-6 displays existing littoral, intertidal, and undeveloped and vegetated upland areas that could be improved by creating gently sloping shorelines and reconnecting the three habitat zones. The shallow littoral layer displays subtidal habitat four meters or less below mean low water, where as the intertidal areas are those which inundate twice daily in the HRE study area.

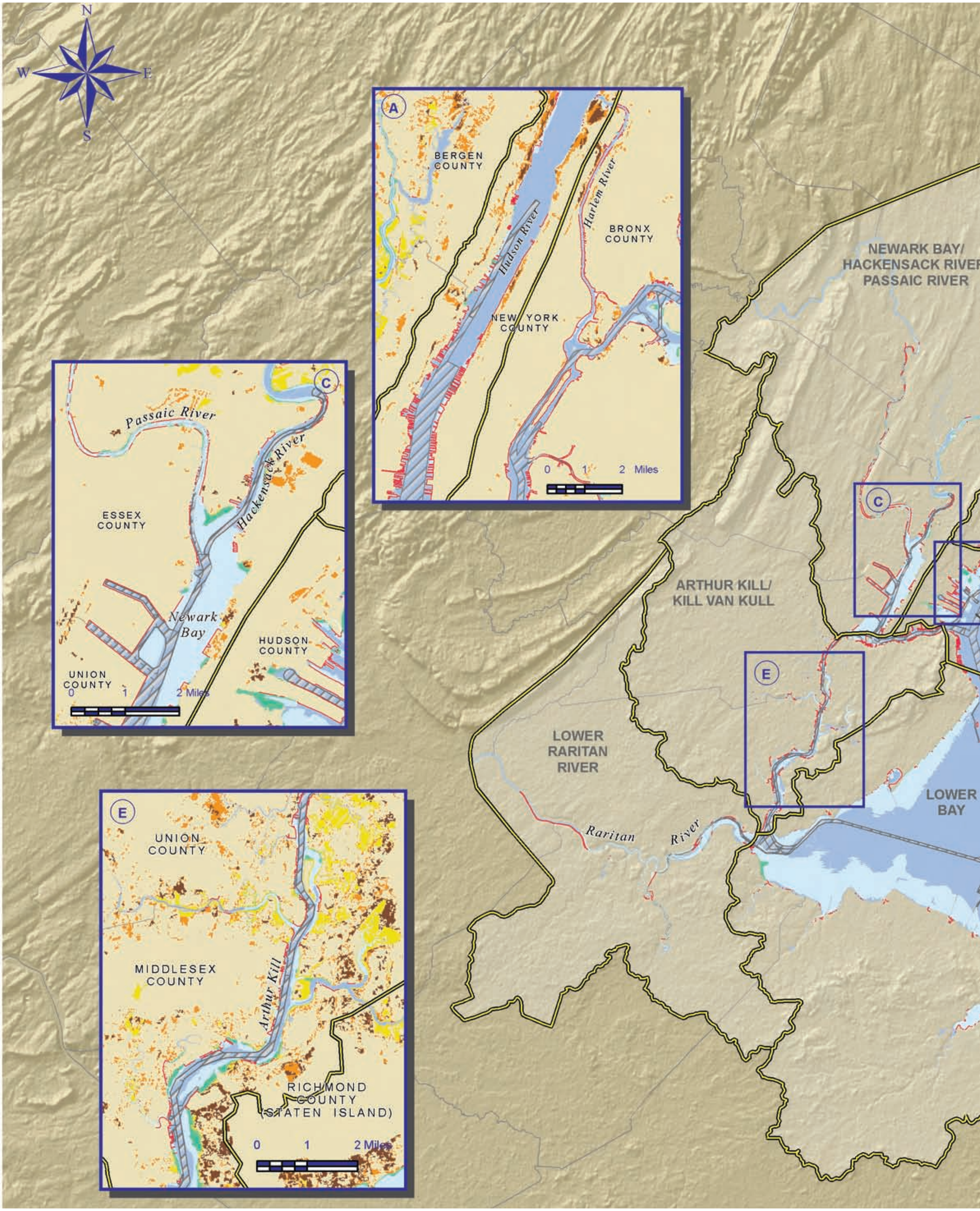
Littoral habitat comprises a large portion of the bays within the estuary, roughly 30%, 54,630 acres [221 kilometers^2]) of the total open water acreage in the HRE study area (Table 3-4). Intertidal areas are relatively rare, comprising less than 2% (3,022 acres [12.2 kilometers^2]) of the total open water in the study area. The adjacent undeveloped upland areas include forests and shrublands, grasslands as well as unvegetated areas. Coastal wetlands and lawn/parklands layers are displayed separately on the inset maps. Only areas of the undeveloped and vegetated layers within 1,000 yards (914 meters) of shore are displayed on the map, which was exaggerated from a typical buffer (100 feet [91.4 meters] wide along shore) so that it would be visible on an estuary-wide scale. Lawn/Parkland represents almost 13% (30,304 acres [123 kilometers^2]) of the land within 1,000 yards of shore, whereas adjacent undeveloped upland and coastal wetlands represent about 9% (21,234 acres [86 kilometers^2]) and 5% (12,544 acres [51 kilometers^2]), respectively.

Table 3-4. Areas of habitat and linear distance of man-made shoreline that could be restored in the HRE study area.

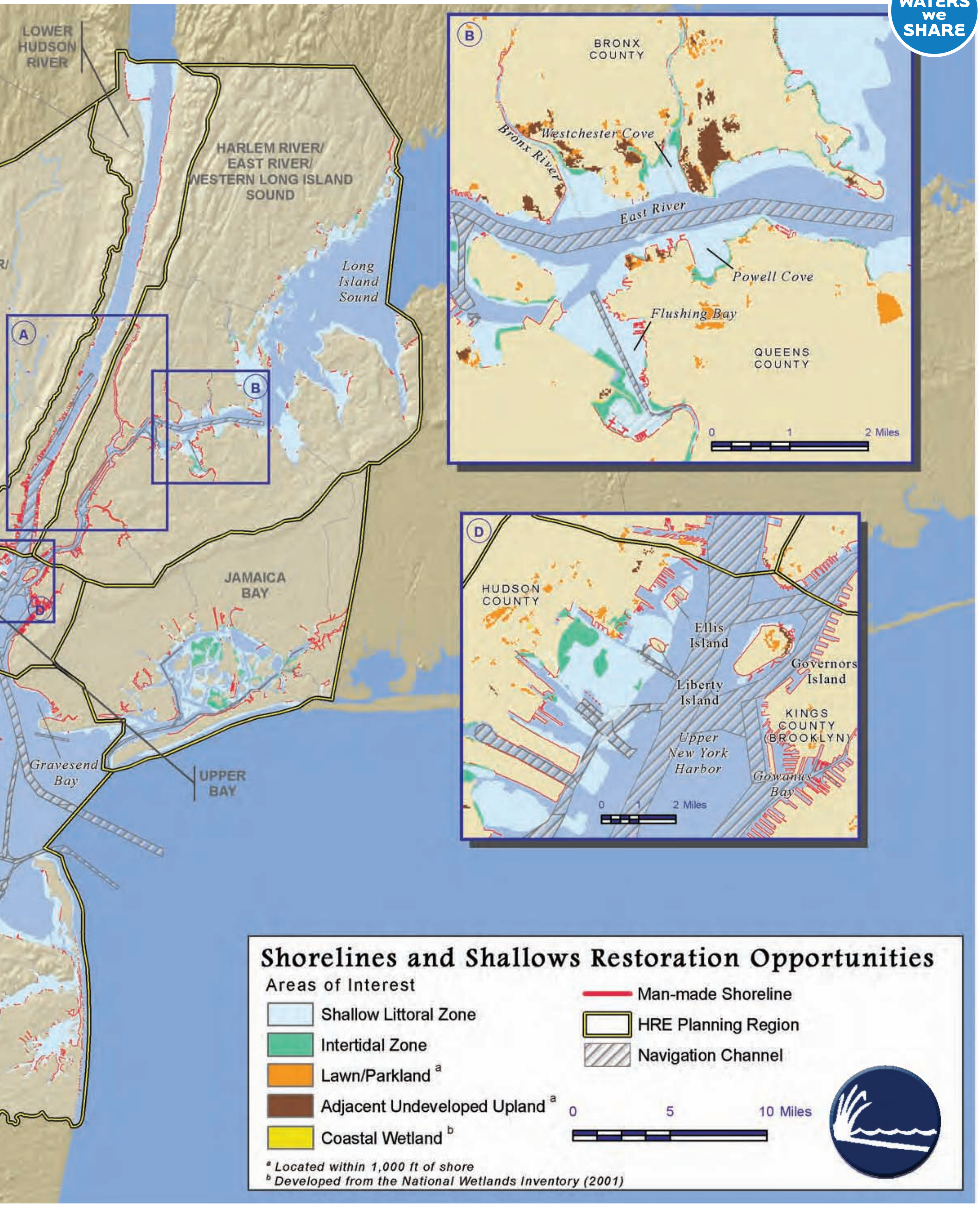
GIS Layer	Area or Distance (Standard / Metric)	
Shallow Littoral Zone (< 4 meters) NOAA Electronic Navigation Charts	54,630 acres	221 kilometers^2
Intertidal Zone (Negative depths) NOAA Electronic Navigation Charts	3,022 acres	12 kilometers^2
Adjacent Undeveloped Upland (within 1,000 yards) 2001 National Land Cover Database	21,234 acres	86 kilometers^2
Lawn/Parkland (within 1,000 yards) 2001 National Land Cover Database	30,304 acres	123 kilometers^2
Coastal Wetlands* USFWS National Wetland Inventory (2001)	12,544 acres	51 kilometers^2
Man-Made Shoreline (including piers) National Geodetic Survey Shoreline	551 miles	887 kilometers
Man-Made Shoreline (no piers) National Geodetic Survey Shoreline	458 miles	737 kilometers

*Does not include acreage or distance for coastal wetland creation.

Map 3~6.



N
W
E
S
A
BERGEN COUNTY
Hudson River
Harlem River
BRONX COUNTY
NEW YORK COUNTY
0 1 2 Miles
C
Passaic River
Hackensack River
ESSEX COUNTY
Newark Bay
HUDSON COUNTY
UNION COUNTY
0 1 2 Miles
E
UNION COUNTY
MIDDLESEX COUNTY
Arthur Kill
RICHMOND COUNTY (STATEN ISLAND)
0 1 2 Miles
NEWARK BAY/ HACKENSACK RIVER PASSAIC RIVER
ARTHUR KILL/ KILL VAN KULL
LOWER RARITAN RIVER
Raritan River
LOWER BAY


LOWER HUDSON RIVER
HARLEM RIVER/ EAST RIVER/ WESTERN LONG ISLAND SOUND
Long Island Sound
JAMAICA BAY
Gravesend Bay
UPPER BAY
A
B
D
BRONX COUNTY
Westchester Cove
Bronx River
East River
Powell Cove
Flushing Bay
QUEENS COUNTY
0 1 2 Miles
HUDSON COUNTY
Ellis Island
Liberty Island
Governors Island
KINGS COUNTY (BROOKLYN)
Upper New York Harbor
Gowanus Bay
0 1 2 Miles
Shorelines and Shallows Restoration Opportunities
Areas of Interest
Shallow Littoral Zone
Intertidal Zone
Lawn/Parkland a
Adjacent Undeveloped Upland a
Coastal Wetland b
Man-made Shoreline
HRE Planning Region
Navigation Channel
0 5 10 Miles
a Located within 1,000 ft of shore
b Developed from the National Wetlands Inventory (2001)

Map 3-6 also displays man-made shorelines (e.g., bulkheads, piers, wharfs, jetties, and rip-rap shorelines) that could be removed to re-create natural shorelines or softened by adding structurally complex features. There are 551 miles (887 kilometers) of man-made shoreline in the HRE study area, 93 miles (150 kilometers) of which are piers. Many hard structures on the interior of the harbor cannot be removed because of nearshore development, port activities, or vessel-induced wakes, and represent opportunities for shoreline enhancement. Some hard structures are no longer necessary or not functioning properly and may represent a shoreline softening opportunity.

The Shorelines and Shallows restoration opportunity map displays several insets, which call out key features and accompanying restoration opportunities where riparian habitat could be created/restored, hardened shorelines could be removed/enhanced, intertidal areas could be created, or littoral areas could be improved:

- *Inset A* – Narrow bands of potential riparian and shallow littoral habitat occur on either shore of the lower Hudson River, particularly in Bergen County, New Jersey and Westchester County, New York. There may be opportunities to develop intertidal habitats along these stretches. Along the west side of Manhattan, there may be opportunities to soften or enhance the shoreline within inter-pier areas. The Harlem River has fairly continuous hardened shorelines and no intertidal and almost no littoral habitat, representing a potential opportunity to create intertidal or littoral habitat.
- *Inset B* – This section of the upper East River contains many, large subtidal flats, in the mouth of the Bronx River, Westchester Creek, Flushing Bay, and Powell Cove. In some cases, the adjacent undeveloped land shown is existing parkland, but in other cases it may be opportunities to improve the riparian plant community. Upstream segments of the Bronx River have hardened shorelines and opportunities exist to soften these.
- *Inset C* – Long stretches of the lower Passaic and Hackensack rivers are hardened and contain few intertidal areas, representing areas to soften shorelines, create intertidal habitat, and improve existing littoral habitat.
- *Inset D* – The Upper New York Bay may be the most difficult planning region in which to find Shorelines and Shallows restoration opportunities because of competing uses and tradeoffs. There are substantial subtidal flats located on the New Jersey shoreline that may be enhanced. As previously mentioned, there may be opportunities to soften shorelines and restore intertidal habitat along some of the islands: Governors, Liberty, and Ellis Islands. Areas along Brooklyn, like Gowanus Bay, may also be appropriate for shoreline enhancement.
- *Inset E* – The Arthur Kill and its tributaries do not have as many hardened shorelines as some water bodies of the HRE study area, but they still represent areas that would greatly benefit from improved intertidal and littoral habitats. Derelict structures can be removed and riparian shoreline vegetation can be planted and encouraged to grow.

Other opportunities – Other opportunities may exist along the lower Raritan River, where there appears to be a length of hardened shoreline. Protected areas within Jamaica Bay and Gravesend Bay may also be appropriate areas for re-creating this habitat complex.

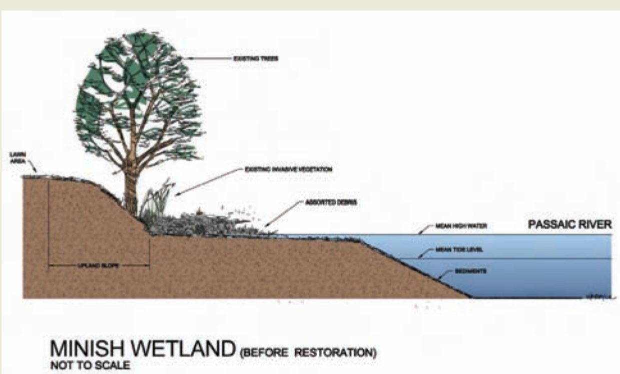
3.2.2 Habitat for Fish, Crabs, and Lobsters

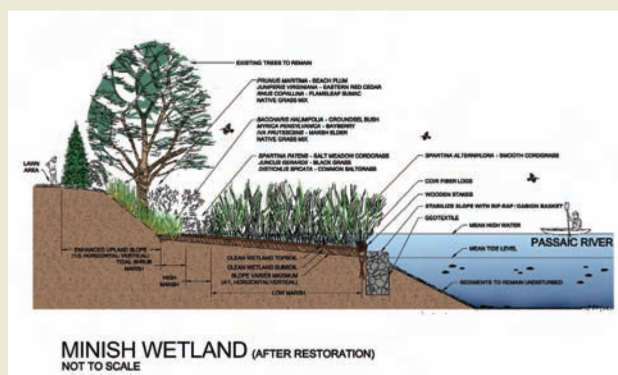
This TEC ensures that suites of habitats will be created to benefit many life stages for a range of resident, transient, and migratory species (Bain et al. 2007). It calls for the restoration or development of a mosaic of diverse, quality habitats intermixed throughout the estuary to sustain fish, crab, and lobster populations. Many important estuarine and marine species are in low or declining abundance throughout the HRE study area, and the relationships among these habitats are important for target species to complete their life history.

This TEC focuses on the spatial arrangement of habitats like oyster reefs, eelgrass beds, and tidal marshes, which are components of other TECs, as well as non-TEC habitats like soft-bottom, unvegetated mudflats. Each fish and crustacean species has specific habitat needs, especially during spawning or early development, for specific substrates or structural elements. For instance, vegetated or structurally complex habitats provide refuge from predators, whereas broad, sandy flats may be ideal foraging areas (Bain et al. 2007). The most effective way to sustain or increase fish populations in the HRE may be to restore and/or create mosaics of critical habitats, to provide what habitat was historically lost (i.e., intertidal wetlands, eelgrass beds, oyster reefs, etc.).

A Mosaic of Target Ecosystem Characteristics

A stream bank restoration plan was designed for the Joseph G. Minish Waterfront Park on the lower Passaic River to serve as a template for shoreline restoration along the river. A major component of the design is to create coastal wetlands along the shore, improving the degraded stream banks, which are dominated by invasive vegetation, have a limited tree canopy, and are lined with debris. The proposed restoration design incorporates components of the coastal wetlands TEC, the shorelines and shallows TEC, and the habitat for fish, crabs & lobsters TEC. In this design, the stream banks are bioengineered with a tidal marsh habitat featuring high and low marsh as well as a scrub-shrub buffer.





Target Statement

The short-term goal of this TEC states that one complex of at least two functionally-related habitats should be created in each HRE planning region by 2015. Further, each region should have four habitat complexes of at least two related habitats by 2050. Progress will be measured in the number and total area of habitat sets developed in the HRE study area.

Ten target species have been selected to represent the demersal or benthic fish and large crustaceans of the HRE study area. These species and the habitats that are critical to their life stages are provided in Table 3-5. The target species are either abundant or economically important, and all are well-studied. Targeting habitat restoration for these species should also benefit other species in the HRE study area.

Restoration Opportunities

This TEC should be considered during any habitat restoration project because the ecological benefits of a restoration project can be increased by creating a variety of habitats designed for target species. Site selection for this TEC would be most effective if project sponsors decided upon a target species and used the restoration opportunities maps developed for other TECs to identify areas to create appropriate habitat sets for the target species. However, it would also be possible to identify areas to conduct restoration based on the opportunities maps and existing restoration sites, and then determine which target species would most benefit from the planned habitat assemblage. Once a target species or a set of target species are identified, slight alterations could be made to the planned habitat assemblage, optimizing conditions and available resources for these species.

Table 3-5. Critical habitats and hypothetical TEC Mosaics for select species in the Hudson-Raritan Estuary study area (Bain et al. 2007, references therein).

Select Species	Critical Habitat	TEC Mosaic
Summer flounder *(Paralichthys dentatus)*	Spawning: continental shelf Immature: sandy inshore/offshore habitat Adult: estuary/coastal, ocean	
Winter flounder *(Pseudopleuronectes americanus)*	Spawning: mud, sand, gravel sediment Immature: estuary/coastal, aquatic vegetation Adult: coastal	
Black sea bass *(Centropristis striata)*	Spawning: continental shelf Immature: estuary/coastal, structured habitat Adult: ocean, coastal, reefs	
Striped bass *(Morone saxitilis)*	Spawning: oligohaline Hudson River Immature: estuary/near salt front Adult: freshwater/coastal	
American eel *(Anguilla rostrata)*	Spawning: Sargasso Sea Immature: continental shelf → estuary → tributary Adult: tributary → ocean	
Horseshoe crab *(Limulus polyphemus)*	Spawning: polyhaline sandy beaches Immature: shallows, burrow in benthic habitat Adult: estuary/coastal, ocean	
American lobster *(Homarus americanus)*	Spawning: continental shelf Immature and Adult: rocky, sediment, marsh, eelgrass	
Blue crab *(Callinectes sapidus)*	Spawning: mouth of estuaries Immature and Adult: ocean → estuary/freshwater, structured habitat	

3.3 Environmental Support Structures

Two of the TECs focus on repairing the environmental degradation associated with infrastructure that restricts the flow of water. The HRE study area contains many dams that serve to store water for a variety of functions, such as drinking water reservoirs or recreational ponds. Other structures that are common in the HRE study area were designed to allow the passage of water, such as culverts under bridges and roadways. These structures can restrict the movement of fish, change the natural circulation or drainage routes, and can result in environmental degradation. The following sections describe the environmental issues associated with these support structures, the objectives for the TECs, and potential restoration opportunities within the HRE study area.

3.3.1 Tributary Connections

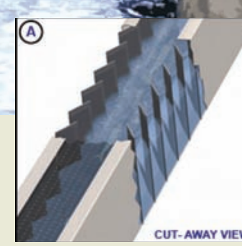
The purpose of this TEC is to reconnect freshwater streams to the estuary and provide a range of quality habitats to aquatic organisms. This TEC focuses on restoring connections between and corridors within streams, including but not limited to restoration of natural stream channels, adjacent freshwater wetlands, riparian uplands, and tributary connections through barrier removal or fish passage construction.

Tidally-influenced streams and creeks provide thruways for fish to access habitats across a gradient of abiotic factors (i.e., salinity, depth, temperature, dissolved oxygen, sediment type). Many migratory or highly mobile fish species require access to these upstream areas to spawn because eggs or larvae have specific life history requirements that are very different from juvenile or adult life stages. In addition to benefiting native migratory species, like American shad (*Alosa sapidissima*), alewife (*A. pseudoharengus*), blueback herring (*A. aestivalis*), striped bass (*Morone saxatilis*), and American eel (*Anguilla rostrata*), re-establishing tributary connections may also benefit resident fish and invertebrate populations by providing greater access to feeding, spawning, and refuge habitats. Several freshwater mussel species (i.e., *Family unionidae*) may also benefit from improved fish passage, as they are dependent upon fish movement for dispersal (Peckarsky et al. 1990).

Barriers can be man-made or natural, "habitat" barriers. Man-made barriers to fish passage are often the easiest to define, such as dams, tide gates, and road culverts. Low dams were typically built in the HRE study area to support early American industry and agriculture. Today, many of these small dams are currently inoperative or no longer needed. However, some dammed waterbodies provide local communities with water supply, recreation, utilities, or have aesthetic/historic value (Bain

Restoring Fish Runs

Fish runs represent the coordinated movement of fish to reproduce or spawn. Anadromous fish are species that spend most of their time in marine settings and migrate to freshwater during spring months to spawn, while catadromous species live in freshwater and spawn in the ocean. Historically, anadromous spawning runs of alewife, blueback herring, striped bass, and American shad and catadromous runs of American eel were common in the Hudson – Raritan Estuary study area (Durkas 1992). However, poor stream conditions and an increased number of obstacles to upstream migration, like tide gates, culverts, and dams, have reduced these species' migration opportunities. Restoring fish passage on major tributaries can be accomplished through the construction of fish ladders, which are inundated structures with small steps that allow fish to navigate around a dam and continue their migration. Other approaches include removing impoundments that are inoperative or no longer serve their purpose, or improving water quality and reducing debris that obstructs passage.



et al. 2007). Reconnecting estuary-tributary pathways can be accomplished by removing derelict or unnecessary barriers, modifying barriers to promote fish passage (e.g., breaching, notching), or constructing fish passage structures (e.g., fish ladders, bypass channels; See box: Restoring Fish Runs). Dams that currently provide a water-supply or safety function, or small historic dams that may be regarded as important historical or cultural resources may be candidates for retro-fitting with passage structures.

Figure 3~2. A culvert was replaced with this small bridge in Finderne Farms on the Raritan River.

Whether partially or completely closed, tide gates are barriers to all upstream fish migration. The control schedule of existing tide gates can be modified so that gates remain completely open during upstream fish runs and during downstream juvenile migrations. New, self-regulating tide gates can be installed in place of conventional gates. These allow normal amplitude tides to enter and exit, but are designed to close in the event of atypical storm tides, preventing flooding of homes, roads, and other infrastructure.

Culverts under roads or rail beds can represent migration barriers due to an excess drop at the culvert outlet, high velocity or turbulence within the culvert barrel, inadequate water depths within the culvert barrel, or debris/sediment accumulation at the culvert inlet or within the barrel (Gibson et al. 2005; Figure 3-2). Barriers also affect in-stream and riparian habitat, creating a need to improve tributaries on a system-level. For instance, a dam removal project may alter in-stream habitat and riparian zones adjacent to where the water was previously impounded.

Target Statement

The short-term objective for the Tributary Connections TEC is to remove one barrier per year that blocks the free movement of aquatic life from estuary waters to at least three different inland habitats. The long-term objective is to continue reconnecting coastal and inland habitats at a rate of one project per year until all near-estuary barriers blocking inland access have been removed or made passable. Half of the new connections during this period should reach at least three new habitats. The habitat types that will ultimately be connected to the open waters of the HRE study area include ponds, lakes, wetlands, streams, and rivers, which should place emphasis on barriers blocking access to a variety of water bodies.

Restoring in-stream habitat upstream or downstream of a barrier and riparian habitat, such as forested floodplains and freshwater wetlands, could fulfill the target statements for this TEC. Where possible, projects should attempt to include multiple components (i.e., in-stream habitat, riparian habitat, barrier removal) to increase the number of functional benefits and the ecological contribution of the tributary to the estuary. Although projects with multiple components are encouraged, small projects that aim to restore even one component also provide substantial benefits and should be conducted.

The measure of performance for this TEC should be the number and types of habitats reconnected to the open waters of the HRE including riparian natural vegetation areas, floodplain wetlands, and other waterway associated habitats. Although there are no official metrics for this TEC, stream length and riparian acreage restored could be appropriate metrics for the goal statement. For restoring habitat under this TEC, the following guidelines should be followed:

- Habitat restoration should focus on riparian habitat that is or once was connected to the estuary.
- Tributaries with higher stream orders that are proximal to an estuary body should be targeted for restoration. These can be freshwater areas with no tidal influence.
- Projects with fish passage components should focus on impediments, which when removed make several miles of stream passable.

A thorough evaluation of the upstream environment should be conducted to determine the impacts of barrier removal. The slow-moving water found upstream of impoundments, whether natural or man-made, typically supports different fish communities and shoreline vegetation and can be highly valued. If these impounded waters provide recreational sport fishing opportunities to nearby residents, it may be extremely difficult to gain support for a barrier removal project. Additionally, the shoreline vegetation may include regulated wetland communities that could be impacted by a barrier removal. In scenarios like these, it is important to gain public support during preliminary planning stages.

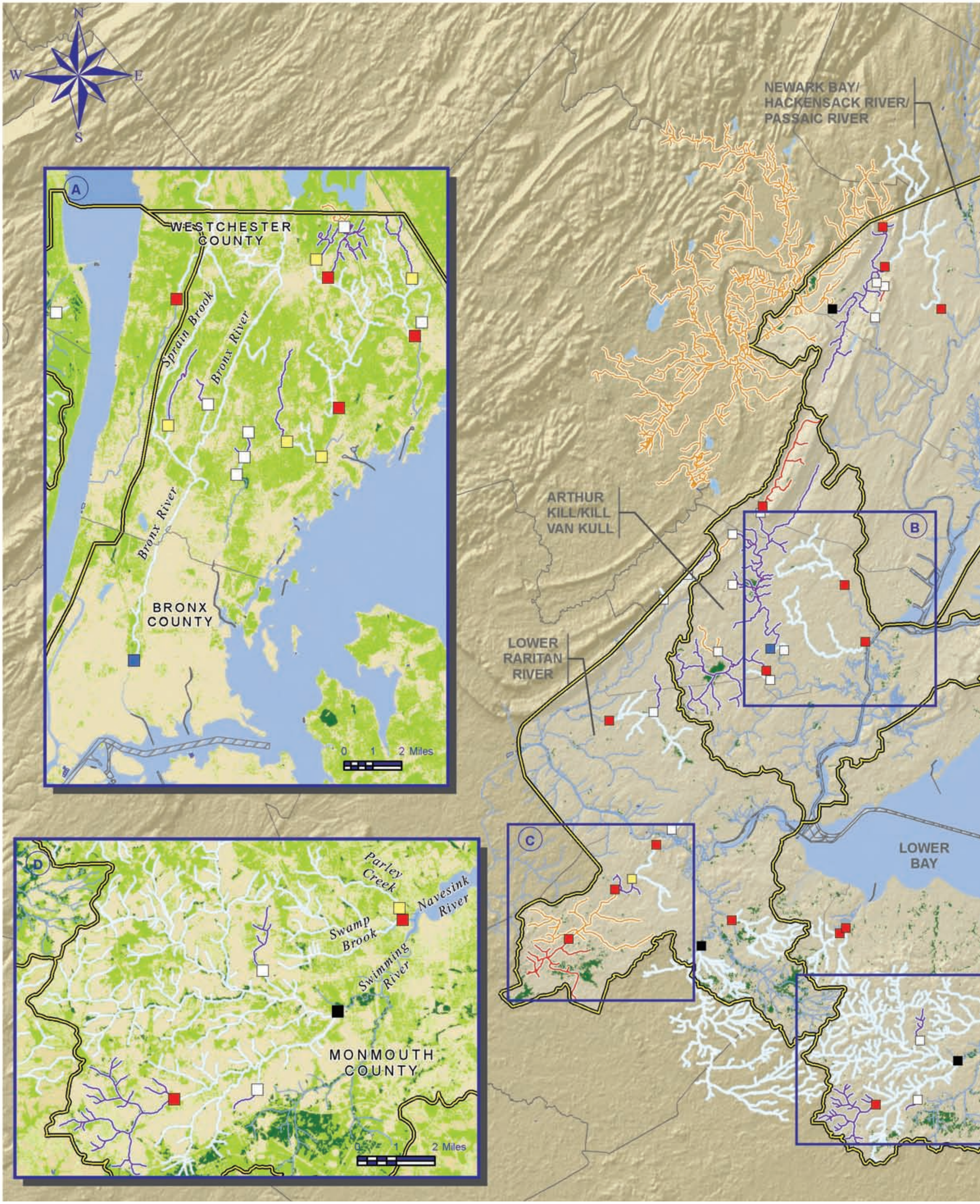
Restoration Opportunities (Map 3-7)

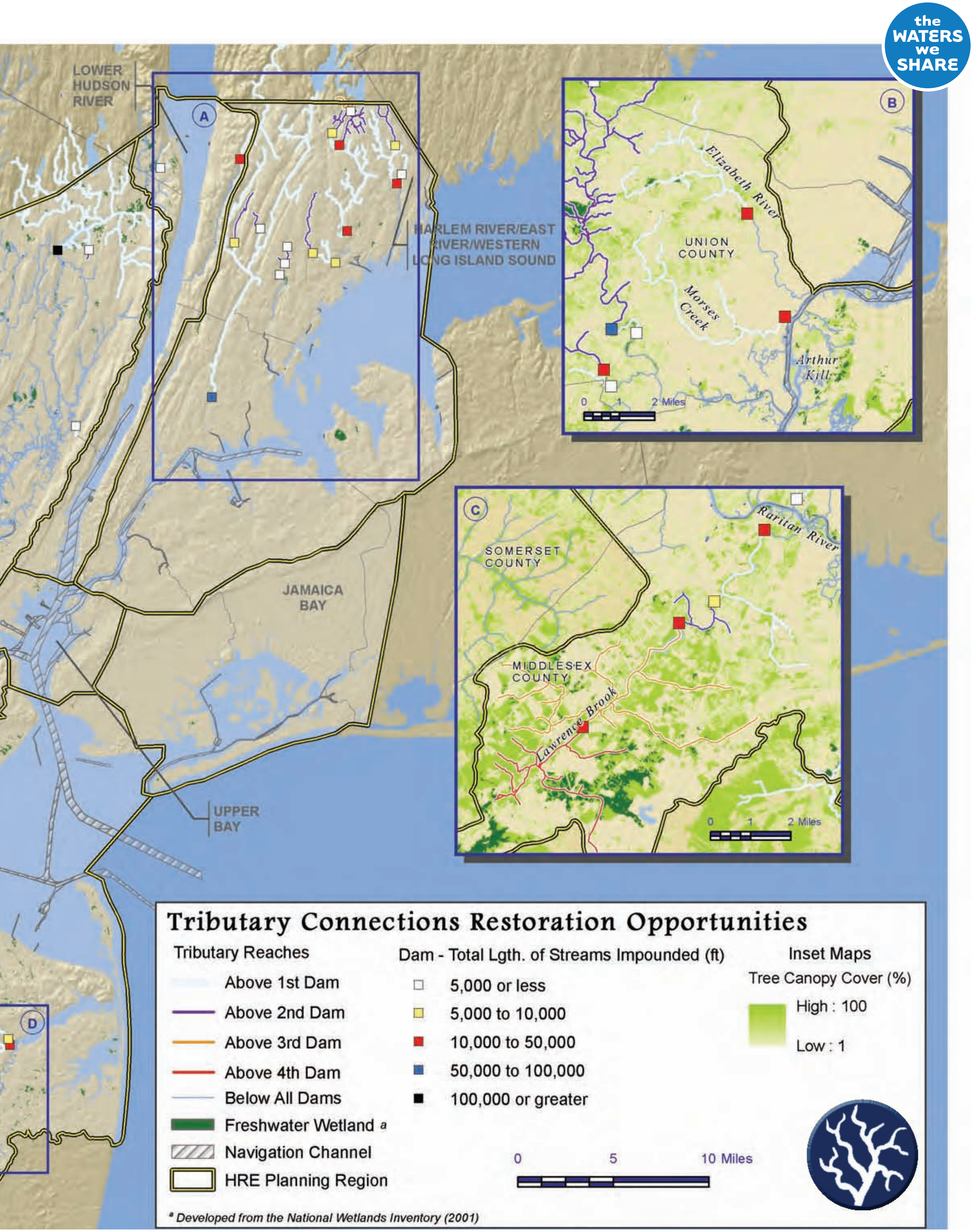
Tributary Connections restoration opportunities included in this section focus on allowing fish passage along tributaries blocked by dams. Restoration opportunities include the removal of derelict dams and the installation of fish ladders or other fish passage measures to restore the connectivity. Opportunities for improving tributary habitat and connectivity exist in most planning regions of the HRE study area, but not within the Upper Bay or Jamaica Bay planning regions. Information used to identify potential restoration opportunities include: known dam locations, tributary reaches (length and number of impoundments), freshwater wetland locations, and percent tree canopy cover.

Map 3-7 displays the Tributary Connections restoration opportunities. The color of the dam represents the total length of stream impounded or the length of stream to the next upstream dam. Impounded tributary reaches are color-coded to represent the number of dams on a tributary reach (see Inset C, the Lawrence Brook). Restoration practitioners should focus on reaches with fewer impoundments (e.g., above first dam) and focus on providing the most upstream habitat possible to benefit migratory species (e.g., blue/black dams with white tributaries). In the HRE study area, there are 60 dams identified on the USACE data set, impounding over 1,000 miles of stream habitat. Removing or making only the most downstream dams passable would open over 500 miles of stream habitat to migratory species.

