HUDSON-RARITAN ESTUARY
ENVIRONMENTAL RESTORATION FEASIBILITY
STUDY

UPPER BAY

STUDY AREA REPORT

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U.S. Army Corps
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New York District

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I. INTRODUCTION

Background

1. The New York District of the Corps of Engineers (the District) is conducting a feasibility study for ecosystem restoration in the Hudson-Raritan Estuary (the Estuary) – the Hudson-Raritan Estuary Ecosystem Restoration Study, herein referred to as "HRE". The study area is delineated as the Port District, an area surrounding greater metropolitan New York City within an approximate 25-mile radius of the Statue of Liberty (Figure 1). However, for purposes of ecological continuity the actual study area may include additional portions of this system beyond the man-made Port District boundary.

2. The overall goal of the HRE is to restore ecological function and diversity that have been lost or degraded as a result of human activities. The HRE will rely on both existing and newly obtained natural resource data to identify areas to be restored or conditions that must be addressed to assure successful ecosystem restoration. The two primary components of the study are the preparation of a Comprehensive Restoration Implementation Plan (CRIP) and the implementation of restorations/enhancements at various locations in the Estuary.

3. The purpose of the CRIP is to serve as a master plan that lays out a comprehensive and coordinated strategy that, when implemented, will guide the ecological restoration of the Estuary. The CRIP will establish a framework within which the actions needed for successful restorations can be holistically evaluated and planned. The plan will address actions to enhance, expand, recreate, and diversify natural habitats, and actions to eliminate constraints to ecological functions, such as sediment contamination. The CRIP will describe the strategy for restoration efforts that will include immediate, mid-term, and long-range options. It will also provide a central focus for public input, data collection, restoration efforts, and management actions and policies, regardless of who might have authority, desire and/or funds to undertake any action.

Study Area Delineation of the Estuary

4. To get a more manageable and understandable picture of the Estuary, its history of degradation, local needs and desires, potential restoration opportunities, and current restoration efforts will be documented in eight Study Area Reports (SARs). The study area boundaries are typically delineated by major watersheds and/or major physical features, such as highways or waterways. By and large, each study area can be characterized by its ecological functions, history of degradation, and resulting needs and opportunities. For example, Jamaica Bay, a historically expansive wetlands complex, has been subject to extensive fill and loss of wetlands; the Hudson River system, to hardened shorelines and contaminated sediment; and the Lower Bay contains coastal and offshore environments, experiencing loss of dunes and benthic habitat. Separating the project area into smaller study areas will enable the study team and potential stakeholders to address study area-specific restoration needs as well as individual restoration opportunities within each study area, and to collect and characterize data in a more usable and understandable way, all under the ultimate umbrella of the CRIP, which links the study areas into one major plan.

5. The eight study areas to be included in the CRIP are as follows (see Figure 1):

1) Jamaica Bay,
2) Lower Bay,
3) Lower Raritan River,
4) Arthur Kill/Kill van Kull,
5) Newark Bay/Hackensack River/Passaic River,
6) Lower Hudson River,
7) Harlem River/East River/Western Long Island Sound,
8) Upper Bay.

Purpose of the Study Area Reports

6. The identification of potential restoration opportunities in each study area will be a two-fold process. First, the District will identify potential restoration sites based upon a preliminary needs and opportunities survey of various interested groups/agencies conducted by the Regional Planning

Association (RPA) and presented in their Needs and Opportunities Report. This information will be supplemented by additional analyses of restoration needs and opportunities on a more local level. Study area needs will be determined based upon the causes of ecosystem degradation and the condition of existing natural resources in each study area. This effort is already underway (but far from completed) and potential restoration sites in the Upper Bay study area have been identified.

7. Second, the District will hold stakeholder meetings in each study area. The purpose of these meetings will be to incorporate additional comments from environmental organizations, community groups, and other individuals and stakeholders in each study area. This process will ensure the needs and opinions of as wide and diverse a group as possible is incorporated into the CRIP.

Format of the Report

8. This SAR addresses the Upper Bay study area (Figure 2). The **Study Area Description** section describes the setting, history of degradation, existing land/water usage, and existing natural resources in the study area. Restoration needs and existing restoration efforts are summarized in the **Ecosystem Restoration** section.

