

# Hudson Raritan Estuary (HRE) Ecosystem Restoration Feasibility Study, New York and New Jersey

Integration of six feasibility studies (four authorizations) with ten sponsors/partners:

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- HRE (8 Planning Regions)
- HRE - Lower Passaic River
- HRE – Hackensack Meadowlands
- Flushing Creek and Bay
- Bronx River Basin
- Jamaica Bay Marine Park, and Plumb Beach



**Purpose:** The purpose of the study is to *restore significant ecological function, structure, and dynamic process* that have been degraded throughout the Hudson Raritan Estuary. Restoration is needed due to the long-term historic habitat degradation and loss via urbanization and industrialization.

## Nationally Significant Estuary

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### Institutional Significance:

- Estuary of National Importance- National Estuary Program
- Ecosystems of National Significance
- One of the largest estuaries in the U.S
- Second largest Port in the U.S.
- HRE Comprehensive Restoration Plan (Regional Goals)
- Regionally Significant Coastal Habitat
- Migratory Bird Treaty Act
- Urban Waters Federal Partnership (Passaic & Bronx Rivers)
- National Estuarine Research Reserve System

### Technical Significance:

- Wetland habitat is extremely scarce and actively declining nationally (99% freshwater >85% of estuarine wetlands)
- Provides habitat for 27 Federally-listed species of special status, 2 candidate species, 400 plant and animal species of special emphasis
- Atlantic Flyway - stop-over point for >500 avian species



### Public Significance:

- Home to over 13 million people
- Collaboration with over 120 federal and state agencies, academic institutions, nonprofit and community organizations to restore the HRE

## Key Problems

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Lost/Degraded Wetlands



Disappearing Marsh Islands



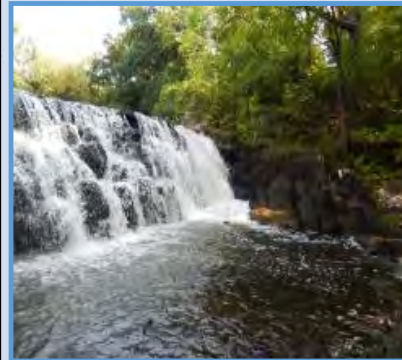
Hardened Shorelines

- Significant habitat loss within study area:  
>85% estuarine wetlands lost  
> 99% freshwater wetlands lost  
~2,000 acres of marsh islands in Jamaica Bay lost
- Filled, eroded, and hardened shorelines
- Loss of ~100% of oyster reefs
- Barriers to fish passage impede spawning and access to habitat
- Scarce habitat and lack of connectivity
- Bed and bank erosion
- Decrease in habitat diversity
- Increase in invasive species
- Poor benthic habitat
- Altered hydrology degrades habitat
- Straightened and deepened channels degrade habitat
- Loss of >95% of eelgrass beds
- Poor sediment and water quality

## Objectives

4

1. Restore the structure, function, and connectivity, and increase the extent of **estuarine habitat**.
2. Restore the structure and function, and increase the extent of **freshwater riverine habitat**.
3. Restore the structure and function, and increase the extent of **marsh island habitat** in Jamaica Bay.
4. Increase the extent of **oyster reefs**.



Fish Passage Barriers



Degraded/Eroding Shorelines

## Comprehensive Restoration Strategy

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Estuary of National Importance  
National Estuary Program

1988

NY/NJ Harbor Estuary Program (HEP)  
Comprehensive Conservation Management Plan

1996

HRE/Jamaica Bay/Bronx River/Flushing Creek Authorizations

1990-1999

HRE and Source Study  
Reconnaissance Reports

1994-2001

HRE Comprehensive Restoration Plan

2009/2016

Integration of all Source Studies into HRE

2013-2016

Coordination with HEP Restoration Work Group & Sponsors

ongoing

Harbor Estuary Program Action Agenda

2018

Long Term Control Plans and Green Infrastructure

2015-2020

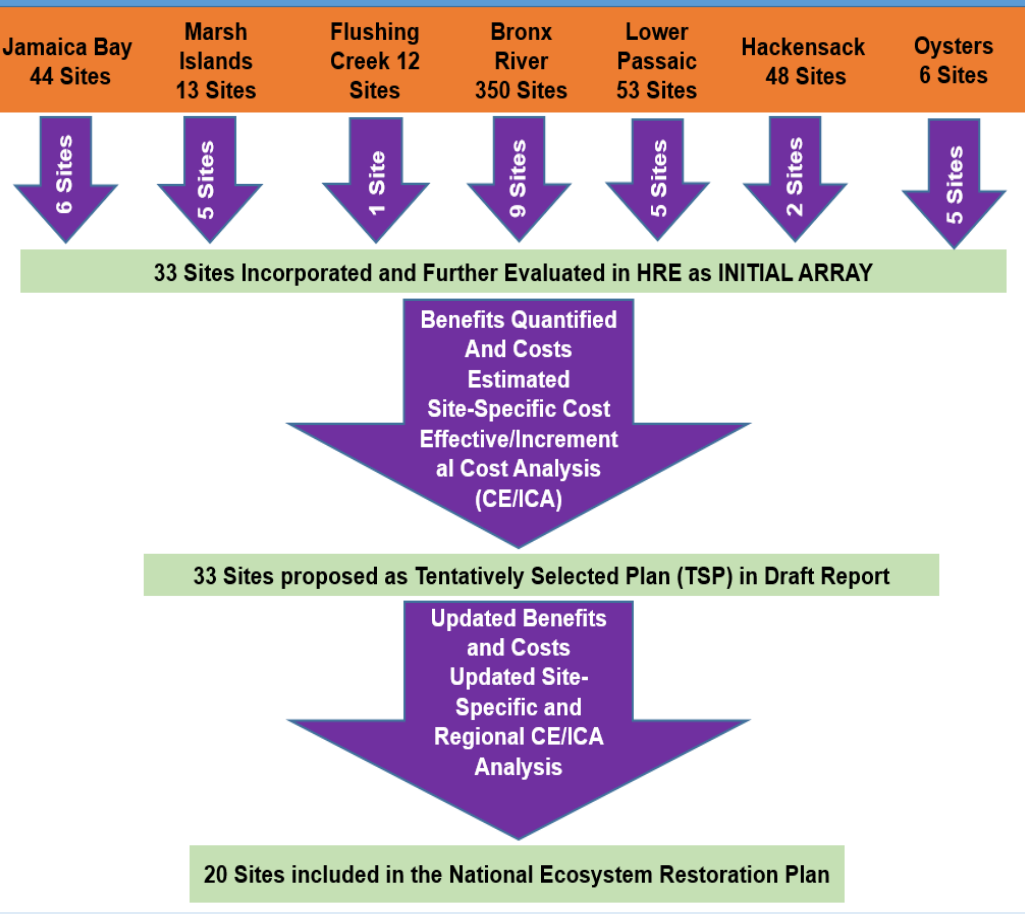
Recommended Plan Significant Contribution to meet Regional Goals

2020



### Hudson-Raritan Estuary Ecosystem Restoration Study

500+ Restoration sites originating from the Comprehensive Restoration Plan (CRP), USACE "source" studies, and the New York-New Jersey Harbor & Estuary Program Restoration Work Group



- Site Screening of 500+ Sites among the 6 "source" studies
- Criteria (including physical constraints, known upland contamination, real estate, sponsor readiness, habitat value, etc.)
- 99 Alternatives were developed at 33 sites
- Management Measures considered: excavation, invasives removal, regrading, native plantings, stream bed restoration, in-stream structures (j-hooks, cross vanes), streambank reestablishment, channel dredging, oyster reefs, fish ladders
- Cost estimated/benefits quantified with approved models including Evaluation of Planned Wetlands, Oyster Habitat Suitability Model and Watershed Scale Connectivity Toolkit
- Plan Evaluation and Comparison: Site and Regional (1,256 plans) Cost Effectiveness/Incremental Cost Analysis, planning objectives, secondary decision factors
- 20 Sites Recommended for construction