- *Inset A* – An impoundment exists along the lower Bronx River that if made passable would open between 50,000 and 100,000 feet of stream. Although this area of the Bronx and lower Westchester County are densely populated, there may also be opportunities for riparian habitat restoration.
- *Inset B* – Opportunities to improve tributary connectivity may exist in New Jersey, along the Arthur Kill, particularly those impoundments on the Elizabeth River and Morses Creek, with each passable impoundment opening 10,000 to 50,000 feet each. There may also be opportunities for freshwater restoration along the Elizabeth River upstream of the impoundment.

Map 3~7.


N
S
E
W
NEWARK BAY/
HACKENSACK RIVER/
PASSAIC RIVER
ARTHUR
KILL/KILL
VAN KULL
LOWER
RARITAN
RIVER
LOWER
BAY
A
WESTCHESTER
COUNTY
Sprain Brook
Bronx River
Bronx River
BRONX
COUNTY
0 1 2 Miles
B
C
D
Parley
Creek
Navesink
River
Swamp
Brook
Swimming
River
MONMOUTH
COUNTY
0 1 2 Miles



the WATERS we SHARE
LOWER HUDSON RIVER
A
HARLEM RIVER/EAST RIVER/WESTERN LONG ISLAND SOUND
JAMAICA BAY
UPPER BAY
D
B
Elizabeth River
UNION COUNTY
Morses Creek
Arthur Kill
0 1 2 Miles
C
Raritan River
SOMERSET COUNTY
MIDDLESEX COUNTY
Lawrence Brook
0 1 2 Miles
Tributary Connections Restoration Opportunities
Tributary Reaches
Above 1st Dam
Above 2nd Dam
Above 3rd Dam
Above 4th Dam
Below All Dams
Freshwater Wetland a
Navigation Channel
HRE Planning Region
Dam - Total Lgth. of Streams Impounded (ft)
5,000 or less
5,000 to 10,000
10,000 to 50,000
50,000 to 100,000
100,000 or greater
Inset Maps
Tree Canopy Cover (%)
High : 100
Low : 1
0 5 10 Miles
a Developed from the National Wetlands Inventory (2001)

- *Inset C* – Lawrence Brook is a major tributary of the Raritan River. This tributary clearly demonstrates the color-coding scheme applied to tributary reaches on the map. There are four dams located on the Lawrence Brook, which is the largest number of dams on any tributary in the HRE study area, according to the USACE dam data set.
- *Inset D* – There are several tributaries of the Navesink River that may be appropriate locations for improving fish passage, such as the dams at the mouth of the Parley Creek and Swamp Brook. Swimming River may also represent an ideal opportunity to restore fish passage, as it would open up over 170,000 feet of stream and is not far from the Navesink River.

Many other opportunities to restore fish passage exist throughout the HRE study area. Every dam that currently does not allow fish passage represents an opportunity. For example, in the Newark Bay, Hackensack River, Passaic River planning region there are two dams that are under consideration for improvements, the Oradell Reservoir Dam on the Hackensack River and the Dundee Lake Dam on the Passaic River. Installation of a fish ladder at the Oradell Reservoir Dam would open more than 110,000 feet upstream, and a fish ladder at the Dundee Dam could open more than 47,000 feet upstream.

3.3.2 Enclosed and Confined Waters

The Enclosed and Confined Waters TEC focuses on poorly flushed, enclosed, constricted, and over-excavated subtidal areas of the HRE study area that exhibit periodic or continuous poor water quality. Examples of enclosed and confined water bodies occurring in the HRE study area include modified tidal creeks, enclosed basins, and man-made bathymetric depressions with poor circulation. These water bodies are often characterized by a host of degraded conditions, including contaminated sediments, hypoxic/anoxic water masses, noxious odors, hardened shorelines, accumulation of fine sediments, and little or no vegetated buffers, creating low quality habitat that is of limited use for foraging, nursery, or refuge by estuarine organisms.

Dead-end tidal creeks are remnant natural tidal drainage features that have been cut off from their headwaters and partially filled. Historically, many tidal creeks were present throughout the HRE study area, as drainage features associated with intertidal wetlands. As the estuary became increasingly populated and developed, these water bodies were successively straightened and/or diverted through culverts, or filled throughout their length (Bain et al. 2007). This created narrow, confined waterways that often exhibit impaired tidal flow, have limited flushing, and are dredged to depths greater than the surrounding estuary, promoting poor water circulation and stratification (Yozzo et al. 2001, Bain et al. 2007).

Man-made bathymetric depressions are deep holes that were created by removing sediment for on-land construction (i.e., borrow pits). Artificial depressions are characterized by impaired water circulation, fine organic sediments, and vertically stratified temperature and dissolved oxygen concentrations that can be as low as 4oC and 0-1 milligrams/Liter, respectively, in the deepest pits of Jamaica Bay (BVA 2005). These bathymetric depressions may also contain debris, such as derelict vessels/vehicles, construction materials, and pilings.

Enclosed and confined waters in the HRE study area often have extremely poor water quality due to years of unregulated dumping and discharge (Yozzo et al. 2001). Because these basins have been cut off from their historic creeks and there is limited tidal flushing from the estuary, major inputs to enclosed and confined waters often include stormwater runoff coupled with human and industrial wastes from CSOs, vessels, and shoreline facilities (Bain et al. 2007). Confined waters typically exhibit low species diversity and abundance, are dominated by a few opportunistic species.

Target Statement

The restoration targets for enclosed and confined waters aim to improve the condition of these water bodies to where they match state-defined designated uses (i.e., shellfishing, bathing, fishing, etc.). The short-term objective is to improve the water quality of confined water bodies to meet their current designated use classification. The long-term objective statement for this TEC is to improve the water quality or environmental conditions of eight confined water bodies to support the designated use of their receiving or overlying waters by 2050. Progress toward the long-term objective could be measured using interim metrics, such as percent compliance of a confined waterway to a higher designated use, because changing state-designated uses can be difficult. Through restoration efforts, these improvements will lead to improved water quality and increase the amount of shallow, protected water habitat in the HRE study area.

Restoration Opportunities (Map 3-8)

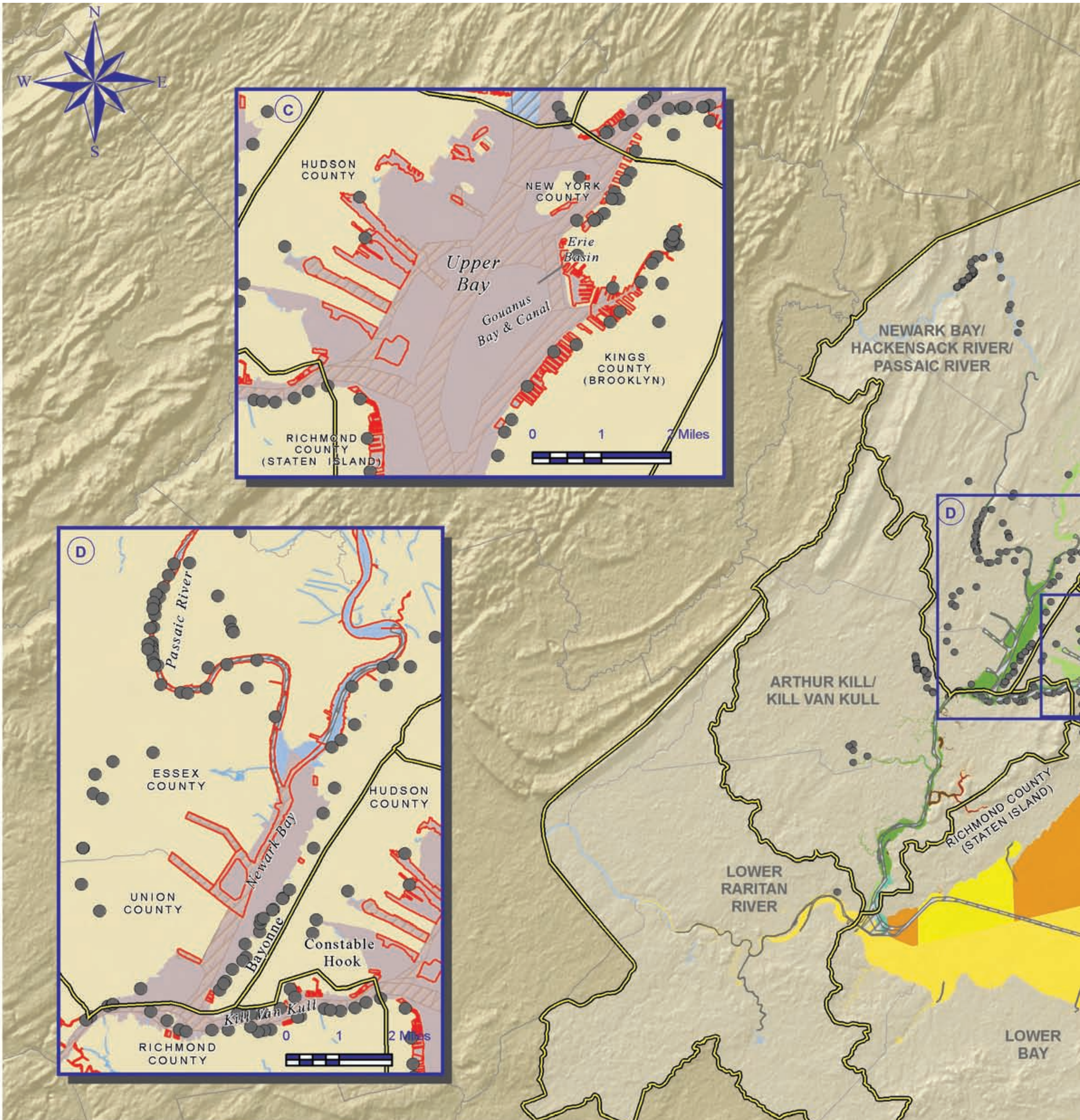
Opportunities for improving Enclosed and Confined Waters exist in each planning region of the HRE study area. Map 3-8 displays these restoration opportunities. Included on the map are areas where dead-end tidal creeks, head-ends of tributaries, bathymetric depressions, and inter-pier areas that do not meet their state designated use. The map also displays the state-designated best use class (Table 3-6), highlighting those waterbodies that have been documented to not meet the water quality standards indicated by their designated use (i.e., on the 303(d) List of Impaired Waters). On the inset maps, areas that are confirmed or assumed to experience hypoxic or anoxic conditions during some portion of the year, and known bathymetric depressions are delineated.

Most of the HRE study area is designated to support at least fishing and secondary contact recreation, even the majority of enclosed or confined water bodies, as defined in this TEC. In New York waters, many of these water bodies do not meet their

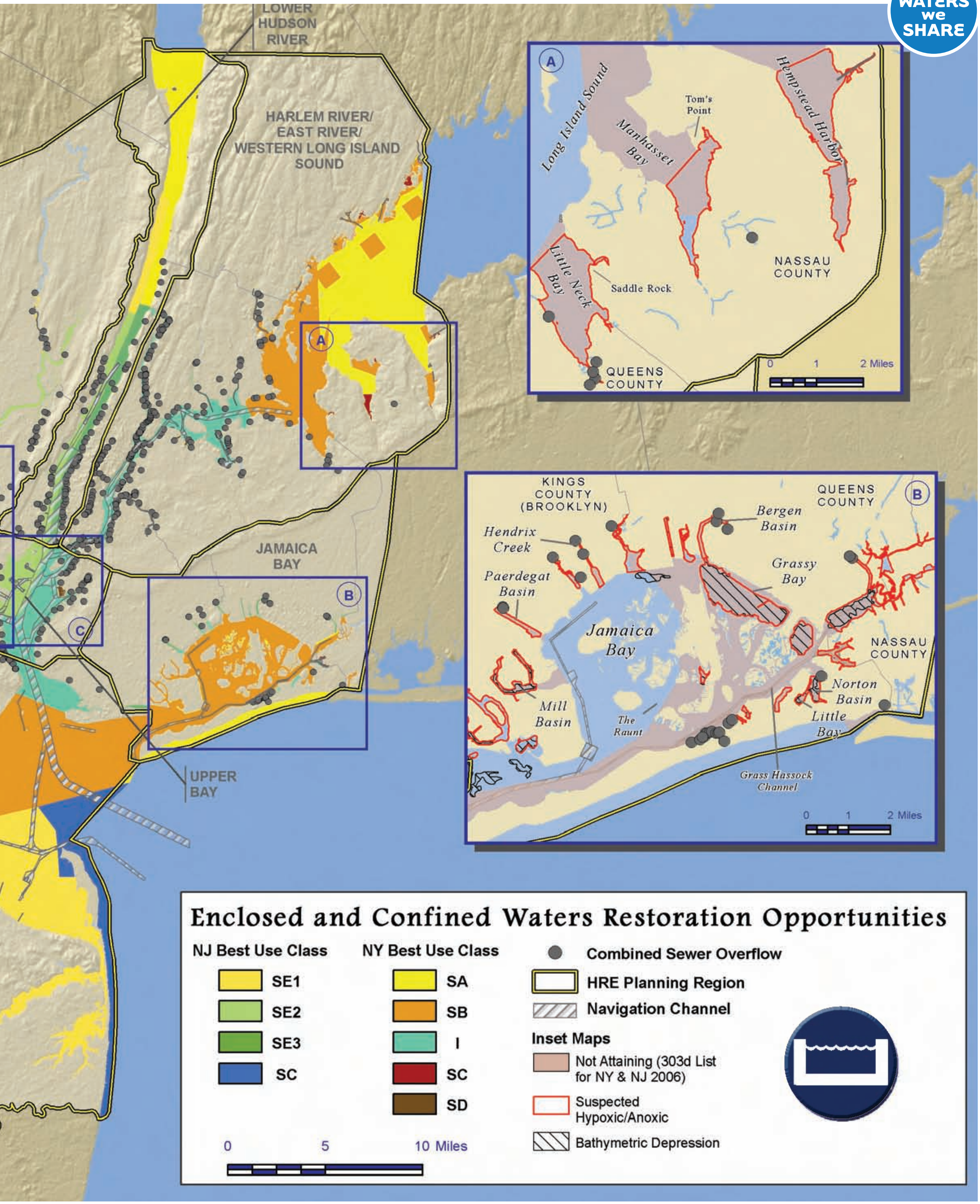
Table 3-6. Designated best use classes for surface water use in estuaries in the states of New Jersey and New York.

State	Class	Best Use
New Jersey	SE1	Saline estuary waters with shellfishing; maintenance, migration and propagation of fish and wildlife; and primary and secondary contact recreation
	SE2	Saline estuary waters with maintenance, migration and propagation of fish and wildlife; and secondary contact recreation
	SE3	Saline estuary waters with maintenance and migration of fish and wildlife; and secondary contact recreation
	SC	Coastal saline waters with shellfishing; primary and secondary contact recreation; and maintenance, migration and propagation of fish and wildlife
New York	SA	Shellfishing, primary and secondary contact recreation and fishing
	SB	Primary and secondary contact recreation and fishing
	SC	Fishing
	I	Secondary contact recreation and fishing
	SD	Fish survival

Map 3~8.



State	Class	Best Use
New Jersey	SE1	Saline estuary waters w/ shellfishing; maintenance/migration/propagation of fish/wildlife; primary/secondary contact
	SE2	Saline estuary waters w/ maintenance/migration/propagation of fish/wildlife; secondary contact
	SE3	Saline estuary waters w/ maintenance/migration of fish/wildlife; secondary contact
	SC	Coastal saline waters w/ shellfishing; primary/secondary contact; maintenance/migration/propagation of fish/wildlife
New York	SA	Shellfishing, primary/secondary contact; fishing
	SB	Primary/secondary contact; fishing
	I	Secondary contact; fishing
	SC	Fishing
	SD	Fish survival


Enclosed and Confined Waters Restoration Opportunities
LOWER HUDSON RIVER
HARLEM RIVER/ EAST RIVER/ WESTERN LONG ISLAND SOUND
JAMAICA BAY
UPPER BAY
A
B
C
Long Island Sound
Manhasset Bay
Tom's Point
Hempstead Harbor
Little Neck Bay
Saddle Rock
NASSAU COUNTY
QUEENS COUNTY
0 1 2 Miles
KINGS COUNTY (BROOKLYN)
Hendrix Creek
Paerdegat Basin
Bergen Basin
Grassy Bay
Jamaica Bay
Mill Basin
The Raunt
Norton Basin
Little Bay
Grass Hassock Channel
NJ Best Use Class
SE1
SE2
SE3
SC
NY Best Use Class
SA
SB
I
SC
SD
Combined Sewer Overflow
HRE Planning Region
Navigation Channel
Inset Maps
Not Attaining (303d List for NY & NJ 2006)
Suspected Hypoxic/Anoxic
Bathymetric Depression
0 5 10 Miles

designated uses due to aesthetic criteria, such as the presence of floatables, or not meeting the criteria for PCBs, metals, or use as migratory fish corridors. In New Jersey, the scale at which non-attaining waters are defined does not distinguish enclosed or confined waters from their receiving waters, but many of the large water bodies had contaminants, metals, or high total suspended solids.

There are also 659 CSOs in the HRE study area, 431 in New York and 228 in New Jersey, some of which cause or contribute to water quality impairments. Many of the CSOs occur in the Lower Hudson River Planning Region and the Harlem River, East River, Western Long Island Sound Planning Region. Restoration opportunities for the long-term objective (i.e., those waters with lower use classifications than their receiving waters) exist in some tributaries of Jamaica Bay, some tributaries of Staten Island, a few bays in Long Island Sound, and Erie Basin off Red Hook, Brooklyn.

For the short-term objective, the Enclosed and Confined Waters restoration opportunity map displays four insets, which call out examples of water feature types that could be targeted for restoration (i.e., enclosed basins, dead-end creeks, poorly flushed bays, and inter-pier areas). The inset displays water bodies not attaining their current best use classification and areas that may be hypoxic or anoxic during portions of the year.

- *Inset A* – The southern bays of Long Island Sound did not attain their state designated use during 2006. Little Neck Bay is designated for shellfishing, primary/secondary recreation, and fishing (Class SA), but did not meet this best use class due to high nitrogen concentrations and presence of pathogens. There are several CSOs feeding into the mouth of Little Neck Bay, which may be causing the high nitrogen levels. Manhasset Bay was designated SA and SB throughout much of the bay, whereas the most inland segment was designated SC, for fishing. The bay did not attain its designated use due to PCB contamination in the Tom's Point area. Hempstead Harbor, which was designated as SA and SB, did not meet its designated use due to pathogens, nitrogen concentrations, and PCB contamination. Manhasset and Hempstead bays are high priority waters, scheduled for Total Maximum Daily Load/restoration strategy development and submission for approval to USEPA within the next two years. All three bays may experience low dissolved oxygen conditions during some portion of the year.
- *Inset B* – Newark Bay, the lower Passaic River, portions of the Hackensack River, portions of the Kill Van Kull are intensively industrialized, with hardened shorelines, inter-pier areas, and enclosed basins. There are several CSOs on the western shore of Bayonne, New Jersey and along both shores of the Kill Van Kull. In addition, dozens of CSOs along the Passaic River drain into Newark Bay. Some of the inlets associated with the CSOs, like those along Constable Hook, NJ, are suspected to be hypoxic or anoxic during portions of the year. Both Newark Bay and the New Jersey side of the Kill Van Kull did not meet their best use during 2006, due to pesticides, PCBs, PAHs, and dioxins. These water bodies also did not meet the mercury standard for Class SE3, which should support secondary contact recreation and maintenance and migration of fish and wildlife.
- *Inset C* – The Upper Bay is intensively developed, with hardened shorelines, inter-pier areas, and enclosed basins. The New Jersey side of the bay is a functioning port, but several nearshore areas may experience periods of hypoxia or anoxia. Although the New Jersey side of Upper Bay was non-attaining during 2006, this is due to contaminants such as pesticides, PCBs, PAHs, and dioxins and not necessarily due to poor water quality conditions caused by confined waters. Inter-pier areas, like those along Brooklyn, are typically well-flushed though they do modify sedimentation patterns and may be areas of concern under this TEC. Erie Basin, the enclosed waterway just

GOWANUS CANAL SPONGE PARK™

The Gowanus Canal Sponge Park, designed by dlandstudio working with the Gowanus Canal Conservancy, is a public open space system. This project is made possible with public funds from the New York State Council on the Arts, a state agency. The SPONGE PARK™ is designed as a public open space system that slows, absorbs and filters surface water runoff with the goal of cleaning up contaminated water of Brooklyn's Gowanus Canal, thereby re-energizing the waters edge and communicating a larger vision for environmental stewardship to the community. Formerly a wetland creek, the 100-ft wide, 1.4-mile long canal is bordered by industrial and residential areas. The 1758-acre watershed contributes water to the canal from Brooklyn's Park Slope, Carroll Gardens and Boerum Hill neighborhoods. In a heavy rainstorm, water currently combines with sewage and drains directly into the Canal. The SPONGE PARK™ is designed to absorb and manage excess surface water runoff to make the water's edge a healthier place for supporting active public access with the canal ecosystem.

The SPONGE PARK™ open space development occurs within a newly zoned canal edge setback and at streets that terminate at the canal. The design includes 7 acres of esplanade, 4.5 acres of recreational open space and 3.5 acres of permeable water remediation and retention area. Proposed back-up water storage cisterns will mediate extreme weather conditions by providing additional storage capacity for irrigation. Plant communities were selected for both their remediative qualities and their capacity to withstand different periodic water inundation events. Remediation wetlands will be created, and these combined with the planted areas will absorb and filter water, then release it gradually into the canal. The plant communities and processes that historically helped control flooding and kept the Gowanus Bay clean will be reintroduced in a 21st Century adaptation.

The Gowanus Canal SPONGE PARK™ has important implications for the future of urban infrastructure development. Storm water management can be successfully integrated within a region's cultural context (e.g., historic sites, recreation areas and neighborhood facilities) and can reduce demand on expensive sewer infrastructure while also cleaning the water and providing programmable urban open space. This environmental approach to urban planning can be implemented across the country. It is applicable to mature cities whose infrastructure is taxed by age and growth as well as in areas where industrial development has left behind brownfields.

north of Gowanus Bay, did not meet its designated use of fishing due to high copper levels. Gowanus Canal has been the target of several improvement projects, and although water quality conditions have improved somewhat, Gowanus Canal did not meet its best use class due to low dissolved oxygen levels. Several CSOs are located along the Gowanus Canal and inter-pier areas that are contributing to the poor water quality conditions of the Upper Bay. These issues are being addressed through a 2004 Administrative CSO Consent Order between NYCDEP and NYSDEC, which calls for comprehensive watershed-based approach to pollution control (Gibbons and Yuhas 2005).

- *Inset D* – Jamaica Bay contains numerous dead-end tidal creeks and several large bathymetric depressions with poor circulation. Most of these former tidal creeks have lower use classes than the main bay, not requiring water quality conditions to support primary contact recreation. Despite this, Jamaica Bay and many of its tidal creeks did not attain their designated uses during 2006. Hendrix Creek and Bergen Basin had high nitrogen and low dissolved oxygen. Most of the other basins, such as Paerdegat Basin and Old Mill Creek, which did not meet their use class, are being addressed through the 2004 CSO Consent Order discussed above. The CSO inputs to many of these waters cause extended periods of hypoxia or anoxia. Mill Basin, on the western side of the bay, is an enclosed basin with a bathymetric depression, and likely experiences hypoxic or anoxic conditions during portions of the year. Grassy Bay, Norton Basin, and Little Bay also contain bathymetric depressions that have poor circulation and experience extended periods of hypoxia.

3.4 Contamination Issues

Centuries of urbanization have resulted in extensive contamination issues throughout the HRE study area. One of the TECs focuses on contamination issues by establishing objectives to remove contamination and to restore conditions to prevent the future accumulation of contaminants. The following sections describe these contamination issues, the objectives for the TECs, and potential restoration opportunities within the HRE study area.

3.4.1 Sediment Contamination

An important goal of Federal and state natural resource agencies, and estuary management programs (i.e., The NY/NJ Harbor Estuary Program) has been to undertake efforts to reduce the degree of contamination within sediments of the HRE study area. Sediment quality is critical to the estuarine ecosystem, to the success of other TECs, to human health and safety, and to the port's economic viability (Bain et al. 2007). Many areas within the HRE study area exhibit sediment contamination to varying degrees, brought about by historical industrial discharges, municipal point and non-point source pollution, and inputs from the upper reaches of the Hudson River Estuary (upstream of the HRE Study area). Sediments of the HRE study area are a long-term repository of contaminants including PCBs, dioxins, mercury, pesticides such as DDT, and PAHs. Although the rate of contaminants entering the estuary have substantially declined since the pre-CWA era, many contaminants still enter from tributaries or are widely distributed throughout the HRE study area as historically contaminated sediments are transported by tides and currents (USACE 2004b).

Once deposited in the sediments, these contaminants can be transported through a variety of mechanisms (Rand 1995; Table 3-7). Although production and uses of many of these chemicals have been banned in the U.S. for many decades, they have persisted in the benthic environment and within aquatic organisms (Bain et al. 2007).

PCBs are a class of organic compounds used in the electrical industry as insulating fluids and oils for industrial transformers and capacitors, and are characterized by high chemical stability, low flammability and high resistance to biological degradation (Nadeau and Davis 1976). They are poorly soluble in water and highly soluble in fats. The primary source of PCB contamination in the HRE, as well as the entire tidal Hudson River from Troy to New York Harbor, was the removal of the Fort Edward Dam in 1973, which allowed approximately 1,000,000 meters^3 of PCB-laden sediment to be transported downstream of two former electrical capacitor manufacturing plants.

Dioxins and furans are chlorinated organic compounds that can be found in the environment due to natural combustion (e.g., forest fires), but also through waste incineration, fuel combustion, and as a manufacturing by-product. Dioxins were a by-product of a widely used defoliant in the 1960s (i.e., Agent Orange), and large amounts of dioxins were released into the lower Passaic River, which have subsequently spread throughout the HRE, with highest concentrations close to the source in the lower Passaic River, in Newark Bay and portions of the Hackensack River, Arthur Kill, and Kill Van Kull. DDT, one of the first and best-known organic pesticides, was used to control insect-vector diseases and as an agricultural insecticide. PAHs are primarily created through the incomplete incineration of organic fuels, and are therefore tightly linked to energy production. PAHs can enter the environment through point sources (e.g., oil spills), and non-point sources (e.g., atmospheric deposition and overland runoff).

A variety of heavy metals may be present in HRE sediments. Some metals such as lead, are widely distributed throughout the HRE study area, as a result of atmospheric deposition and other non-point source inputs. Others, such as cadmium, mercury, chromium and copper may occur in very high concentrations in specific geographic areas, as a result of direct point-source inputs.

Currently, every planning region of the HRE study area has exhibited some degree of sediment degradation due to contamination. The Regional Environmental Monitoring and Assessment Program conducted by the USEPA in 1993-1994 and again in 1998, found that pervasive contamination across chemical groups in the HRE study area had declined (Adams and Benyi 2003). Contamination can greatly reduce the biological and recreational value of the HRE study area through fish consumption advisories, human health risks, and economic impacts through restrictions of commercially harvested species. Sediment contamination also affects navigation and commerce within the HRE study area. The port industry is valued at an

Table 3-7. Properties of the aquatic environment important in predicting the fate and transport of a contaminant (adapted from Rand [1995]).

Physical Properties	Chemical Properties	Biological Properties
Surface area Depth Flow, extent of mixing, bottom scouring Sedimentation rate Solar irradiation (at surface) and irradiance (wavelength and water depth)	Temperature pH Suspended solids Hardness, salinity, ionic strength Concentration of major ions Concentration of dissolved organic matter Bottom sediments (nature, including organic carbon content)	Microbiological populations and activity Trophic status Nutrient concentrations

estimated $25 billion annually and directly or indirectly supports approximately 229,000 jobs. Contaminated sediments can increase the cost of maintaining navigation channels by as much as four to five times due to the added cost of transporting and processing the material for disposal or reuse (USACE 2008b).

Although sediment and the pollutants that contaminate sediment originate throughout the HRE study area, management of sediment has historically taken a highly localized and narrowly focused approach – one that is largely based on the tightly defined responsibilities of regulatory and resource management agencies and port interests. Sediment management responsibilities are spread among different agencies, authorities and jurisdictions. In addition, there is no existing regional framework in which to address these cross-jurisdictional issues. As a result, the policy and regulatory framework required to improve regional sediment management throughout the HRE study area does not exist and many sediment-related problems remain unaddressed or under-addressed.

The potential benefits of managing sediment regionally are:

- Cost savings resulting from a reduced need to dredge navigation channels and dredging cleaner sediments which do not require costly treatment;
- Improved habitat quality resulting from the cleanup of contaminated sediments;
- Improved availability of habitat based on reintroduction of sediment into "sand starved" littoral systems;
- Shared regional-scale data management systems, models and other scientific tools to help make sediment management decisions;
- Improved relationships between agencies and the public that produce opportunities for collaboratively leveraging financial and manpower resources; and
- Improved relationships of the regulatory processes resulting from better intergovernmental collaboration and coordination. (Tavolaro 2008)

Acknowledging the need for a better management approach, the HEP Regional Sediment Management (RSM) Workgroup was formed to develop a plan for a Regional Sediment Management Program that integrates various sediment management activities in the HRE. The HEP Policy Committee charged the Workgroup with developing a scope and structure for the RSM Program that includes a plan with specific goals and targets to improve the ecosystem, public health and the economy, sustainability in carrying out future tasks, technical credibility and regional support.

The Regional Sediment Management Plan (HEP 2008) established a collaborative process that resulted in a plan with three major components to the regional sediment management approach: sediment quality, sediment quantity and dredged material management. Specific objectives for each of these major components were established describing the challenges they present, status of current work, and recommended actions for each objective. A total of eight objectives and 45 specific actions were recommended as the consensus for the Workgroup. Primary Sediment Quality Objectives included: ensure new sediments are clean and new sediments entering the system remain clean, reduce toxic exposure, and reduce transport of contaminants to other areas. Specific Sediment Quantity Objectives included ensure sufficient sediment to support healthy ecosystem and reduce sediment deposition in shipping channels and berths. Dredged Material objectives included the improvement of dredging operations and dredged material management.

Key recommendations of the RSM Plan include:

- Creation of a Regional Sediment Management advocate at the State level in New York and New Jersey;
- Strengthen regional coordination and consistency on regulatory issues, watershed planning and dredged material management (e.g., dredging windows, beneficial uses, identification of upland placement sites, sedimentation control, etc.);
- Develop a sediment quality map that prioritizes areas for cleanup;
- Accelerate Hudson River and Lower Passaic River remedial actions due to the significant impact contaminated sediments from these areas have on the harbor estuary;
- Identify watersheds with excessive sediment loads and develop plans to reduce loads;
- Update technical information through research, monitoring and modeling (e.g., develop sediment transport models and CARP model updates)

Target Statement

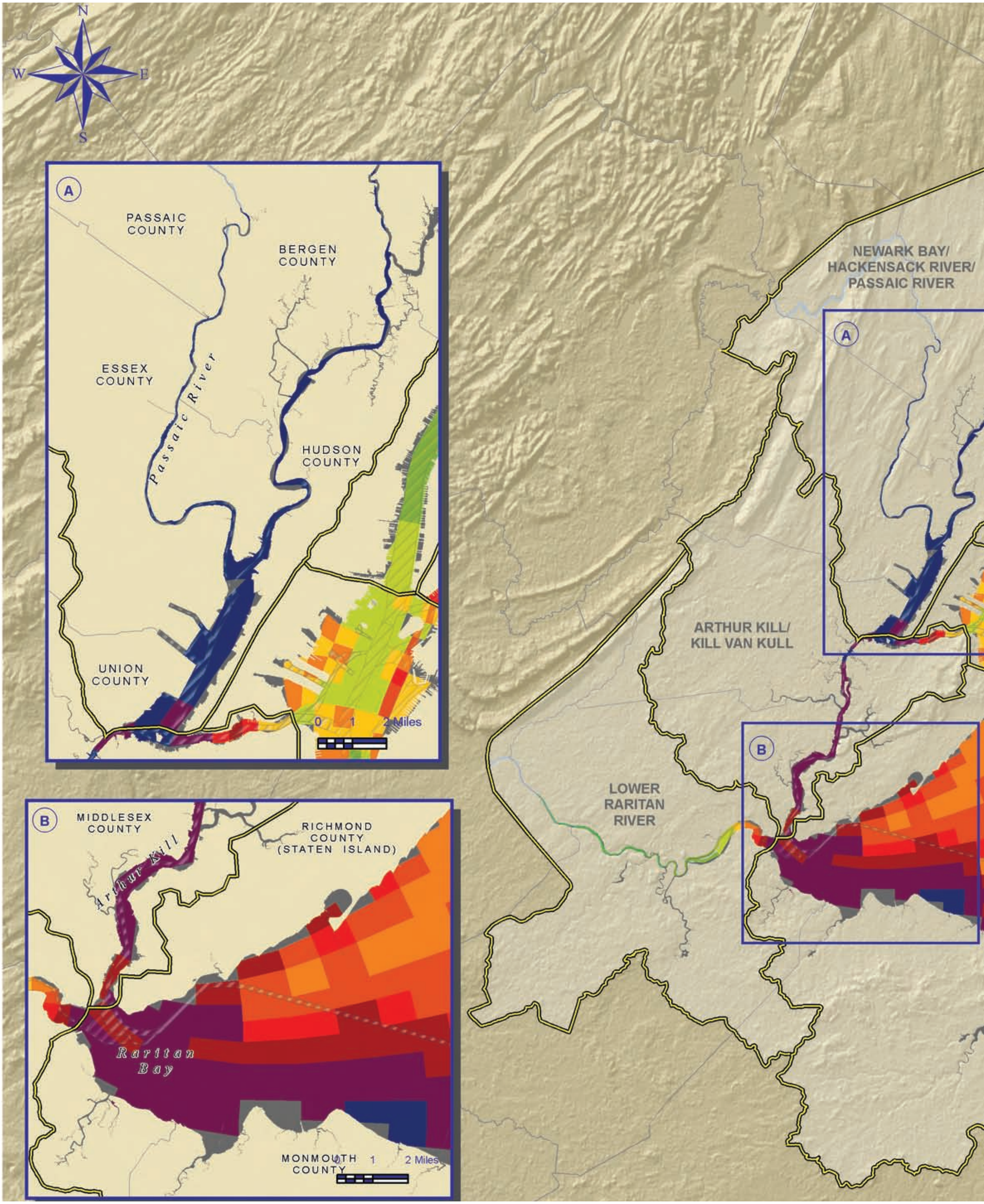
The Target Ecosystem Characteristic for sediment quality was developed to be consistent with the goals of the HEP RSM Workgroup. In addition to the RSM's specific objectives and recommended actions, short-term and long-term objectives were established through the TEC workshops. The short-term objective for this TEC is to isolate or remove one or more sediment zone(s) totaling at least 25 acres which is contaminated based on 10-day toxicity testing, 28-day bioaccumulation testing and direct measurements of concentrations weighed against state-imposed risk-based limits by 2015. The long-term objective is to, starting in 2014, isolate or remove one or more such areas totaling at least 25 acres every 2 years until 2050 or until such time as all HRE sediments are considered uncontaminated based on the all related water quality standards, related fishing/shelling bans or fish consumption advisories, and any newly-promulgated sediment quality standards, criteria or protocols.