II. STUDY AREA DESCRIPTION

Setting

9. The Upper Bay is at the mouth of the Hudson River, where it converges with the East River and includes upland portions of the Boroughs of Manhattan, Brooklyn, and Staten Island, as well as Jersey City and Bayonne, New Jersey. The Upper Bay is separated from the Lower Bay by the Verrazano Narrows and is connected to the Arthur Kill study area by the Kill van Kull (Figure 2).

Study Area History

10. The recorded history of the Hudson River and New York Harbor began with its exploration by Henry Hudson in 1609. Dutch colonists subsequently settled an area near the mouth of the Hudson River, which eventually became New York City. A thriving natural port, the Dutch colony welcomed people from different nations who were willing to work. By the 1640s, there were 18 different languages spoken in the city.

11. The city grew fairly rapidly during Colonial times, due to its central location within the colonies and its large natural harbor. Following the American Revolution, the Hudson River Valley became an area of industrialization, and New York became the economic capital of the new nation. The introduction of steamboat travel in 1807 was instrumental in getting people and supplies up and down the Hudson River and promoting development of the city. By 1850, estimates suggest that roughly 150 vessels carried as many as a million passengers each year (HTRC, 2002). During the industrial period, the Hudson River served as the nation's first great commercial transportation artery, linking the growing New York City to the west by the Erie Canal, and to the coal mines of Pennsylvania by the Delaware and Hudson Canal.

12. In 1825, New York was peaceful, orderly, and rural city, with a population of under 175,000. However, a huge wave of immigration from Europe in the 19th century brought hundreds of thousands of new arrivals, spurred by the Irish famine, and German political and economic unrest, and inspired by the opening of land in the West, causing a huge surge in the New York City population. By the end of the 19th century, New York had grown into a world-class city; only Tokyo and London would be bigger.

13. The city continued to expand in the 20th century as the country's primary port. To accommodate the tremendous vessel traffic, hundreds of piers and dozens of shipping terminals were constructed on the shores of the upper, well-protected harbor. Construction of the terminals and piers required hundreds of thousands of cubic yards of fill. Hardly any piece of natural shoreline was untouched during development in the upper harbor.

14. Today, much of the maritime cargo traffic in the New York City region has moved to Port Newark and Port Elizabeth in Newark Bay. Terminals in Brooklyn have closed, and smaller terminals in Bayonne, New Jersey and the Red Hook section of Brooklyn are threatened. Closure of many of the terminals and facilities along the upper bay shoreline has resulted in a continuing deterioration of the piers, bulkheads, and old terminal buildings. Many are in such a deteriorated state that they have been condemned.

History of Degradation

15. Most of the wetlands and upland areas in the study area have been filled to accommodate commercial, residential, and industrial development. With the exception of small areas in Bayonne adjacent to the U.S. Military Ocean Terminal (MOTBY) and at Caven Point, the entire shoreline of the Upper Bay has been hardened with bulkheads or riprap.

16. The contamination of both marine sediments by chemical pollutants and heavy metals, and the resulting spread of those materials through aquatic and terrestrial food chains have been recognized as key environmental problems in the Estuary. Numerous studies of the problems have been undertaken by various organizations and agencies, including the Environmental Protection Agency, the National Oceanic and Atmospheric Administration (NOAA), the USACE, and the States of New York and New Jersey, which have focused on the relationship between sediment contaminant levels and benthic habitat quality. Previous studies have identified areas within the Upper Bay study area as containing slightly elevated levels of chromium and nickel. More detailed discussions and results of past and current studies of sediment contamination are described in the more detail in the *Summary of Sediment Characterization Studies* (USACE – under development).

17. Land in the Upper Bay is almost entirely developed. As a result of the industrial history of the region, many remaining natural areas, including littoral zones and benthic habitat, are severely

degraded. A prime example of severe habitat degradation in the study area is the Gowanus Canal. The canal was constructed in the bed of the Gowanus Creek in 1848 to allow barge traffic to access heavily industrialized portions of Brooklyn. Wetlands surrounding the canal were then filled to support more industry. Industrial facilities adjacent to the canal discharged hazardous materials into the canal and the surrounding area. As a result, the sediments of the canal are highly toxic and water quality became so poor that few living organisms could survive in the canal.