#### Environmental Compliance

- ✓ Environmental Assessment completed
- ✓ All coordination complete (Endangered Species Act, Fish and Wildlife Coordination Act Report, Essential Fish Habitat)
- ✓ Section 106, Programmatic Agreement
- ✓ Preliminary Water Quality Certificates and Coastal Zone Consistency
- ✓ Supported by State and Federal Resource Agencies

### The Recommended Plan

- The **National Ecosystem Restoration (NER) Plan** is the restoration of **20 restoration sites** within the HRE that address long-term and large-scale degradation of aquatic habitat.
- Restoration supports Comprehensive Restoration Plan's regional goal, "to develop a mosaic of habitats that provides society with renewed and increased benefits from the estuary environment".
- **NER Plan** provides restoration of approximately:
  - ✓ 381 acres of **estuarine wetlands** including 16 acres/30,650 linear feet of tidal channels;
  - ✓ 50 acres of **freshwater riverine wetlands**;
  - ✓ 27 acres of **maritime forest/uplands**;
  - ✓ 39 acres of **shallow water habitat**;
  - ✓ 52 acres of **oyster habitat**;
  - ✓ 1.6 miles of **streambank restoration**;
  - ✓ 72 acres of **bed and channel restoration**; and
  - ✓ **Two fish ladders** would be installed and three weirs would be modified to re-introduce or **expand fish passage (24 miles)** along the Bronx River.
- **Future spin-off feasibility studies** to be carried out under the existing HRE authority.



### Cost Summary (FY 21 Price Level)

Project Total First Cost	\$420,473,000
Project Total Federal Share (65%)	\$273,307,000
Project Total Non-Federal Share (35%)	\$147,166,000
Lands and Damages	\$7,328,000
Cash Balance	\$139,838,000
Project Total Fully Funded Cost	\$598,042,000 (escalated to the mid-point of construction for each site)

### Average Annual Costs & Benefits

Total Average Annual Cost	\$15,222,000
Average Annual OMRR&R Cost	\$154,000
Total OMRR&R Cost (100% Non-fed)	\$7,452,000
Total Average Annual Benefits (AAFCUs)*	341
Costs/AAFCU*	\$44,700

\* Average Annual Functional Capacity Units = Habitat Units

### Significance of Recommended Plan

**621 Total Acres of Nationally Significant Habitat Restored**

- Restoration of 431 acres of wetland habitat that is extremely scarce and actively declining nationally
- Habitat supports 27 Federally-listed species
- Key stop-over points for migratory birds (>500 species) along the Atlantic Flyway
- Estuarine marshes/wetlands serve as nursery, feeding, spawning sites and refuge to predators
- Reconnecting scarce and fragmented habitat
- Connectivity for migratory fish (anadromous and catadromous)
- Marsh island restoration of 175 acres of habitat in Jamaica Bay to counteract the loss of >2,000 acres providing ecosystem benefits and secondary coastal storm risk management benefits to coastal communities

# The Recommended Plan Details

## Recommended Sites and Measures/Habitat Type at Each Site



### Restoration Measures/Habitat Types

- |                              |                           |
|------------------------------|---------------------------|
| 1. Estuarine Wetlands        | 6. Freshwater Wetlands    |
| 2. Tidal Channel Restoration | 7. Streambank Restoration |
| 3. Maritime Forest           | 8. Bed Restoration        |
| 4. Oyster Reefs              | 9. Fishway                |
| 5. Shallow Water Habitat     | 10. Sediment Forebay      |

**HUDSON RARITAN ESTUARY ECOSYSTEM RESTORATION RECOMMENDED PLAN (APRIL 2020/ Updated FY21 Price Level - October 2020)**

Site	Proposed Habitat Types and Actions (Acres/Linear Feet/Miles)	Net Ecological Output (AAFCU/AAHU)	First Costs (\$)			Fully Funded Cost (\$)	Average Annual Economic Cost (\$)	Annual OMRR&R Cost (\$)	Sponsor
			Federal (\$)	Non-Federal (\$)	Total (\$)				
<b>Jamaica Bay Planning Region – Perimeter Sites</b>									
Dead Horse Bay	Low Marsh (19 acres); High Marsh (5.4 acres); Scrub/Shrub (6.2 acres); Upland (8 acres) Tidal Channels (2.31 acres) [Total Habitat: 40.91 acres]	30.3	\$27,277,250	\$14,687,750	\$41,965,000	\$69,491,000	\$1,530,745	\$4,432	NYCDEP, NYSDEC
Fresh Creek	Low Marsh (16.1 acres); High Marsh (4.4 acres); Scrub/Shrub (3.6 acres); Maritime Forest (10.7 acres); Bed/Channel Restoration (45.08 acres) [Total Habitat: 79.88 acres]	36.9	\$22,698,650	\$12,222,350	\$34,921,000	\$45,282,000	\$1,262,798	\$4,964	NYCDEP, NYC Parks
<b>Total:</b>		<b>67.2</b>	<b>\$49,975,900</b>	<b>\$26,910,100</b>	<b>\$76,886,000</b>	<b>\$114,773,000</b>	<b>\$2,793,543</b>	<b>\$9,396</b>	
<b>Jamaica Bay Planning Region – Marsh Islands</b>									
Duck Point	Low Marsh (24.9 acres); High Marsh (5.6 acres); Scrub/Shrub (8.1 acres); Tidal Channels (1.03 acres); Shallows (7.57 acres) [Total Habitat: 47.2 acres using 213,776 CYD of dredge material]	28.4	\$14,329,900	\$7,716,100	\$22,046,000	\$27,871,000	\$796,346	\$4,620	NYSDEC, NYCDEP
Stony Creek	Low Marsh (26 acres); High Marsh (22.5 acres); Scrub/Shrub (3.49 acres); Tidal Channels (1.43 acres); Shallows (8.67 acres) [Total Habitat 62.09 acres using 151,360 CYD of dredge material]	37.3	\$15,546,050	\$8,370,950	\$23,917,000	\$28,630,000	\$868,038	\$5,138	NYSDEC, NYCDEP
Pumpkin Patch West	Low Marsh (13.7 acres); High Marsh (8.61 acres); Scrub/Shrub (.9 acres); Tidal Channels (0.74 acres); Shallows (3.88 acres) [Total Habitat: 27.83 acres using 327,686 CYD of dredge material]	18.4	\$13,478,400	\$7,257,600	\$20,736,000	\$32,386,000	\$746,263	\$4,222	NYSDEC, NYCDEP
Pumpkin Patch East	Low Marsh (15.6 acres); High Marsh (10.1 acres); Scrub/Shrub (3.1 acres); Tidal Channels (0.58 acres); Shallows (5.22 acres)[Total Habitat: 34.6 acres using 351,952 CYD of dredge material]	22.1	\$14,452,100	\$7,781,900	\$22,234,000	\$39,289,000	\$801,519	\$4,277	NYSDEC, NYCDEP
Elders Center	Low Marsh (15.2 acres); High Marsh (10.9 acres); Scrub/Shrub (1.4 acres); Tidal Channels (0.95 acres); Shallows (5.49 acres) [Total Habitat: 33.94 acres using 284,891 CY of dredge material]	21.6	\$13,113,750	\$7,061,250	\$20,175,000	\$28,830,000	\$726,120	\$4,264	NYSDEC, NYCDEP
<b>Total:</b>		<b>127.8</b>	<b>\$70,920,200</b>	<b>\$38,187,800</b>	<b>\$109,108,000</b>	<b>\$157,006,000</b>	<b>\$3,938,286</b>	<b>\$22,521</b>	
<b>East River, Harlem River and Western Long Island Sound Planning Region</b>									
Flushing Creek	Low Marsh (9.76 acres); High Marsh (2.47 acres); Scrub/Shrub (1.8 acres); Maritime Forest (3.89 acres); Shallows (1.37 acres)[Total Habitat = 19.29 acres]	8.3	\$10,829,650	\$5,831,350	\$16,661,000	\$20,260,000	\$602,940	\$4,528	NYCDEP
Bronx Zoo and Dam	Emergent Wetlands (1.16 acres); Forested Scrub/Shrub Wetland (0.48 acres); Invasives Removal/Native Plantings (0.42 acres); Streambank (750 linear feet); Fishway Opening (0.8 river miles opened) [Total Habitat: 2.06 acres]	1.9	\$7,376,850	\$3,972,150	\$11,349,000	\$13,366,000	\$418,641	\$15,806	NYC Parks