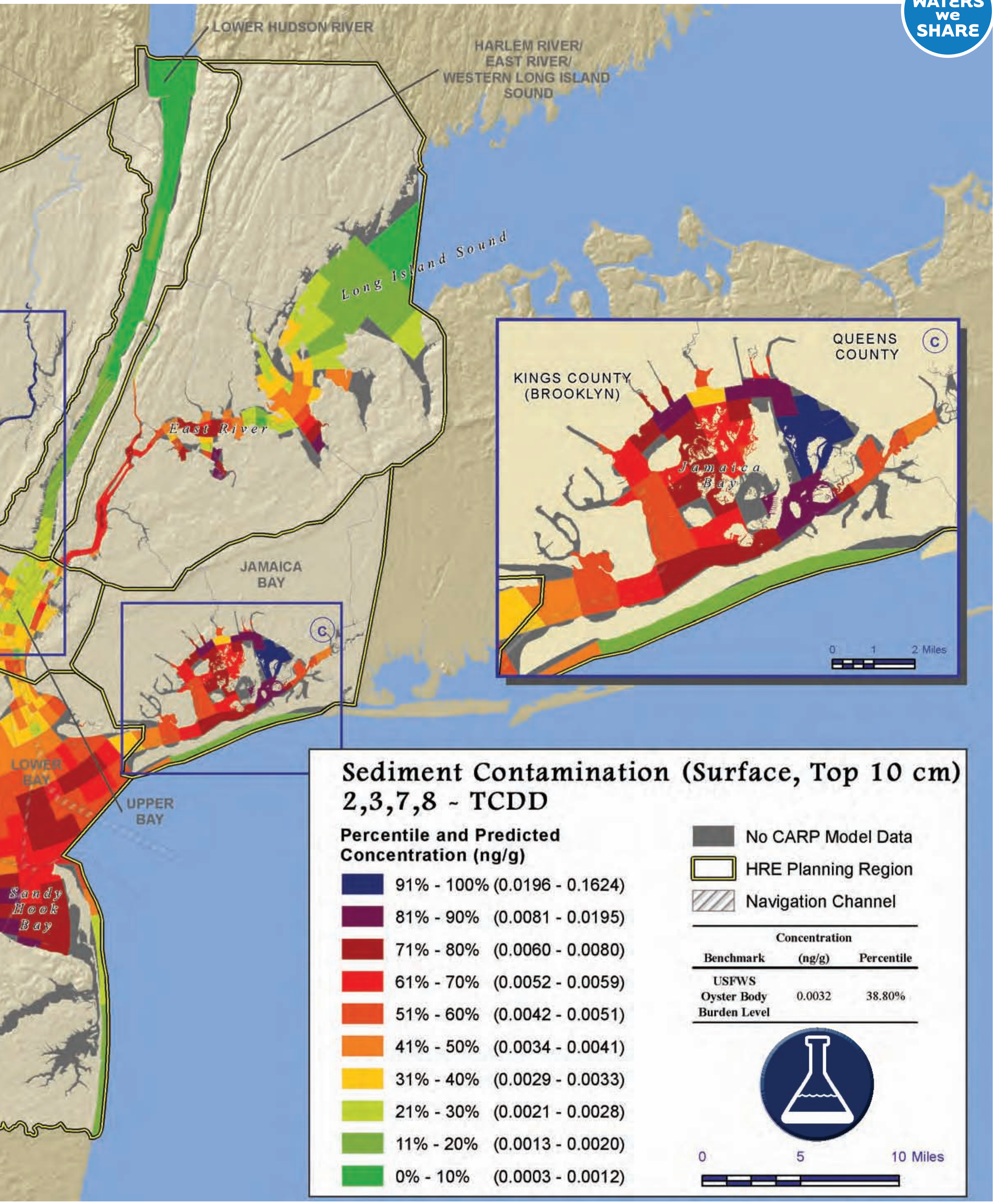
Restoration Opportunities (Maps 3-9 and 3-10)

It has been long documented that the industrial past of the HRE study area has degraded the quality of the sediments. Contaminated sediments are present throughout the HRE study area, and many opportunities for improving sediment quality exist. The TEC objective for improvement of sediment quality through isolation or removal of contaminated sediments within the HRE is consistent with the RSM workgroup objectives. A key action recommended by the RSM Plan was to develop a sediment quality map that prioritizes areas for cleanup.

An initial step of this key action was conducted through the evaluation of predictions from the CARP model that allow for an estuary-wide assessment of chemical concentrations in the top 10 centimeters of the sediments. To display these contaminant reduction opportunities, current day predictions (or "now-casts") from the CARP model were incorporated into a GIS framework to display the aerial extent of surface sediment contamination throughout the HRE study area. Two analytes were selected as examples of the contaminants of concern for the analysis: 2,3,7,8 tetrachlorodibenzo-p-dioxin (TCDD) and Total PCB. Additional analytes are evaluated in Appendix C. The relative concentration of these contaminants throughout

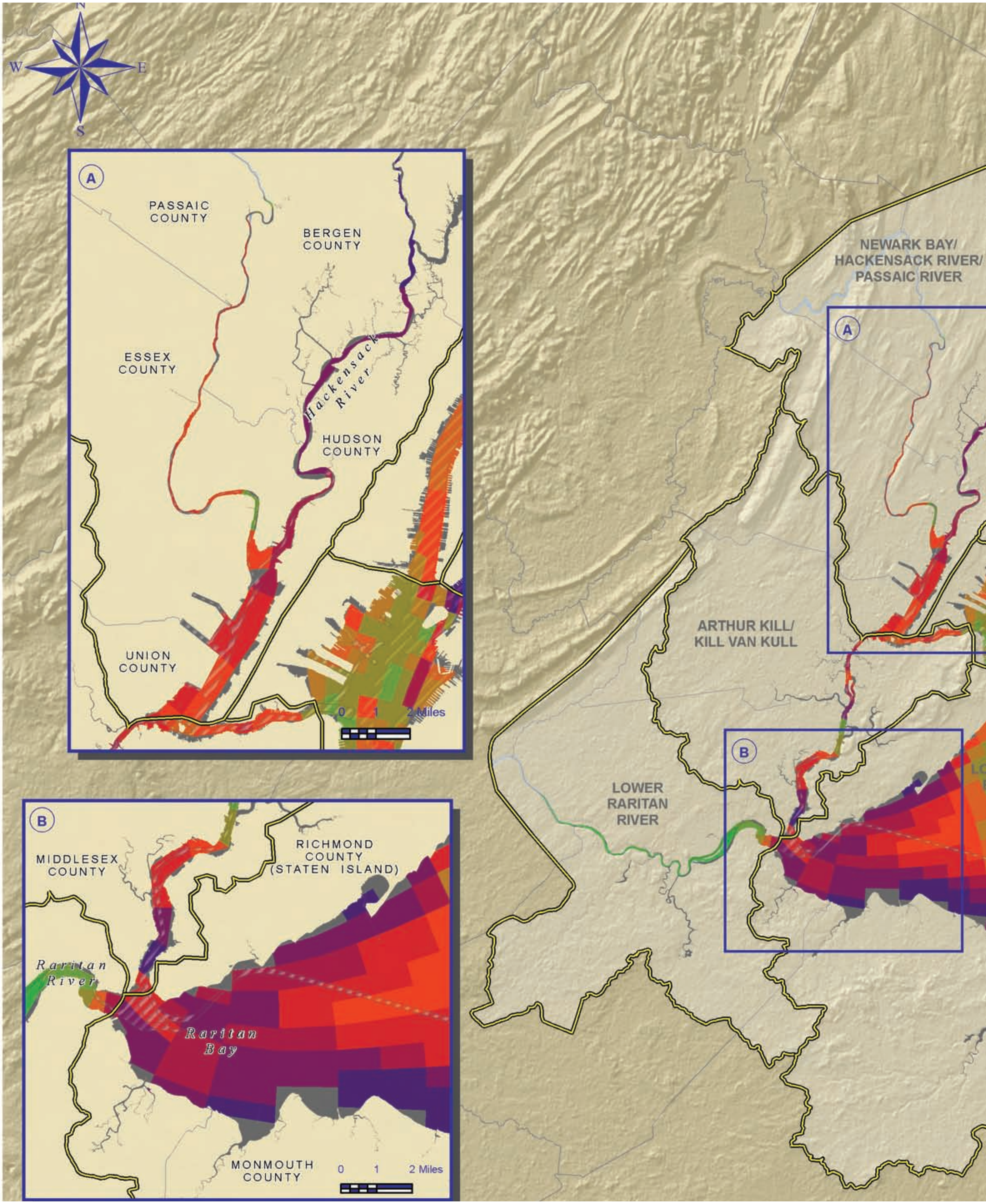
Map 3~9.

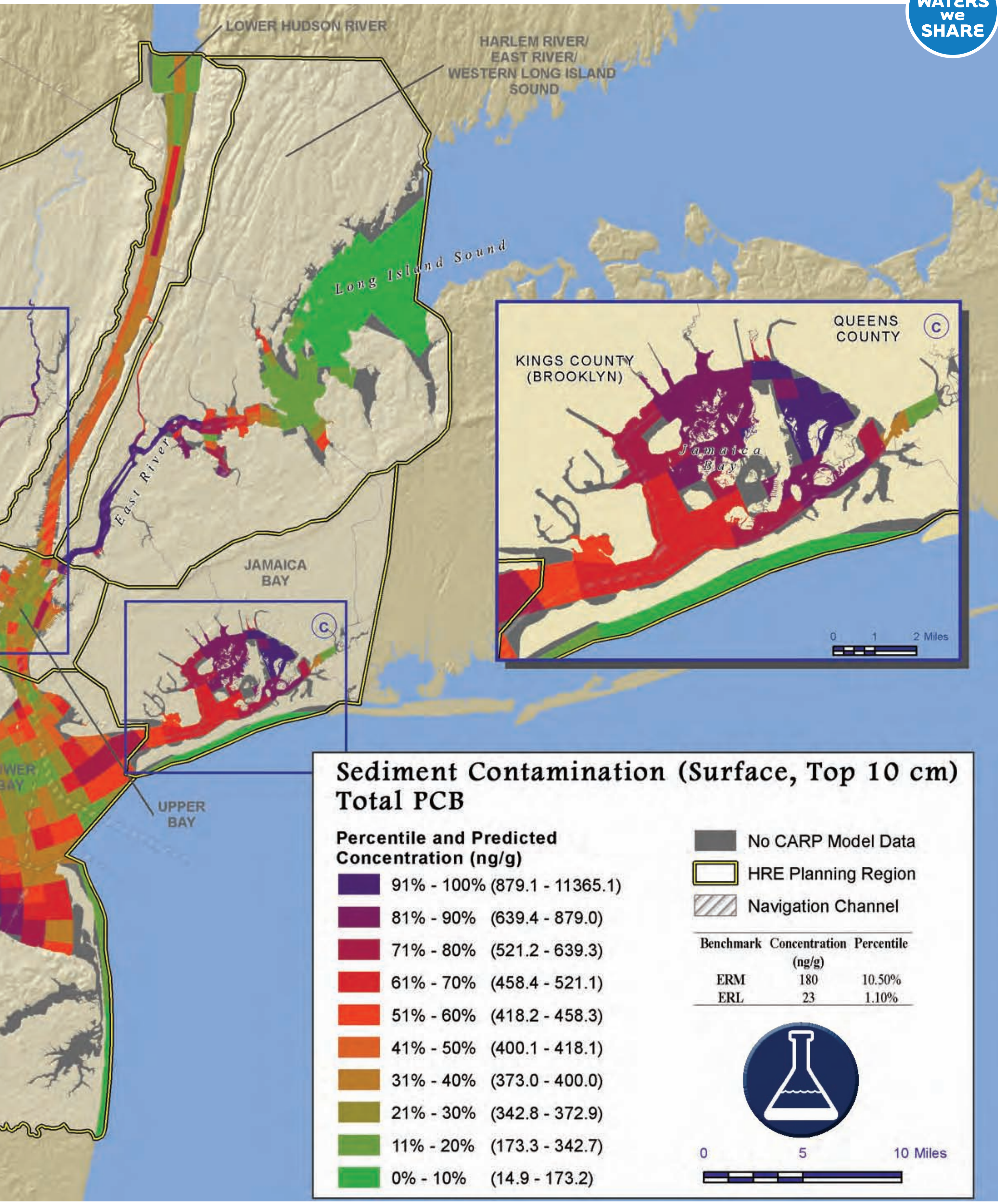

N
S
E
W
NEWARK BAY/
HACKENSACK RIVER/
PASSAIC RIVER
ARTHUR KILL/
KILL VAN KULL
LOWER
RARITAN
RIVER
A
B
A
PASSAIC
COUNTY
BERGEN
COUNTY
ESSEX
COUNTY
Passaic River
HUDSON
COUNTY
UNION
COUNTY
0 1 2 Miles
B
MIDDLESEX
COUNTY
Arthur Kill
RICHMOND
COUNTY
(STATEN ISLAND)
Raritan
Bay
MONMOUTH
COUNTY
0 1 2 Miles



Note: This figure shows predicted surface contamination in 2008, from the Contamination Redcution and Assessment Program (CARP). Legacy chemicals buried below 10 cm are not shown.

Map 3~10.


N
W
E
S
A
PASSAIC COUNTY
BERGEN COUNTY
ESSEX COUNTY
Hackensack River
HUDSON COUNTY
UNION COUNTY
0 1 2 Miles
B
MIDDLESEX COUNTY
RICHMOND COUNTY (STATEN ISLAND)
Raritan River
Raritan Bay
MONMOUTH COUNTY
0 1 2 Miles
NEWARK BAY/ HACKENSACK RIVER/ PASSAIC RIVER
ARTHUR KILL/ KILL VAN KULL
LOWER RARITAN RIVER



Note: This figure shows predicted surface contamination in 2008, from the Contamination Redcution and Assessment Program (CARP). Legacy chemicals buried below 10 cm are not shown.

the HRE study area is presented as percentiles on Maps 3-9 and 3-10. Established benchmarks are displayed on the maps to enable interpretation of the potential risks associated with contaminant levels. These evaluations will be conducted on a more localized basis through specific follow-up risk assessment activities.

These maps are not at a scale where contaminant "hot spots" can be identified. However, they can be used to understand the extent of contamination in the sediments, and to identify the large areas with the highest concentrations of surficial sediments (top 10 centimeters) within the HRE study area. Detailed evaluations of site specific cores at depth within individual study areas would need to be conducted to identify individual hot spots.

2,3,7,8 TCDD

Map 3-9 displays the predicted concentrations of 2,3,7,8 – TCDD for the top 10 centimeters of sediments in the HRE study area. Although there are no Effects Range Medium (ERM) or Effects Range Low (ERL) benchmarks for this type of dioxin, the USFWS derived a benchmark based upon the effects of 2,3,7,8 TCDD tissue concentrations on the egg fertilization and development of eastern oyster (*Crassostrea virginica*) (Winterbyer and Cooper 2003). Effects are assumed to occur at sediment concentrations of 0.0032 parts per billion. Predicted concentrations of 2,3,7,8 TCDD range from 0.0003 to 0.1624 parts per billion throughout the HRE study area. The CARP model predicted that approximately 61.2% of the surface sediments in the HRE study area have concentrations of 2,3,7,8 – TCDD that exceed this benchmark. The highest concentrations were predicted in the lower Passaic River (Inset A) and surrounding waters. The lower Passaic River is the location of many chemical manufacturing plants that produced DDT and other herbicides during the 20th century. This restoration opportunity is being investigated under the HRE Lower Passaic River Restoration Project (see Section 2.4). It is important to note that although surface sediment concentrations in the lower Passaic River are among the highest in the region, exponentially higher concentrations (5 ppm) exist several feet below the surface, with the highest concentrations adjacent to the USEPA's Diamond Alkali Superfund Site. Sediment core samples collected on the lower Passaic River had 2,3,7,8 TCDD concentrations generally ranging from about 10 parts per trillion (.01 parts per billion) to more than 10,000 parts per trillion (10 parts per billion).

Other areas with very high concentrations in the surface sediments (higher than 0.02 parts per billion) include the eastern portion of Jamaica Bay (Inset C), the Arthur Kill and western Raritan Bay (Inset B). Concentrations above the oyster effects benchmark are predicted for the entire Lower Bay, Sandy Hook Bay, the East River, and the western portion of Jamaica Bay (Inset C). The lowest 2,3,7,8 TCDD concentrations were predicted for the lower Hudson River and western Long Island Sound.

Total PCB

The Total PCB concentrations predicted for the top 10 centimeters of sediment within the HRE study area are displayed on Map 3-10. Concentrations were predicted to range between 14.9 and 11,365.1 parts per billion throughout the HRE study area. PCBs are among the most pervasive contaminant in the HRE study area, with 98.9% of the surface sediments predicted to exceed the ERL for Total PCB of 23 parts per billion, and 89.5% of the surface sediments predicted to exceed the ERM of 180 parts per billion. The highest concentrations (>879 parts per billion) are predicted in the East River, the Hackensack River (Inset A), the western Raritan River (especially on the shorelines, Inset B) and throughout Jamaica Bay (Inset C). The only area where the sediments were predicted to be below the ERM for Total PCBs was western Long Island Sound.

Summary

Surface sediment contamination is pervasive throughout the HRE study area, but the highest concentrations of several contaminants of concern occur in relatively few places. The Passaic River, Hackensack River, Newark Bay, western Jamaica Bay and Raritan Bay have nearly the highest predicted concentrations for each contaminant evaluated. This is a concern due to the potential effects of interaction among these contaminants, bioaccumulation, and toxicity. These regions represent opportunities to significantly increase the habitat value by decreasing the effects of contamination. Further evaluation of sediment contamination should be conducted for human health and ecological risk to inform remedial decision making. Such evaluations are currently underway within the lower Passaic River, Newark Bay, Gowanus Canal and Hackensack River. Future evaluation of sediment contamination and recommendations for sediment contaminant reduction for this TEC should be implemented under the auspices of HEP's Regional Sediment Management Workgroup.

3.5 Societal Values

An important component of this restoration plan is to recognize that people are a part of this ecosystem, and the plan should incorporate features that will benefit the public. One TEC was designed to promote access to natural areas for the public. The following section describes the public access TEC and its objectives, and presents potential restoration opportunities within the HRE study area.

3.5.1 Public Access

According to the Public Trust Doctrine, public trust lands, waters, and living resources in a State are held by the State in trust for the benefit of all of the people. The doctrine establishes the right of the public to enjoy these resources for a wide variety of recognized public uses (NYSDOS 2008). Public access to the estuary means providing residents of the HRE study area with accessible routes to natural areas, enabling them to enjoy local scenic, natural, cultural, historic, and recreational resources. Contact with nature can afford numerous public benefits in the form of educational experiences, relaxation, and improved quality of life (Bain et al. 2007; Figure 3-3). Types of public access points include:

- Direct access (e.g., boat launching, swimming, recreational fishing),
- Indirect access (e.g., waterfront promenade),
- Vistas (e.g., scenic overlook), and
- Upland access routes (e.g., pedestrian route, bike path; Bain et al. 2007).

Throughout the HRE's history, there has been a conflict of interest concerning the use of the waterfront. Differing views among government, local communities, and private industries were rarely able to reach a consensus when deciding between urban or natural uses, or some combination thereof, for the waterfront. Often, attempts to create parkland during the 19th century were rejected as being inconsistent with the economic goals and commercial opportunities for the city. By the mid-20th century, views had changed and the focus became urban renewal (Bone 1997).

Since then, water quality improvements have been matched by a reanimation of recreational activities along the waterfront and within water bodies of the estuary (Bone 1997). A reconnection with the estuary has accompanied these activities, resulting in increased popularity and momentum of community-led environmental programs and restoration efforts. Through environmental improvements and increased community participation in the HRE study area, there has been an increased demand for recreational and outdoor educational opportunities at parks and natural areas.

Figure 3~3. Public Access Walk in the Woodbridge River Watch Wildlife Sanctuary, New Jersey.

The Public Access TEC may encounter more land use trade-offs than other TECs. Industrial or commercial land uses can be considered conflicting if they create safety issues for direct access or lack aesthetic quality. Access will be limited around airports, port terminals and other secure areas. Although industrial activity and public access co-exist in the Hackensack Meadowlands, Newtown Creek, and the Bronx River, active ports and maritime industries may take precedence over creating new public access points. Through strategic partnerships, vacant lots and brownfields could be restored to offer access opportunities. Similarly, all natural habitats, except for environmentally sensitive areas (e.g., nesting habitat), should be viewed as opportunities to create public access. Providing access creates scenic destinations and peaceful retreats from urban life.

Target Statement

The goal of the Public Access TEC is to improve direct access to the water and create linkages to other recreational areas, as well as provide increased opportunities for fishing, boating, swimming, hiking, education, or passive recreation. The short-term objective for this TEC is to create one new public access site and one access improvement or upgrade of an existing access site in each of the eight study areas by 2015. By 2050, the objective is to make waters of the Hudson-Raritan Estuary and tributary rivers accessible to all residents within a short (approximately twenty minute) walk or public transit trip. The creation of direct access points should be encouraged, so that at least 80% of access points contain a direct access component (e.g., boat launch, public bathing area). When restoration programs are initiated, siting of new public access areas could be integrated with other TECs and provide informational displays related to those restoration actions.

Restoration Opportunities (Map 3-11)

Opportunities for improving existing public access points and creating new public access sites likely exist in every planning region of the HRE study area. A data set that includes known public access points was developed by the Metropolitan Waterfront Alliance. A map was created using this data set and land use data, so that areas appropriate for public access creation can be visually identified (Map 3-11). This map can be used as an overview that highlights large expanses of shorelines without access points and to show places where people currently access the water.

The existing public access points displayed on Map 3-11 may be in need of upgrades, facilities or access improvements. The map also displays buffers of 0.75 and 1.5 mile radii around the access points to represent a short walking distance, and it displays the land use.

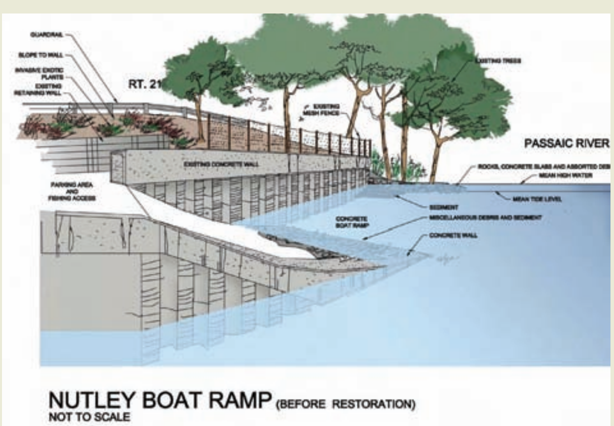
In the HRE study area, there are 436 identified waterfront access points, most of which occur within 1.5 miles of adjacent points. The restoration opportunities map has several inset maps that provide examples of areas where existing access points could be improved or new waterfront access points could be created:

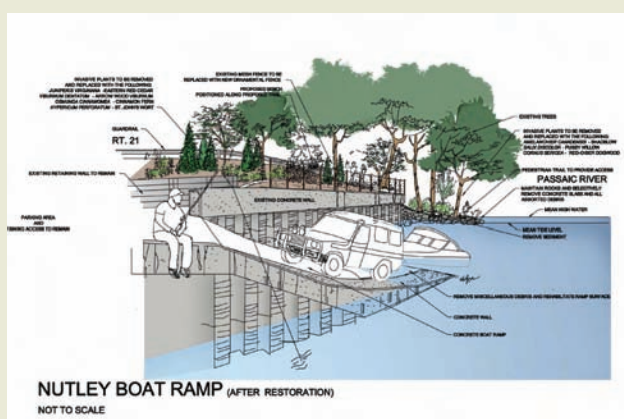
- *Inset A* – The area along the Harlem and East rivers and the northern shoreline of Brooklyn and Queens represent access points that may need to be upgraded to offer additional amenities to the thousands of nearby residents. Safer travel routes should also be considered as many of these access points are separated from residents by large, impassable highways.
- *Inset B* – Shorelines of the Arthur Kill and Rahway River have large gaps between public access points. Although many of these shorelines support industrial uses and have relatively low population densities, important habitats are scattered among them and they may be appropriate for interpretive signage, nature trails or birding opportunities.
- *Inset C* – Similar to the Arthur Kill, the lower Raritan River may have areas appropriate for waterfront access points, whether they be active, passive, or upland routes.

Other opportunities – Other waterfront creation opportunities may exist along the southern coast of Staten Island and the southern portion of the Sandy Hook peninsula. In addition, there are opportunities to allow public access in the lower Passaic River and Newark Bay where very few public access points exist (e.g., Kearny and Nutley Boat Ramps). However, the Lower Passaic/Saddle River Watershed Alliance are working with the National Park Service to develop a 32 mile water trail for

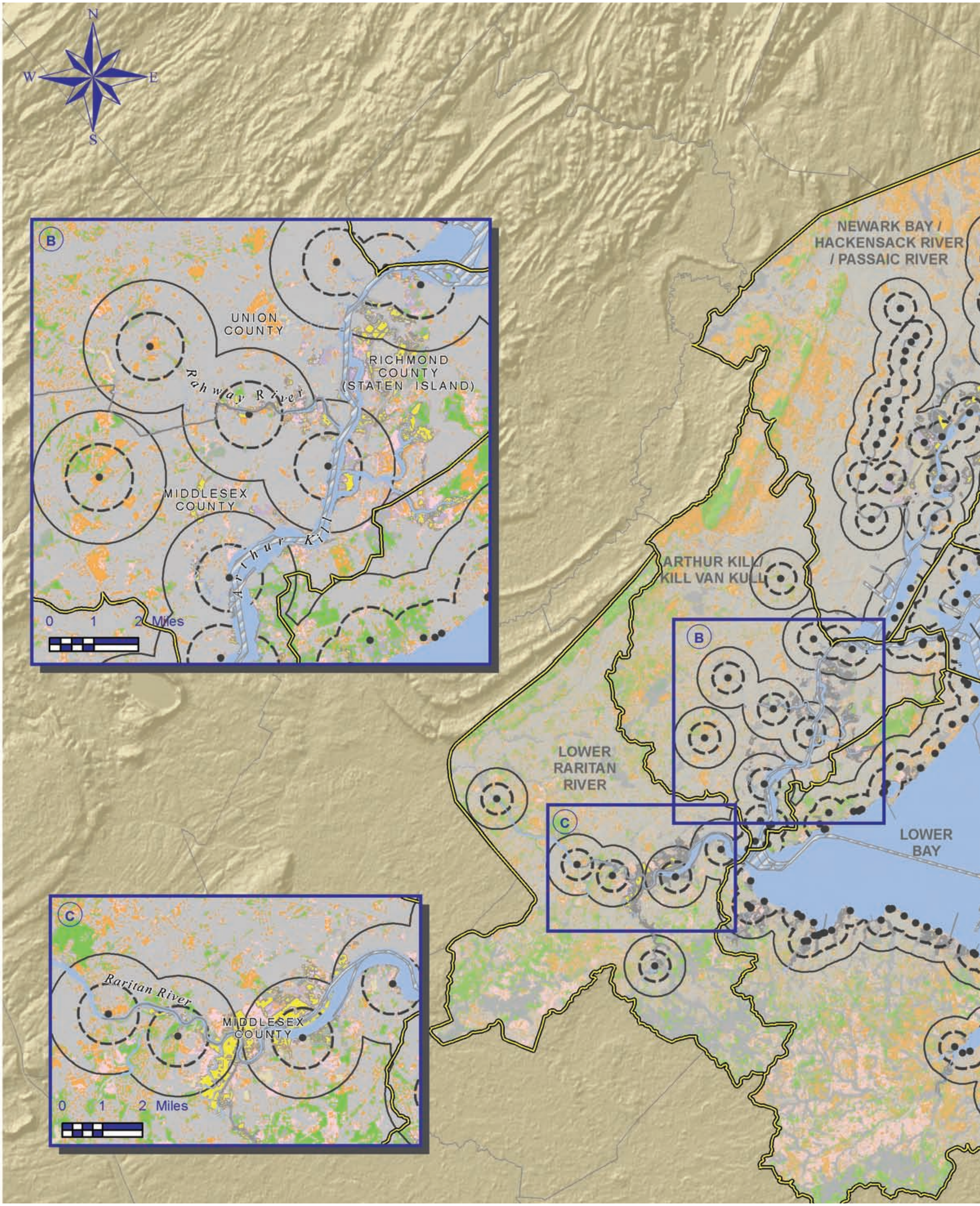
A Public Access Design

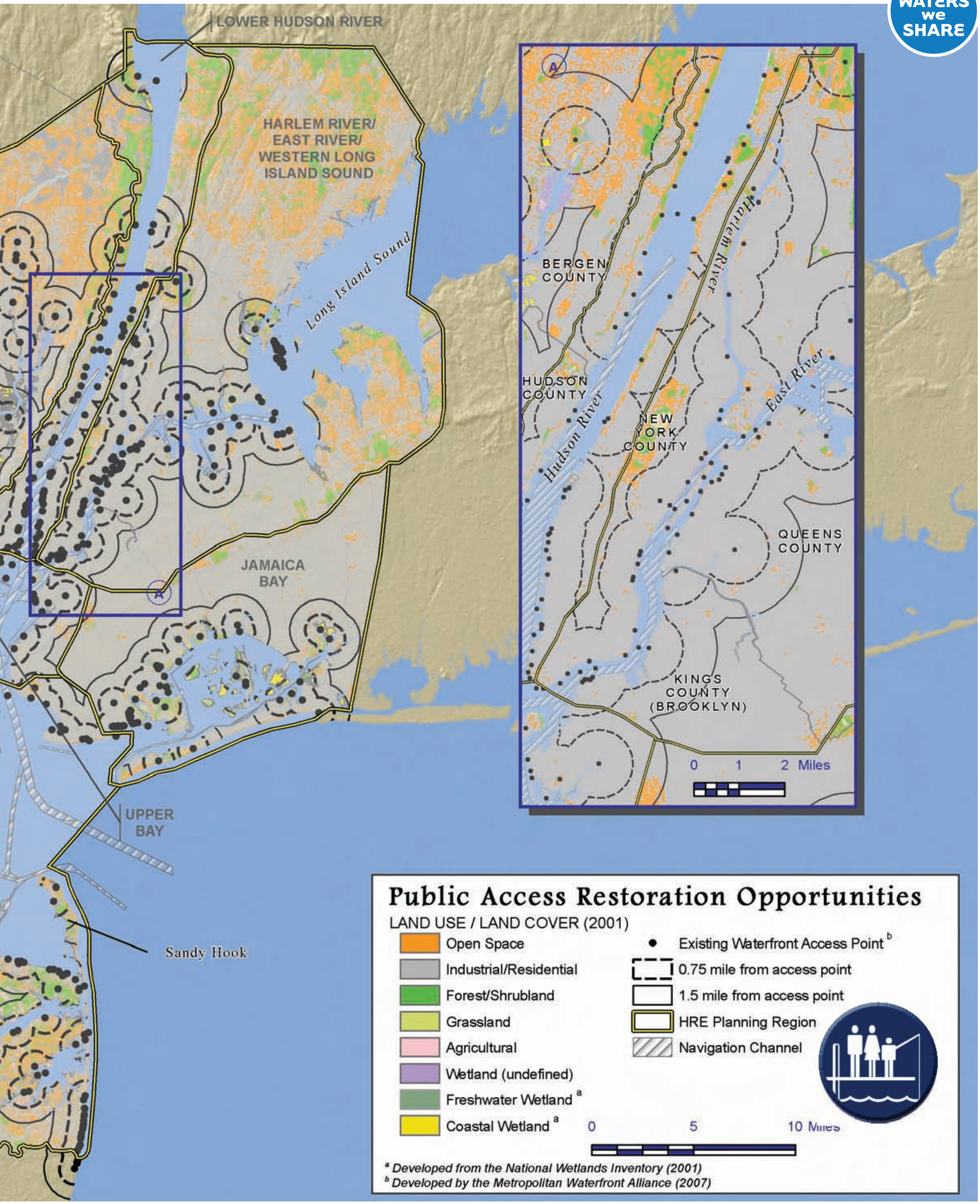
The Nutley Boat Ramp is one of many underutilized public access points along the lower Passaic River and represents an opportunity to improve an existing access. The schematics below call out features that could be incorporated into any access enhancement project. The shorelines along this portion of the Passaic River are bulkheaded and lined with debris. The access improvement design proposes to enhance the shorelines by removing debris and invasive vegetation, while planting native understory to improve the riparian buffer.





Map 3~11.


N
W
E
S
B
UNION COUNTY
RICHMOND COUNTY (STATEN ISLAND)
Rahway River
MIDDLESEX COUNTY
Arthur Kill
0 1 2 Miles
NEWARK BAY / HACKENSACK RIVER / PASSAIC RIVER
ARTHUR KILL / KILL VAN KULL
B
LOWER RARITAN RIVER
C
LOWER BAY
C
Raritan River
MIDDLESEX COUNTY
0 1 2 Miles


LOWER HUDSON RIVER
HARLEM RIVER/ EAST RIVER/ WESTERN LONG ISLAND SOUND
Long Island Sound
JAMAICA BAY
UPPER BAY
Sandy Hook
A
BERGEN COUNTY
HUDSON COUNTY
NEW YORK COUNTY
QUEENS COUNTY
KINGS COUNTY (BROOKLYN)
Hudson River
Harlem River
East River
0 1 2 Miles
Public Access Restoration Opportunities
LAND USE / LAND COVER (2001)
Open Space
Industrial/Residential
Forest/Shrubland
Grassland
Agricultural
Wetland (undefined)
Freshwater Wetland [a]
Coastal Wetland [a]
Existing Waterfront Access Point [b]
0.75 mile from access point
1.5 mile from access point
HRE Planning Region
Navigation Channel
0 5 10 Miles
[a] Developed from the National Wetlands Inventory (2001)
[b] Developed by the Metropolitan Waterfront Alliance (2007)

kayaking and canoeing from the upper Passaic River to Lincoln Park on the Hackensack River. The plan will map 20 or more paddle access points and suggests locations for new locations or rehabilitation of existing points.