18. Sediments in other small tributaries, canals, boat basins, and even abandoned inter-pier areas, in the Upper Bay likewise suffer from toxic contamination as a result of local runoff, CSOs, etc. However, there is minimal sediment deposition in the main body of the Upper Bay itself (almost no periodic maintenance of the Federal channels is required). This may be attributed to the extent of flushing in the bay due to the Hudson River, Kill Van Kull, East River, and Verrazano Narrows.

19. The industrial history of the study area has led to widespread soil contamination of the waterfront areas. For example, heavy metals (e.g., arsenic, lead, zinc, copper) and polyaromatic hydrocarbons (PAHs) are found in nearly all of the fill sediments in the areas surrounding Liberty State Park, in New Jersey. Additionally, fill materials also contain volatile organic compounds (VOCs), chromium, PCBs, and organochlorine pesticides (e.g., dieldrin, DDT).

20. Historically, the study area consisted of extensive tidal salt marshes dominated by species including smooth cordgrass (*Spartina alterniflora*) and saltmeadow cordgrass (*Spartina patens*). Most of these marshes were filled or disturbed to construct industrial facilities, railroad terminals, and other commercial facilities. Shallow water habitats in the study area were dredged to allow passage or docking of commercial shipping vessels. Other portions of the shoreline were filled and stabilized using bulkheads, seawalls, or riprap.

21. The majority of remaining, undeveloped wetland and upland habitats in the Upper Bay study area have, in fact, been disturbed at one time or another. As a result invasive, non-native species have colonized these disturbed habitats. Areas dominated by these species generally represent low-quality wildlife habitat. For example, much of the interior of Liberty State Park, while natural in appearance, is the result of natural reclamation of the former rail yard and terminal. Colonizing species in this type of environment are typically more hearty, invasive species, such as common

reed (*Phragmites communis*) that essentially out-compete native species and form wetlands and other habitats of different and often less diverse and valuable habitat when compared to historical conditions.

22. Hydrologic modifications and construction of man-made structures such as bridges, dams, and tide gates have restricted tidal flow in numerous locations. This restricted flow has led to the degradation of wetland habitats, allowed for invasion by common reed, and led to the decline of historically productive oyster beds. These structures also act as impediments to anadromous fish.

23. As early as the mid-19th century, the Upper Bay was subject to dredging. Channels were dredged to rail terminals in Bayonne and Brooklyn, as well as to Ellis Island. In 1917, the main channel, Anchorage Channel, was first deepened to allow larger ship traffic into the harbor. In addition to channels, the Red Hook Flats, a large natural expanse of shallow water between the Bayridge Channel and the Anchorage Channel, has also been deepened to serve as a primary anchorage for shipping in New York, where vessels wait for access to berths or to offload cargo to smaller craft. Channel deepening and the existing anchorages have resulted in a significant loss of natural benthic habitat in the Upper Bay.

Existing Land/Water Usage

24. Most the shorefront land use within the Upper Bay is commercial and industrial. Along the waterfront, land and water uses include shipping terminals, marinas and other marine-related activities which are completely or partially abandoned. In addition, there are other non-marine industries intermingled with parkland or public promenades, some vacant disturbed or filled land (wetlands and uplands), a few tidal wetlands, and a sprinkling of residential land. Few public parks and open spaces are present in the study area. Existing parks include Liberty State Park and West Side Park, however, these are not “natural” areas but are bulkheaded, recreational grasslands.

25. Two sewage treatment plants (STPs) discharge treated wastewater that is assimilated by the receiving waters: Passaic Valley in New Jersey and Owls Head in New York. There are no power plants withdrawing cooling water from the Upper Bay, and there are no public bathing beaches

within this study area. As stated previously, these waterways are used for commercial and recreational navigation and recreational activities including water/jet skiing and fishing.

Natural Resources Conditions

26. The few remaining salt marshes in the study area are dominated by cordgrass (*Spartina alterniflora, S. patens*), with black grass (*Juncus gerardii*), marsh elder (*Iva frutescens*), and groundsel bush (*Baccharis halimifolia*) present in the high-tide zone. Common reed (*Phragmites communis*) is invasive along many of the wetlands in the study area.