**HUDSON RARITAN ESTUARY ECOSYSTEM RESTORATION RECOMMENDED PLAN (APRIL 2020/ Updated FY21 Price Level - October 2020)**

Site	Proposed Habitat Types and Actions (Acres/Linear Feet/Miles)	Net Ecological Output (AAFCU/AAHU)	First Costs (\$)			Fully Funded Cost (\$)	Average Annual Economic Cost (\$)	Annual OMRR&R Cost (\$)	Sponsor
			Federal (\$)	Non-Federal (\$)	Total (\$)				
Stone Mill Dam	Invasive Removal/Native Planting (.03 acres); Bed Restoration (0.5 acres); Fishway Opening (22.9 river miles opened) [Total Habitat: 0.53]	19.2	\$3,136,250	\$1,688,750	\$4,825,000	\$5,772,000	\$180,476	\$9,765	NYC Parks
Shoelace Park	Emergent Wetland (2.07 acres); Forested Scrub/Shrub Wetland (1.1 acres); Invasives Removal/Native Planting (7.9 acres); Bed Restoration (5.7 acres); Streambank (7,415 linear feet) [Total Habitat: 16.77 acres]	9.6	\$13,883,350	\$7,475,650	\$21,359,000	\$28,565,000	\$781,574	\$22,890	NYC Parks
Bronxville Lake	Emergent Wetland (0.86 acres); Forested Scrub/Shrub Wetland (2.49 acres); Invasives Removal/Native Planting (1.39 acres); Bed Restoration (0.65 acres); Sediment Forebay (0.3 acres) [Total Habitat: 5.69 acres]	3.8	\$10,331,100	\$5,562,900	\$15,894,000	\$22,830,000	\$571,398	\$4,928	Westchester County
Garth Woods - Harney Road	Emergent Wetland (0.82 acres); Wet Meadow (1.67 acres); Forested Scrub/Shrub Wetland (0.57 acres); Invasive Removal/ Native Planting (1.63 acres); Bed Restoration (2.19 acres); Streambank (200 linear feet) [Total Habitat: 6.88 acres]	4.3	\$6,914,050	\$3,722,950	\$10,637,000	\$13,436,000	\$389,231	\$12,893	Westchester County
<b>Total:</b>		<b>47.1</b>	<b>\$52,471,250</b>	<b>\$28,253,750</b>	<b>\$80,725,000</b>	<b>\$104,229,000</b>	<b>\$2,944,260</b>	<b>\$70,810</b>	
<b>Newark Bay, Hackensack River and Passaic River Planning Region</b>									
Oak Island Yards	Low Marsh (5.32 acres); High Marsh (0.85 acres); Scrub/Shrub (0.44 acres); Maritime Forest (2.85 acres); Tidal Channel Restoration (1.36 acres) [Total Habitat: 10.82 acres]	2.8	\$10,336,300	\$5,565,700	\$15,902,000	\$26,250,000	\$553,484	\$4,205	NJDEP
Essex County Branch Brook Park	Emergent Wetland Creation (10.25 acres); Forested Scrub/Shrub Wetland (8.8 acres); Invasives Removal/Native Planting (8.91 acres); Bed Restoration (18.09 acres) [Total Habitat: 46.05 acres]	26.9	\$34,749,650	\$18,711,350	\$53,461,000	\$77,042,000	\$1,929,530	\$7,703	NJDEP
Metromedia Tract	Low Marsh (26.5 acres); High Marsh (11.7 acres); Scrub/Shrub (13.8 acres); Tidal Channel Restoration (2.79 acres); Shallows (6.51 acres)[Total Habitat: 61.3 acres]	20.6	\$20,810,400	\$11,205,600	\$32,016,000	\$43,872,000	\$1,155,220	\$5,047	NJDEP, NJSEA*
Meadowlark Marsh	Low Marsh (56.2 acres); High Marsh (6.5 acres); Scrub/Shrub (5.4 acres); Tidal Channel Restoration (4.6 acres) [Total Habitat: 72.7 acres]	14.6	\$19,861,400	\$10,694,600	\$30,556,000	\$47,058,000	\$1,104,957	\$4,944	NJDEP, NJSEA*
<b>Total:</b>		<b>64.9</b>	<b>\$85,757,750</b>	<b>\$46,177,250</b>	<b>\$131,935,000</b>	<b>\$194,222,000</b>	<b>\$4,743,191</b>	<b>\$21,899</b>	
<b>Oyster Reef Restoration (Multiple Planning Regions)</b>									
Naval Weapons Station Earle	Oyster restoration with oyster castles, shell and gabions (10.0 acres) [Total Habitat: 10.0 acres]	9.6	\$5,710,250	\$3,074,750	\$8,785,000	\$10,620,000	\$321,953	\$8,134	NJDEP, NY/NJ Baykeeper*
Bush Terminal	Oyster restoration with spat on shell, oyster castles and gabions (31.9 acres) [Total Habitat: 31.9 acres]	19.5	\$4,655,950	\$2,507,050	\$7,163,000	\$9,733,000	\$262,542	\$9,864	NYC Parks, NY Harbor School*

**HUDSON RARITAN ESTUARY ECOSYSTEM RESTORATION RECOMMENDED PLAN (APRIL 2020/ Updated FY21 Price Level - October 2020)**

Site	Proposed Habitat Types and Actions (Acres/Linear Feet/Miles)	Net Ecological Output (AAFCU/AAHU)	First Costs (\$)			Fully Funded Cost (\$)	Average Annual Economic Cost (\$)	Annual OMRR&R Cost (\$)	Sponsor
			Federal (\$)	Non-Federal (\$)	Total (\$)				
Head of Jamaica Bay	Oyster restoration with spat on shell and gabions (10.1 acres)Total Habitat: 10.1 acres]	5.2	\$3,816,150	\$2,054,850	\$5,871,000	\$7,459,000	\$218,048	\$11,626	NYCDEP
<b>Total:</b>		<b>34.3</b>	<b>\$14,182,350</b>	<b>\$7,636,650</b>	<b>\$21,819,000</b>	<b>\$27,812,000</b>	<b>\$802,543</b>	<b>\$29,624</b>	
<b>Jamaica Bay Planning Region: Perimeter Sites</b>	Low Marsh (35.1 acres); High Marsh (9.8 acres); Scrub/Shrub (9.8 acres); Maritime Forest/Upland (18.7 acres); Tidal Channels (2.31 acres) and Bed/Channel (45.08 acres) [Total Habitat Restoration: 120.79 acres]	67.2	\$49,975,900	\$26,910,100	\$76,886,000	\$114,773,000	\$2,793,543	\$9,396	NYSDEC, NYCDEP, NYC Parks
<b>Jamaica Bay Planning Region: Marsh Islands</b>	Low Marsh (95.4 acres); High Marsh (57.71 acres); Shrub/Scrub (16.99 acres); Tidal Channel Restoration (4.73 acres); Shallows (30.83 acres) Using 1,329,665 CY of dredged material[Total Habitat Restoration: 205.66 acres]	127.8	\$70,920,200	\$38,187,800	\$109,108,000	\$157,006,000	\$3,938,286	\$22,521	NYSDEC, NYCDEP
<b>Harlem River, East River Western Long Island Sound Planning Region</b>	Low Marsh (9.76 acres); High Marsh (2.47 acres); Scrub/Shrub (1.8 acres); Maritime Forest (3.89 acres); Shallows (1.37 acres); Emergent Wetland (4.91 acres); Wet Meadow (1.67 acres); Forested Scrub/Shrub (4.64 acres); Invasive Removal/Native Planting (11.37 acres); Bed Restoration (9.04 acres); Sediment Forebay (0.30 acres); Fishway Opening (23.70 miles opened); Streambank (8,365 linear feet)	47.1	\$52,471,250	\$28,253,750	\$80,725,000	\$104,229,000	\$2,944,260	\$70,810	NYCDEP, NYC Parks, Westchester County
<b>Newark Bay, Hackensack River, and Passaic River Planning Region</b>	Low Marsh (88.02 acres); High Marsh (19.05 acres); Scrub/Shrub (19.64 acres); Maritime Forest (2.85 acres); Tidal Channel Restoration (8.75 acres); Shallows (6.51 acres); Emergent Wetland (10.25 acres); Invasive Removal/Native Planting (8.91 acres); Forested Scrub/Shrub (8.8 acres); Bed Restoration (18.09 acres) [Total Habitat Restoration: 191.57 acres]	64.9	\$85,757,750	\$46,177,250	\$131,935,000	\$194,222,000	\$4,743,191	\$21,899	NJDEP, NJSEA*
<b>Oyster Reef Restoration</b>	Oyster restoration using spat on shell, gabions, oyster castles or shell, [Total Habitat: 52.0 acres]	34.3	\$14,182,350	\$7,636,650	\$21,819,000	\$27,812,000	\$802,543	\$29,624	NYCDEP, NY/NJ Baykeeper*, NY Harbor School*, NYC Parks