A comprehensive plan for public access TEC will require additional information from the municipalities in the HRE study area. As a part of their Feasibility Investigation, the USACE will work with HEP's Public Access Workgroup and the Metropolitan Waterfront Alliance to gather local planning documents to identify planned and existing access points. This information will be used to create an HRE-wide data set of pubic access locations for inclusion within the NYC OASIS database that include site-specific information, including access type, ownership, acreage, amenities, number of annual visitors, and overall quality rating.

3.6 Other Restoration Actions

Although the TECs are the focused targets of the CRP, habitat restoration opportunities that do not address the TECs can still result in benefits to the HRE study area. For example, there are five vessel graveyards along the Arthur Kill where hundreds of derelict ships scatter the shorelines of Staten Island along with abandoned wooden piers (USACE 2004a). Although these vessels provide some form of artificial intertidal habitat to supplement natural nesting, foraging, and refuge areas, they also smother shoreline vegetation and are a source of dangerous waterborne drift material. Removal of these ships would result in improved intertidal and shoreline habitat.

The restoration of valuable habitat types that are not included in the TECs can also provide increased benefits to the HRE study area. For example, natural grasslands are a quickly disappearing habitat type that provides critical habitat to many species. The northern harrier (*Circus cyaneus*), which is listed as threatened in New York and endangered in New Jersey requires maritime grasslands to nest and forage in. Grasslands are successional habitats that often become overgrown with shrubs and trees, unless they are maintained or subject to periodic disturbance. These habitats should be protected and restored wherever practicable.

Other types of restoration and habitat improvements are necessary and underway in the HRE study area. Some of these restoration practices are covered under separate programs, such as the USACE Drift Program that provides for removing abandoned piers, wharves, derelict vessels and debris, and also for repairing in-use deteriorated shore structures throughout the HRE study area. The New York City Department of Environmental Protection's Floatables Reduction Program focuses on the reduction of water-borne litter and debris that entered the Estuary through storm drains and sewers. The program includes the use of catch basins to decrease the amount of floatable debris from entering the waterways and booming and skimming operations to remove debris from the waters. Their CSO abatement program is also improving the water quality of the HRE through the collection and treatment of sewage prior to release into the HRE. The Passaic Valley Sewerage Commissioners have several initiatives to improve the waters of Newark Bay and the Passaic River. Their Skimming Program includes two pontoon boats that skim floating debris from the Passaic River. They also sponsor volunteer clean up programs and have a dedicated clean up crew that clean large debris from the Passaic River, Newark Bay and their tributaries (PVSC 2008). The New Jersey Harbor Dischargers Group is also in the planning stages of their CSO Long Term Control Plan. The Harbor Dischargers Group consists of representatives from the City of Paterson, the Towns of Guttenberg, Harrison and Kearny, the Borough of East Newark, the Passaic Valley Sewerage Commissioners, and the Municipal Utilities Authorities of Jersey City, Bayonne, and North Bergen (PVSC 2008).

The concept of green building design is becoming increasingly popular throughout the country, and the HRE region is no exception. Many new buildings incorporate features such as rooftop gardens and porous paving blocks that collect stormwater. These features reduce the amount of stormwater that discharges into waterways. The Office of the Mayor's PlaNYC initiative addresses stormwater impacts to the surface waters through the concept of incorporating green design features and trees to collect stormwater. The City launched the MillionTreesNYC initiative in 2007 with the goal of planting one million trees on the streets of New York City over the next decade. PlaNYC also includes incentive programs for the installation of green roofs. The City Council has approved a green parking lot zoning amendment that includes design regulations for new parking lots, regulating the landscaping, perimeter screening, and requirements for canopy trees in planting islands in the lots.

To help promote stormwater control through green infrastructure, HEP supported a local group in Elizabeth, NJ in planning and constructing three rain garden demonstrations. These projects were established at local schools where students could get hands-on training with the intention of building additional rain gardens in other areas. HEP also is a partner with the NY-NJ Baykeeper and the Interstate Environmental Commission in working with the City of Newark, New Jersey to identify a location where multiple green technologies can be designed and built in 2009.

4.0 Restoration Opportunities

The overall program goal of the Hudson-Raritan Estuary Study is the restoration of the estuary through the establishment of a mosaic of habitats that provide society with renewed and increased benefits from the estuary environment. In order to meet the overall goal of the program, multiple TECs should be incorporated into a restoration opportunity or project in order to achieve the greatest ecological benefits at a single location.

Early in the planning process, many potential restoration sites were identified through the HEP Habitat Workgroup's process of nominating sites for acquisition or restoration and early outreach efforts conducted as a part of the USACE's Needs and Opportunities evaluation. These sites now known collectively as the CRP sites, have been cataloged by the USACE and HEP and along with existing information about each, are included in HEP's NYC OASIS database. To date, a total of 296 CRP sites have been identified that have opportunities to conduct restoration activities that will help to achieve the TEC objectives. Some of the sites are currently undergoing habitat restoration, but most are waiting on funding, partnering, design, permits or resolution of logistical issues. While hundreds of CRP sites have been identified, restoration of these sites will likely not achieve the ambitious objectives of the TECs.

The TEC opportunities that were identified in Chapter 3 would supplement the restoration opportunities available at the CRP sites. Each planning region within the HRE was evaluated for potential restoration opportunities including CRP sites and those identified in Chapter 3. The types and quantity of restoration vary greatly between the planning regions, as do the TECs they support, as evidenced by the breakdown summarized in Table 4-1 and the discussion in the following descriptions of the opportunities by planning region.

4.1 Jamaica Bay

The Jamaica Bay Planning Region has tremendous potential for the creation and restoration of a variety of habitats, including coastal wetlands, oyster reefs, eelgrass beds, islands for waterbirds and maritime forests. Centered by a national park, Jamaica Bay includes a complex of shallow littoral and intertidal areas as well as marine habitats that offer the potential for aquatic and wetland habitat improvements. Upland restoration opportunities include improvements to island habitats and coastal and maritime forests. In this region, there is also the potential to reduce the effects of human disturbance by improving water and sediment quality in the former tidal creeks that are now enclosed basins and in the bathymetric depressions that experience seasonal hypoxic conditions. Fifty-five (55) of the CRP Restoration Sites are within the Jamaica Bay Planning Region (Table 4-1; Map 4-1).

Coastal wetland restoration and creation opportunities are abundant throughout Jamaica Bay, and 38 of the CRP Restoration Sites within this planning region have identified opportunities for coastal wetland restoration. Many of these sites are marshes within the main body of Jamaica Bay (e.g., Big Egg Marsh [#611], Black Wall Marsh [#614], Yellow Bar Marsh [#617], and Silver Hole Marsh [#638]). Some of the restoration opportunities located to the east of the main bay include marshes in Idlewild Park (#105), Hook Creek (#601), and Thurston Basin (#634). Other of these sites are located along former tidal creeks, such as Paedegat Basin (#731), Fresh Creek (#730), and Hendrix Creek (#168).

Table 4-1. Comprehensive Restoration Plan Restoration Sites tallied by Hudson-Raritan Estuary Planning Region and Target Ecosystem Characteristic.

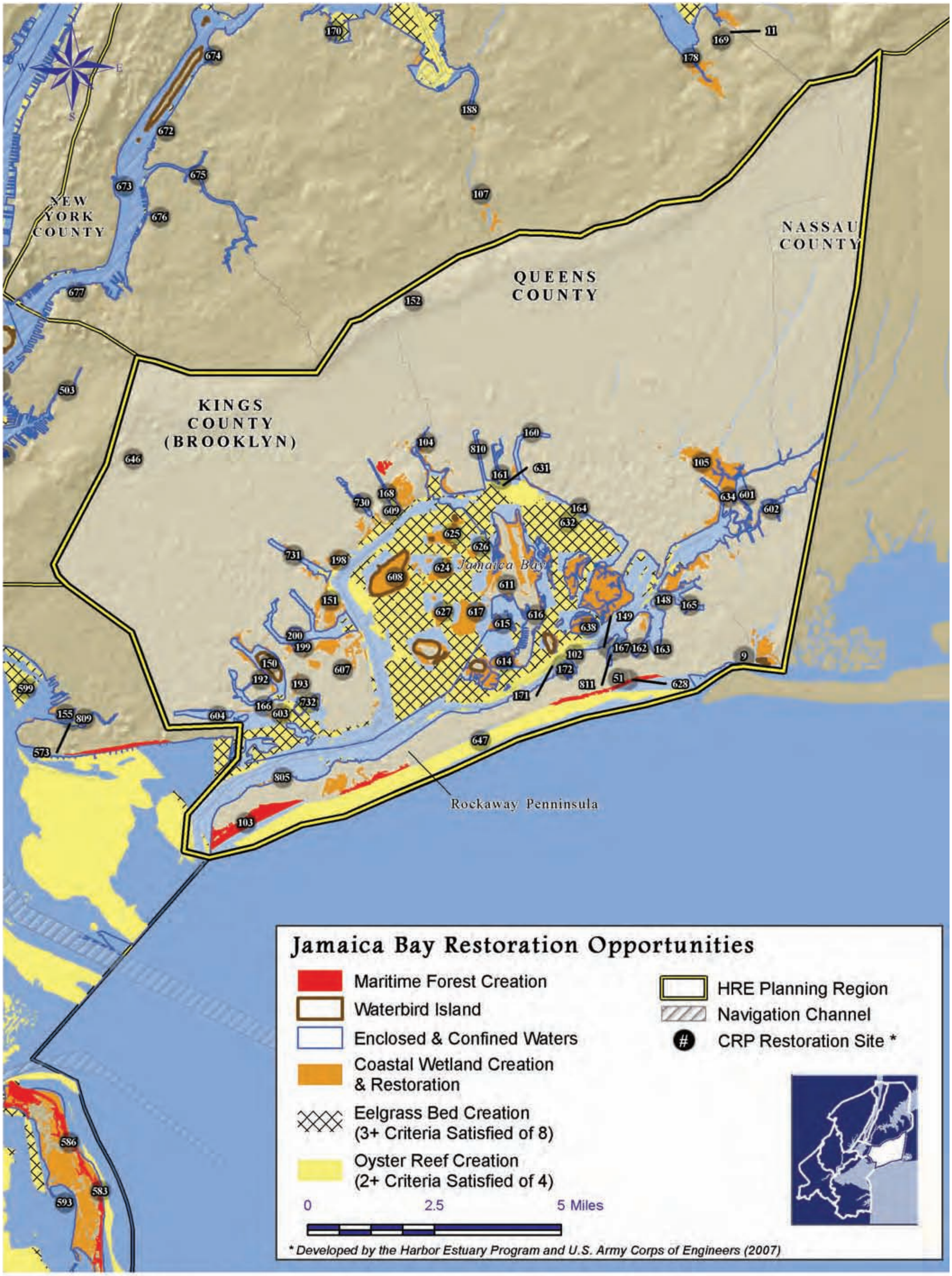
HRE Planning Region	CRP Sites*								Fish Passage	Freshwater Wetland			
Jamaica Bay	55	38	0	20	0	0	0	10	2	1	9	6	10
Lower Bay	57	15	1	12	4	1	3	7	5	3	0	2	2
Lower Raritan River	33	4	0	6	0	0	2	0	0	0	0	6	2
Arthur Kill/Kill Van Kull	54	14	2	8	0	0	9	4	2	3	0	2	4
Newark Bay/ Hackensack River/ Passaic River	40	23	2	15	0	0	6	15	3	6	0	7	11
Lower Hudson River	9	5	0	4	0	0	2	3	0	0	0	2	4
Harlem River/ East River/W. Long Island Sound	41	20	3	11	0	0	10	7	3	6	2	3	8
Upper Bay	5	2	0	1	0	0	1	2	0	1	1	1	4
TOTAL CRP Sites	296	121	8	77	4	1	33	48	15	20	12	29	45

*Specific CRP Sites for each Planning Region are presented in Appendix D: Atlas of Restoration Opportunities.

Based on the GIS analysis of the TEC opportunities, Jamaica Bay appears to be one of the most suitable regions for oyster and eelgrass restoration projects within the HRE study area. Most of the open waters of Jamaica Bay appear to meet some of the habitat requirements of eelgrass, oysters and oyster larvae. Although none of the CRP Restoration Sites in this region have identified a plan for these types of restoration, it may be possible to include an oyster restoration component or eelgrass restoration component with these projects to create multi-TEC habitat complexes suitable for fish, shellfish and crustaceans (i.e., Fish, Crabs, and Lobsters TEC).

The Jamaica Bay Planning Region contains areas where the establishment of maritime forest communities appears to be possible; these are relatively rare opportunities within the HRE study area. Breezy Point (#103) and other areas along the Rockaway barrier beach could provide these opportunities. In addition, many of the CRP Restoration Sites identify the possibility to create coastal forests or other coastal communities on uplands adjacent to coastal wetland opportunities. Examples of sites that include both coastal wetlands and associated upland coastal communities include Spring Creek to the north of Jamaica Bay (#104), Bayswater State Park (#148), and Conch Basin (#162).

Map 4~1.



NEW YORK COUNTY
QUEENS COUNTY
NASSAU COUNTY
KINGS COUNTY (BROOKLYN)
Jamaica Bay
Rockaway Penninsula
Jamaica Bay Restoration Opportunities
Maritime Forest Creation
Waterbird Island
Enclosed & Confined Waters
Coastal Wetland Creation & Restoration
Eelgrass Bed Creation (3+ Criteria Satisfied of 8)
Oyster Reef Creation (2+ Criteria Satisfied of 4)
HRE Planning Region
Navigation Channel
CRP Restoration Site *
0
2.5
5 Miles
* Developed by the Harbor Estuary Program and U.S. Army Corps of Engineers (2007)

the WATERS we SHARE

Envisioning Gateway

Gateway National Recreation Area, stretching across a total of 26,607 acres of land parcels and islands within the New York-New Jersey Harbor, was created in 1972 as one of the U.S. National Park System's first urban national recreational areas. The park contains many cultural and historic sites, including Native American archeological sites and three historic forts, as well as tremendous ecological resources like sanctuaries for birds traveling along the Atlantic migratory flyway, salt marshes in Jamaica Bay, and tracts of coastal woodlands. Unfortunately, difficulties managing the park parcels and obtaining sufficient funds for operations and restoration have resulted in degraded natural habitats and facilities in disrepair. The potential, and vision, of Gateway has never been fully realized.

Envisioning Gateway, an innovative international design competition and public engagement program launched in 2007, aims to improve services and facilities within the park, integrate the diverse recreational, ecological, and historical opportunities within Sandy Hook, Staten Island, and Jamaica Bay, and create a unified and iconic national park experience for visitors to Gateway. An open, international competition solicited ideas from around the world for a new design and revitalized vision for Gateway. An esteemed jury and the public identified the most compelling submitted designs and priority issues at Gateway for consideration of inclusion in the revision of the General Management Plan for Gateway. The revised plan will be an important document for the park, guiding its layout, use, and management for the next generation.

Envisioning Gateway occurs at an opportune time, perhaps accelerated by Mayor Bloomberg's PlaNYC 2030 which emphasizes open space and a greener city. In addition, because Gateway protects some of the largest expanses of open space in the HRE, Envisioning Gateway could provide key opportunities to incorporate Target Ecosystem Characteristics (TECs) into Gateway's redesign and make large strides towards meeting the restoration objectives of the Comprehensive Restoration Plan for the Hudson Raritan Estuary. For more information on Envisioning Gateway visit www.npca.org/gateway.

More than any other planning region, Jamaica Bay provides many opportunities to improve water quality by reducing the human-induced effects of enclosed and confined waters. The shorelines of most of the tributaries of Jamaica Bay have been hardened and straightened, reducing tidal flushing. Opportunities to improve water circulation exist in many of these waterways. In addition, several deep borrow pits exist could be recontoured to improve hydrodynamics and water quality. Several restoration actions identified for the CRP Restoration Sites include recontouring the benthic environment to improve local hydrodynamics: Bergen Basin (#160), Shellbank Basin (#166), Hendrix Creek (#168), Mill Basin (#200), Grassy Bay (#632), and Thurston Basin (#634).

Other habitat restoration opportunities identified for the CRP Restoration Sites include the restoration of a freshwater wetland in Forest Park (#152) at the northern end of the planning region, and the removal of impediments to fish passage at Doxey Creek (#602) at the eastern end of the planning region. Although not included in plans for the CRP Restoration Sites, there may be several opportunities to improve the habitat of the islands in the bay for waterbirds. For example, under its Jamaica Bay Marsh Islands Ecosystem Restoration Program, the USACE is in the process of restoring 70 acres of marsh habitat on Elders Point (#625, USACE 2006b). Public access opportunities, which can be incorporated into many future habitat restoration projects, exist throughout this planning region, as much of the region is within the National Park System. The Envisioning Gateway design competition, sponsored by a partnership between the Van Alen Institute, National Parks Conservation Association and Columbia University Graduate School of Architecture Planning and Preservation, represents an opportunity to provide public access within this planning region by designing these features into the park.

Although there is much potential to conduct habitat restoration within the Jamaica Bay Planning Region, contamination issues are pervasive within the Bay and its tributaries. The water quality of the eastern end of the bay is degraded and does not

Marsh Island Restoration: Elders Island West

In response to the marsh island losses in Jamaica Bay, the Port Authority of New York and New Jersey and the U.S. Army Corps of Engineers has sponsored the Elders Point West marsh restoration project. Elders Point, located in Jamaica Bay was historically a 132-acre island, but severe marsh losses in the center of the island created a western and an eastern half connected by a mudflat. Partner agencies, the National Park Service, the New York State Department of Environmental Conservation, and the New York City Department of Environmental Protection, are supportive of salt marsh island restoration in Jamaica Bay as a strategy for improving the bay's environmental quality. Various resource agencies, including the National Oceanic and Atmospheric Administration, the New York State Department of State, and the U.S. Fish and Wildlife Service, have been active stakeholders in the design development of this project and Yellow Bar Hassock marsh restoration. The proposed plan for Elders Point West Marsh Island is to beneficially use dredged material to restore a 40-acre marsh area. Dredged material will be placed to increase elevations of the exposed mudflats to support low marsh and transitional marsh plant growth. A combination of nursery grown native plants and existing marsh plants, replanted onsite, will be used to restore the marsh habitat.

currently meet its Best Use Class. The surface sediments within this region have among the highest concentrations of PCBs, DDT, as well as Total Dioxins and Furans, well above the associated benchmarks or action levels (e.g., ERL, ERM).

4.2 Lower Bay

Similar to Jamaica Bay, the Lower Bay Planning Region appears to be suitable for the restoration of a variety of habitats, including oyster reefs, coastal wetlands, eelgrass beds, and maritime forests. The extensive shallow littoral, marine and intertidal habitats have the potential to offer numerous opportunities for aquatic habitat restoration along the coats of southeastern Staten Island and southwestern Brooklyn in New York, and Monmouth County, New Jersey. This region also contains coastal forest restoration opportunities, and the potential to reverse the effects of human disturbance. Fifty-seven (57) of the CRP Restoration Sites are within the Lower Bay Planning Region (Table 4-1; Map 4-2).

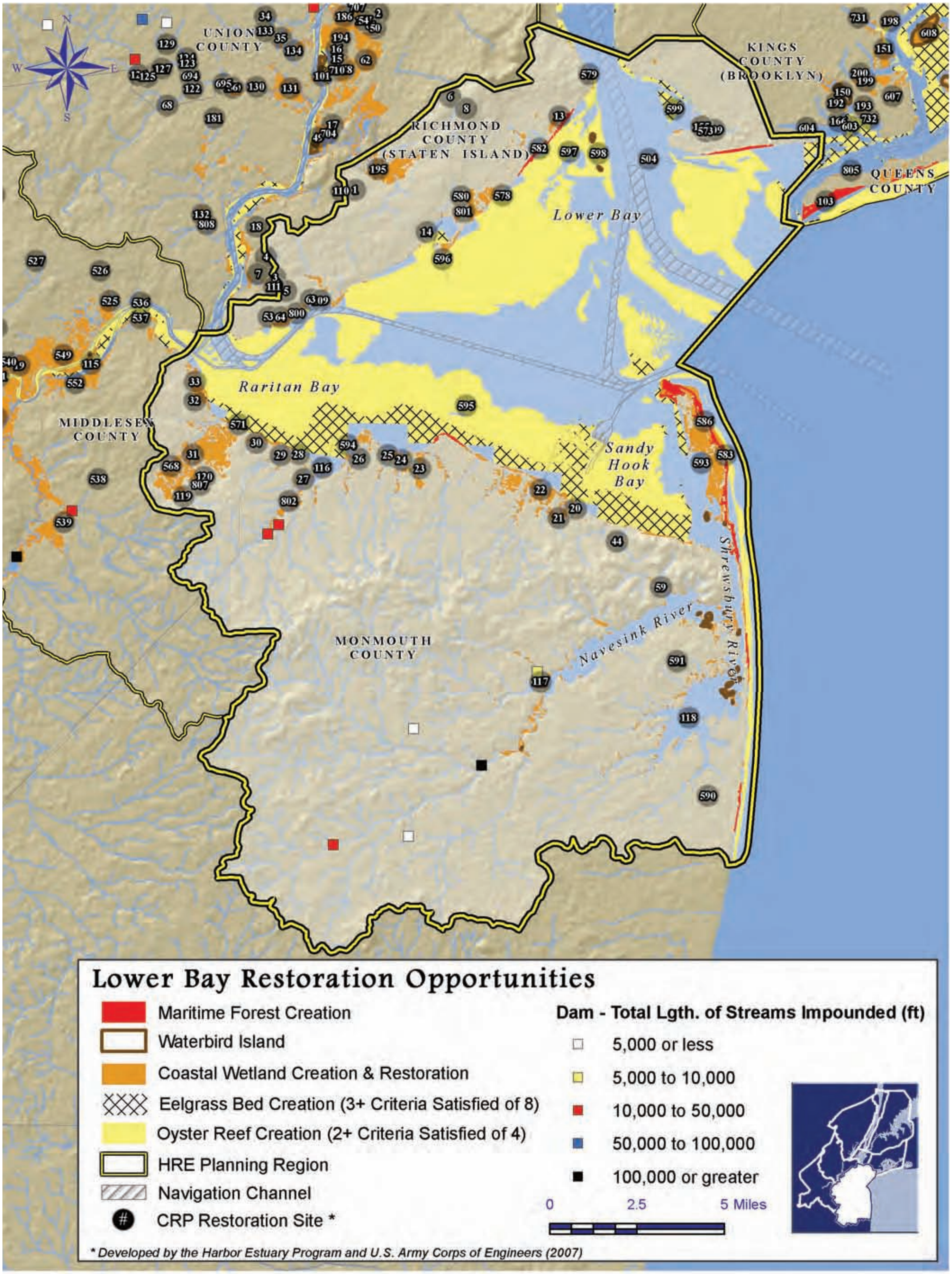
Oyster restoration opportunities appear to be the most abundant in the Lower Bay Planning Region, when compared to other regions. Large expanses of the Lower Bay meet many of the physical and water quality properties to support the growth of oysters. CRP Restoration Sites with identified plans for oyster restoration are unique to this planning region. Oyster restoration projects have been identified in Lower Bay (#504), Keyport Harbor and Matawan Creek in Keyport, New Jersey (#27 and #116), and in Raritan Bay (#594).

Sandy Hook Bay and the Shrewsbury and Naversink rivers also meet many of the habitat requirements of eelgrass beds. The only mapped existing eelgrass beds are present in the Shrewsbury River, and the only CRP Restoration Site (#591) that includes plans for eelgrass restoration is in this river. Substantial coastal wetland creation and restoration opportunities exist along the shorelines of numerous tidal creeks and rivers, harbors and protected coastlines of Lower Bay. Thirty-eight (38) of the CRP Restoration Sites in this planning region include plans for coastal wetland restoration, the most of any planning region in the HRE study area.

Due to the variety of aquatic and intertidal habitat types that could be restored in the Lower Bay Planning Region, there is the potential to restore habitat complexes to support target fish, crustacean and shellfish species. There is great potential to create restoration plans that include two or more complementary habitat types within this planning region. For example, the restoration of oyster or other shellfish beds near coastal wetland restoration opportunities exist throughout this planning region, and in some areas it may also be possible to incorporate eelgrass bed restoration into the project. The incorporation of a rock reef or other structural features into other aquatic restoration plans can also increase the benefits of the project. These types of structural features are included in CRP Restoration Site plans for Raritan Bay (#595), Gravesend Bay in Brooklyn (#599), and off the shoreline of Staten Island (#597).

The Lower Bay Planning Region also offers the potential for the restoration of maritime forest and other upland habitats. Sandy Hook has one of the last remaining stands of maritime forest communities in the HRE study area, and appears to be one of the few areas within the HRE that meets the habitat requirements for these communities. The coasts of Staten Island and Brooklyn within this planning region also appear to meet the habitat requirements for maritime forest communities. Two CRP Restoration Sites on Sandy Hook have identified plans for the restoration of coastal forests (#583 and #586). Other

Map 4~2.


Lower Bay Restoration Opportunities
Maritime Forest Creation
Waterbird Island
Coastal Wetland Creation & Restoration
Eelgrass Bed Creation (3+ Criteria Satisfied of 8)
Oyster Reef Creation (2+ Criteria Satisfied of 4)
HRE Planning Region
Navigation Channel
CRP Restoration Site *
Dam - Total Lgth. of Streams Impounded (ft)
5,000 or less
5,000 to 10,000
10,000 to 50,000
50,000 to 100,000
100,000 or greater
0
2.5
5 Miles
* Developed by the Harbor Estuary Program and U.S. Army Corps of Engineers (2007)
UNION COUNTY
RICHMOND COUNTY (STATEN ISLAND)
KINGS COUNTY (BROOKLYN)
QUEENS COUNTY
Lower Bay
Raritan Bay
MIDDLESEX COUNTY
Sandy Hook Bay
MONMOUTH COUNTY
Navesink River
Shrewsbury River

CRP Restoration Sites within this planning region including plans for the restoration of coastal forest and upland communities are located on the shoreline of Raritan Bay (#28, #30, #32, and #33), near Cheesequake Creek in Monmouth County, New Jersey (#568), along the Shrewsbury River, New Jersey (#118), on Staten Island, New York (#579, #596, and #801), and in Brooklyn, New York (#573).

Fish passage in the Lower Bay Planning Region could be improved on several tidal rivers impacted by dams, improper culverts, or antiquated tide gates. Five CRP Restoration Sites include plans to improve the ability of anadromous fish to swim to upstream spawning areas. The installation of a fish ladder at Lemon Creek, a tributary to the Navesink River (#117), would allow more than 5,000 linear feet of upstream movement. The removal of low-head dams on the Shrewsbury River would allow for upstream movement of the American eel (#118). The installation of a fish ladder in Richmond Creek during installation of a new culvert (#195) will allow for the migration of anadromous fish. The installation of larger culverts to increase tidal flow and allow fish passage has been proposed for two of the CRP Restoration Sites (#183 and #571). In addition, installation of a fish passage structure on the Swimming River Reservoir dam on Robins Swamp Brook (a tributary to the Navesink River) would provide anadromous fish access to more than 170,000 feet of upstream habitat.

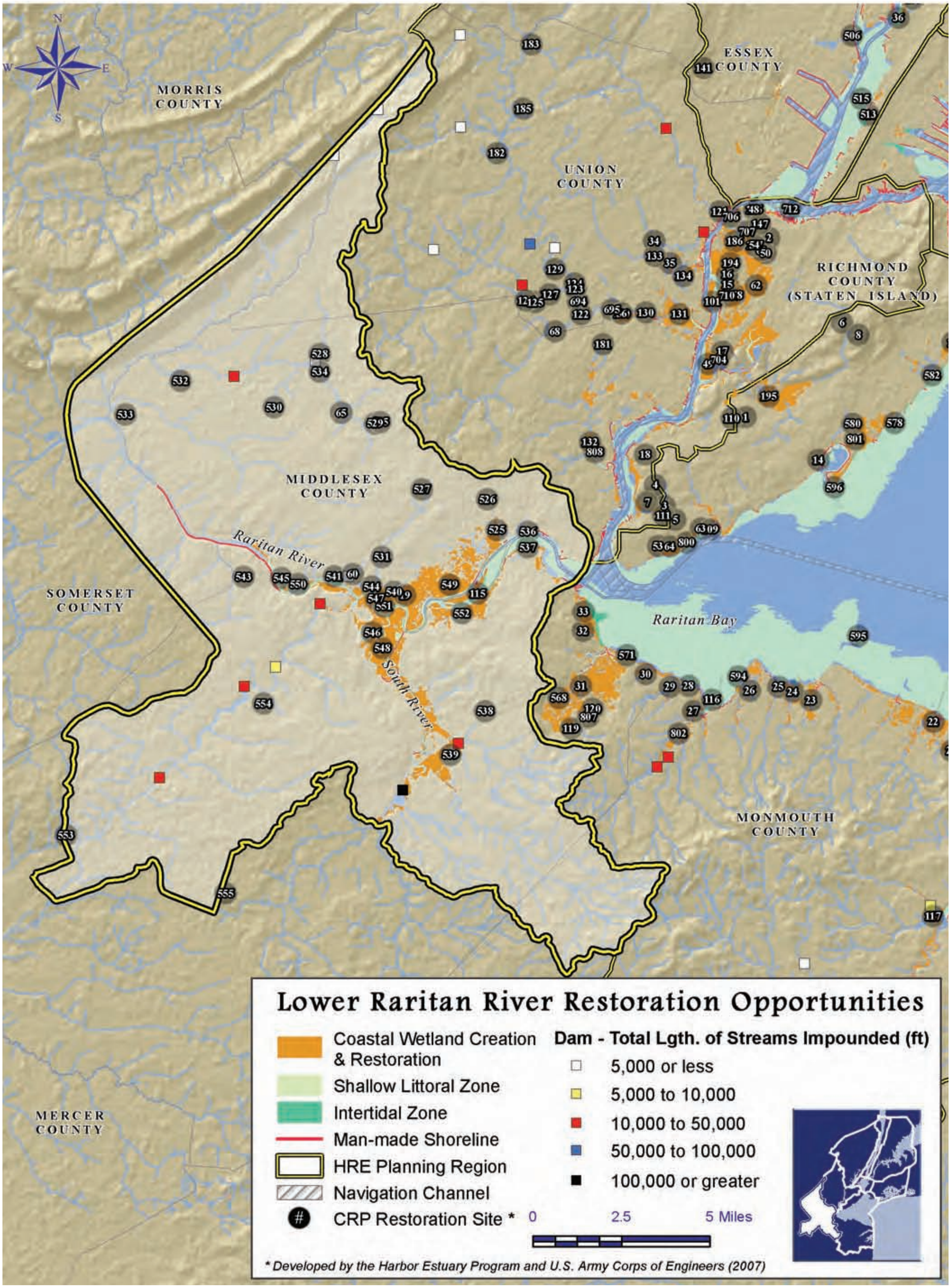
Other identified restoration opportunities in this planning region include habitat improvements for the waterbirds on Hoffman and Swinburne Islands (#598), and the restoration of freshwater wetlands near the shore of Raritan Bay (#28 and #33). Shoreline softening opportunities have also been identified in Staten Island (#801), the Shrewsbury River (#118), and Natco Lake and Thorns Creek in Monmouth County (#23). Many of the habitat creation and improvement opportunities described above will offer the potential to incorporate a public access component or to improve an existing access point.

It is important to note that, although the Lower Bay Planning Region offers abundant habitat restoration opportunities, the region also has extensive contamination issues. The sediments of Raritan Bay and to a lesser extent Sandy Hook Bay and Lower Bay contain relatively high concentrations of DDT, PCBs, Dioxins and Furans.

4.3 Lower Raritan River

The Lower Raritan River Planning Region includes the lower Raritan River and much of its extensive tributary network. The region includes opportunities to restore coastal wetlands, coastal forests, and potentially oyster reefs along the lower Raritan River, and to improve tributary connections throughout the planning region. Thirty-three (33) CRP Restoration Sites are located within this planning region, although specific restoration actions have not been identified for 21 of these sites (Table 4-1; Map 4-3) Coastal wetland restoration opportunities are abundant in the Lower Raritan River Planning Region. The extensive coastal wetlands along the lower Raritan and its southern tributaries represent opportunities to restore and expand this valuable habitat type. The results of the preliminary screening suggest that it may be possible to expand coastal wetlands in this planning region by thousands of acres. CRP Restoration Sites that identify coastal wetland restoration opportunities include the Raritan Arsenal (#536), at the KIN-BUC landfill (#547), along the South River (#548), and at the Raritan Center (#549). It is likely that future evaluations will reveal additional coastal wetland restoration opportunities.

Map 4~3.



MORRIS COUNTY
ESSEX COUNTY
UNION COUNTY
RICHMOND COUNTY (STATEN ISLAND)
MIDDLESEX COUNTY
SOMERSET COUNTY
MONMOUTH COUNTY
MERCER COUNTY
Raritan River
South River
Raritan Bay
Lower Raritan River Restoration Opportunities
Coastal Wetland Creation & Restoration
Shallow Littoral Zone
Intertidal Zone
Man-made Shoreline
HRE Planning Region
Navigation Channel
CRP Restoration Site *
Dam - Total Lgth. of Streams Impounded (ft)
5,000 or less
5,000 to 10,000
10,000 to 50,000
50,000 to 100,000
100,000 or greater
0
2.5
5 Miles
* Developed by the Harbor Estuary Program and U.S. Army Corps of Engineers (2007)

No oyster reef restoration opportunities were identified by the CRP Restoration Sites; however a portion of the lower Raritan River meets many of the habitat requirements for this species. Somewhat unique to this planning region is the quality of the sediments in the areas that could support oysters. Although sediments close to the mouth of the Raritan have relatively high concentrations of many contaminants of concern, concentrations of Total Dioxins, Furans and PCBs, and other contaminants decrease with distance from Raritan Bay.

Although this planning region would likely not support maritime forests, the upper reach of the lower Raritan River have the potential for other riparian habitat, coastal forest and grassland restoration opportunities. Former industrial sites, such as National Lead (#537), the Cornell Dublier Superfund Site (#534), and the KIN-BUC Landfill (#547) are examples of sites that have been identified as having the potential for restoration of upland communities. Further evaluations will likely reveal additional opportunities for upland coastal communities.

A substantial portion of shorelines of the upper reaches of the lower Raritan River have been hardened, and these may present restoration opportunities. Shorelines throughout this planning region should be evaluated to determine whether it would be possible to soften the shorelines or incorporate engineered structures to improve aquatic habitat. The Raritan and South River shorelines were identified as shallows and shoreline restoration opportunities (#548 and #552, respectively).

