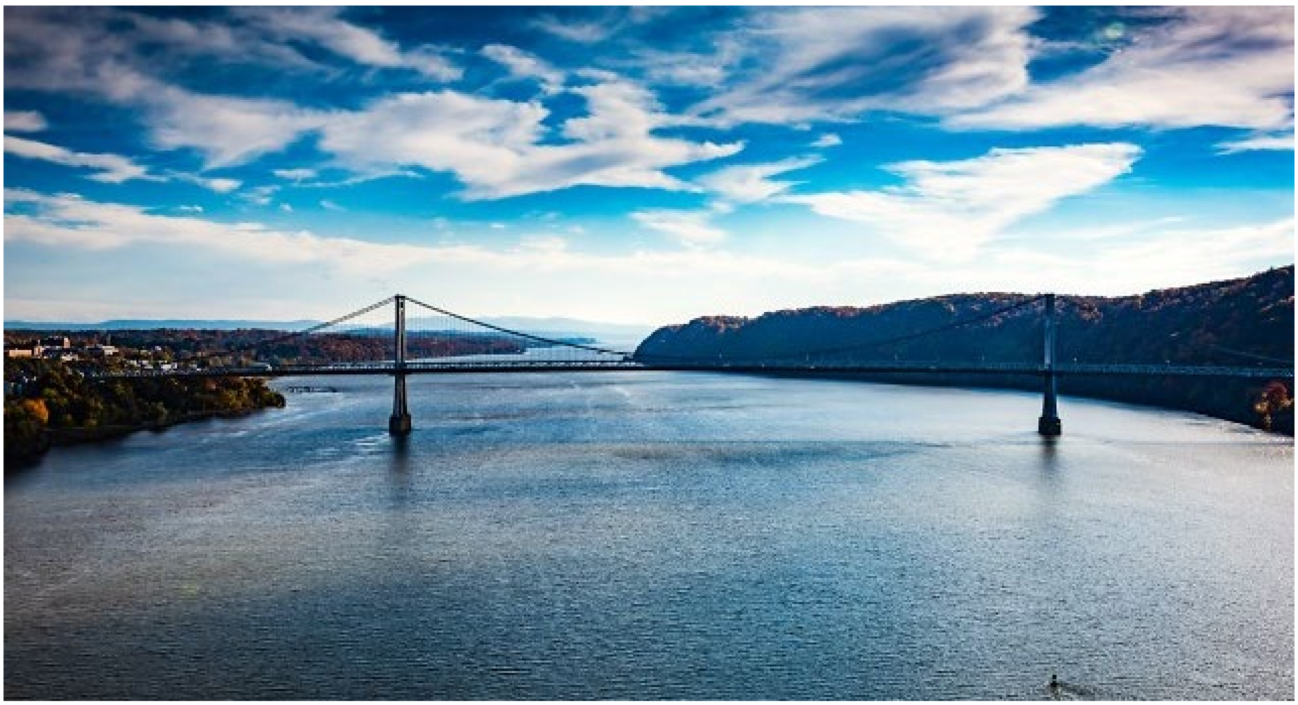
Hudson River Habitat Restoration Ecosystem Restoration Feasibility Study



Final Integrated Feasibility Report and Environmental Assessment
October 2020

Prepared by the U.S. Army Corps of Engineers, North Atlantic Division, New York District in partnership with the New York State Departments of Environmental Conservation and State

NEW YORK STATE OF OPPORTUNITY | Department of Environmental Conservation

NEW YORK STATE OF OPPORTUNITY. | Department of State

Comments and Questions

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Executive Summary

The Hudson River Habitat Restoration Ecosystem Restoration Feasibility Study was conducted by the U.S. Army Corps of Engineers (USACE) with the New York State Department of Environmental Conservation (NYSDEC) and New York State Department of State (NYSDOS), the study's non-federal sponsors. The study was authorized by Section 551 of the Water Resources Development Act of 1996 (P.L. 104-303):

a) *Habitat Restoration – The Secretary shall expedite the feasibility study of the Hudson River Habitat Restoration, Hudson River Basin, New York, and may carry out not fewer than 4 projects for habitat restoration in the Hudson River Basin, to the extent the Secretary determines such work to be advisable and technically feasible. Such projects shall be designed to-*