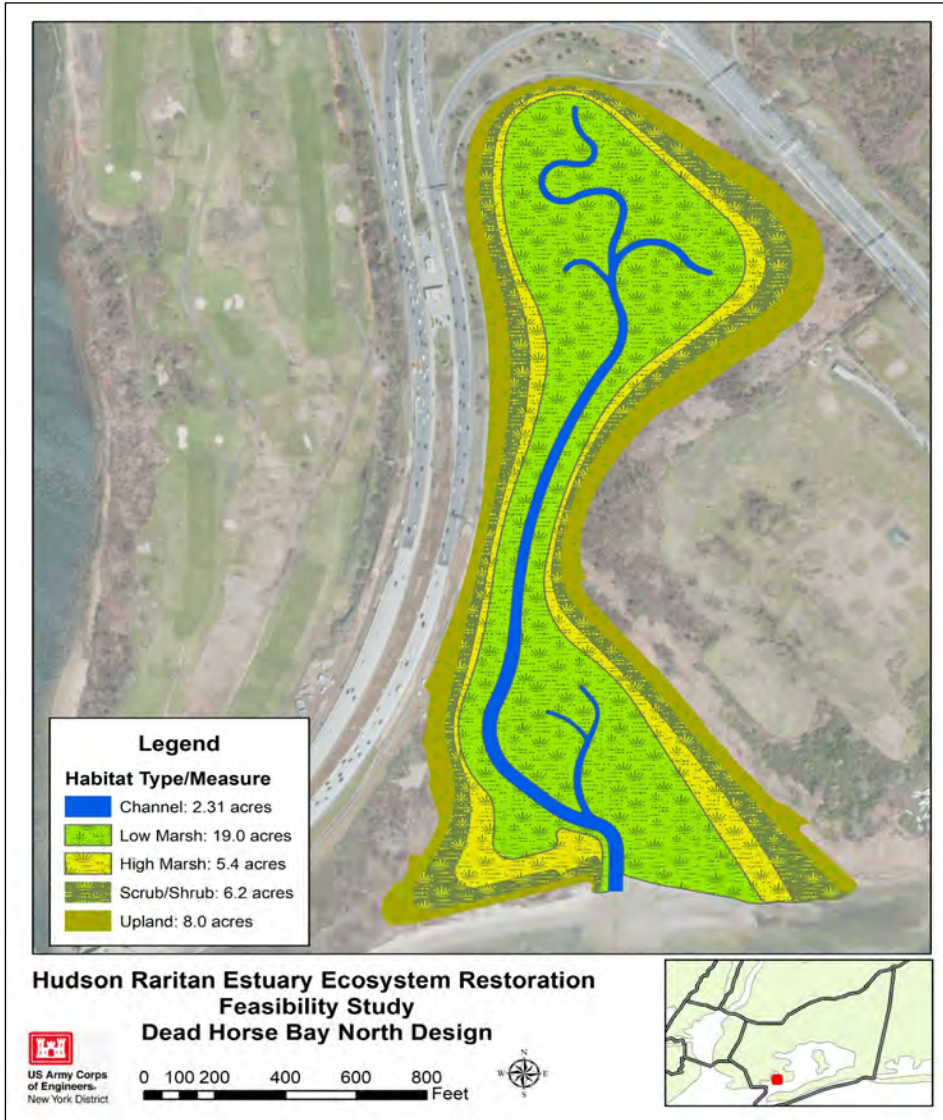
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Site	Proposed Habitat Types and Actions (Acres/Linear Feet/Miles)	Net Ecological Output (AAFCU/AAHU)	First Costs (\$)			Fully Funded Cost (\$)	Average Annual Economic Cost (\$)	Annual OMRR&R Cost (\$)	Sponsor
			Federal (\$)	Non-Federal (\$)	Total (\$)				
All Sites	Low Marsh (228.28 acres); High Marsh (89.03 acres); Scrub/Shrub (48.23 acres); Maritime Forest/Upland (25.44 acres); Emergent Wetland (15.16 acres); Shallows (38.71 acres); Wet Meadow (1.67 acres); Forested Scrub/Shrub (13.44 acres); Invasive Removal/Native Planting (20.28 acres); Tidal Channels (15.79); Channel/Bed Restoration (72.21 acres); Sediment Forebay (0.3 acres); Bank Stabilization (8,365 linear feet); Fish Passage (23.7 miles opened); Oyster Reef (52 acres)[Total Habitat Restored: 620.54 acres]	341.3	\$273,307,450	\$147,165,550	\$420,473,000	\$598,042,000	\$15,221,823	\$154,250	NYSDEC, NYCDEP, NY Parks, NJDEP, NJSEA*, Westchester County, NY Harbor School*, NY/NJ Baykeeper