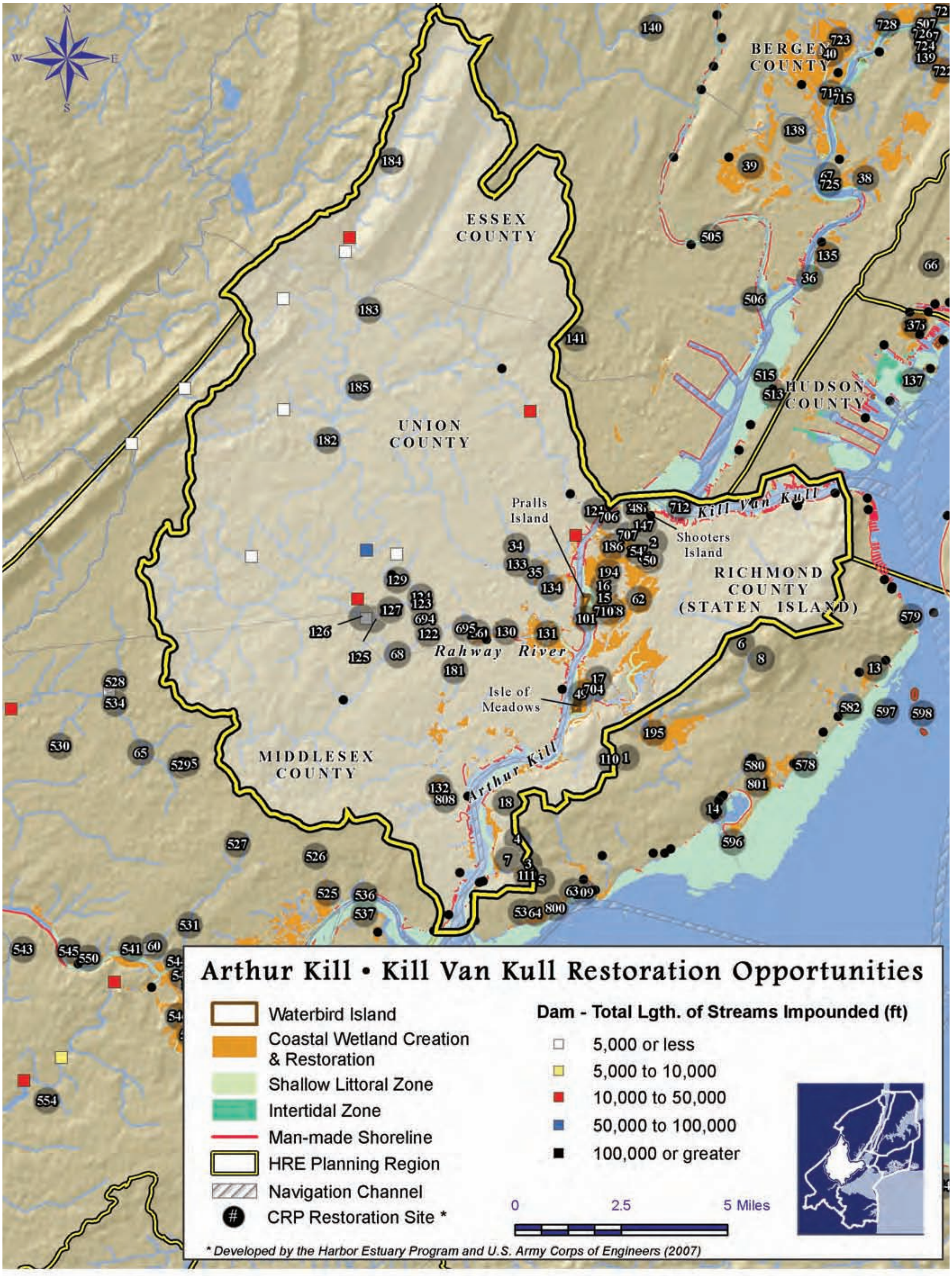
There are several opportunities to improve fish passage and connect habitats along tributaries throughout the Lower Raritan River Planning Region. For example, the installation of fish passage structures on the Duhernal Dam on the South River would open over 170,000 feet of stream for fish migration. There are four other dams in this planning region, each of which may present the opportunity to open between 20,000 and 30,000 feet of stream for fish passage. These dams include the Davidsons Mill Pond Dam, New Markets Pond Dam, Tennets Brook Dam and the Farrington Dam.

Relatively few public access points have been identified on the lower Raritan River and its tributaries. This planning region represents a substantial opportunity to bring the public to the waterfront. Restoration plans within this planning region should incorporate public access points, such as kayak and canoe launches, nature trails, interpretational materials, and picnicking opportunities.

4.4 Arthur Kill and Kill Van Kull

The Arthur Kill and Kill Van Kull Planning Region appears to offer substantial opportunities to restore coastal wetlands, shorelines and shallows, tributary connections, public access, and waterbird habitat. There are large expanses of coastal wetlands along the tributaries to the Arthur Kill that could benefit from restoration activities, and adjacent areas may be appropriate for the creation of additional acreage. The islands of this planning region once supported large colonies of waterbirds, but today do not support any nesting activities. There are also opportunities within this planning region to reverse human-induced alterations that have led to habitat degradation. There are 54 CRP Restoration Sites in this planning region, which is one of the largest number of identified acquisition and restoration sites per planning region in the HRE study area (Table 4-1; Map 4-4).

Map 4~4.


Arthur Kill • Kill Van Kull Restoration Opportunities
Waterbird Island
Coastal Wetland Creation & Restoration
Shallow Littoral Zone
Intertidal Zone
Man-made Shoreline
HRE Planning Region
Navigation Channel
CRP Restoration Site *
Dam - Total Lgth. of Streams Impounded (ft)
5,000 or less
5,000 to 10,000
10,000 to 50,000
50,000 to 100,000
100,000 or greater
0
2.5
5 Miles
* Developed by the Harbor Estuary Program and U.S. Army Corps of Engineers (2007)
ESSEX COUNTY
UNION COUNTY
MIDDLESEX COUNTY
BERGEN COUNTY
HUDSON COUNTY
RICHMOND COUNTY (STATEN ISLAND)
Pralls Island
Shooters Island
Isle of Meadows
Kill Van Kull
Rahway River
Arthur Kill

Coastal wetland restoration opportunities are abundant in the Arthur Kill and Kill Van Kull Planning Region. Tidal creeks and rivers on both the New Jersey and New York sides of the Arthur Kill could benefit from the establishment and expansion of native salt marsh vegetation. Fourteen of the CRP Restoration Sites include a coastal wetland component, and several projects have been initiated, including the Woodbridge Creek wetland restoration project (#132), which is already constructed. Many of the CRP Restoration Sites are located along the Rahway River (e.g., Essex Street [#122], Joseph Medwick Park [#130, already constructed], Rahway River Parkway [#182]), and smaller tributaries in Middlesex County, New Jersey (e.g., Morses Creek [#34] and Piles Creek [#35]). The northwest portion of Staten Island also has several tidal creeks and streams that are listed as CRP Restoration Sites (e.g., Old Place Creek [#194] and Bridge Creek, where restoration activities are already underway [#707]). Additional opportunities may be available for coastal wetland creation and restoration in this planning region.

Pralls Island, Shooters Island and the Isle of Meadows once had established colonies of hundreds of waterbirds. Since the 1990s, waterbird populations on these islands have crashed. These islands represent an opportunity to restore the habitat in an effort to attract nesting waterbirds again. Pralls Island has been identified as one of the CRP Restoration Sites (#101). Current plans include wetland creation and restoration around the island. However, since the site was identified, much of the vegetation has been removed in response to an infestation by the Asian longhorned beetle. Replanting native trees and shrubs will be evaluated as a potential restoration opportunity. Shooters Island has also been identified as a CRP Restoration Site (#712). Similar to Pralls Island, restoration plans call for the creation of wetlands along the edges of the island. This site will be evaluated for other opportunities to restore the upland habitats for waterbirds. Potter's Island on the Rahway River in Middlesex County, New Jersey (#131) has been identified as another opportunity to enhance habitat for waterbirds. Other islands in this planning region may provide opportunities for creating and restoring habitat for waterbirds.

The Arthur Kill and Kill Van Kull Planning Region has potential for the creation, restoration, and preservation of coastal forests and other uplands. Several of the plans for the CRP Restoration Sites include these actions, although most focus on the protection of existing forests. For example, plans for the Rang Road Forest (#56) along the Rahway River, which forms the border of Union and Middlesex counties in New Jersey, include preservation of upland and wetland forests and creation of additional wetland acreage. Plans for the Arden Heights Woods (#110) on Staten Island include forest preservation and freshwater wetland restoration. Plans for the Essex Street Restoration Project on the Rahway River in the City of Rahway, New Jersey (#122) include the restoration of forested uplands. Floodplain habitat restoration is planned for the Union/Allen Streets restoration site in the City of Rahway (#124). Other opportunities for coastal upland restoration are likely present throughout this planning region.

A significant proportion of the coastal shorelines in this region are hardened, though many of these derelict structures could be removed and replaced with habitat of higher ecological function. Nine of the CRP Restoration Sites include plans for softening the shorelines or otherwise improving the riparian habitat. Most of these sites are located along the Rahway River in or near the City of Rahway, New Jersey (e.g., Madison and Maple Avenues [#125], Milton Lake [#126], Rahway River Parkway Lake [#129], and two locations on Central Avenue [#127 and #128]). Farther upstream on the Raritan, riparian restoration is planned in Cranford (#183), at the Orange Reservoir (#184), and at Vauxhall Creek in Union, New Jersey (#185). One CRP Restoration Site has plans for shoreline softening on the Elizabeth River, in Elizabeth, New Jersey (#121).

The Arthur Kill and Kill Van Kull Planning Region includes 11 impoundments. Of the dams in the HRE impounding at least 10,000 feet of stream, almost 30% occur in the Arthur Kill and Kill Van Kull planning region. Two of the CRP Restoration Sites include plans for improved fish passage. Plans for Milton Lake (#126) include the possible installation of a fish ladder at the Milton Lake Dam, which would allow passage along more than 2,000 feet upstream. Plans for the Woodbridge River (#808) in Middlesex County, New Jersey include the reconnection of the site to the estuary by reestablishing tidal flooding. There may be additional opportunities to provide upstream fish passage to the tributaries to the Arthur Kill. There are several dams in this planning region that should be evaluated for opportunities to improve fish passage and connect the tributaries to other valuable habitats.

Water quality issues and surface sediment contamination are present in the Arthur Kill and Kill Van Kull Planning Region. Dozens of CSOs discharge into the Kill Van Kull, the Elizabeth River and the Rahway River. Surface sediments of the Arthur Kill and Kill Van Kull have well above average concentrations of many contaminants of concern in the HRE study area when compared to other regions. Predicted concentrations of DDT and PCBs are more than twice the ERM values, concentrations of 2,3,7,8 TCDD are also well above the predicted effects range for oysters. Concentrations of Total Dioxins and Furans, 2,3,4,7,8 Pentachlorodibenzofuran (PeCDF), and Total Chlordane are also above the median concentrations for the HRE study area.

Public waterfront access opportunities are limited in this planning region. There are currently 20 public access sites identified, which is one of the least number of access points per planning region in the HRE study area. There is the potential to create new public access areas with almost every intertidal and upland habitat restoration site.

4.5 Newark Bay, Hackensack River, and Passaic River

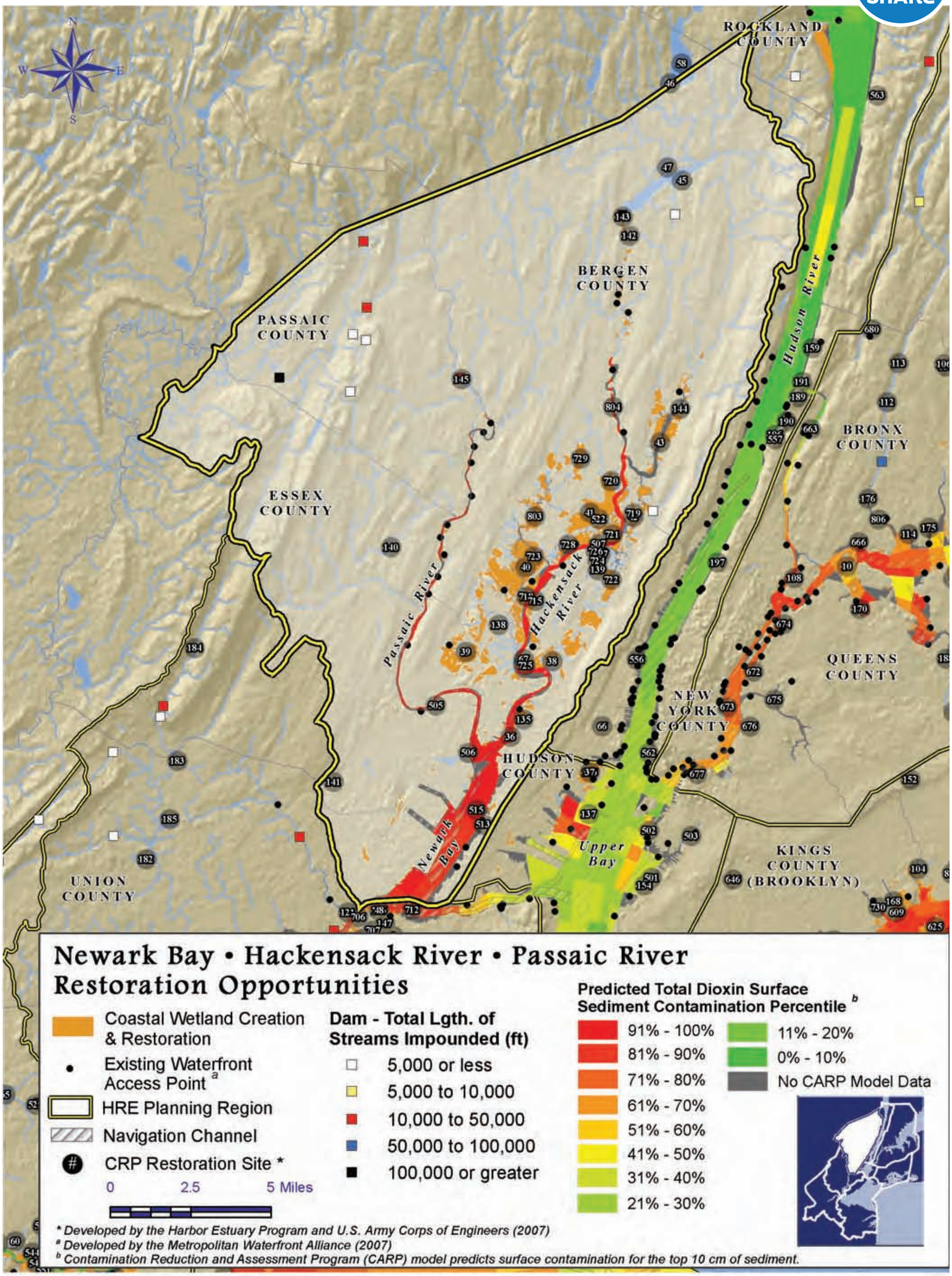
The Newark Bay, Hackensack River, and Passaic River Planning Region offers substantial opportunities to restore coastal and freshwater wetlands, create and restore coastal upland habitats, repair human-induced habitat degradation, and provide increased public access to the waterfront. Forty (40) of the CRP Restoration Sites are located in this planning region (Table 4-1; Map 4-5).

Preliminary screening indicates that this planning region offers more than 2,000 acres of coastal wetland creation opportunities. Twenty-three coastal wetland restoration opportunities were identified within the CRP Restoration Sites. Most of these sites are within the Meadowlands District, examples of which include Penhorn Creek (#38), Kearny Marsh (#39), Berry's Creek (#40), Bellhorn Creek (#42), fringe marshes along the New Jersey Turnpike (#138), Mill Creek (#139), Anderson Creek Marsh (#715), Lyndhurst Riverside Marsh (#718), Meadowlark Marsh (#719), Metro Media Tract (#721), Steiners Marsh (#728), and Oritani Marsh (#723). Other opportunities have been identified along the lower Passaic River (#505), and on the shoreline of Newark Bay (#506 and #513).

Although this planning region does not appear to provide habitat suitable for maritime forest communities, coastal upland habitat restoration opportunities have been identified for 15 CRP Restoration Sites. Most of these opportunities were

Map 4~5.

the WATERS we SHARE

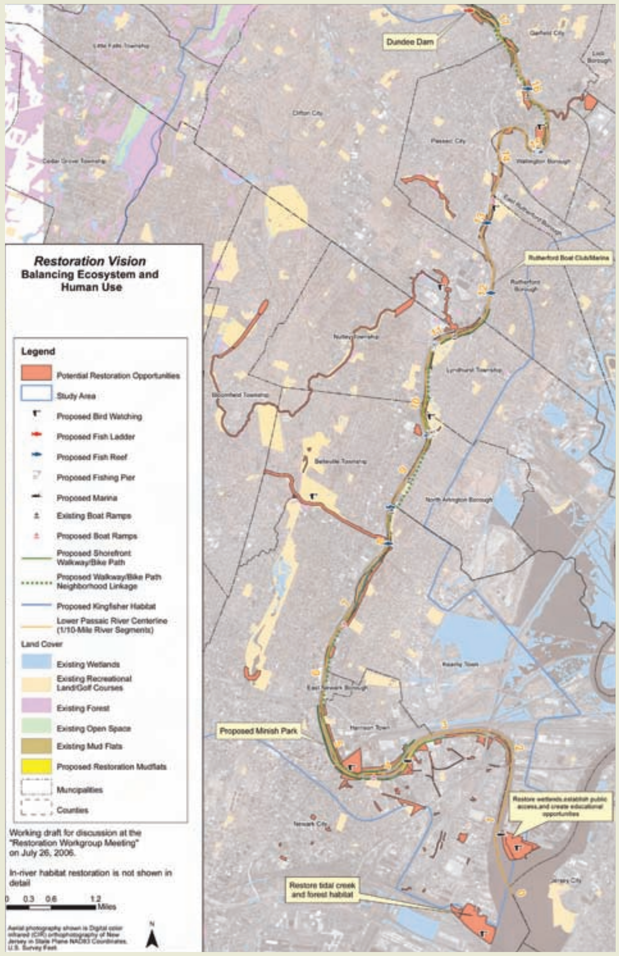


The Lower Passaic River is a 17-mile tidal stretch from Dundee Dam to the river mouth at Newark Bay. The river has a long history of industrialization, which has resulted in degraded water quality, sediment contamination, loss of wetlands and abandoned or underutilized properties along the shore.

The U.S. Environmental Protection Agency, U.S. Army Corps of Engineers and New Jersey Department of Transportation have formed a partnership with the National Oceanic and Atmospheric Administration, U.S. Fish and Wildlife Service and New Jersey Department of Environmental Protection to carry out the Lower Passaic River Restoration Project.

Overall goals of the Lower Passaic River Restoration Project include:

- Remediate Contaminated Sediments
- Improve Water Quality
- Restore Degraded Shorelines
- Restore and Create New Habitats
- Enhance Human Use



The agencies are bringing together the authorities of the Superfund Program, the Water Resources Development Act, the Clean Water Act and other laws to develop a comprehensive watershed-based plan for the remediation and restoration of the Lower Passaic River Basin. Habitat losses of floodplains, wetlands, waterfowl nesting areas, and valuable fish spawning and benthic habitats will be improved through restoration of specific habitats, vegetative buffer creation, shoreline stabilization, and aquatic habitat improvements. Comprehensive restoration will include long-term, effective reduction of toxicity, mobility, and volume of sediment contamination to improve habitat and reduce potential effects to human health and the environment.

To date, the project has evaluated a range of alternatives for potential early remedial actions for contaminated sediments within the lower eight miles of the river. USEPA's Focused Feasibility Study and future Proposed Plan will outline the proposed cleanup, while the 17-mile investigation continues. Restoration opportunities within the lower 8 miles will be outlined in a Focused Ecosystem Restoration Plan, followed by the preparation of an overall Comprehensive Restoration Plan for the 17-mile Lower Passaic River watershed. In the nearterm, USEPA and Tierra Solutions, Inc plan to remove 200,000 cyd of the most contaminated sediment adjacent the Diamond Alkali Site.

identified as parts of restoration plans that include a coastal wetland component (e.g., Penhorn Creek [#38], Overpeck Creek [#43], and Steiners Marsh [#728]). The Teterboro Woods (#729) is an approximately 258-acre site that has been slated for preservation of valuable forest habitat.

Freshwater wetland restoration and creation opportunities are also present in this planning region. These opportunities have been identified along Penhorn Creek (#38), Mill Creek (#139), Van Buskirk Island (#142), along the Hackensack River (#507), Mehrhof Pond (#172), and within the Teterboro Woods (#729).

There are many opportunities to connect the habitats along tributaries to allow fish passage between valuable habitat types. The installation of a fish ladder at the Oradell Reservoir Dam (#143) would open more than 110,000 feet of stream for anadromous fish migration on the Hackensack River. The incorporation of a fish passage structure into the restoration plans for the Dundee Dam (#145) in the City of Clifton would open more than 47,000 feet of the Passaic River. In addition, the Third River (#140), a tributary to the Passaic River, has been identified as an opportunity to construct a fish ladder. Other potential opportunities to improve fish passage may exist on the Beatties Mill Dam in Wayne Township, New Jersey and the Great Falls Dam in the City of Patterson, New Jeresy.

Additional habitat restoration opportunities include softening shorelines and recontouring shallow water habitat along the Passaic and Hackensack rivers and along Newark Bay (#505, #507, #513). Creation of upland islands to provide waterbird nesting habitat is planned for Kearny Marsh (#39) and Anderson Creek Marsh (#715). This planning region is the location of the HRE Lower Passaic River Restoration Project and the Hackensack Meadowlands Restoration Project, two ecological restoration feasibility studies that are in the process of identifying and prioritizing specific restoration actions (see box: HRE Lower Passaic River Restoration Project). It is expected that many specific restoration opportunities will be identified as a result of these studies.

This planning region would benefit from the creation of public access points. Although there are many opportunities along the upper reaches of the lower Passaic River and in the Hackensack Meadowlands, there are stretches along the lower Passaic and lower Hackensack rivers, and Newark Bay where very few access points exist. Public access facilities should be incorporated into future habitat restoration plans wherever feasible.

Contamination issues are pervasive in the Newark Bay, Hackensack River, and Passaic River Planning Region. Dozens of CSOs are located along the lower Passaic River and within Newark Bay, and poor water quality in Newark Bay fails to meet the NJDEP Best Use Class identified for the waterbody. The surface sediments in this planning region have among the highest concentrations of each of the contaminants of concern evaluated in Chapter 3 and Appendix C. Numerous USEPA Superfund Sites are located within the planning region, perhaps most notably the Diamond Alkali site including a 17-mile stretch of the lower Passaic River. Habitat restoration plans will take contamination concentrations, the potential for the transport of contaminants, and attractive nuisance issues into consideration prior to construction.

4.6 Lower Hudson River

The Lower Hudson River Planning Region includes the brackish and marine waters of the Hudson River, bounded by an extensive shoreline from the Tappan Zee Bridge to lower Manhattan and Hudson County, New Jersey. Coastal wetland and oyster restoration opportunities exist along the Lower Hudson River. The high density urban development along the shorelines in this planning region may offer opportunities to enhance shoreline structures and adjacent waters by incorporating habitat features and structures into their designs. Relatively few of the CRP Restoration Sites are located in this planning region. Nine (9) of these sites are located along the Manhattan and Bronx shorelines in New York, and two are located in New Jersey (Table 4-1; Map 4-6). Specific restoration actions have not been planned for three of these sites.

The shorelines of existing parkland in Manhattan and the Bronx have been identified as opportunities to create and restore coastal wetlands. The wetlands near Riverdale Park in the Bronx (#159) provide a wetland restoration opportunity, while it may be possible to create wetlands along the shorelines of Inwood Park (#189), Fort Tryon Park (#190), Fort Washington Park (#196), and Hudson River Park Estuarine Sanctuary (#562). The Hudson River Breakwater project in Hudson County, New Jersey (#556) includes plans to create a series of breakwaters to promote the growth of coastal wetlands. Because most of these restoration sites are located adjacent to or within parkland, there is the potential to restore coastal upland habitat adjacent to the wetlands. In addition to the opportunities identified in the CRP Restoration Sites, opportunities to restore and create coastal wetlands may be present adjacent to the Piermont Marsh, Rockland County, New York.

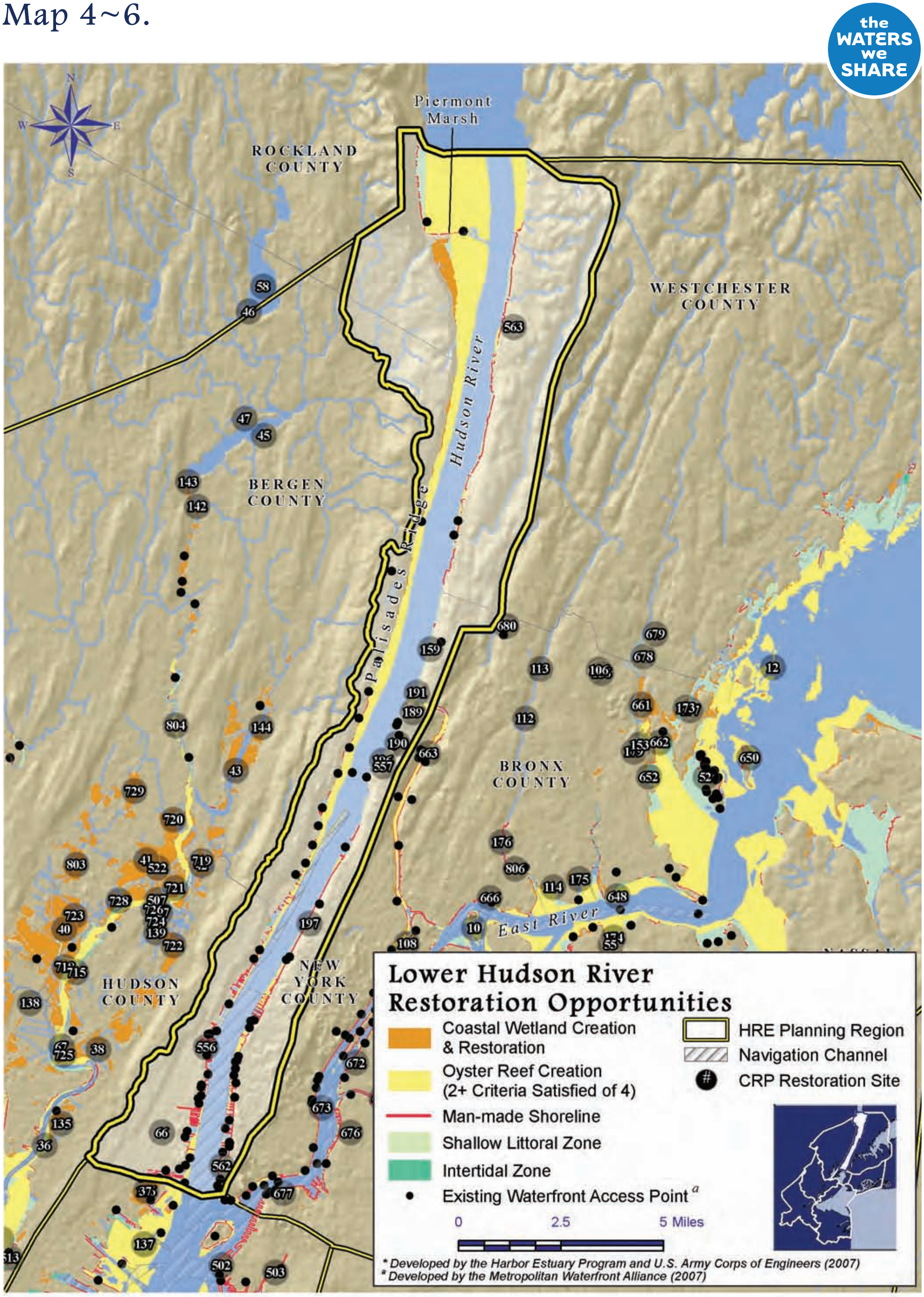
The Lower Hudson River Planning Region may offer opportunities for oyster restoration projects. Much of the shallow waters on the western shoreline of the lower Hudson meet at least three of the habitat requirements for oysters. Opportunities to soften shorelines in this planning region, or to otherwise improve the shoreline habitat for fish and crustacean species, should be further investigated.

Public access to the waterfront is a very important TEC in this densely populated region. Nearly the entire shoreline of western Manhattan is available to the public along the existing bikeway and esplanade, but this park could be improved by incorporating a variety of recreational features. Plans for the Hudson River Park Estuarine Sanctuary (#562) include recreational piers and passive recreation features as well as habitat improvements for fish and wildlife (Hudson River Park 2008). Few public access points have been identified for lower Westchester County and the Bronx, New York.

When compared to the Manhattan shoreline, the western shoreline of the Hudson offers relatively fewer public access points. Very few access points have been identified in southern Rockland County, New York and northern Bergen County, New Jersey. Parklands along the top of the Palisades Ridge provide views of the Hudson in southern Bergen County and Hudson County.

The surface sediments of the Lower Hudson Planning Region have the lowest concentrations of nearly all of the contaminants of concern within the HRE study area. However, contaminated sediments are present in localized areas such as interpier basins and around CSOs. Dredging out the degraded sediments within an interpier basin in Hudson and Bergen counties (#556) has been identified as an opportunity to restore benthic habitat.

Map 4~6.



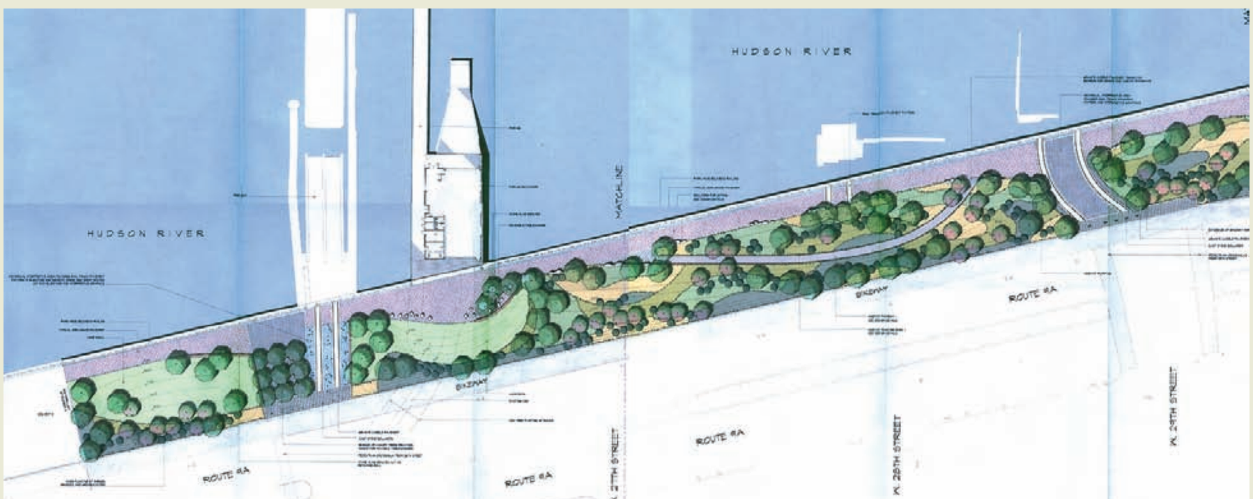
the WATERS we SHARE
Piermont Marsh
ROCKLAND COUNTY
WESTCHESTER COUNTY
BERGEN COUNTY
Hudson River
Palisades Ridge
BRONX COUNTY
HUDSON COUNTY
NEW YORK COUNTY
East River
Lower Hudson River Restoration Opportunities
Coastal Wetland Creation & Restoration
Oyster Reef Creation (2+ Criteria Satisfied of 4)
Man-made Shoreline
Shallow Littoral Zone
Intertidal Zone
Existing Waterfront Access Point a
HRE Planning Region
Navigation Channel
CRP Restoration Site
0 2.5 5 Miles
* Developed by the Harbor Estuary Program and U.S. Army Corps of Engineers (2007)
a Developed by the Metropolitan Waterfront Alliance (2007)

Project Example: New York City's Waterfront Development

Brooklyn Bridge Park – When complete, this park will be an 85-acre, 1.3-mile redesign of Piers 1-6 into a greenway along the Brooklyn waterfront. The Brooklyn Bridge Park Development Corporation proposed this project to allow reuse of the deteriorated East River waterfront for public benefit, and to once again make the waterfront an asset for the City and the region. This park will reconnect Brooklyn citizens and visitors to the waterfront, replacing abandoned piers and lots with areas for direct and indirect access: boardwalks, safe paddling areas, multi-purpose playing fields, shaded areas, and natural landscapes for wildlife. Construction began in January 2008 and is expected to be completed in 2012.

Hudson River Park – The park encompasses 550 acres of marine sanctuary, piers and upland, from 59th Street to Battery Place. The dilapidated timber piers are being completely reconstructed into public spaces for a variety of uses, including lawn/garden areas, scenic overlooks, playgrounds, athletic fields and courts, gathering spaces, community boating, historic resources, and educational and river research facilities. On the 5-mile historic bulkhead, a dedicated pedestrian esplanade will be created with a wide walking path, seating areas, vistas of the Hudson River, planted gardens and lawn areas, to connect Lower Manhattan, Greenwich Village, Chelsea and Clinton. Pier reconstruction in Chelsea and Clinton will include substantial amounts of public open spaces, including areas for direct water access via boat houses. More than half of the reconstructed piers are now complete and currently being enjoyed by local residents and visitors in Tribeca, Greenwich Village, northern Chelsea and Clinton.

Hudson River Park – Esplanade between Chelsea and Clinton



Brooklyn Bridge Park

4.7 Harlem River, East River, and Western Long Island Sound

The Harlem River, East River, and Western Long Island Sound Planning Region offers a variety of opportunities to create and restore each of the TEC habitats. This planning region has extensive shallow littoral and subtidal waters that provide the opportunity to create a variety of aquatic habitat types. Many islands are within the waters of this planning region representing the potential to improve that habitat for waterbirds. There are also many opportunities to reverse human-induced habitat degradation. Forty-one (41) CRP Restoration Sites are located within this planning region (Table 4-1; Map 4-7).