27. Remaining upland habitat consists of old field and scrub-shrub/woodland habitats. Frequently, disturbed old-field habitats are dominated by common mugwort (*Artemisa vulgaris*). In other places, old-field habitats are characterized by mixed forbs and grasses such as goldenrod (*Solidago* spp,), aster (*Aster* spp.), and switch grass (*Panicum virgatum*). Scrub-shrub/woodland habitats are characterized by species such as black cherry (*Prunus serotina*), bayberry (*Myrica cerifera*), sumac (*Rhus* spp.), black locust (*Robinia pseudoacacia*), tree-of-heaven (*Ailanthus altissima*), and common mugwort. Many of these upland communities exist on former wetlands that were filled with material that is contaminated, as discussed above. Other upland communities have grown on abandoned or vacant properties that are former developed sites.

28. The few remaining salt marshes in the study area support a variety of waterbirds. Great blue herons (*Ardea herodias*), great egrets (*Casmerodius albus*), snowy egrets (*Egretta thula*), black-crowned night herons (*Nycticorax nycticorax*) and double-crested cormorants (P*halacrocorax auritus*) commonly forage in the area. Diamond-backed terrapins (*Malaclemys terrapin terrapin*) are also found in the study area. Waterfowl species that use the study area include American black duck (*Anas rubripes*), Canada goose (*Branta Canadensis*), mallard (*Anas platyrhynchos*), and gadwall (*Anas strepera*). Mammals common to the study area include Norway rat (*Rattus norvegicus*), deer mouse (*Peromyscus maniculatus*), raccoon (*Procyon lotor*), striped skunk (*Mephitis mephitis*), and feral dogs (*Canis familaris*) and cats (*Felis catus*).

III. ECOSYSTEM RESTORATION

Hudson-Raritan Estuary Ecosystem

29. The New York-New Jersey Harbor Estuary Program (HEP 1996) has identified five primary factors that have caused ecosystem impairments or otherwise degraded water or habitat quality in the Estuary. These factors are:

- Habitat Loss and Degradation: Recent wetland inventories estimate at least 80% of the Estuary's wetlands have been lost or significantly altered.

- Toxic Contamination: The presence of toxins in the Estuary's waters, sediments, and biota is the result of historic and residual contamination by industrial and non-point sources. Today, wastewater discharges, combined sewer overflows (CSOs), accidental releases, vehicle exhaust emissions, household chemicals, pesticides, atmospheric deposition, landfill leachate, urban runoff, and other non-point sources are continuing sources of toxic substances (HEP 1996).

- Pathogens: The primary sources of pathogens include CSOs, sewage treatment plant malfunctions, illegal connections to storm sewers, vessel sewage discharge, urban runoff, and other non-point sources.

- Floatable Debris: Floatable debris is made up of two primary components: trash or litter and harbor drift. Trash and litter enters the Estuary via runoff, storm sewer discharges, CSOs, beach and boat litter, and poor solid waste handling operations. Harbor drift composed primarily of material from dilapidated shoreline structures such as piers, bulkheads, and pilings, is a significant of floatable debris in the Estuary.

- Nutrient and Organic Enrichment: Eutrophication due to excessive discharges of nitrogen is a significant problem in the Estuary. Organic matter comprised primarily of carbon is decomposed as DO and used in the biochemical process. Nitrogen and carbon enter the Estuary through point and non-point sources such as sewage

treatment plants, runoff (primarily from over-fertilized lawns), rivers and tributaries and atmospheric deposition.

Primary Restoration Needs of the Hudson-Raritan Estuary

30. The overall goal of the HRE is to restore and enhance aquatic and nearshore terrestrial habitats that have been lost or degraded as a result of human activities. To achieve this goal, primary restoration needs of the Estuary have been established. These categories were identified in the document entitled *Restoration Opportunities in the Hudson-Raritan Estuary* (USACE 2001). These need are:

- Restore and create intertidal wetlands and mudflats,
- Restore benthic habitats and remediate "hot spots" of contaminated sediments,
- Restore and create freshwater/riparian wetlands,
- Restore fish habitat (remove impediments to fish passage; construct artificial reefs),
- Restore shellfish habitat,
- Restore and enhance shoreline/coastal fringe habitat (including upland areas),
- Create, restore, or enhance vegetated and non-vegetated shallow water habitat.