\* Construction Partner

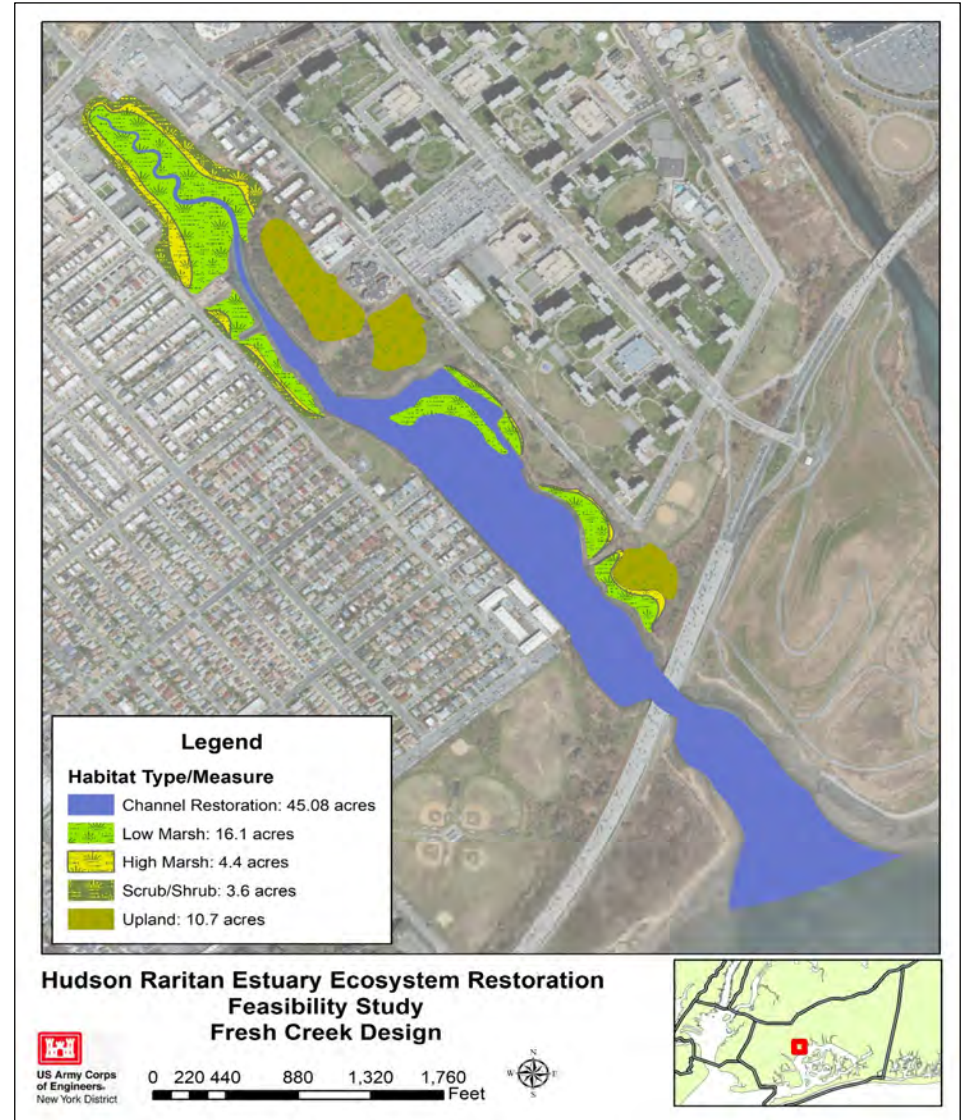
# Hudson Raritan Estuary Ecosystem Restoration Recommended Plan – Jamaica Bay Perimeter Sites

## Dead Horse Bay



40.91 acres of Habitat Restoration

## Fresh Creek



79.88 acres of Habitat Restoration

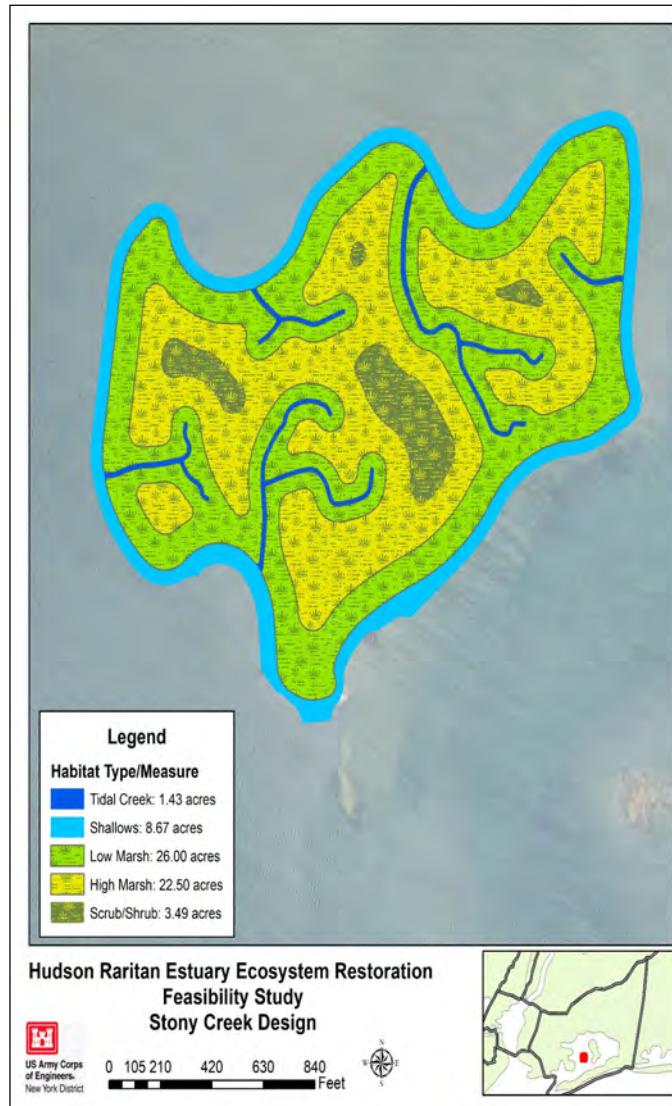


# Hudson Raritan Estuary Ecosystem Restoration Recommended Plan – Jamaica Bay Marsh Island Sites

## Duck Point



## Stony Creek



## Pumpkin Patch West



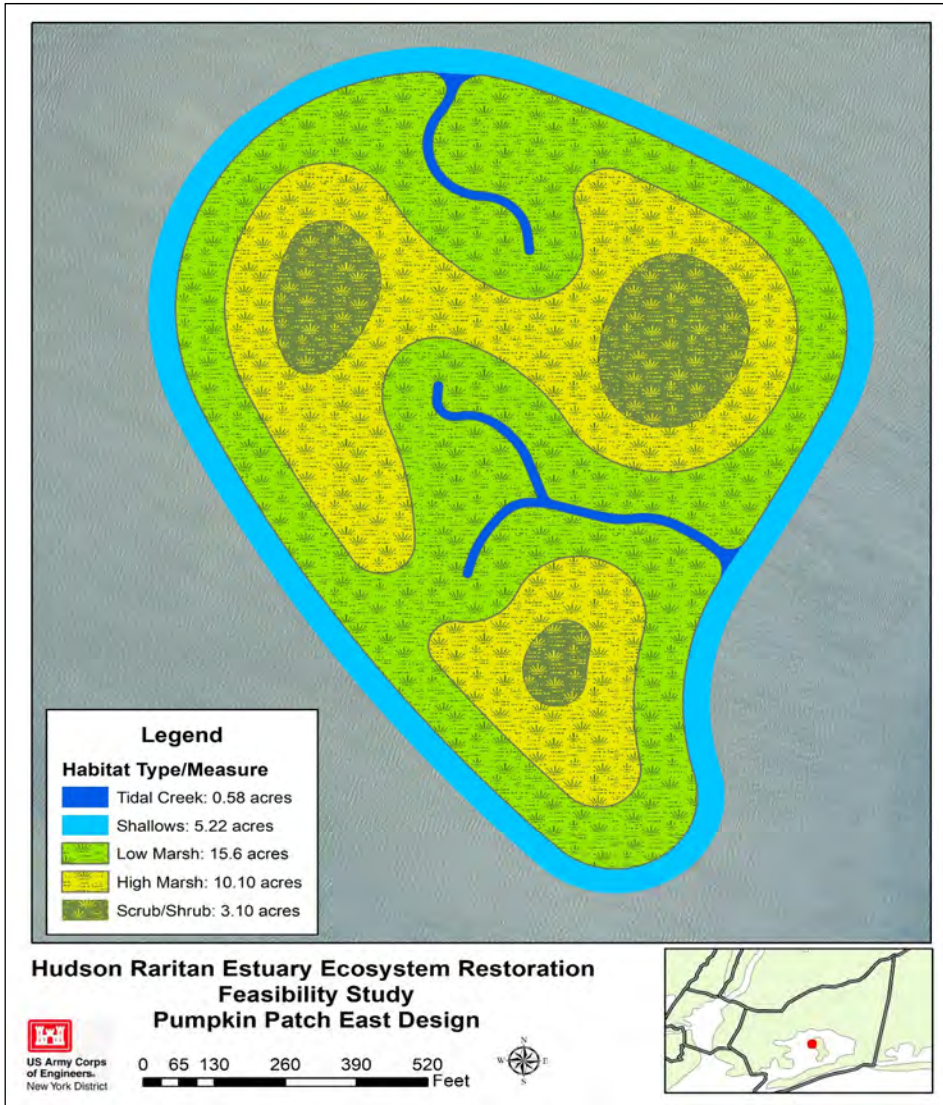
39.63 acres of Habitat Restoration using 213,776 CY of dredged material