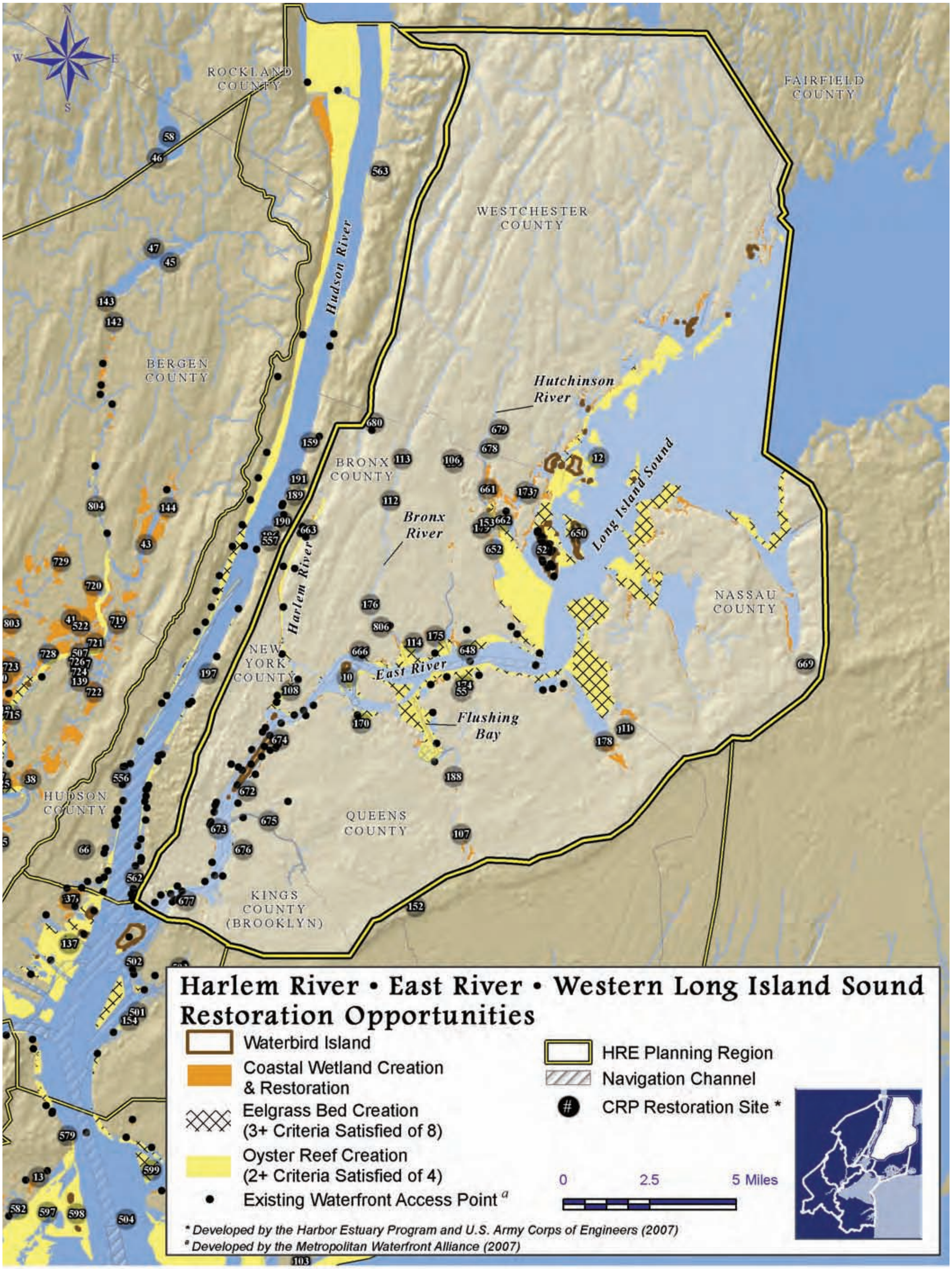
Coastal wetland creation opportunities are abundant in this planning region. Results of the GIS analyses presented in Chapter 3 suggest that more than 1,000 acres of coastal wetlands could be restored in this region. Twenty of the CRP Restoration Sites in this region include a coastal wetland restoration or creation component. These sites include areas located along the Bronx River (e.g., Soundview Park [#114]), the Manhattan shoreline (e.g., Sherman Creek [#663]), the Hutchinson River (e.g., Palmer Inlet [#153], Rice Stadium Wetlands [#652], more northern reaches of the river [#679]), on the shoreline of City Island (#52), in Brooklyn (e.g., Newtown Creek [#675] and Bushwick Inlet [#676]), and the coves and harbors of western Long Island Sound (e.g., Hempstead Harbor [#669], Alley Pond Park [#178], and Hart Island [#650]). Many of these restoration projects also include a coastal upland habitat restoration component.

Although the CRP Restoration Sites do not include plans for oyster or eelgrass restoration projects in this planning region, there may be opportunities to create these habitats. Areas protected from wave action and navigation channels along the upper East River have physical and chemical properties that meet four of the habitat requirements for oysters. It may be possible to include an oyster restoration component to current restoration plans in Flushing Bay (#188), Bowery Bay (#170), and Powell Cove (#174). An oyster restoration project has recently been completed at the mouth of the Bronx River (#114). Eelgrass restoration opportunities may exist in many of these areas as well. Restoring two or more complementary habitat types for fish, shellfish and crustacean appears to be possible in the upper East River and western Long Island Sound.

The majority of islands in the HRE study area are located within the Harlem River, East River, and Western Long Island Sound Planning Region. Islands on the East River include North and South Brother Islands, Mill Rock, Roosevelt Island, and U Thant. Islands in western Long Island Sound include David's Island, Huckleberry Island, Pea Island, Hart Island, City Island, and Goose Island. Reports of invasive vine and tree species on many of these islands suggest that there are numerous opportunities to improve habitat for roosting and nesting waterbirds. The CRP Restoration Sites include restoration projects for South Brother Island (#10), and Hart Island (#650). There are likely additional opportunities to restore waterbird habitat in this planning region that will be identified during future evaluations.

Opportunities to improve the connectivity of habitats along tributaries and to improve the ability for fish to move between these habitats exist in this planning region. The Hutchinson River Fish Impediment Removal project (#678) includes plans for the installation of a fish ladder to allow passage for anadromous fish. There are also four dams in this planning region that may block access to more than 10,000 feet of upstream waters. In particular, the Bronx River Dam may represent an

Map 4~7.


ROCKLAND COUNTY
FAIRFIELD COUNTY
WESTCHESTER COUNTY
BERGEN COUNTY
BRONX COUNTY
NEW YORK COUNTY
HUDSON COUNTY
QUEENS COUNTY
KINGS COUNTY (BROOKLYN)
NASSAU COUNTY
Hudson River
Harlem River
Bronx River
Hutchinson River
Long Island Sound
East River
Flushing Bay
Harlem River • East River • Western Long Island Sound Restoration Opportunities
Waterbird Island
Coastal Wetland Creation & Restoration
Eelgrass Bed Creation (3+ Criteria Satisfied of 8)
Oyster Reef Creation (2+ Criteria Satisfied of 4)
Existing Waterfront Access Point [a]
HRE Planning Region
Navigation Channel
CRP Restoration Site *
0 2.5 5 Miles
* Developed by the Harbor Estuary Program and U.S. Army Corps of Engineers (2007)
[a] Developed by the Metropolitan Waterfront Alliance (2007)

opportunity to restore fish passage to more than 63,000 feet of stream. Freshwater wetland restoration opportunities have been identified at Meadow Lake (#107), Pugsley Creek (#175), and Bronx Park (#112).

This planning region provides opportunities to improve water quality in the bays and harbors of western Long Island Sound. The surface waters of Flushing Bay, Little Neck Bay, Manhasset Bay, and Hempstead Harbor fail to meet the water quality requirements for their Best Use Classifications. CSOs line the shorelines of eastern Manhattan, along Brooklyn, as well as many rivers draining into the upper East River and western Long Island Sound. Two CRP Restoration Sites include plans to improve local water quality habitat, Sherman Creek (#674), and Newtown Creek (#675). Future evaluations will likely identify many more opportunities to improve water quality in this planning region.

Surface sediment contamination issues are pervasive along the East River in this planning region. In particular, predicted concentrations of PCBs in the sediments along the entire East River are among the highest in the HRE study area. Relatively high concentrations (above the ERL) of Benzo(a)pyrene were also predicted for the upper East River. Predicted dioxin and furan concentrations were also high when compared to the Lower Hudson and Lower Raritan River planning regions.

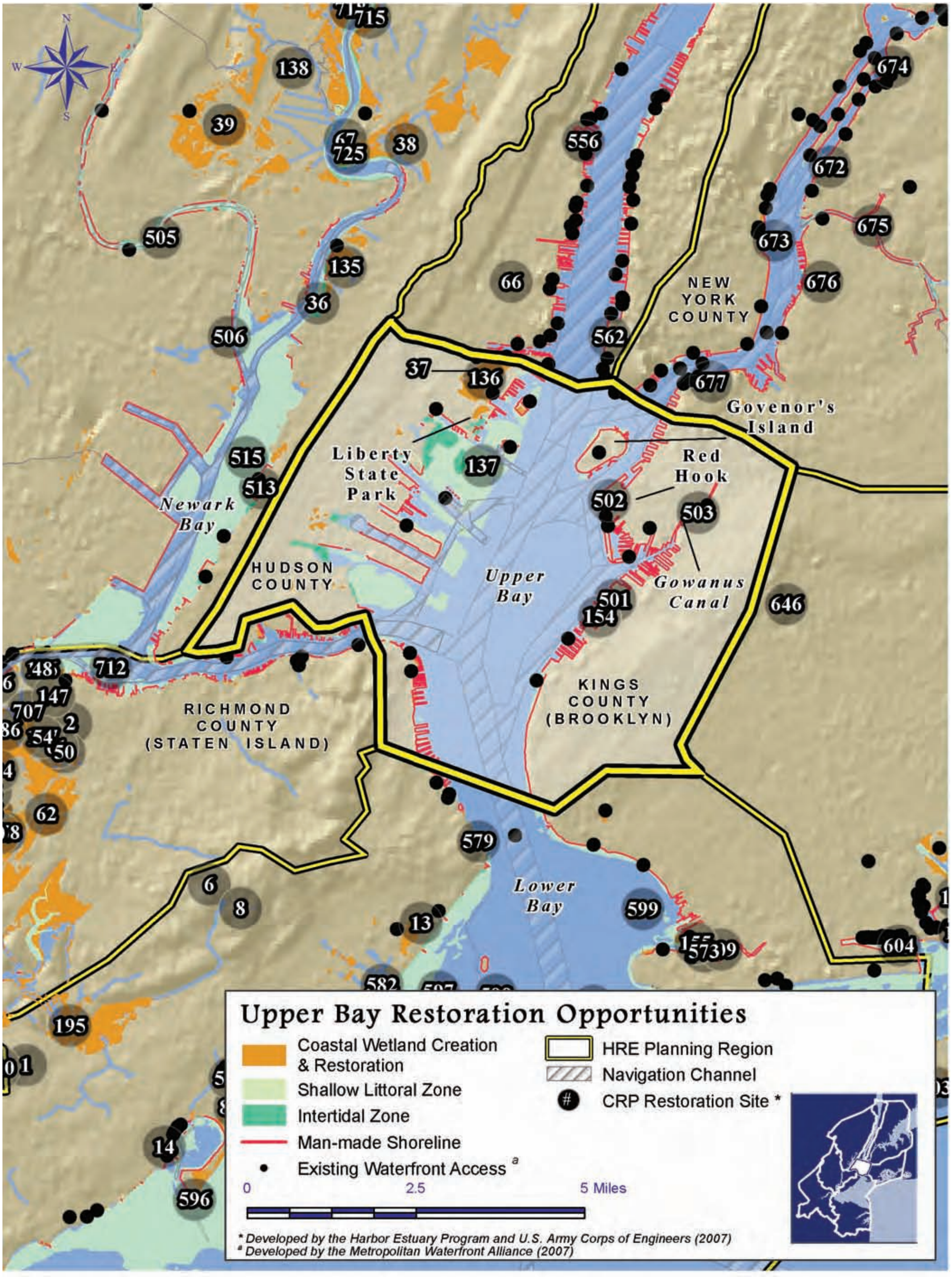
4.8 Upper Bay

The Upper Bay Planning Region is the smallest and among the most urbanized of the HRE planning regions. The northeastern shoreline of Staten Island, the shorelines of Hudson County, New Jersey, Governor's Island, and a portion of Brooklyn (including Red Hook) are within this planning region. Shallow littoral and intertidal habitat occurs along the western shorelines, and there are existing coastal wetlands on the New Jersey side of this planning region. Some shallow littoral habitat is also present around Governor's Island. These areas provide potential opportunities to restore aquatic and wetland habitat. The shorelines of the region are heavily lined with piers and bulkheads, and a network of navigation channels runs throughout the subtidal waters of this planning region. Relatively few habitat restoration opportunities have been identified for this planning region. Only five of the CRP Restoration Sites are located within the Upper Bay, and three of these sites are potential public access points with no habitat restoration component (Table 4-1; Map 4-8). Liberty State Park in Jersey City, New Jersey and the Gowanus Canal in Brooklyn, New York are the only CRP Restoration Sites in this region with plans for habitat restoration.

Existing coastal wetlands are relatively rare within the Upper Bay Planning Region, occurring in only a few areas in Bayonne and Jersey City, New Jersey. Two of the CRP Restoration Sites include plans for coastal wetland creation, Liberty State Park (#37) and along the Gowanus Canal (#503). The Gowanus Canal Restoration Project will have the potential to result in a minor increase coastal wetland acreage (3 to 5 acres). The major restoration action planned for Liberty State Park is a more than 40-acre tidal marsh complex. Plans to improve upland coastal habitat (including a maritime forest community) and freshwater wetlands are also included in this project (USACE 2004c). This will substantially increase the overall acreage of habitat available in this Planning Region.

The shallow littoral waters of the planning region may have the potential to support oyster reefs. These regions meet at least four of the physical and chemical habitat requirements for this species. Although oyster restoration opportunities have not

Map 4~8.



Upper Bay Restoration Opportunities
Coastal Wetland Creation & Restoration
Shallow Littoral Zone
Intertidal Zone
Man-made Shoreline
Existing Waterfront Access [a]
HRE Planning Region
Navigation Channel
CRP Restoration Site *
0
2.5
5 Miles
* Developed by the Harbor Estuary Program and U.S. Army Corps of Engineers (2007)
[a] Developed by the Metropolitan Waterfront Alliance (2007)
NEW YORK COUNTY
HUDSON COUNTY
KINGS COUNTY (BROOKLYN)
RICHMOND COUNTY (STATEN ISLAND)
Liberty State Park
Newark Bay
Upper Bay
Lower Bay
Govenor's Island
Red Hook
Gowanus Canal

been identified in the CRP Restoration Projects, further evaluations may demonstrate that these opportunities are feasible in the relatively shallow waters of the Upper Bay.

Water quality in the Upper Bay is somewhat degraded and does not meet its Best Use Class for either New York or New Jersey Standards. Although surface sediment contamination is present throughout the HRE study area, sediments in the middle of Upper Bay generally have contaminant concentrations below the median for the HRE study area. However, predicted total DDT concentrations are well above the ERM of 46 parts per billion on the eastern side of the Bay along the shoreline of Brooklyn. This area also has predicted concentrations of PCBs well above the ERM of 180 parts per billion. Predicted concentrations of Total Dioxin and Furan on the northwestern side of the bay along the shoreline of Jersey City, New Jersey were among the highest in the HRE study area. In addition, localized areas of degraded sediment and water quality likely exist in areas with restricted water circulation, such as interpier basins and modified tidal creeks. The Gowanus Canal Restoration Project (#503) is an example of a CRP Restoration Site where the plan focuses on localized improvements that will benefit the larger estuary. The plan calls for the removal of contaminated sediments within the canal and the installation of measures to improve water circulation to minimize future contamination issues. The creation of coastal wetlands along the shoreline will further improve the habitat.

Relatively few public access points have been identified in the Upper Bay Planning Region. Although there are several access points in Jersey City and Bayonne, on the islands in the region, and on the Brooklyn shoreline, there are large expanses of shoreline that currently do not allow public access. Brooklyn Sunset Park (#501), Coffey Street Park (#502), and Bush Terminal (#154) have been identified as CRP Restoration Sites to create waterfront access points in Brooklyn. Additional planned and existing public access points will be identified as a result of future municipality outreach efforts.

4.9 Summary

Opportunities to restore habitats and reduce the effects of human disturbance are abundant throughout the HRE study area. As highlighted in this chapter and Appendix D, many site-specific opportunities have been identified. However, this is not the comprehensive list. It is likely that these restoration actions represent only a small fraction of those possible. As discussed in Chapter 3, additional zones of restoration opportunities were identified through a series of GIS analyses. These estuary-wide analyses were used to estimate whether the TEC objectives are achievable and to identify zones where successful restoration projects may be likely.

As part of further evaluation during the USACE HRE Feasibility Study, additional CRP sites will be indentified within each TEC restoration zone at a more refined scale. The region's stakeholders are encouraged to identify additional restoration opportunities to increase the number of CRP Restoration Sites.

Site reconnaissance would be undertaken to verify GIS information and develop preliminary assessments noting site characteristics and conditions, potential restoration options, and other factors that could affect the feasibility of a restoration project. Potential restoration sites would also be determined utilizing the new GIS information and site inspections. These sites would then be added to the existing CRP Restoration Site database (OASIS) with a standard set of site attributes and general notes regarding restoration potential.

Brownfield to World-Class Golf Course: Beneficial Use of Dredged Material

The Bayonne Golf Course project, located on a 160-acre site in Hudson County, New Jersey, exemplifies an urban Brownfield redevelopment project and has successfully integrated a variety of estuarine habitat enhancement elements into its overall design. The site historically consisted of degraded, debris-covered landscape with both a contaminated fill site and a municipal landfill. This degraded and underutilized urban site has been significantly improved by creating a mix of high-quality habitats and recreational opportunities.

The approved remediation plan for the site included the use of 4.5 million cubic yards of amended dredged material to cap and fill the site. The project also created almost 14 acres of estuarine habitat including subtidal open water, a mudflat, and a smooth cordgrass-dominated wetland to mitigate for impacts to adjacent contaminated wetlands. The wetland mitigation area was designed to increase the productivity of the estuary and to provide habitat for fish, waterfowl, and wading birds. A nearly 900–foot section of the Hudson River Walkway spans the wetlands, providing public access opportunities for passive and active recreation, such as fishing access to a deep-water channel, beautiful views of the estuary, and opportunities for bird-watching.

Currently, the Bayonne Golf Club is attempting to establish the Bayonne Marine Sanctuary through a public-private partnership with Greenvest (a natural resource management company), the City of Bayonne, several environmental groups and regulatory agencies. The sanctuary would result in the enhancement of nearly 300 acres of shallow water habitat located near the confluence of the Upper Bay and the Kill Van Kull. Conceptually, the proposed project would integrate many of the TECs including creating oyster/shellfish reefs, habitat for fish, crabs and lobsters and improving contaminated sediments. This enhancement project would be done through the creation of complex subtidal habitat structure such as that associated with submerged reefs and cleaner substrate. It is envisioned that complex subtidal habitat structures such as submerged reefs and associated clean substrates would be possible in part through the beneficial reuse of clean dredged material. The Bayonne Golf Club Site provides a unique opportunity to use clean dredged material to enhance the functions and values of the estuary.

5.0 Comprehensive Restoration Plan Implementation and Management

Habitat restoration requires coordination among agencies and organizations since restoration opportunities do not always follow park boundaries, state, or county lines. Virtually any stakeholder with financial and logistical support can plan, implement, and monitor a habitat restoration project in the HRE study area. Although smaller groups and community organizations are more suited for smaller, localized actions, Federal agencies are strategically positioned to hold leadership and key partnership roles in large-scale ecological restoration, protection, and sustainable use programs. Many agencies, such as the USACE, have mission statements that include environmental protection/improvement or a role in the watershed planning process (Table 5-1).

Federal, state, and municipal agencies and organizations that may have an interest in ecosystem restoration either through their existing programs or through actions requiring mitigation include (but not limited to): the PANYNJ, USACE, USEPA, NOAA, NJDEP, NYSDEC, NYCDEP, NJDOT, New York State Department of Transportation, New York City Economic Development Corporation, NJMC, Environmental Defense Fund, NY/NJ Baykeeper, Hackensack Riverkeeper, Hudson Riverkeeper, Passaic River Coalition, Hudson River Foundation, Clean Ocean Action, National Parks Conservation Association and the National Park Service. Restoration and preservation of ecological habitat is extremely important to both New York and New Jersey. State agencies and organizations are encouraged to exchange information and expertise and undertake joint projects. Municipalities also partner on many of these projects.

With such a large group of stakeholders conducting habitat restoration within the HRE study area under a variety of programs, it is important to identify funding sources and strategic partnerships to work towards achieving the TEC objectives. Restoration projects are typically planned on a one-by-one basis, with no measure of the benefits achieved in the context of the entire HRE. Coordination of these programs in the context of the estuary-wide goal and objectives will be challenging. A critical component of the CRP implementation will be to develop a management structure able to coordinate and evaluate restoration activities among a vast group of stakeholders. The following sections identify potential funding opportunities for restoration projects and present potential management strategies for the CRP.

5.1 Implementation

Habitat restoration requires coordination among agencies and organizations since restoration opportunities do not always follow park boundaries, state, or county lines. Virtually any stakeholder with financial and logistical support can plan, implement, and monitor a habitat restoration project in the HRE study area.

Although smaller groups and community organizations are more suited for smaller, localized actions, Federal agencies are strategically positioned to hold leadership and key partnership roles in large-scale ecological restoration, protection, and sustainable use programs. Many agencies, such as the USACE, USEPA, NOAA and others have mission statements that include environmental protection/improvement or a role in the watershed planning process (Table 5-1).

Table 5-1. Select Federal agencies and activities related to the watershed planning process. Adapted from NRC (1999).

VARIABLES	BLM	BOR	DOT	NMFS	NRCS	USACE	USEPA	USFS	USFWS	USGS
PRIMARY AUTHORITIES/MISSION										
Regulatory				●		•	●		●	
Land Management	●	•	•			•		●	•	
Water Resources Management	•	●			●	●		•		
Planning Assistance			●	•	●	●	●		•	
Research		•	•	●	•	•	●	●	•	●
WATERSHED PERSPECTIVE										
Planning Framework	•	●	•	•	●	●	●	●	•	
Education/Communication	•				●	•	●	•		
Research			•		●	•	●	●		●
NEPA Compliance	●	●	●	●	●	●		●	●	●
NEPA Enforcement							●			
CWA Compliance	●	●	●	●	●	●		●	●	●
CWA Enforcement						●	●			
ESA Compliance	●	●	●	●	●	●	●	●	●	●
ESA Enforcement	•	•	•	●	•	•	•	•	●	•
Coordinate fiscal partnerships				●	●	●	●	●		●
Work with State and local partners		●	●		●	●	●			
WATERSHED BASED DECISIONS										
Watersheds define mission										
Set program goals (strategic)	•			•	•		●	●	•	
Set project objectives (tactical)	●	•	•	•	●	●		•	•	●
Establish program priorities	●			•			●	●	•	•
Coordinate decision process	•	•	•	•	●	●	●	●	•	•
ID objective indicators	●	•	•	•	●	•	●	●	•	●
Guide information inventory	●	●	●	●	●	•	●	●	●	●
Define management measures	●	●	●	●	●	•	●	●	●	
Guide measures monitoring	●	•	•	•	•	•	●	●	•	●

Note: Federal agencies include the U.S. Bureau of Land Management (BLM), U.S. Bureau of Reclamation (BOR), U.S. Department of Transportation (DOT), National Marine Fisheries Service (NMFS), Natural Resources Conservation Service (NRCS), U.S. Army Corps of Engineers (USACE), U.S. Environmental Protection Agency (USEPA), U.S. Forest Service (USFS), U.S. Fish and Wildlife Service (USFWS), and the U.S. Geological Service (USGS). Other acronyms: NEPA (National Environmental Policy Act), CWA (Clean Water Act), and ESA (Endangered Species Act).

Table 5-1. Continued

VARIABLES	BLM	BOR	DOT	NMFS	NRCS	USACE	USEPA	USFS	USFWS	USGS
WATERSHED BASED DECISIONS										
Monitor objective indicators	●	•	•	●	•	•	●	●	●	•
Evaluate objective achievement	●						●	●		
ID decision stakeholders	●	●			●		●	●		
Organize stakeholder concerns	●	●			●		●	●		
WATERSHED OBJECTIVE FOCUS										
Water supply		●			•	•	•	•		•
Water quality	•	•	•	•	•	•	●	•	•	•
Erosion/sediment control	•	•	•		●	•	●	•	•	•
Recreational Fish and Wildlife	•	•		●	•	•	•	●	●	•
Commercial Fish and Wildlife				●			•		•	•
Endangered species/ ecological diversity	•	•	•		•	•	•	•		•
Flood damage reduction	•	●			●	●		•		•
Transportation/navigation			●			●				
Hydropower		●				•				
Sustainability of process	•			•			•	●	•	
Monitoring and research	•	•	•	•	•	•	●	●	•	●
FOCUS OF WATERSHED SCALE										
Small	●		●	•	●	•	●	●	●	●
Medium	•	●	•	●	•	●	●	•	●	●
Large		●	•	●		●	●		•	●

Dot size approximates relative activity

Federal, state, and municipal agencies and organizations that may have an interest in ecosystem restoration either through their existing programs or through actions requiring mitigation include (but not limited to): the PANYNJ, USACE, USEPA, NOAA, NJDEP, NYSDEC, NYCDEP, NJDOT, New York State Department of Transportation, New York City Economic Development Corporation, NJMC, Environmental Defense Fund, NY/NJ Baykeeper, Hackensack Riverkeeper, Hudson Riverkeeper, Passaic River Coalition, Hudson River Foundation, Clean Ocean Action, National Parks Conservation Association and the National Park Service.

With such a large group of stakeholders conducting habitat restoration within the HRE study area under a variety of programs, it is important to identify funding sources and strategic partnerships and encourage exchanging information and expertise to work towards achieving the TEC objectives. Restoration projects are typically planned on a one-by-one basis, with little consideration of the overall system needs and no measure of the benefits achieved in the context of the entire HRE. Coordination of these programs in the context of the estuary-wide goal and objectives will be challenging but critical

Table 5-2. Observed high, median, and low costs of conducting restoration of selected TECs.

TEC	Unit of restoration	Low observed ($/unit)	Median observed ($/unit)	High observed ($/unit)	# of data sets used	Data sources and references
Coastal Wetlands	Acre of wetlands restored	$218,587	$277,009	$713,569	5	USACE, New York District cost estimates for Brooklyn Union Gas, Staten Island, NY; Elders Point East, Jamaica Bay, NY; Medwick Park Restoration, NJ; Woodbridge Creek Restoration & Mitigation (+ Option), NJ
	Cubic yard of material excavated or filled	$49	$53	$144		
Oyster Reefs	Acre of habitat restored	$51,457	$52,478	$109,776	3	USACE, Baltimore District cost estimate for Cheapeake Bay Oyster Restoration, MD, and USACE, Norfolk District cost estimates for the Great Wicomico and Lynnhaven rivers oyster restoration projects, VA.
	Cubic yard of shell placed for habitat1	$30	$65	$75		
Eelgrass	Acre of habitat restored2	$1,080	$16,600	$170,083	8	Shafer, D., & Bergstrom, P. (USACE-ERDC & NOAA Chesapeake Bay Office, 2007). Large-Scale Submerged Aquatic Vegetation Restoration in Chesapeake Bay: Status Report, 2003-2006.
Habitat for Fish, Crabs & Lobsters	Cubic yard of rock placed for habitat	$38	N/A	$621	2	(1) USACE, New York District cost estimate for proposed lobster habitat restoration, New York Harbor. (2) Massachusetts Division of Marine Fisheries, cost estimate for hard-bottom habitat mitigation project, Boston Harbor, MA.
Tributary Connections[3]	Dam removal: square feet of dam removed	$32	$180	$378	8	University of Rhode Island, The Costs for Environmental Restoration Projects. Retreived from: http://www.edc.uri.edu/restoration/html/tech_sci/socio/costs.htm
	Fish ladders: river miles accessible	$7,069	$26,772	$280,900	7	
Enclosed & Confined Waters	Cubic yard of material excavated or filled[4]	$17	$43	$61	3	USACE, New York District cost estimates for Norton Basin, Fresh Creek and Paerdegat basins, Jamaica Bay, New York.
Sediment Contamination	Cubic yard of sediment excavated[5]	$184	$296	$1,003	12	Lower Passaic River, NJ Draft Focused Feasibility Study. (2007) Appendix J, Cost Estimates. Retrieved from http://www.ourpassaic.org

Notes: Actual construction costs are escalated to January 2008 price levels and adjusted for New York City locality. Construction management costs are included and determined by NY District USACE methodology. Management costs are a function of total construction cost. Engineering and design costs were approximated at 2% of total construction cost. Where applicable, monitoring costs are assumed based on complexity and frequency and generally for a period of five years. Contingency costs were estimated at approximately 20% for projects not yet constructed (assumed contingencies were included for constructed projects).

1 Lower unit costs based on shell material provided by state-owned (Virginia) fossil shell bed, including transportation to restoration site.

2 Lower unit costs based on passive seed dispersal methods; higher unit costs based on intensive hand-planting by divers, including storage of plant material and monitoring All costs normalized to a common 8.4% survival rate.

3 Costs for dam removals dependent on construction materials of dam, debris removal, complexity of disassembly. Costs for fish ladders dependent on type of ladder installed, height, complexity of installation.

4 Costs based on net volume of material cut and filled.

5 Includes costs for excavation and placement

and will acquire a management structure able to coordinate and evaluate restoration activities among a vast group of stakeholders. The following sections identify potential funding opportunities for restoration projects and present potential management strategies for the CRP.

5.1.1 Potential Funding Opportunities

Meeting the restoration targets described in Chapter 4 depends upon planning, constructing, and monitoring many restoration projects, which will have substantial costs. Economies of scale will benefit from larger, coordinated efforts, where the average unit cost decreases as the project size increases or cumulative benefits with adjacent areas adding to the overall value. Volunteers can also help reduce costs, typically through assistance with planting and monitoring components. The American Littoral Society regularly engages hundreds of volunteers in habitat restoration projects, including activities such as removing debris from smothered marshes, planting native dune plants, removing invasive plants, and bagging shell for oyster reef restoration.

For projects depending upon Federal or state funding mechanisms, it should be recognized that Congress and State Legislatures' funding decisions would be made over a period of months or years following plan adoption. The recommendations made in this plan have been crafted to recognize these limitations.

Even when restoration practitioners efficiently and resourcefully plan their projects, the thousands of acres of upland, intertidal, and subtidal habitat necessary to meet the short and long-term TEC goals will require a large investment (Table 5-2). For example, to meet the short-term objective for the Coastal Wetlands TEC (i.e., creation and restoration of 1,200 acres by 2015), using the average cost per acre for salt marsh creation, it is estimated to cost between $262 and $856 million. Meeting the long-term objective (i.e., creation of 15,200 acres by 2050) is estimated to cost $3.3 to $10.8 billion. Considering that these are only the costs associated with one of the eleven TECs, funding to implement all TECs will be difficult to secure over the timeframes identified. It is therefore important to take great care to ensure these projects are in the best interest of the local community. Investing in natural resources brings major returns to the region as ecosystem services, promotes the region's culture, and benefits local economies within the estuary.

Finance planning is time-consuming, but necessary for long-term success and progress toward the CRP's goal and restoration targets. Securing funds to properly manage the CRP, support program operations, and implement restoration programs represents a challenge but one that may be aided by the CRP, in that, for the first time provides a common restoration agenda for the region to collectively support. It is important to establish base funding sources to support ongoing programmatic components (e.g., newsletters, website, data management, tracking progress), then later to enhance and expand the program by increasing the base funding. Moreover, funding to implement the CRP should not interfere or conflict with existing restoration efforts by drawing money away from successful programs. Instead, a complimentary finance plan should be developed to identify and evaluate:

- Funding sources for managing and implementing restoration (Sections 206 of WRDA 1996 and 1135 of WRDA 1986) in the HRE study area,

- How these mechanisms will be executed, and
- In what time period implementation should occur (USEPA 2005).

A variety of Federal, state, local, and private funding opportunities should be evaluated when developing the finance plan. For many endeavors, it may be beneficial to develop strategic partnerships with other organizations, whether formal or informal. Examples of these partnerships include the Lower Passaic River Restoration Project and the Long Island Sound Habitat Restoration Initiative, and the HEP, which include a combination of Federal, state, and local partners. Developing cost-sharing agreements and partnerships can result in larger programs to achieve economy of scale benefits. Several funding opportunities that may be used for habitat restoration in the HRE study area are described below.

5.1.1.1 U.S. Army Corps of Engineers Programs

There are partnering opportunities with the USACE to restore habitats through the Continuing Authorities Program (CAP), General Investigation (GI) studies and Construction General (CG) funds. These programs require a cost-share agreement between the USACE and the non-Federal sponsor. The non-Federal share can be contributed as in-kind products or services (Table 5-3).

Hudson-Raritan Estuary Ecosystem Restoration Study Authority

Resolved by the Committee on Transportation and Infrastructure of the United States House of Representatives, That, the Secretary of the Army is requested to review the reports of the Chief of Engineers on the New York and New Jersey Channels, published as House Document 133, 74th Congress, 1st Session; the New York and New Jersey Harbor Entrance Channels and Anchorage Areas, published as Senate Document 45, 84th Congress, 1st Session; and the New York Harbor, NY Anchorage Channel, published as House Document 18, 71st Congress, 2nd Session, as well as other related reports with a view to determining the feasibility of environmental restoration and protection relating to water resources and sediment quality within the New York and New Jersey Port District, including but not limited to creation, enhancement, and restoration of aquatic, wetland, and adjacent upland habitats.

- Under the CAP, small-scale ecosystem restoration projects can be conducted under several standing authorities, including the beneficial use of dredged material (Sections 204 of WRDA 1992 and 207 of WRDA 1996), environmental restoration (Sections 206 of WRDA 1996 and 1135 of WRDA 1986) and estuary habitat restoration (Sections 102-110 of the Estuary Restoration Act of 2000. These projects are undertaken by the USACE at the request of local partners, such as state agencies, county governments, and municipalities. CAP projects are cost-shared between the Federal government and a non-Federal sponsor, and are generally funded with 65% to 75% Federal funds.
- GI studies are the common way for the USACE to help a community solve a complex and/or large-scale water resource problem such as habitat restoration. Specific Congressional authorization and appropriations are necessary, such as the HRE Ecosystem Restoration Study resolution and appropriations under which this report was developed. The costs for those feasibility studies are evenly shared between the Federal and non-Federal partners, while project implementation is typically funded with 65% Federal funds. Recommendation stemming from the feasibility must then be approved by Congress and funded for construction via CG accounts.