Restoration Needs of the Upper Bay Study Area

31. Shoreline ecosystem degradation in the Upper Bay area has resulted primarily from urban development and hardening of the shoreline. Intense industrial use within the study area has caused sediment contamination in several areas in the Upper Bay. As a result, habitat quality in littoral or shallow, sheltered areas has been degraded. Therefore, the primary restoration needs in the study area are:

- Contaminated sediment removal,
- Restore shallow water habitat,
- Wetlands restoration,

- Upland restoration,

- Soften shorelines.

32. The Upper Bay study area is an important component of the Estuary because it connects the Lower Hudson River study area with the Lower Bay. This is an important migratory pathway for anadromous fish that move up the Hudson River, Passaic River, Hackensack River, and other tributaries from the Lower Bay and the Atlantic Ocean. The Upper Bay is also in close proximity to the Arthur Kill/Kill van Kull study area. Herons and gulls that nest in colonies in the Arthur Kill study area may travel to the habitats of the Upper Bay to forage. Habitat restoration efforts in this study area would enhance habitat for migratory fish and provide foraging habitat for waterbirds nesting on nearby islands.

Restoration of Shallow Water Habitat

33. The Upper Bay study area is characterized by intense urbanization. As a result, there are limited opportunities for wetland and upland restoration. The potential exists to restore shallow water/shoal and mudflat habitat in areas that are no longer important shipping channels. Shallow water habitats and mudflats can be restored through the beneficial use of dredged material. This can be accomplished through thin-layer placement of uncontaminated sediment dredged from other portions of the Estuary. Restoration of shallow water habitats would be beneficial to fish because shallow water habitats, especially those that support aquatic vegetation, provide important cover for juvenile fish. Restoration of shallow water habitats would also benefit wadingbirds, gulls, and terns as these species forage for fish in these types of habitat. Creation of mudflat habitats would be beneficial to benthic macroinvertebrates and the shorebirds that feed on this group of organisms.

Wetland Restoration

34. Remnant tidal wetlands and vacant upland areas may provide limited opportunities for expansion and restoration in the study area. Filled wetland sites could be regraded to restore tidal flow, eliminate common reed, and reestablish native salt marsh vegetation (*Spartina* spp.) and adjoining uplands could also have fill removed to expand existing natural or restored wetland areas. Restoration of these habitats will improve foraging habitat for wading birds, waterfowl, raptors

(e.g., northern harrier, *Circus cyaneus*), and various species of fish. Erosion is a problem in many of salt marsh areas because of high wave energy that is the result of heavy commercial boat traffic. Therefore, wave attenuation structures should be incorporated into restoration plans for this study area to reduces erosion problems in the remaining and newly restored marshes.

Upland Restoration

35. Upland habitats within the study area are severely fragmented and degraded. Grassland restoration in places such as Liberty State Park, where there now exist expanses of lawn grass or invasive species, would enhance nesting habitat for grassland birds. A need is present for the remediation or capping of contaminated soils in upland areas. These efforts would prevent leaching of contaminants into groundwater, surrounding surface water environments, and would open the sites to more natural habitat (e.g., woodland/shrubland).

Contaminated Sediment Removal

36. Contaminated bottom sediments are a significant problem in the littoral areas, and canals and boat basins in the study area. Most areas are "sinks" for contaminated sediments. These "sinks" accumulate contaminated sediments that are moved by the currents within the waters of the Upper Bay or from local runoff. Those contaminated sediments effect not only the immediate area but spread throughout the ecosystem through resuspension and natural dispersion. Several options exist for the remediation of contaminated sediments. One potential option is to cap areas of contaminated sediments using clean dredge material. Another option is to remove the contaminated sediments by excavating or dredging them and replacing the sediments that were removed with clean material. Contaminated sediments that are removed from through dredging could be treated and then disposed of in upland locations. Because of the on-going deepening of many navigation channels in the area there is an especially good opportunity to have available millions of cubic yards of good quality dredged material to accomplish this in an especially cost-effective manner. However, this material will only be available over the next 10 years and plans to take advantage of this limited opportunity must be expedited to maximize clean-up of this area-wide problem.