53.42 acres of Habitat Restoration using 151,360 CY of dredged material

23.95 acres of Habitat Restoration using 327,686 CY of dredged material

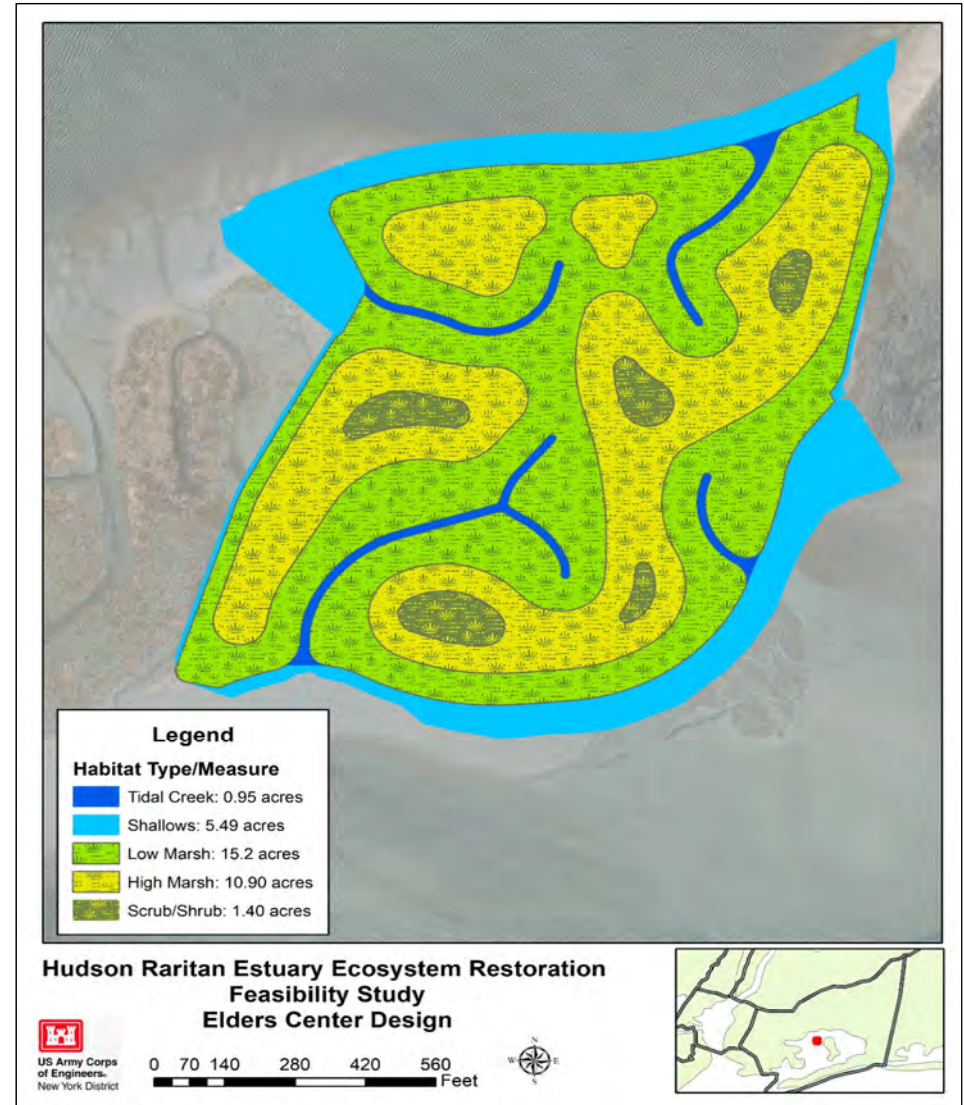
# Hudson Raritan Estuary Ecosystem Restoration Recommended Plan – Jamaica Bay Marsh Island Sites

## Pumpkin Patch East



29.38 acres of Habitat Restoration using 351,952 CY of dredged material

## Elders Center



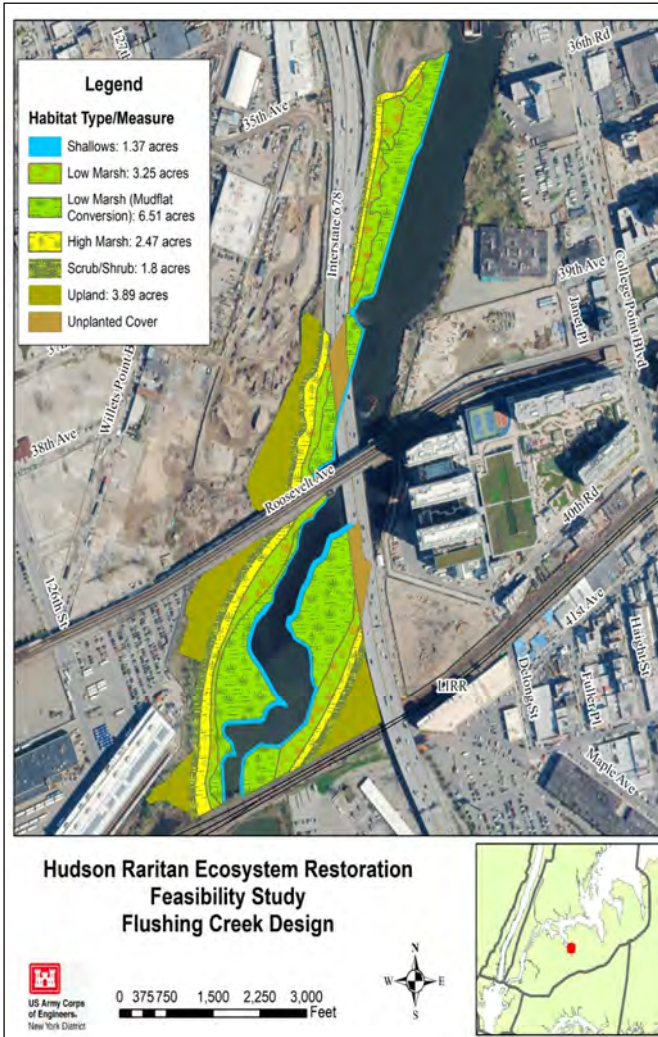
28.45 acres of Habitat Restoration using 284,891 CY of dredged material

# Hudson Raritan Estuary Ecosystem Restoration Recommended Plan – Flushing Creek and Bronx River Sites

## Flushing Creek

## Bronx Zoo and Dam

## Stone Mill Dam



19.29 acres of Habitat Restoration



2.15 acres of Habitat Restoration;  
0.8 River Miles Opened



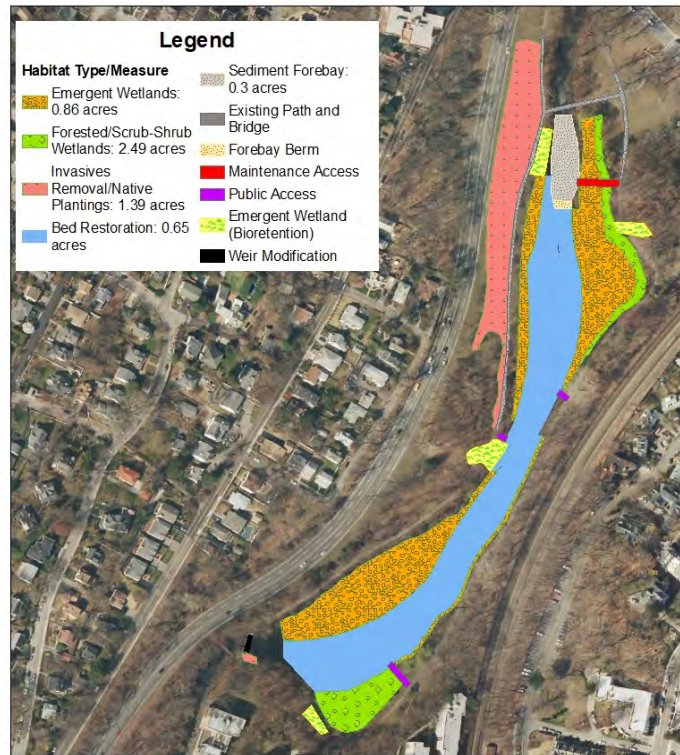
0.53 acres of Habitat Restoration;  
22.9 River Miles Opened