Both CAP and GI studies require formal requests for assistance from a non-Federal project sponsor. Depending on the program and type of project, a non-Federal partner can be:

- A legally constituted public body with full authority and capability to perform the terms of its agreement

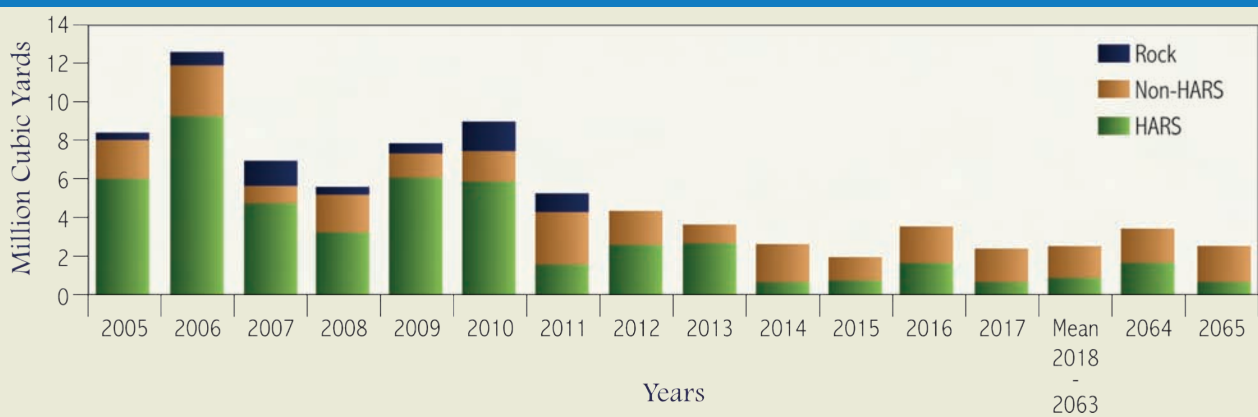
- A national not-for-profit organization that is capable of undertaking future requirements for operation, maintenance, repair, replacement and rehabilitation (OMRR&R)
- Any not-for-profit organization if there is no future requirement for OMRR&R.
- All potential non-Federal partners must be able to provide any required lands, easements, rights-of-way, relocations and dredged or excavated material disposal areas.

Demonstration projects are eligible for funding through the USACE's Engineer Research and Development Center (formerly, the Waterways Experiment Station) in Vicksburg, Mississippi. The Center annually issues requests for proposals for research and demonstration projects, with a funding limit of approximately $200,000, which approximates the estimated construction cost. In addition, smaller projects can be nominated to an interagency committee for funding under the National Estuary Restoration Act, implemented by the USACE and NOAA, such as the current restoration of diked area adjacent to Old Place Creek on Staten Island.

Another potential strategy to decrease overall project costs is the beneficial use of dredged material for habitat restoration, a primary goal of the USACE Dredged Material Management Plan (USACE 2008b). Large-scale projects in the HRE study area use dredged material for a number of projects that contributes to the TECS, such as offshore reefs, restoring shallow marine

Dredged Material Management Plan (2005 – 2065)

Data Source: USACE 2008b



The Dredged Material Management Plan for the Port of New York and New Jersey forecasts future dredged material volumes and management options over a 60-year planning horizon. An estimated total of 195 million cubic yards (MCY) of material will be dredged from the HRE study area between 2005 and 2065, which includes both maintenance dredging and the authorized harbor deepening.

In the HRE study area, dredged material is categorized as either suitable or unsuitable for placement at the Historic Area Remediation Site (HARS). The HARS, a past ocean disposal site for dredged material and refuse, is located in the NY Bight outside of the HRE study area. Only suitable, tested cap material (estimated to be a total of 89 MCY) can be used in the remediation of the HARS. All other material unsuitable for HARS will be managed in the future: Non-HARS estimated at 101 MCY; rock estimated at 5 MCY.

Beneficial use of dredged material is a priority within the region. HARS, non-HARS material, and rock can all be used beneficially for habitat restoration, enhancement, and creation of wetlands, bottom surface habitat, oyster/shellfish reefs, bird habitat, beach nourishment, land remediation, and decontamination technologies.

Table 5-3. U.S. Army Corps of Engineers Restoration Authorities in the Hudson-Raritan Estuary Study Area.

Type	Authority	Program/Authority Description	Funding Opportunities
Environmental Restoration	Section 306 of the Water Resources Development Act (WRDA) 1990	Environmental Restoration was added as one of USACE's primary missions.	
	Estuary Restoration Act of 2000	Promote restoration of estuary habitat; develop a national Estuary Habitat Restoration Strategy; provide Federal assistance for and promote efficient financing of estuary habitat restoration; and develop and enhance monitoring, data sharing, and research capabilities.	
	Section 1135, WRDA 1986	Continuing authority to modify Corps structures and operations built or to perform restoration at other locations affected by construction or operation of Corps projects.	Program authorization cap $35 million; w/up to $5M allowed as Federal share Cost Shared 75/25 (Federal/sponsor)
	Section 206, WRDA 1996	USACE carries out ecosystem restoration and protection projects if the project will improve environmental quality, is in public interest, and cost effective	Federal limit: $5 million. Cost Shared 65/35 (Federal/sponsor)
	Individual Project authorizations	Project specific authorizations to address aquatic ecosystem restoration.	Feasibility studies cost shared 50/50 Construction cost shared: 65/35 (Federal/sponsor)
Beneficial Use of Dredged Material to Restore Aquatic Ecosystems	Section 204 of the WRDA 1992, as amended, and Section 207 of WRDA 1996.	Continuing authority that allows the USACE to carry out ecosystem restoration and protection projects in connection with new or maintenance dredging of Federal Projects.	Study and Construction Cost Share: 75/25 (Federal/sponsor)
	Federal Standard	State under Coastal Zone Management or CWA recommends use of the dredged material for a State beneficial use	
Environmental Dredging	Section 312 of WRDA 1990	Provides authority for the USACE to participate in the removal of contaminated sediments (a) outside of the boundaries of and adjacent to Federal navigation projects as part of operations and maintenance, and (b) for the purposes of ecosystem restoration, not related to operations and maintenance of navigation channels. This authority requires coordination with USEPA.	The cost-sharing formula for this authority is condition-specific.
Regulatory Programs		Protection of aquatic ecosystems under avoidance, minimization and mitigation; use of special area and general permits to encourage environmental preferred activities	Opportunity for multi-agency and public resource management
Aquatic Plant Control	Section 104 of the Rivers & Harbors Act of 1958, Section 103 of WRDA 1986, Section 225 of WRDA 1996, and Section 540 if WRDA 1996	USACE may cooperate with non federal agencies for authorized plant control on navigable waters not under jurisdiction of USACE or other federal agencies	Cost share 50/50.
Planning Assistance to the States	Section 22 of WRDA 1974, Section 605 (Public Law 96-597), and Section 221 of WRDA 1996	General authority to cooperate with states providing technical assistance.	Cost Share 50/50; not more than $500,000 to any one state per year

benthic habitat in the formerly used channel at the Military Ocean Terminal – Bayonne, and restoring vanishing marsh islands in Jamaica Bay, as well as recreation and beach nourishment, and remediation (USACE 2008a). Diverting uses of dredged materials to restore habitat is a valuable, cost-effective method that can also reduce the need for mining virgin materials to complete these restoration projects.

The NY/NJ Harbor Deepening Project presents a well-timed, ample supply of dredged material for beneficial placement around the estuary (USACE 2008b). However, there are several considerations to beneficially using dredged material including assessing demand, relative benefits, and timing of availability. Although most aquatic restoration projects require relatively little material, recontouring subaqueous borrow pits, creating upland habitat, creation of artificial reefs, and restoring wetland islands present opportunities in the estuary to use large amounts of clean dredged material and rock for restoration. The restoration of upland habitat presents another opportunity to use dredged material for restoration. The coordination of restoration projects and dredging projects will present a challenge for the beneficial use of dredged material. During the duration of the Harbor Deepening Project, the quantity and types of material will vary. However, through timely, coordinated planning, restoration programs can benefit from reusing dredged materials.

5.1.1.2 Federal Grant Programs

Many Federal grant programs can assist with funding restoration programs. The following sections describe examples of these programs.

U.S. Environmental Protection Agency

The USEPA's many grant programs that can aid in implementation of restoration include:

- The National Estuary Program provides grants in support of habitat restoration projects. These grants are provided through the CWA and require a match commitment from a local sponsor.
- Wetlands Program Development Grants in support of developing new or refining existing comprehensive wetland protection, management or restoration programs.
- Community Action for a Renewed Environment is a competitive grant program offering financial and technical assistance to communities to reduce pollution in their local environment.
- The Environmental Justice Grant Programs assists local organizations to identify and/or address environmental/public health issues in their community.
- The Environmental Education Grants Program supports environmental education projects that increase the public awareness about environmental issues and increase people's ability to make informed decisions that affect environmental quality.
- The Five Star Restoration Program brings together various stakeholder groups (e.g., students, citizen groups, corporations, landowners, government agencies) to provide environmental education and training through projects that restore wetlands and streams.
- The Clean Water State Revolving Fund assists states wanting to implement water quality protection projects for

wastewater treatment, non-point source pollution control, and watershed and estuary management.

- Section 319 of the CWA provides grants to states with comprehensive watershed projects aimed at protecting or enhancing water quality from non-point source pollution. The Section 319 Nonpoint Source Management Program currently awards over $200 million annually to watersheds nationwide. While generally not applied to habitat restoration, they are instrumental in setting the stage for establishing the water criteria necessary for restoration project success.
- Targeted Watershed Grants Program encourages successful community-based approaches and management techniques to return real environmental results in improved and sustained water quality.

National Oceanic and Atmospheric Administration

NOAA is dedicated to improving and preserving coastal and riverine habitats throughout the nation. NOAA offers funding opportunities through several of their programs.

- The Community-based Restoration Program provides funding to local communities from NOAA-Fisheries. These grants require 1:1 matching funds or in-kind services on restoration projects. There are a few spin-offs of this program, where partnerships have been formed with the NEP and with the National Association of Counties. The NEP/Community-based Restoration Partnership funds citizen-driven habitat restoration projects within watersheds of the NEPs.
- NOAA's National Sea Grant Program offers funding for marine and estuarine research programs. Sea Grant is NOAA's primary university-based program in support of coastal resource use and conservation. The New York Sea Grant, which is administered from the State University of New York, focuses on coastal-dependent businesses, fisheries, seafood products, coastal hazards and processes, coastal water quality, coastal habitats, and aquatic nuisance species. The New Jersey Sea Grant is managed by the New Jersey Marine Science Consortium. The program supports research, education and information sharing to foster sustainable use of marine resources and provide solutions to coastal management and policy issues.
- Other NOAA programs include the Open Rivers Initiative, the Estuary Habitat Restoration Program, and the Marine Debris Prevention and Removal Program.

U.S. Fish and Wildlife Service

The USFWS funds restoration and conservation under many separate programs, including:

- The National Coastal Wetlands Conservation Grants, which are available to state agencies;
- The Coastal Program that provides incentives for voluntary species protection;
- The Partners for Fish and Wildlife Program assists private landowners with habitat improvement projects that benefit Federal Trust Species (e.g., migratory birds, inter-jurisdictional fish, threatened and endangered species);
- Restoration programs specific to enhancing marine or anadromous fisheries, including constructing artificial reefs, salt marshes, and freshwater habitats, can be funded through the 1988 USFWS Federal Aid in Sport Fish Restoration Act, 16 U.S.C. sec. 777; and
- Further fisheries restoration support comes from the Wallop-Breaux Act amendments, where an excise tax was extended to previously untaxed fishing equipment.

U.S. Department of Agriculture

The U.S. Department of Agriculture-Natural Resources Conservation Service offers technical assistance and up to 75% cost-share assistance to establish and improve fish and wildlife habitat through its Wildlife Habitat Incentives Program. These funds are available to private landowners, agencies, and non-government organizations.

5.1.1.3 State Programs

TThe NYSDEC offers a number of assistance programs to their municipalities and community-based organizations, including ecological restoration, brownfields restoration, and water quality improvement projects. Many of these programs are appropriated through the 1996 Clean Water/Clean Air Bond Act, which provides millions of dollars each year for qualified restoration programs in New York. Other New York grant programs were established through different means.

NYSDEC also manages the Hudson River Estuary Program whose mission is to conserve the natural resources, promote full public use and enjoyment of the river and clean up the pollution that affects our ability to use and enjoy it. The Estuary Program implements its Hudson River Estuary Action Agenda through numerous partners in government, the non-profit and business sectors, and concerned citizens (NYSDEC 2009).

In fall 2001, Federal legislation established the State Wildlife Grants (SWG) program to provide funds from offshore oil and gas leasing to state wildlife agencies for conservation of fish and wildlife species and their associated habitats in greatest need of conservation. In New York, this program is implemented by NYSDEC's Division of Fish, Wildlife and Marine Resources with funding from "Teaming with Wildlife," a national organization dedicated to fish and wildlife conservation.

The SWG program is unique in that it provides funds for species not traditionally hunted or fished. Within the geographic extent of the HRE, there are 267 species of greatest conservation need eligible for funding through the New York State Wildlife Grants program.

The NJDEP maintains several grant and loan programs under the themes of environmental regulation, land use management, brownfields restoration, natural and historic resources, among others. Through these programs, the State offers low-interest loans for dam restorations, assists municipalities in implementing Forestry Management Plans, and funds to develop and maintain trails and trail facilities.

New Jersey Department of Transportation/Office of Maritime Resources manages two grant programs to fund coastline and shoreline improvement projects for recreational boaters. The I BOAT NJ Program provides grants funded by a portion of New Jersey boater registration fees to promote, improve and enhance the marine industry in New Jersey for the benefit of the general boating public. The National Boating Infrastructure Grant Program, funded by the U.S. Department of the Interior, U.S. Fish and Wildlife Service, are distributed annually to States "to construct, renovate, and maintain tie-up facilities" recreational vessels. With these funds, there are numerous opportunities to develop purposeful and objective projects to fulfill the program's mission and enhance New Jersey's coastline, shoreline, and inland waterways.

5.1.1.4 Natural Resource Damage Assessment

The Natural Resource Damage Assessment (NRDA) process pursuant to the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA or Superfund) can also provide opportunities and funding for Federal and state agencies, and private entities to implement ecosystem restoration projects. NOAA and USFWS have programs to provide funds for habitat restoration (including salt marshes) in areas that have experienced environmental degradation as a result of oil spills and other losses of ecological resources. These funds are derived from litigation and financial settlement with the responsible parties, with oversight of a committee of trustees pursuant to CERCLA/Superfund. In New Jersey, the Natural Resource Restoration is administered by the Office of Natural Resource Restoration, which was established to ameliorate environmental injury caused by multiple oil spills and discharges. The Commissioner of the NJDEP is the designated "trustee" charged with administering and protecting the State's natural resources. In New York State, the Governor has designated the NYSDEC as the trustee for New York trust resources.

In addition to seeking funding from "natural resource damage" claims from natural resource trustees, it may also be possible to coordinate with potential responsible parties (PRPs) of Superfund sites to identify habitat restoration actions. Implementation of potential restoration opportunities, restoring specific natural resource losses, could fulfill a PRPs liability with the Federal and State trustees. In all cases, projects should attempt to maximize the ecological value of the site and be designed to be self-maintaining.

5.1.1.5 Mitigation

For several TECs, it may be possible to obtain mitigation funding to support restoration projects. Agencies (e.g., the USACE, PANYNJ, NJDOT, NYCDEP, NYC Economic Development Corporation) and private entities are often required to mitigate for unavoidable project impacts. The USACE and USEPA 2008 Final Compensatory Mitigation Rule emphasize that the process of selecting locations for compensation sites should be driven by a watershed approach and watershed needs identified within the analysis (USACE and USEPA 2008). Specific wetland creation, restoration, preservation and protection projects should best address those needs. Mitigation actions could be selected based on CRP recommendations within the CRP to ensure that the mitigation projects benefit the watershed, while also meeting mitigation requirements.

The 2008 Mitigation Rule also indicates a preference for mitigation banking in order to fulfill a permitee's mitigation requirements. The restoration opportunities identified within the CRP could focus site selection for the creation of a wetland mitigation bank within the HRE.

5.1.1.6 Non-Profit Organizations

Coordination with non-profit organizations actively engaged in restoration/preservation activities may be another opportunity to raise funds for restoration. Non-profit organizations are ideally suited to receive contributions from the private sector and disburse funds for research studies, environmental monitoring, and educational programs. It may also be possible to solicit non-profit organizations to identify actions they can implement that would correspond to their missions. In addition, several non-profit organizations have grant programs, including:

- The Hudson River Foundation awards grants that focus on capital construction, development, and improvement, including public access facilities, habitat preservation/restoration, and educational facilities.

- American Rivers is a non-profit organization that funds many community-based environmental restoration programs ranging from restoring natural river function (including barrier removal projects), floodplains, and wetlands to establishing public access opportunities near rivers.
- National Fish and Wildlife Foundation (NFWF) has keystone initiatives that focus on bird conservation, fish conservation, marine and coastal conservation, and wildlife and habitat conservation. The NFWF also has many special grant programs that range from water quality improvements to innovative conservation practice.

5.1.1.7 Additional Funding Sources

Private partnerships, such as Coastal America's Corporate Wetlands Partnership provide another avenue for project funding. Through these partnerships, private companies help their communities make the required local match for federal funds for community-based restoration projects. Other creative methods for funding implementation projects can occur through affinity credit cards, specialty license plate fees (e.g., Conserve Wildlife license plates [NJ]), capital giving campaigns, or utility fees (USEPA 2005).

5.1.2 Policy Considerations for Implementation

As an organization, agency, municipality or other group begins the process of conducting restoration within the HRE study area, there may be critical policy considerations that should be discussed with a number of regulatory agencies to improve overall success and encouraging consistency in operation. Some of the critical policy issues include:

- Habitat Exchange
- Placement of Fill (for creation of wetlands and shallow water habitat)
- Beneficial Use of Dredged Material
- Attractive Nuisances
- Oyster Reef Creation/Restoration
- Lobster Habitat Creation
- Sediment Contamination

Overarching Regulatory Issues

Currently, there are differences in the regulatory approach and policies among agencies that have the statutory authority to regulate restoration activities. The CRP provides an opportunity to open a dialogue among the varying agencies involved. Limited funding and staff have been consistent issues for regulatory agencies while they attempt to accomplish their agency's goals of administrative procedures and timeframes. Setting the administrative issues aside, there are generic policy issues that should be addressed.

The HRE is a highly urbanized environment with significant legacy impacts (chemical contaminants, sedimentation, loss of habitat). Regulatory positions are currently geared to protect the existing resources and are likely to dominate management of the aquatic resources of the HRE in the near future. However, as environmental restoration becomes an expected part of aquatic habitat management, goals for the protection of existing resources and the restoration of the ecosystem should converge. This convergence could be facilitated with policies that integrate environmental protection, environmental restoration, and economic development. Some proponents for restoration would argue that restoration projects should be given priority during regulatory actions, and that policies should be changed to favor restoration. However, this action may require legislative action resulting in changes in state laws. The purpose of this CRP is to identify potential conflicts stemming from current laws/practices and to bring meaningful dialogue to the table with all regulatory agencies and restoration practitioners, in an effort to make the process run more smoothly and be more transparent from the onset of the process. This would allow the regulatory challenges in completing a restoration effort to be highlighted and potentially resolved in advance of any implementation effort even longer-term changes requiring legislative action.

Habitat Exchange

While there is no specific regulation that states that habitat exchange (creating one type of habitat which is presently a functional habitat of another type), cannot be permitted, regulatory agencies interpret their rules regarding the placement of fill and/or dredging to also encompass the habitat exchange issue. This is typically due to the fact that some alteration of the physical environment, through either filling or dredging, has to take place in order to change the habitat type. NYSDEC, NJDEP, New York State Department of State (NYSDOS), and USACE all have jurisdiction in regulating these types of activities.

All of these policies and their supporting laws have implications when initiating a restoration effort that may involve exchanging one habitat type for another. This may be most prevalent in the case of the Coastal Wetland TEC and the Shorelines and Shallows TEC. Regulatory agencies tend to place preservation of existing habitat above its alteration, possibly due to uncertainty of success and/or absence of overriding comprehensive plan. Currently regulations require alternatives analyses, studies or modeling of existing habitat quality or diversity, justification for the proposed exchange of habitats and monitoring of the success of the restoration effort if permitted. In and of themselves, these are all reasonable if evaluated within the framework of an open mind and larger restoration agenda. Cooperation with the regulatory agencies through the CRP should allow for an appreciation of the need for a diversity of habitat types and for the desire to support potential actions that on their surface may now appear as undesirable changes. In addition to improving habitat diversity, bigger-picture approach should aid the restoration community in achieving the TEC goals identified in this CRP.

Placement of Fill

While there may be opportunities where fill placement would have a positive effect on the aquatic environment, many regulatory agencies routinely view this type of effort in a negative manner. Fill placement activities can be involved in the creation of wetlands, shorelines and shallow water habitat, all of which advance the TECs. One example of a “fill” is the placement of new pile fields, such as those in the Hudson River at the Hudson River Park. The purpose of this activity was to create foraging habitat for fish, shield juvenile fish from predators, and provide habitat for sessile invertebrate species. NYSDEC, NJDEP, NYSDOS, and USACE all have jurisdiction in regulating these types of activities. The applicants worked extensively with these agencies along with the NOAA-Fisheries to obtain the requisite permits. In a similar manner, an extensive interagency team worked with NYSDEC to permit the fill of shallow water/mudflat habitat to create marshes that were being lost at an accelerating rate. Both examples suggest a growing trend or at least willingness to examine this important issue on individual merit.

Placement of dredged material has become a policy issue over the past few years. According to the 2008 Dredged Material Management Plan, the beneficial use of dredged material is a priority for the NY/NJ Regional Dredging Team. Policy issues for using dredged materials are similar to those raised for the placement of fill and are regulated by NYSDEC, NJDEP, NYSDOS, and USACE. While there have been opportunities to use dredged material for restoration projects (Jamaica Bay Marsh Islands restoration), use of the material is limited based on the specific policies of the agencies involved.

Attractive Nuisances

An attractive nuisance is something that causes, or is perceived to cause, an unintended problem. Attractive nuisance problems relate to both human health risk and ecological health risk due to exposure to contaminants and can occur at any site that has unacceptable levels of contamination. An attractive nuisance refers to an area, habitat, or feature that is attractive to wildlife and has, or has the potential to have, waste or contaminants left on site that are harmful to plants or animals after a completed remedial action. Therefore, an attractive nuisance can potentially cause harm to wildlife and subsequently humans, if an exposure pathway exists from contaminants on site that could directly harm wildlife or could then travel up the food chain.

Creation of both oyster reefs and artificial reefs for lobsters has regulatory implications. The states of New York and New Jersey believe that oyster restoration in prohibited or specially restricted waters creates an attractive nuisance. Both states generally believe that the ecological benefits of having sustainable populations in these waters are outweighed by the potential health risks of consuming poached oysters. There are potential economic repercussions that the consumption of tainted oysters may affect the rest of the shellfish industry. In the case of both oysters and lobsters, there is concern that fishing could lead to consumption of shellfish that are not safe to eat. This would result in the need to restrict harvesting or fishing in these areas, which will lead to greater enforcement needs and increased costs to the regulatory agencies. Other potential policy issues stemming from creation of reefs would be considered under both the habitat exchange and placement of fill sections. The NYSDEC, NJDEP, NYSDOS, and USACE have jurisdiction in regulating these types of activities. Blanket restrictions on oyster reef restoration will prevent implementation of the Oyster Reefs TEC and achieving the agreed upon TEC goals. The CRP and its comprehensive evaluation of habitat will encourage future dialogue on this issue such that safety and economic needs are integrated and not oppose any TEC goal.

Another concern is attracting wildlife to areas where they may be hazardous to public safety. Migratory and nesting birds in the region are a concern to airport operators, particularly within a five-mile radius of airports (FAA 2007). Increasing the amount of habitat in the vicinity of airports could attract birds and other animals that are particularly hazardous to aircraft, resulting in an increased number of strikes by planes. Bird and animal strikes are a serious economic and public safety issue to the aviation industry. These concerns are often addressed through cooperative interagency policies, like Wildlife Hazard Management Plans, that detail preventative measures to reduce wildlife attractants, minimize hazards, and identify responsible parties. This guidance should be an integral component of community land-use planning within a five-mile radius of airport and any restoration actions should be planned with full realization and compliance with these plans to maximize safety of the flying public.

Sediment Contamination

Sediment contaminant activities are also regulated by NYSDEC, NJDEP, NYSDOS, and USACE. While the removal or capping of contaminated sediments is an important part of HRE restoration, there is no definition of how clean the sediments must be for the restoration to be considered successful. Due to the urban nature of the HRE, it is unlikely that the HRE would be cleaned up to acceptable risk guidance benchmarks. In order to implement restoration in the HRE, agencies need to discuss the concept of "acceptable" for this urban estuary. While, policy makers and restoration practitioners realize that it is impossible to remove all of the contaminated sediments from the HRE study area, one of the biggest issues is the level of residual contamination after restoration.

There are many policy issues that should be considered when planning a restoration project. The appropriate regulatory agency should be consulted early in the planning process in order to resolve issues and work towards a mutually agreeable restoration plan. More importantly, the resolution of these policy considerations is mandatory in order to implement the CRP and achieve the consensus restoration goals set forth by the regional stakeholders.

5.1.3 Public Involvement and Support

Public involvement has been an important proponent and source of support for an aquatic resources restoration agenda for the HRE study area. To maintain their interests and "hands-on" involvement, any public involvement program should (1) make the public's desires, needs and concerns known to decision-makers and incorporate them into the CRP, (2) provide a forum for consultation prior to reaching planning decisions, (3) inform the public about proposed restoration activities (especially on a site specific basis, and (4) consider the public's views in restoration plans. Participation in the CRP public outreach should occur on three levels: elected officials, stakeholders, organizations and the general public.

The HRE managing body should reach out to elected officials and engage them in the planning process. These relationships should be formed in the hope of establishing a commitment to restoration in the HRE study area, which could translate into funding opportunities for program implementation, especially as it relates to individual constituencies

Environmental stakeholder groups have been active participants in the HEP and have taken a variety of individual actions to strengthen environmental protection regulations and initiate restoration programs for selected species and local sites. Coordination with well-established stakeholder groups in the HRE study area will increase program visibility and support, as well as increase the number of sites that could be used to meet TEC goals

In the transition from a draft plan to a working plan, there is a need to promote the CRP and to initiate the public awareness that will be necessary to achieve the long-term objectives of the plan. The MWA and HEP represent existing organizations and workgroups that can provide an outlet and forum for environmental restoration discussions by focusing on the estuary and the waterfront. The leadership for CRP implementation will also include the use of professional expertise in public outreach to extend interest in environmental restoration beyond the stakeholders already engaged in HRE study area-specific issues.

Public support for the CRP also includes the general public, which is involved in outreach and habitat restoration programs more at the local level. Wetland restoration, oyster restoration, dredged material management, and environmental education programs, which have been underway in the HRE study area for many years, are all manifestations of an attempt to reverse the degradation of the estuary's aquatic resources. Many of these efforts are looked upon as isolated, local activities and not connected to the functioning of an estuarine ecosystem. A public involvement campaign should attempt to connect these 'isolated' programs and demonstrate the potential estuary-wide benefits of collective restoration activities to their local needs and goals.

There is a strong public interest in habitat restoration, evident for some time by the participation of the public in permitting actions and advisory boards for various programs affecting the estuary. Through this participation, the public has made its interest in ecosystem restoration clear to resource management agencies working with them to help expand widespread public support is essential because the CRP is a long-term program, which will need funding support on a continuing basis. The general public needs to be aware of the potential long-term public benefits of a comprehensive approach to environmental restoration, and how they should support it.

The following components should be considered to improve public participation and support.

- Newsletters, brochures, and fact sheets should be prepared to document the status of the CRP. Written materials provide continuity to the planning process for participants and help to maintain interest and hold public attention during the intervals between outreach events. Newsletters should provide estuary-wide and region/site-specific information in an engaging format with many graphics. Photographs of work in progress and interviews with community leaders involved in projects should also provide planning region identification and demonstrate involvement at the local level. Brochures and fact sheets can describe the history and goals of the program or be single-topic discussions on individual restoration sites or on technical matters, such as contaminated sediments management. The format and graphic look of all materials should be consistent with the CRP to maintain estuary-wide identification with the project and project materials. These publications should also be translated into the languages of prominent minority groups (e.g., Spanish) to promote public participation of all socioeconomic groups in the HRE study area.
- A CRP website should be managed regularly to serve as a two-way communication vehicle, as well as an electronic newsletter to disseminate project-related materials. The internet is an immediate source of information for the general public and may become the first exposure residents of the HRE study area have to the program. The website should be seamlessly accessible from HEP's, MWA's, and other important stakeholders' websites through a conspicuous web link.
- The NYC OASIS program is an online, interactive mapping tool that offers an engaging format that relays specific information on jurisdictional boundaries, land use (including wetlands, parks, and protected areas), and locations of acquisition and restoration sites to the public. With support from HEP, components of the HRE Study have already been integrated into this mapping tool to help communicate project-related information and will continue to be updated
- Periodically after the CRP report becomes available to the public, TEC-specific workshops should be conducted to discuss lessons learned and include stakeholder groups in the decision-making process. Because stakeholder groups will be initiating many restoration programs, their input is imperative after the initial restoration strategy

has been approved and throughout the CRP implementation. Technical members should be invited to provide information on the latest research developments. However, the selection of workshop topics could be driven by the regional areas of the CRP and the specific restoration sites/needs. Since regional area boundaries correspond to watershed drainage basins and jurisdictional boundaries and may not reflect the way communities define themselves. For the purpose of public outreach, planning region-specific programs should reflect the most appropriate way to reach local communities and therefore may cross-planning region boundaries, as appropriate. These gatherings can create a mechanism for involving the public in early planning stages, thereby obtaining a clear understanding of the public's needs and concerns and hopefully generating enthusiasm for planning efforts, future sponsors, and future projects.

- It may also be beneficial to establish Planning Region Workgroups through HEP to regularly update residents and regional stakeholder groups on the status of the CRP, lessons learned, upcoming events or projects, and ways to get involved within their specific regional area. The Planning Region Workgroups can meet annually in an informal open house style meeting that can also be a platform for exchanging ideas, information, and addressing concerns in a non-technical, engaging manner. This regional coordination will ensure consideration of municipalities' planning efforts in overall regional restoration planning within the CRP Study Area. Meeting announcements should be made in local newspapers and radio so that as many people with expressed interests in the proceedings can attend, but mailings should be targeted at community leaders and policy makers, members of regional stakeholder groups, and other individuals already on an HRE stakeholder mailing list.

5.2 Management

The success of the CRP in improving the estuary ecosystem is directly related to and dependent upon successful collaborating and cooperation among stakeholders. CRP management must accommodate the dynamic process of long-term environmental restoration. Ecological changes that will be brought about by plan implementation, as well as ongoing changes to the physical and chemical environment of the harbor induced by human activities, will require adjustments to the CRP over time. The CRP management framework must accommodate the major roles of the plan:

- Technical guidance. Environmental restoration within the HRE study area is an emerging science that will evolve as the CRP is implemented. Data, insight gained, and challenges overcome through implementing the restoration objectives (i.e., TECs) in the HRE study area should be available and provide a tremendous resource to all stakeholders and therefore must be updated as the science advances and lessons learned builds practical experience.
- Financial guidance. Funding for restoration projects is currently envisioned primarily as a partnering process, but many sources of funding are needed to achieve major progress. The role of the CRP managing body should include identifying and helping to secure promising funding sources for environmental restoration within the framework of the CRP.
- Public involvement. Long-term support for the program can be achieved if the stakeholders and public participates through direct involvement and through awareness of the plan's progress. Management and implementation of the CRP should be an inclusive process to foster this dedicated support.

- Monitoring. As restoration projects progress and move towards achieving the TEC objectives, lessons learned during the process will be documented. Both successes and failures represent information learned that can improve restoration in the HRE study area at existing sites through adaptive management and in design/construction of new sites. The CRP managing body should provide regular updates of progress toward the restoration objectives and recommend/redirect efforts or change management strategies to more effectively meet the restoration targets.

5.2.1 Program Management Team

Pursuant to the HRE Ecosystem Restoration Project, the USACE and the PANYNJ provided the funding and the USACE provided the staff for the development of the CRP. The USACE through the HEP process has brought together agencies, stakeholders, and institutions for important contributions to the CRP development. This collaborative process has resulted in a restoration agenda inclusive of ideas, setting stakeholders' objectives on a common path and increasing support for and visibility of the program. Among the organizations directly involved in CRP development, those listed below have a major stake in guiding and/or managing aspects of its implementation:

Regulatory Agencies

Through their permitting authorities, regulatory agencies (e.g., NYSDEC, NYCDEP, NJDEP, USACE, USEPA, NOAA, USFWS, etc.) have been working to protect aquatic resources from degradation. Over time, these programs have created an essential baseline for environmental restoration. Regulatory programs have brought about greatly enhanced water quality, stopped the loss of wetland and shoreline habitats through filling, and regulated activities that in the past created a degraded and ever-changing aquatic environment in the estuary. The importance of a reasonably stable physical and chemical environment cannot be overemphasized as a strong baseline for environmental restoration against which restoration can result in a net gain. The regulatory agencies will play a critical and multifaceted role in implementation of the CRP through their permitting of individual restoration projects, ongoing efforts to address residual pollution and contamination, management of aquatic resources, and technical expertise applied directly to restoration projects.

Regulatory agencies also play an integral part in the management of aquatic habitats through their mitigation programs. These programs dictate and enforce the creation or restoration of habitat to mitigate for filling or dredging activities. Future mitigation projects should be aligned to be consistent with the goals of the CRP. Restoration opportunities identified through the CRP process could be advanced through mitigation.

New York/New Jersey Harbor Estuary Program (HEP)

The HEP was authorized in 1987, by the USEPA and is comprised of stakeholders from agency groups, scientists, citizens, business interest, and non-government organizations. The program represents a multi-year effort to develop and implement a plan to protect, conserve, and restore the HRE. The HEP has played an integral role in the development of the CRP by working with the USACE and the PANYNJ to develop the framework for the plan. HEP plays a major role in environmental stakeholder coordination within the HRE study area, enabling these organizations to advance their objectives. HEP's workgroups consist of representatives from local, state, and Federal environmental agencies, scientists, citizens, business interests, environmentalists, and others. HEP workgroup meetings and additional outreach meetings have helped develop the CRP by providing tools to understand stakeholders' interests and needs. The TECs represent the restoration objectives necessary to achieve the goals of these stakeholders. HEP manages a centralized, online information center, the NYC OASIS database, whereby stakeholders can obtain information on activities throughout the HRE study area.

HEP's workgroups (Habitat, Management, Policy, Nutrients, Pathogens, Toxics, Regional Sediment Management, and Public Access), each maintain a list of goals and priority actions in the estuary, and the Citizens Advisory Committee shares program-specific information with the public. The HEP Policy Committee is comprised of representatives from USEPA, USACE, NJDEP, NYSDEC, NYCDEP, the PANYNJ, New York and New Jersey Local Government, and the Citizens Advisory Committee. The Habitat and Public Access workgroups provide direction for site acquisition and restoration in the HRE study area. HEP also distributes mini-grants to applicants annually, supporting HRE-specific programs. Many of these grant-funded programs focus on environmental education and providing stewardship opportunities, although several programs seek to gain information that can be used for planning public access and open spaces in the estuary.