Existing Restoration Efforts

37. Habitat restoration work in the Estuary has been underway for some time and various organizations, most notably, the Harbor Estuary Program (HEP) Habitat Workgroup, have identified potential sites and sought to promote restoration efforts. The District and other stakeholders have initiated or completed restoration efforts in the study area.

Liberty State Park

38. Liberty State Park is located in Jersey City, New Jersey in the vicinity of Ellis Island and the Statue of Liberty. The park is comprised of nearly 1,100 acres, of which 300 acres are developed for public recreation. Historically, the area was entirely coastal wetlands that were filled during the late 19th century to create marine and rail terminals. Restoration activities were initiated at this site because of local support and a cost-share sponsor. Detailed site investigations to select and develop a recommended restoration plan are now underway. The plan is likely to include the enhancement of tidal and freshwater wetlands, as well as the development and enhancement of coastal grasslands on a 250-acre portion of the park's interior. Preliminary plans include restoring tidal flow to a historic salt marsh through the creation of a tidal creek and the removal of dredged material. The tidal wetland will then transition to a freshwater wetland system. The existing on-site freshwater wetland system may be enhanced through measures such as invasive species removal. Invasive species in the freshwater wetlands include purple loosestrife (*Lythrum salicaria*) and common reed. Freshwater wetlands habitat will then transition to upland habitat. Existing upland woodlots and successional forest will be preserved and old-field/meadow habitat will be enhanced. At least three state listed threatened or endangered species are known to use the existing, degraded meadow habitat on-site. Enhancement of this habitat type may help the continued survival of certain species in the Upper Bay study area.

Gowanus Canal

39. The Gowanus Canal was constructed in 1881 to accommodate commercial shippers on the Brooklyn waterfront. The canal extends approximately one mile north from the Upper Bay and the Williams Avenue Bridge. Historic industrial use in the area caused a significant amount of hazardous materials to be deposited in the canal. Early in the HRE, this area was identified as

warranting more detailed analysis because of its complicated problems and a tremendous local interest to address these problems. As a result, Congress authorized a separate feasibility study under the HRE to assess the environmental problems and potential solution remediation of hazardous materials and ecosystem restoration the Gowanus Canal. Restoration efforts at this site will likely include hot-spot removal, contaminant reduction measures, wetland creation, water quality improvement, and alteration of hydrology/hydraulics to improve water flow and quality. Though the subject of a separate feasibility study, the Gowanus Canal project will be closely coordinated with the HRE. Additionally, the recommendations of the Gowanus Canal feasibility study will be consistent with the goals of the HRE.

Liberty Flats Oyster Reef

40. At one time, oysters were an important component of the Estuary. However, overharvesting and poor water quality let to significant declines throughout the Estuary. Today water quality has significantly improved and studies conducted by the NY/NJ BayKeeper in 1997 indicated water in the Estuary is clean enough to support adult oysters. Despite improved water quality, oyster populations did not appear to be growing in portions of the Estuary. One of the primary factors that limits oyster population growth in the Estuary is the lack of suitable substrate for larval settlement. Successful reproduction among existing oysters is further limited by abundance and density in certain areas.

41. The NY/NJ BayKeeper decided to take advantage of improved water quality in the Estuary and formed partnerships with the National Oceanic and Atmospheric Administration (NOAA) and the National Fish and Wildlife Foundation to restore oyster beds to this portion of the Estuary. This project, located at Liberty Flats, near Ellis Island, was used as a demonstration project and to provide a broodstock oyster bed. Oyster shells were collected and used to establish a 0.01-acre oyster bed in at Liberty Flats. Oysters were then grown by community volunteers and placed on the demonstration bed. Volunteer divers monitored the bed for recruitment, growth, siltation, and predation.

Potential Restoration Sites

42. Five potential restoration sites have been identified by the District for the Upper Bay study area and are listed in Table 1. Each site will be evaluated to determine which of the proposed restoration activities, if any, are feasible from an engineering and economic perspective.