# Hudson Raritan Estuary Ecosystem Restoration Recommended Plan – Flushing Creek and Bronx River Sites

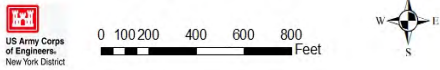
## Shoelace Park

## Bronxville Lake

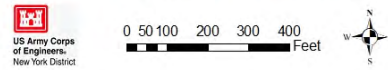
## Garth Woods – Harney Road



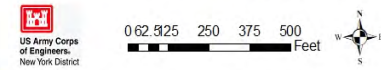
Hudson Raritan Estuary Ecosystem Restoration Feasibility Study Shoelace Park Design



Hudson Raritan Estuary Ecosystem Restoration Feasibility Study Bronxville Lake Design



Hudson Raritan Estuary Ecosystem Restoration Feasibility Study Garth Harney Design



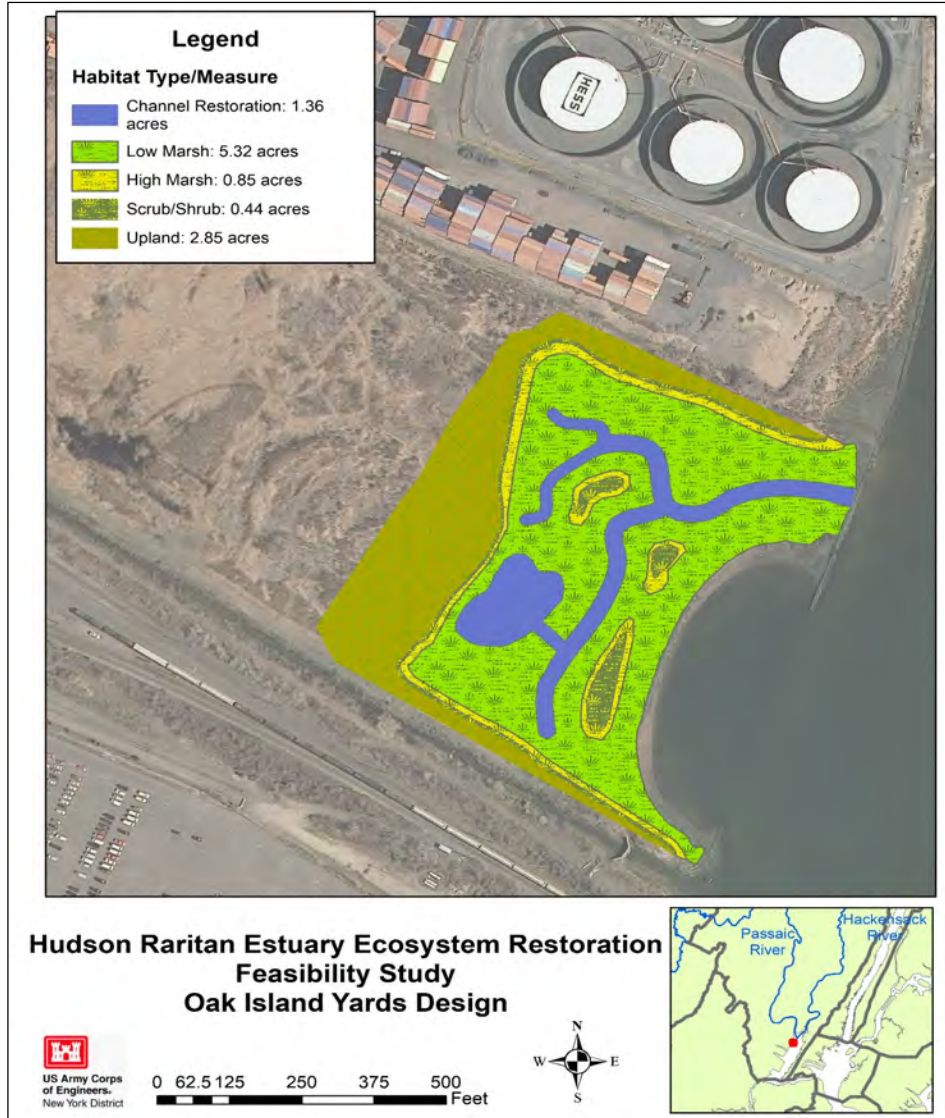
16.77 acres of Habitat Restoration

5.69 acres of Habitat Restoration

6.88 acres of Habitat Restoration

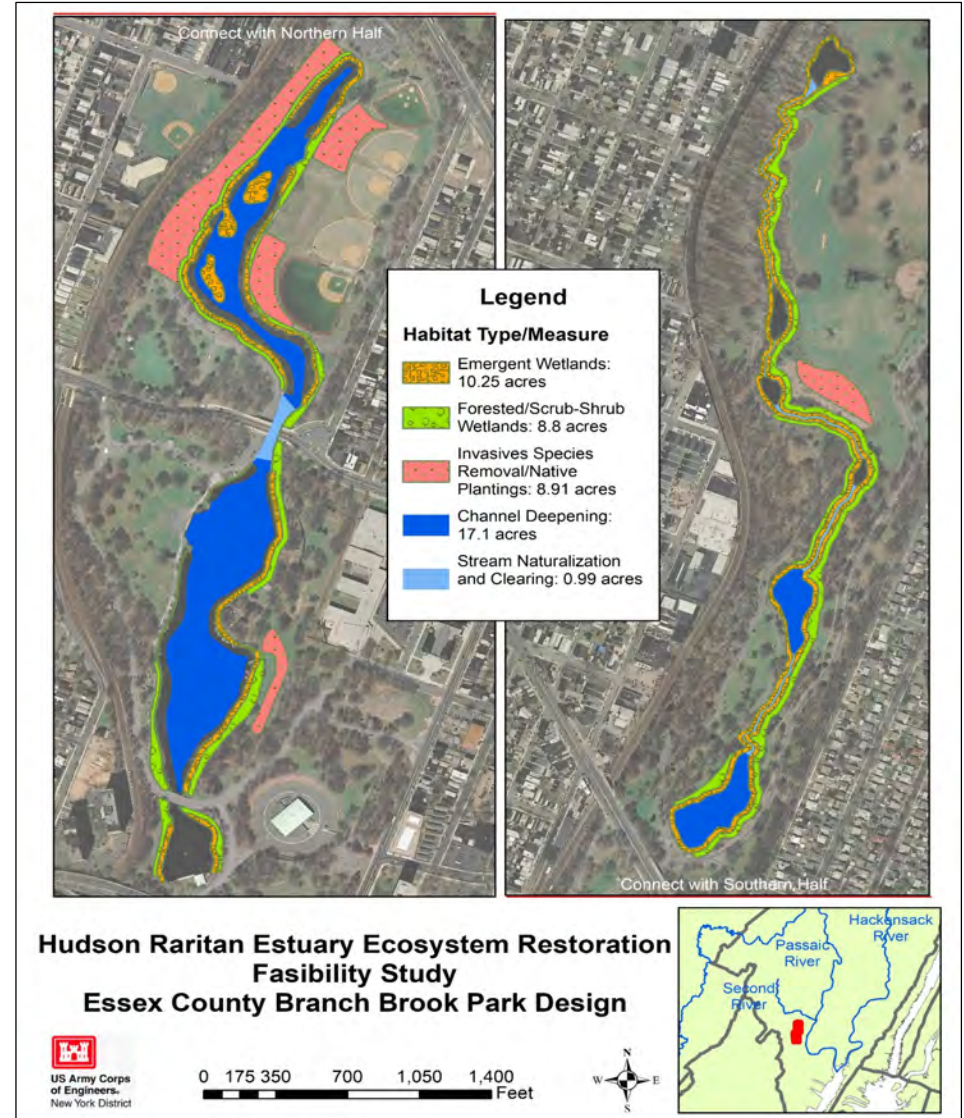
# Hudson Raritan Estuary Ecosystem Restoration Recommended Plan – Lower Passaic Sites