Hudson River Foundation (HRF)

The HRF has been sponsoring ecological research focused on the Hudson River and HRE study area and providing technical information for all segments of the environmental community. Under HEP's direction, HRF has coordinated major environmental investigations such as the Contaminant Assessment and Reduction Program (CARP), and the development of the TECs as a science-based method for identifying the ecological objectives of the CRP. The HRF has brought together technical teams to help refine the TECs. These teams represent diverse expertise that can provide guidance in achieving each of the TECs and will continue to participate with technical aspects of restoration in the HRE study area.

Other Stakeholders

Various local organizations are active in many aspects of environmental protection in the HRE study area. These groups may represent local areas and issues, they may lobby and petition for regulatory change, they may acquire and manage areas with important ecological values, and they may actively undertake restoration efforts. These groups have diverse objectives and are comprised of individuals with different experiences, needs, values, and beliefs, but collectively have an interest in bettering environmental conditions.

The Metropolitan Waterfront Alliance (MWA) is an umbrella organization, which has become a focal point for many stakeholder groups in the HRE study area. The MWA represents all facets of interest in the waterfront, with particular attention paid to opening of the waterfront for public access and use of the water. The MWA's involvement in CRP management will be important because public access is a critical objective of the plan that allows the surrounding communities to appreciate their ecological resources.

The NY/NJ Baykeeper, established in 1990, conducts many important habitat restoration and preservation projects and represents environmental concerns of citizens of the HRE. The Baykeeper, which is also an active member of HEP's committees, has been a prominent figure in many pollution prevention and harbor deepening projects. Many of these projects would not be as successful without the support from hundreds of devoted volunteers. They conduct many of the

HRE study area's oyster gardening and restoration programs and are important players in developing and reviewing the CRP.

The NYCDPR and its NRG division are important stakeholders in the HRE study area. The NYCDPR is the steward for green spaces within the City and its boroughs and implements many educational, preservation, and restoration programs.

The American Littoral Society, established in 1961, restores habitats important to the coast in the northeast from Jamaica Bay south to Delaware Bay and in the southeast in Sarasota Bay. The Society works with community stewards and public agencies to implement hands-on, community-based projects.

New York City Audubon Society is the lead organization running the Harbor Herons Project and protecting the uninhabited islands of New York City. They have provided valuable information about the species and habitats discussed in the Islands for Waterbirds TEC, and should play a role in the Maritime and Coastal Forests TECs.

The National Parks Conservation Association is a national non-profit organization committed to protecting the country's national parks. The northeast regional office, located in New York City, has taken a prominent role in improving parks in the HRE study area, including those within the Gateway National Recreation Area (i.e., Sandy Hook, Jamaica Bay). The National Parks Conservation Association will likely continue their role in refining the TECs and assist in their implementation.

There are dozens of community-based organizations taking an active role in environmental outreach, environmental improvement, and stewardship causes within the HRE study area. These organizations represent a collective voice of the local communities, and it is important they support the restoration agenda of the CRP. These organizations include the Bronx River Alliance, Friends of Liberty State Park, Lower Passaic Watershed Alliance, Passaic River Coalition, Riverkeeper, Rockaway Waterfront Alliance, the River Project, and the Waterkeeper Alliance.

Several universities and colleges have played a large role in the development and refinement of the TECs and may continue their high level of involvement by monitoring projects or evaluating progress of the TECs. For instance, the Cornell University and the HRF helped develop and write the TECs, coordinated workshops to gather local input and acceptance, and revised the TEC Report based on substantive comments and concerns. Many academic institutions have participated in the TEC development process: Cornell University, Rutgers University, Virginia Institute of Marine Science, City University of New York (Manhattan College, Brooklyn College, Queens College, Hunter College), State University of New York (College of Environmental Science and Forestry, Stony Brook University), among others.

5.2.2 Plan Management Mechanisms

The many environmental agencies and groups discussed through this report provide a diverse, but complex set of management skills and options to implement the CRP. To be effective, their personnel and respective skills must be organized in a way that builds on their interests, authorities, mandates, expertise and availability. The management framework must have mechanisms built around the major roles (i.e., technical, financial, monitoring, public involvement) of the CRP that can operate with long-term continuity. The management framework must accommodate change over time as the CRP is intended to be a "living document" that will undergo further development as it is reviewed, and additional information is collected from its implementation.

For the management strategy to be successful, it should be implemented by the existing program management team (the HEP, USACE, the PANYNJ, HRF, Regulatory Agencies, and Stakeholders), with roles and responsibilities of each team member clearly defined. The management team must work together to ensure that, going into the future, the CRP will evolve to address changes in technical knowledge, funding sources and regulatory climate, and to continue to represent the wishes of the HRE stakeholders. CRP management must also have a mechanism to track the progress in meeting the program goals and documenting lessons learned during implementation.

To date, there has not been a permanent staff identified as working on harbor-wide restoration within any of the organizations with an interest in environmental restoration. The HEP is staffed by USEPA, and has directly addressed objectives of the CCMP, but not the specific restoration objectives represented by the TECs. Regulatory agencies, while dealing with aquatic resource management on a daily basis, do not have programs specific to the CRP objectives. Most stakeholder groups have a limited staff or are staffed by volunteers and do not generally address restoration efforts on a harbor-wide basis. Permanent staff to manage CRP implementation appears to be a necessity and could give the CRP permanence and prominence in the management of aquatic resources in the HRE study area. Achievement of the CRP's objectives will has the potential to bring profound changes to the ecology of the estuary, and change of this magnitude cannot be attained and managed without a dedicated staff.

Federal funding, with local partnering, is supporting ongoing restoration work in the HRE study area. This mechanism is expected to be a major source of funding for future large-scale restoration projects. In the future, some project sponsors may obtain funding independently, but others may need alternative funds to implement their projects. The CRP management must provide guidance on funding opportunities to potential project sponsors. The CRP staff will need to place emphasis on the critical role of funding projects on an ongoing basis.

One potential strategy is for the USACE to provide the staffing for the management of the CRP. The USACE has led the effort to develop the CRP with Federal funding and partnering funds from the PANYNJ. A staff has been assembled within the USACE for this effort, which provides a potential foundation for a dedicated CRP staff to implement the plan. The maintenance of a CRP staff would require dedicated funding separate from the funding of individual restoration projects. The USACE has mechanisms to utilize Federal funding and has an established history of conducting large-scale habitat restoration projects in the HRE and throughout the country. Alternative funding for a bi-state management effort would require complex political action to implement.

The HEP is an alternative mechanism for the leadership role in implementing the CRP. HEP has a longstanding presence in the HRE study area in dealing with management and restoration of aquatic resources. The majority of organizations that participated in the development of the CRP are represented on HEP workgroups. A HEP-supported CRP staff could be funded by the USEPA, while funding with local partnering through the USACE could continue to be a major mechanism to fund individual projects. The USACE and the USEPA have many well-defined working relationships that could be expanded to include CRP management.

A significant advantage of HEP for leadership in CRP management is their well-established role in coordinating stakeholders and in gaining public support. The work of HEP's Habitat Workgroup is the foundation of the CRP, continuing the vision of establishing and maintaining a healthy ecosystem with full beneficial uses, as defined in the CCMP. The HEP has identified restoration sites and provided funding for the acquisition of sites for protection and restoration. Many programs, like the CARP and workgroups in HEP, have already played or will play a major role in furthering the restoration agenda of the CRP. The HEP Policy Committee has agreed to adopt the CRP as the blueprint and regional agenda for future restoration in the HRE study area.

The HEP has formed a CRP Workgroup, comprised of senior staff from state, Federal, municipal agencies and non-profit organizations with specific expertise in the HRE study area and a willingness to spend time and effort reviewing documents and addressing the issues identified. Members are expected to comment on the project and disseminate information about the program to their agencies and organizations. This group has been provided with draft CRP materials, such as the measurable objectives and site-specific and estuary-wide restoration implementation plans, on which to review. They will also help to identify successes and lessons learned, identify potential regulatory hurdles, and re-evaluate the appropriateness of the program goals periodically. The CRP Workgroup could be an appropriate mechanism for regulatory agencies and stakeholders to guide the management of the CRP going into the future and could be integrated into the adaptive management strategy for the CRP.

The CRP incorporates a level of technical refinement to restoration in the HRE study area not previously attempted, raising issues of feasibility and ecological iterations. Given the broad range of TEC objectives, one cannot expect a dedicated CRP staff to maintain the level of expertise needed to address all of the potential questions that will be generated through the implementation of the plan. Future refinements to the CRP and interpretation of monitoring results would require the collective judgment of a technical staff that is current in the field of restoration ecology. The HRF represents an organization equipped to guide technical aspects of the CRP.

To continue in their scientific advisory role, the HRF advanced the TEC concept and gained stakeholder support for the TECs utilizing their experience with engaging specialized expertise and distilling a technically sound position with regard to environmental issues in the HRE study area. The HRF has demonstrated the ability to bring technical experts together in the region in a productive format to provide technical guidance. Consultation with HRF will continue to provide technical guidance to prospective project sponsors, to review project proposals, to review project monitoring data, and to work with a CRP staff in refining the CRP, as needed.

5.2.3 Tracking Performance at the Estuary-Scale

The TECs provide a means to measure existing and future environmental conditions in the HRE study area. Tracking TEC performance and maintaining an accurate, comprehensive database of project sites and estuary-wide changes should be a priority of the CRP management team. However, collecting and tracking project-specific data will depend on restoration practitioners voluntarily providing this information and project updates to a central location. To ensure that information is collected, the management team also needs to actively seek and retrieve the information. .

To effectively track and provide environmental data, the CRP management team should solicit, summarize and make available to the broader community information from restoration practitioners, such as:

- Project name and sponsors
- Project Objective (e.g., applicable TECs)
- Project location and total project size (if possible, a mapped perimeter with GPS coordinates)
- Created/restored habitat types and their acreages preserved or restored
- Total project cost
- Status updates: Planning/Feasibility, Construction, Post-Construction Monitoring, Construction Completed, Acquisition Completed, etc.

Ideally, restoration practitioners would also be able to post photographs, data, graphics and/or any reports generated from the construction or monitoring phases. These reports would be extremely valuable to those interested in conducting restoration and seeking guidance. This type of documentation would also help the CRP management team in determining project success and assessing functional performance of the TECs, and planning further restoration efforts.

Regular reporting of acreages restored per TEC by planning region, as well as a cumulative total per TEC for the HRE study area will help maintain interest in the program and track success in meeting its short and long-term goals. This will aid in determining if current actions and resources are sufficient. The habitats restored and protected and their acreages should be reported to the USEPA for inclusion in the National Estuary Program, to show how the HRE study area is contributing to national restoration efforts.

Data from the environmental monitoring programs should periodically be summarized in 'Health of the Harbor' reports, similar to the one published in 2004 for the estuary. Generating reports helps to identify data gaps and information needs. Currently, determining trends in environmental health in the HRE study area is difficult or impossible for some categories because detailed information is incomplete. Future monitoring programs may help to fill in these gaps, especially if government or stakeholder programs are initiated on an estuary-wide scale and data collection methods are kept consistent throughout the program.

Tracking Progress

Programmatic monitoring should address planning region and estuary-wide trends, evaluating whether TEC target statements are being met and what steps should be taken to ensure they are met. Programmatic monitoring can also include posting workgroup and committee activities, outreach activities completed, research and restoration milestones, the amount of funding spent, and changes in public awareness and perception of the program (USEPA 2005). It may be beneficial to monitor whether partners follow-through on their commitments and what might be preventing them from doing so (USEPA 2005).

Many of these topics could be documented in an environmental report card for the HRE study area, which could be produced every two to three years. A matrix of TECs by planning region could show progress toward the targets by assigning a number, letter, or color-coded symbol to each cell, and then give an overall estuary-wide score for that TEC. Beneath each TEC, text could be written to describe major projects or provide explanations why certain TECs may have received low scores.

The report card could also discuss critical needs and educate the public on emerging issues or new priorities within the estuary (USEPA 2005).

General recommendations to consider during plan implementation include:

- Build upon existing monitoring efforts, and use the HEP Workgroups or other group as a coordinating body to fill data gaps;
- Adopt monitoring protocols to provide a consistent means for comparing information across geographical and temporal scales; and
- Continue efforts to develop an estuarine-wide database from which to share data

5.2.4 Adaptive Management

Adaptive management has been an important planning and assessment tool in ecosystem restoration and is based on the approach of "learning by doing" (Walters and Holling 1990) and is critical to success in a developing science that depends on many factors that cannot always be predicted in advance. Adaptive management requires monitoring the condition of the system using selected indicators, assessing progress using previously established goals and performance criteria, and making decisions when corrective actions are needed. When the goals or performance criteria are not met, corrective actions based on the monitoring data should be implemented. Other actions include doing nothing or modifying the goal to a different but equally acceptable state. The final component of an adaptive management program involves incorporating successful techniques and lessons learned into successive projects within the same program or geographic range. Adaptive management recognizes and prepares for uncertain outcomes, and if established early in the planning phase and correctly implemented through the assessment phase, adaptive management can be a valuable tool for efficiently improving program performance.

All facets of the CRP can be adaptively managed. Each restoration project implemented as part of the CRP should incorporate a monitoring element sufficient to support adaptive management options. This approach will ensure the highest probability of success and verify that sites have been set on a trajectory to meet the project's goals. By employing these corrective measures at future restoration sites throughout the estuary successes will be improved (vs. no action) and lessons learned can be used to improve success of the next project, thereby bringing the HRE study area closer to its restoration goal more quickly and efficiently.

5.2.5 Future CRP Updates

The CRP has been developed with input from Federal, state, academic, non-governmental organization representatives, and interested citizens. It has been an extensive endeavor to assemble a comprehensive study of HRE restoration concerns and potential solutions. The actions recommended in the CRP were based on the current understanding of conditions, as they existed at the time the plan was developed. Over the years, new data will be collected, conditions may change, regulatory and funding programs may change, and new projects affecting water resources may be proposed within the region. In addition, the implementation process may result in some modifications of the recommended actions. As lessons are learned, the feedback should improve success rate, reduces risk, increase efficiency and effectiveness of future actions.

The CRP is a long-term strategy for restoration in the HRE study area, and thus should be periodically reviewed and updated to acknowledge successes, outline new restoration targets, specify implementation schedules, and reaffirm commitments to the estuary and its stakeholders. This review should be carried out by the Project Management Team, in conjunction with all the interested parties and should address:

- What actions have been implemented?
- What TECs have been addressed?
- Is the overall intent of the plan being met?
- Is there new information or are changing conditions occurring?
- Are there new concerns not originally considered that need resolution?

During this process, it may also be advantageous to evaluate the structure established to manage the CRP. How this plan is managed directly relates to program momentum and success and can affect how decisions are reached, what perceptions are held, and which organizations are most influential (USEPA 2005). Although the CRP is a planning document to coordinate stakeholders and build consensus, conflicts among jurisdictions, agencies, and the public are inevitable. Therefore, updates to the plan can propose ways to resolve these conflicts and restore a balance of power and influence among stakeholders.

References

Able, K. W., and J. T. Duffy-Anderson. 2006. Impacts of piers on juvenile fishes in the Lower Hudson River. Pages 428-440 in Levinton, J. S., and J. R. Waldman, editors. The Hudson River Estuary. Cambridge University Press, Cambridge, New York.

Adams, D., and S. Benyi. 2003. Sediment quality of the NY/NJ Harbor system : A 5 year revisit. U.S. Environmental Protection Agency. Final Report. EPA/902-R-03 2003.

Bain, M., J. Lodge, D.J. Suszkowski, D. Botkin, A. Brash, C. Craft, R. Diaz, K. Farley, Y. Gelb, J.S. Levinton, W. Matuszeski, F. Steimle and P. Wilber. 2007. Target Ecosystem Characteristics for the Hudson Raritan Estuary: Technical Guidance for Developing a Comprehensive Ecosystem Restoration Plan. A report to the Port Authority of NY/NJ. Hudson River Foundation, New York, NY. 106 pp.

Barbour, M.G., J.H. Burk, W.D. Pitts, F.S. Gilliam, M.W. Schwartz. 1999. Terrestrial plant ecology. Third edition. Benjamin/ Cummings, an imprint of Addison Wesley Longman, Inc. Menlo Park, CA.

Bernick, A. J. 2006. New York City Audubon's Harbor Herons Project: 2006 Interim Nesting Survey. New York, NY: New York City Audubon Society.

Bernick, A.J. 2007. New York City Audubon's Harbor Herons Project: 2007 Nesting Survey. Prepared for the New York City Audubon. New York, NY.

Blanchard, P. P., P. Kerlinger, and M. J. Stein. 2001. An islanded nature: Natural area conservation and restoration in Western Staten Island, including the Harbor Herons Region. The Trust for Public Land and the New York City Audubon Society.

Coen, L. D., and M. W. Luckenbach. 2000. Developing success criteria and goals for evaluating oyster reef restoration: Ecological function or resource exploitation? Ecological Engineering 15(3-4):323-343.

Costanza R., R. d'Arge, R. de Groot, S. Farber, M. Grasso, B. Hannon, K. Limburg, S. Naeem, R.V. O'Neill, J. Paruelo, R.G. Raskin, P. Sutton, M. van den Belt. 1997. The value of the world's ecosystem services and natural capital. Nature 387:253-260.

Department of City Planning. 2006. New York City population projections by age/sex and borough, 2000-2030. Briefing booklet by the City of New York, NY.

Durkas, S. J. 1992. Impediments to the spawning success of anadromous fish in tributaries of the NY/NJ Harbor watershed. A report prepared for the American Littoral Society Baykeeper, Sandy Hook Highlands, NJ.

Durkas, S. J. 1993. A Guideline to restore anadromous fish runs in selected tributaries of the NY/NJ Harbor watershed. A report prepared for the American Littoral Society Baykeeper, Sandy Hook Highlands, NJ.

Edinger, G.J., D.J. Evans, S. Gebauer, T.G. Howard, D.M. Hunt, and A.M. Olivero (editors). 2002. Ecological communities of New York State. Second edition. A revised and expanded edition of Carol Reschke's Ecological Communities of New York State. (Draft for review). New York Natural Heritage Program, New York Department of Environmental Conservation, Albany, NY.

Federal Aviation Administration, U.S. Department of Transportation (FAA). 2007. Hazardous wildlife attractants on or near airports. Advisory Circular: 150/5200-33B.

Findlay, S., C. Wigand, and W. C. Nieder. 2006. Submersed macrophyte distribution and function in the tidal freshwater Hudson River. Pages 230-241 in Levinton, J. S., and J. R. Waldman, editors. The Hudson River Estuary. Cambridge University Press, Cambridge, New York.

Fonseca, M.S., W.J. Kenworthy, and G.W. Thayer. 1998. Guidelines for the conservation and restoration of seagrasses in the United States and adjacent waters. NOAA Coastal Ocean Program Decision Analysis Series No. 12. NOAA Coastal Ocean Office, Silver Spring, MD.

Fonseca, M.S., W.J. Kenworthy, D.R. Colby, K.A. Rittmaster, and G.W. Thayer. 1990. Comparisons of fauna among natural and transplanted eelgrass Zostera marina meadows: criteria for mitigation. Marine Ecology Progress Series 65:251-264.

Gibbons, S., and C. Yuhas. 2005. Combined Sewer Overflows: What's happening in New York City. The Tidal Exchange. Autumn 2005. NY/NJ Harbor Estuary Program.

Gibson, R.J., R.L. Haedrich, and C.M. Wernerheim. 2005. Loss of fish habitat as a consequence of inappropriately constructed stream crossings. Fisheries 30(1): 10-17.

Good, R.E., N.F. Good, and B.R. Frasco. 1982. A review of primary production and decomposition dynamics of the belowground marsh component. pp. 139-157 in: V.S. Kennedy, Ed., Estuarine Comparisons. Academic Press, NY.

Harding, J. M., and R. Mann. 1999. Fish species richness in relation to restored oyster reefs, Piankatank River, Virginia. Bulletin of Marine Science 65(1): 289-300.

HEP. 1996. New York-New Jersey Harbor Estuary Program, Final Comprehensive Conservation and Management Plan. New York/New Jersey Harbor Estuary Program, New York, NY.

Homziak, J., M.S. Fonseca, and W.J. Kenworthy. (1982). Macrobenthic community structure in a transplanted eelgrass meadow. Marine Ecology Progress Series 9:211-21.

Hudson River Park. 2008. Hudson River Park Estuarine Sanctuary. http://www.hudsonriverpark.org/estuary/index.asp

Hudson River Estuary Program. 2009. New York State Department of Environmental Conservation. Accessed January 4, 2009. http://www.dec.ny.gov/lands/4920.html

Hydroqual. 2007. A model for the evaluation and management of contaminants of concern in water, sediment, and biota in the NY/NJ Estuary: Contaminant Fate and Transport and Bioaccumulation Sub-models. Contamination Assessment and Reduction Program.

Kemp, M.W., R. Batiuk, R. Bartleson, P. Bergstrom, V. Carter, C.L. Gallegos, W. Hunley, L. Karrh, E.W. Koch, J.M. Landwehr, K.A. Moore, L. Murray, M. Naylor, N.B. Rybicki, J.C. Stevenson, D.J. Wilcox. 2004. Habitat requirements for submerged aquatic vegetation in Chesapeake Bay: water quality, light regime, and physical-chemical factors. Estuaries 27(3):363-377.

Kennish, M. J. 2002. Environmental threats and environmental future of estuaries. Environmental Conservation 29(1):78-107.

Kerlinger, P. 2004. New York City Audubon Society's Harbor Herons Project: 2004 Nesting Survey. New York, NY: New York City Audubon Society.

Kreske, D.L. 1996. Environmental Impact Statements: A practical guide for agencies, citizens, and consultants. John Wiley & Sons, Inc., New York, NY.

Leslie, L.L., C.E. Velez, and S.A. Bonar. 2004. Utilizing volunteers on fisheries projects: benefits, challenges, and management techniques. Fisheries 29(10): 10-14.

Levinton, J. S., and J. R. Waldman. 2006. The Hudson River Estuary. Cambridge University Press, Cambridge, New York.

Lindstedt, D. M., and E. M. Swenson. 2006. The case of the dying marsh grass. Louisiana Department of Natural Resources. In partial fulfillment of DNR Interagency Agreement No. 2512-05-12.

MacKenzie, C. L. 1992. The Fisheries of Raritan Bay. Rutgers University Press, New Brunswick, NJ.

Mayo, R., F. Serchuk, and E. Holmes. 2006. Status of fishery resources off the Northeastern United States. NOAA's National Marine Fisheries Service Northeast Fisheries Science Center. http://www.nefsc.noaa.gov/sos/

National Biological Service. 1995. Ecology of maritime forests of the southern Atlantic coast: A community profile. U.S. Department of the Interior, Biological Report 30.

National Research Council. 1992. Restoration of Aquatic Ecosystems: Science, Technology, and Public Policy. National Academy Press, Washington, DC.

Neckles, H. and M. Dionne. (1999). Regional standards to identify and evaluate tidal wetland restoration in the Gulf of Maine. A GPAC Workshop, June 2-3, 1999. Wells National Estuarine Research Reserve, Wells, ME.

New Jersey Department of Environmental Protection. 2008. Fish Smart Eat Smart NJ http://www.state.nj.us/dep/dsr/njmainfish.htm

New Jersey Department of Environmental Protection. http://www.state.nj.us/dep/

New York City Department of City Planning (NYCDCP) 2007. PlaNYC A Greener Greater New York. The City of New York: Mayor Michael R. Bloomberg.

New York City Department of Environmental Protection. 2003. New York Harbor Water Quality Regional Summary. New York City, NY.

New York City Department of Environmental Protection. 2004. New York Harbor Water Quality Regional Summary. New York City, NY.

New York City Department of Parks and Recreation, Natural Resources Group. 2008. http://www.nycgovparks.org/sub_about/parks_divisions/nrg/nrg_home.html

New York - New Jersey Harbor Estuary Program (HEP) 2008. Regional Sediment Management Plan for the NY/NJ Harbor Estuary.

New York State Department of Environmental Conservation. 2001. Tidal wetland losses, Jamaica Bay, Queens County,NY. http://www.dec.ny.gov/lands/5489.html.

New York State Department of Environmental Conservation 2009. Hudson River Estuary Program. http://www.dec.ny.gov/lands/4920.html

New York State Department of Conservation. 2008. http://www.dec.state.ny.us/

New York State Department of Health. 2008. 2008-2009 Health Advisories on eating sportfish. http://www.health.state.ny.us/environmental/outdoors/fish/fishengl.htm

New York State Department of State. 2008. Public Trust Doctrine. http://www.nyswaterfronts.com/waterfront_public_trust.asp

Niedowski, N. L. 2000. New York State Salt Marsh Restoration and Monitoring Guidelines. A report prepared for the New York State Department of State, Division of Coastal Resources and New York State Department of Environmental Conservation.

Olsvig, L.S., J.F. Cryan, and R.H. Whittaker. 1998. Vegetational gradients of the pine plains and barrens of Long Island, New York. pp. 265-282 in: R.T.T. Forman, ed. Pine Barrens: Ecosystem and landscape. Rutgers University Press, New Brunswick, NJ.

Orth, R.J., M. Luckenbach, and K.A. Moore. 1994. Seed dispersal in a marine macrophyte: implications for colonization and restoration. Ecology 75:1927-39.

Parkman, A. 1983. History of the waterways of the Atlantic Coast of the United States. National Waterways Study, U.S. Army Corps of Engineers Water Resources Support Center, Institute for Water Resources. Navigation History NWS-83-10.

Passaic Valley Sewerage Commissioners. 2008. River Restoration. http://www.pvsc.com/rr/about.htm

Pastorok, R.A., A. MacDonald, J.R. Sampson, P. Wilber, D.J. Yozzo, and J.P. Titre. 1997. An ecological decision framework for environmental restoration projects. Ecological Engineering 9:89-107.

Peckarsky, B.L., P.R. Fraissinet, M.A. Penton, and D.J. Conklin, Jr. 1990. Freshwater macroinvertebrates of Northeastern North America. Cornell University Press. Ithaca, NY.

Pickerell, C.H., S. Schott, and S. Wyllie-Echeverria. 2005. Buoy deployed seeding: Demonstration of a new eelgrass (Zostera marina L.) planting method. Ecological Engineering 25:127-136.

Reilly, F.J., R.J. Spagnolo, and E. Ambrogio. 1996. Marine and estuarine shallow water science and management. Estuaries 19(2A):165-168.

Reschke, C. 1990. Ecological Communities of New York State. New York Natural Heritage Program, New York Department of Environmental Conservation, Latham, NY. 96p. +xi.

Rutgers Environmental Research Clinic (RERC) 2008. Benthic Habitat Restoration. http://rerc.rutgers.edu/benthic/index.html.

Sanderson, E. W. 2005. Urban Legend: Discovering Manahatta's wetlands. National Wetlands Newsletter 27(1).

Seitz, S., and S. Miller. 2001. The Other Islands of New York City: A history and guide. Second edition. The Countryman Press, Woodstock, Vermont.

Seneca, E. D., and S. W. Broome. 1992. Restoring tidal marshes in North Carolina and France. Pages 53-78 in G. W. Thayer, editor. Restoring the nation's marine environment. Maryland Sea Grant College, College Park, Maryland.

Short, F.T., L.K. Muehlstein, and D. Porter. 1987. Eelgrass wasting disease: Cause and recurrence of a marine epidemic. Biological Bulletin 173:557-62.

Simenstad, C.A., W.G. Hood, R.M. Thom, D.A. Levy, D.L. Bottom. 2000. Landscape structure and scale constraints on restoring estuarine wetlands for Pacific coast juvenile fishes. Pages 597-630 in M. P. Weinstein and D. A. Kreeger, editors. Concepts and controversies in tidal marsh ecology. Kluwer Academic Publishers, Dordrecht, Netherlands.

Smith, I., M.S. Fonseca, J.A. Rivera, and K.A. Rittmaster. (1989). Habitat value of natural versus recently transplanted eelgrass, Zostera marina, for the bay scallop, Argopecten irradians. Fishery Bulletin 87:189-96.

Squires, D. F. 1992. Quantifying anthropogenic shoreline modification of the Hudson River and estuary from European contact to modern time. Coastal Management 20:343-354.

Stanley, J.G., and R. DeWitt. 1983. Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (Mid-Atlantic) – Hard Clam. U.S. Fish & Wildlife Service Biological Report 82 (11.41). U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg MS. Technical Report EL-82-4.

Steinberg, N., D.J. Suszkowski, L. Clark, and J. Way. 2004. Health of the Harbor: The first comprehensive look at the state of the NY/NJ Harbor Estuary. A report to the NY/NJ Harbor Estuary Program. Hudson River Foundation, New York, NY. 82pp.

Thayer, G.W., S.M. Adams, and M.W. LaCroix. (1975). Structural and functional aspects of a recently established Zostera marina community. pp. 518-540 in: L.E. Cronin (Ed.) Estuarine Research. Academic Press, New York.

The New York Waterfront: Evolution and building culture of the Port and Harbor. 1997. Kevin Bone, ed. Monacelli Press, Inc., New York.

The New York/New Jersey Baykeeper. 2007. http://www.nynjbaykeeper.org/

The Regional Plan Association. 2003. Needs and Opportunities for Environmental Restoration in the Hudson-Raritan Estuary. Unpublished report submitted by the Regional Planning Association to the U.S. Army Corps of Engineers, New York District, New York, NY.

The Tidal Exchange. Winter 1990. Newsletter of the NY/NJ Harbor Estuary Program & NY Bight Restoration Plan.

Thom, R.M. 1990. A review of eelgrass (Zostera marina L.) transplanting projects in the Pacific Northwest. The Northwest Environmental Journal 6:121-37.

U.S. Census Bureau. 2005. Population Estimates Program. www.census.gov.

USACE. 1999. Environmental Impact Statement for the New York and New Jersey Harbor Navigation Study. Final Report. U.S. Army Corps of Engineers, New York District, New York, NY.

USACE. 2000. Draft Expedited Reconnaissance Study: Hudson-Raritan Estuary Environmental Restoration.

USACE. 2004a. Hudson-Raritan Estuary Environmental Restoration Feasibility Study. Study Area Reports. U.S. Army Corps of Engineers, New York District, New York, NY."

USACE. 2004b. Meadowlands Environmental Site Investigation Compilation (MESIC): Hudson-Raritan Estuary, Hackensack Meadowlands, New Jersey. Final Report. U.S. Army Corps of Engineers, New York District, New York, NY.

USACE. 2004c. Liberty State Park Environmental Resources Inventory. Draft Report. U.S. Army Corps of Engineers, New York District, New York, NY.

USACE. 2005b. Restoration authorities of the U.S. Army Corps of Engineers: A Discussion Paper. Environmental Advisory Board of the U.S. Army Corps of Engineers.

USACE. 2006a. Hudson-Raritan Estuary Ecosystem Restoration Study: Building a world-class estuary. Brochure. U.S. Army Corps of Engineers, New York District, New York, NY.

USACE. 2006b. Stemming the Tide of Marsh Loss in Jamaica Bay With $13M Urban Wetlands Project. http://www.nan.usace.army.mil/news/newsrels/marsh.pdf

USACE. 2008a. Lower Passaic River Commercial Navigation Analysis. U.S. Army Corps of Engineers, New York District, New York, NY."
www.ourpassaic.org

USACE. 2008b. Dredged material management plan for the Port of New York and New Jersey: Volume I. 2008 Update. U.S. Army Corps of Engineers, New York District, New York, NY.

USEPA. 2005. Chapter 5: Implementing the Management Plan. Community-based watershed management: Lessons from the National Estuary Program. EPA 842-B-05-003.

USEPA. 2008. Hudson River PCB's. http://www.epa.gov/hudson/

USEPA and USACE, 2008. Compensatory Mitigation for Losses of Aquatic Resources. Federal Register: April 10, 2008. Volume 73, Number 70.

USFWS. 1997. Significant Habitats and Habitat Complexes of the New York Bight Watershed. Coastal Ecosystem Program.

Vittor & Associates. 2005. Norton Basin/Little Bay technical summary report: 2000-2003 baseline surveys. Prepared for New York District, U.S. Army Corps of Engineers, New York, NY. Barry A. Vittor & Associates, Inc, Lake Katrine, NY.

Weinstein, M.P., J.H. Balletto, J.M. Teal, and D.F. Ludwig. 1997. Success criteria and adaptive management for a large-scale wetland restoration project. Wetlands Ecology and Management 4:111-127.

Wintermyer M. and Cooper K, 2003. "Dioxin/Furan and PCB concentrations in easter oyster (Crassostrea virginica, Gmelin) tissues and the effects on egg fertilization nad development." Journal of Shellfish Research. 22(3):737-746.

Yozzo, D., and J. Sexton. 1996. Planning and evaluating restoration of aquatic habitats from an ecological perspective. IWR Report 96-EL-4. Prepared for the U.S. Army Corps of Engineers, Waterways Experiment Station, MS and Institute for Water Resources, VA.

Yozzo, D.J., J.E. Davis, and P.T. Cagney. 2003. Coastal Engineering for Environmental Enhancement. Chapter V – 7: in: L. Vincent and Z. Demirbilek, (eds.), Coastal Engineering Manual, EM-1110-2-1100, U.S. Army Corps of Engineers, Washington, D.C.

Yozzo, D.J., J.M. Rhoads, P. Wilber, W. Nuckols, L. Hollen, and R. Will. 2001. Beneficial uses of dredged material for habitat creation, enhancement, and restoration in NY/NJ Harbor. U.S. Army Corps of Engineers, New York District, New York, NY.

Yozzo, D.J., P. Wilber, R.J. Will. 2004. Beneficial use of dredged material for habitat creation, enhancement, and restoration in New York—New Jersey Harbor. Journal of Environmental Management 73:39-52.

Zieman, J.C. 1982. The ecology of seagrasses of south Florida: a community profile. U.S. Fish and Wildlife Service USFWS/ OBS-82/25. 158 p.

Hudson-Raritan Estuary
Draft Comprehensive Restoration Plan
Contributing Authors

U.S. Army Corps of Engineers
Lisa Baron
Peter Weppler
Jodi McDonald
Olivia Cackler
Jeffrey Cusano
Susan Ryan-Stumpf
Sean Stumpf
Gail Woolley
Kerry Anne Donohue

HDR Inc.
Jennifer Curran
Laura Csoboth
David Yozzo
Kevin VerWeire
Ronald Alevras

URS Corporation
John Dromsky-Reed

The Port Authority of NY & NJ
Rosalie Siegel
Christopher Zeppie

New York - New Jersey Harbor Estuary Program
Robert Nyman, USEPA, HEP Coordinator
Alexander Brash, NPCA, Habitat Workgroup Chairman

Hudson River Foundation
James Lodge
Dennis Suszkowski

Special Acknowledgements

U.S. Army Corps of Engineers
Leonard Houston

Paul Sabalis
William Slezak
Thomas Hodson
Joseph Redican
Robert Will
Darin Damiani
Roselle Henn
Bobbi Jo McClain

Cornell University
Mark Bain

Regional Planning Authority
Albert Appleton

Target Ecosystem Characteristics Work Groups
See Appendix A for complete list of all participants in the TEC workshops