Table 1 - Potential Restoration Sites in the Upper Bay

HRE Site ID	Name	Restoration Opportunities[(1)]
1UB	Liberty State Park	1,3,6
2UB	Coffey Street Park	*
3UB	Gowanus Canal	1,2,6,9
4UB	Brooklyn Sunset Park	*
5UB	Bush Terminal**	*

(1) Restoration Opportunities:
1 – Restoration/Creation of Intertidal Wetlands/Mudflats
2 – Benthic Habitat Restoration (Hotspot Removal)
3 – Restoration/Creation of Freshwater/Riparian Wetlands
4 – Restoration of Fishery Habitats (Anadramous Fish Migration, Artificial Reefs)
5 – Shellfish Habitat Restoration
6 – Restoration/Enhancement of Shoreline/Coastal Fringe Habitat (Dunes, Bird Habitat)
7 – Creation/Restoration/Enhancement of Shallow Water Habitat (including Eelgrass)
8 – Shoreline Enhancement/Bank Stabilization
9 – Water Quality Improvement
10 – Riparian Habitat Restoration
11 – Environmental Interpretation
* To be determined
** Potential restoration site is a recent addition, therefore, is not discussed at any length in this report. Site obtained from the New York New Jersey Harbor Estuary Program Habitat Workgroup database.

IV. CONCLUSIONS

43. Based upon the history of degradation and the natural resource conditions, opportunities may exist to restore intertidal wetlands and mudflats and enhance shoreline/upland habitat in the Upper Bay study area. The HRE has identified 5 potential restoration sites in the Upper Bay study area (Appendix A). Each site will be evaluated to determine which of the proposed restoration activities, if any, are feasible from an engineering and economic perspective.

44. The study area encompassing the Upper Bay is an important component of the Estuary. However, nearly 300 years of intense human use of the study area has led to significant losses of natural habitat areas. Restoration of wetland and upland habitats will provide habitat for resident and migratory fish and birds. Such efforts may also increase habitat available to reptiles and amphibians.

V. REFERENCES

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.

HEP. 2001. New York/New Jersey Harbor Estuary Program Habitat Workgroup 2001 Status Report; A regional model for estuary and multiple watershed management. New York/New Jersey Harbor Estuary Program and the City of New York/Parks and Recreation, Natural Resources Group. New York, NY.

Hudson River Trustee Council. 2002. Hudson River Natural Resource Damage Assessment Plan.

Northern Ecological Associates. 2003. Draft Phase I Environmental Site Assessment of Priority Sites, Part I Liberty State Park, Jersey City, Hudson County, New Jersey. Unpublished report prepared for the USACE. Northern Ecological Associates, Fredonia, NY.

NY/NJ BayKeeper. 2003. New oyster reef created in Keyport Harbor, Raritan Bay. Retrieved 9/23/03 from http://www.nynjbaykeeper.org.archive.htm.

NOAA. 2001. Environmental Sensitivity Index Maps.

Regional Planning Association. 2003. Needs and opportunities for the environmental restoration in the Hudson-Raritan Estuary. Unpublished report submitted by the Regional Planning Association to the US Army Corps of Engineers, New York District, New York, NY.

USACE. 1999. Dredged Material Management Plan for the Port of New York and New Jersey. Draft Implementation Report. US Army Corps of Engineers – New York District, New York, NY.

USACE. 2001. Restoration opportunities in the Hudson-Raritan Estuary: Final Report. US Army Corps of Engineers - New York District, New York, NY.

USACE. 2004 (under development). Summary of Sediment Characterization Studies. US Army Corps of Engineers - New York District, New York, NY.

US Environmental Protection Agency. 2003. Hudson-Raritan Estuary Keyport Oyster Reef Restoration (NOAA#247). Retrieved 9/12/03 from http://yosemite.epa.gov/water/restorat.nsf.

USFWS. 1997. Significant habitats and habitat complexes of the New York Bight Watershed. USFWS, Southern New England – New York Bight Coastal Ecosystems Program, Charlestown, RI.

URS Corporation. 2003. Unpublished field notes documenting wildlife use and habitat conditions at Liberty State Park. URS Corporation, Wayne, NJ.

FIGURES