## Oak Island Yards



10.82 acres of Habitat Restoration

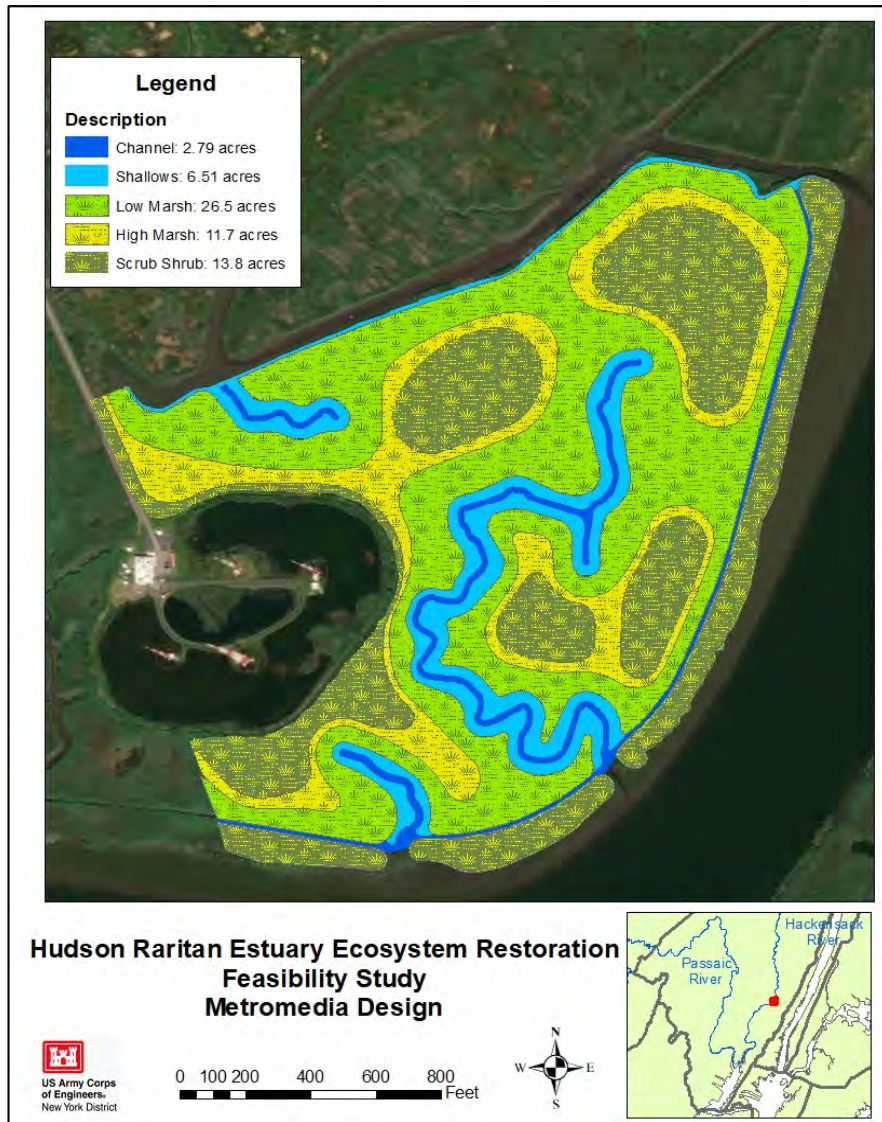
## Essex County Branch Brook Park



46.05 acres of Habitat Restoration

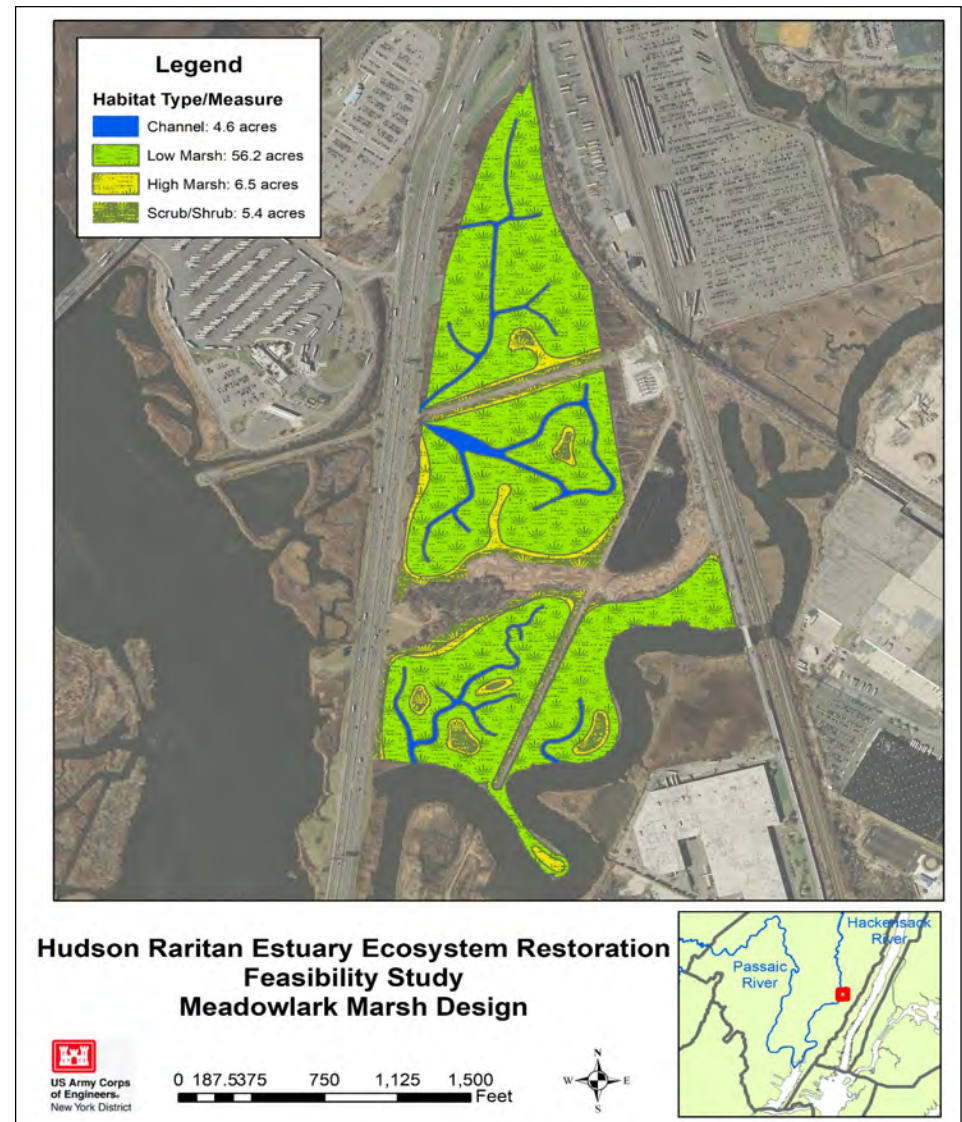
# Hudson Raritan Estuary Ecosystem Restoration Recommended Plan – Hackensack River Sites

## Metromedia Tract



61.3 acres of Habitat Restoration

## Meadowlark Marsh



72.7 acres of Habitat Restoration

# Hudson Raritan Estuary Ecosystem Restoration Recommended Plan – Oyster Reef Restoration Sites

## Naval Weapons Station Earle



Restoration of 10 acres using Gabions and Oyster Pyramids

## Bush Terminal



Restoration of 31.9 acres using Spat on Shell and Gabions

## Head of Bay



Restoration of 10.1 acres using Gabions, Hanging Super Trays, Oyster Pyramids and Spat on Shell