   1. *assess and improve habitat value and environmental outputs of recommended projects;*
   2. *evaluate various restoration techniques for effectiveness and costs;*
   3. *fill an important local habitat need within a specific portion of the study area; and*
   4. *take advantage of ongoing or planned actions by other agencies, local municipalities, or environmental groups that would increase the effectiveness or decrease the overall cost of implementing one of the* recommended restoration project sites.

b) *Non-Federal Share. – Non-Federal interests shall provide 25 percent of the cost of each project undertaken under subsection (a). The non-Federal share may be in the form of cash or in-kind contributions.*

c) *Authorization of Appropriations. – There is authorized to be appropriated to carry out this section $11,000,000.*

The study area included approximately 125 miles of the Hudson River, from the Federal Lock and Dam at Troy, New York, to the Governor Mario M. Cuomo (formerly Tappan Zee) Bridge. Tributaries in this reach, from the river up to the first natural barrier to migratory fish, were also included. The study area is located entirely in New York State - in Albany, Rensselaer, Greene, Columbia, Ulster, Dutchess, Orange, Putnam, Rockland, and Westchester counties. The study area includes Congressional districts 17, 18, 19, and 20.

The Hudson River provides a unique ecosystem with highly diverse habitats. Tidal influence extends upriver from the New York-New Jersey Harbor to the Federal Lock and Dam at Troy, and under average runoff conditions the saltwater front can be found 50 to 60 miles north of the Battery, between West Point and Poughkeepsie. Approximately 85% of New York State's fish and wildlife species, including over 200 fish species, inhabit the river. There are over 2,000 species of plants and vertebrates in the estuarine portion of the river.

For more than 200 years, human activities, including federal, state, local, and private development, have degraded the integrity of the Hudson River ecosystem. USACE maintains a federal navigation channel in the study area. In creating the navigation channel, USACE constructed longitudinal dikes and dams along the river, dredged the river bottom, and placed dredged material in between islands in the river as well as in shallow, marshy side channels. Additional dredging and filling occurred along the shores of the Hudson River south of Catskill, NY, to accommodate transportation and industrial activities, especially around population centers. Meanwhile, in the greater Hudson River watershed, approximately 1,600 dams and thousands of culverts were built in the 90 tributaries to the Hudson River. Cumulatively, these human activities changed the morphology and hydrology of river.

The changes to the Hudson River resulted in large-scale losses of critical shallow water and intertidal wetland habitats, and fragmented and disconnected habitats for migratory fish and other species. In the upper third of the estuary, a total of approximately 4,000 acres of aquatic habitats, including shallow, intertidal, and wetland habitats, were lost. Of those, about 3,300 acres were lost to filling, which converted aquatic habitats to upland habitats. The other approximately 700 acres were lost to dredging, which deepened previously shallow waters to more than six feet deep at low tide. More than 85% of the river's islands were eliminated and most of the river's side channels were filled in, resulting in the loss of 71 miles of shoreline (Miller, 2013; USACE, 1996). The dams and culverts in the river's tributaries impede fish passage and significantly reduce habitat available for American eel and other migratory species (Partners Restoring the Hudson, 2018).

The planning objectives developed for the study, to address problems and take advantage of opportunities for ecosystem restoration in the study area, were to:

1. Restore a mosaic of interconnected, large river habitats, and
2. Restore lost ecological connectivity within the Hudson River and its tributaries.

1,800 restoration sites in the study area were screened and prioritized to select six sites to develop alternatives for: Henry Hudson Park, Charles Rider Park, Schodack Island, Binnen Kill, Moodna Creek, and Rondout Creek. In total, 23 alternatives were developed for the sites. Cost-effectiveness and incremental cost analyses (CE/ICA) were used to compare the alternatives' costs and benefits. Cost estimates for the alternatives used FY 2018 price levels and benefits were evaluated using the Evaluation of Planned Wetlands (EPW) procedure and a Watershed-Scale Upstream Connectivity Toolkit (WUCT). The units for these benefits models are functional capacity units and habitat units, respectively. Not only were alternatives for each site compared to each other - combinations of alternatives across sites within the same restoration category (shoreline restoration, large river mosaic/side channel, and tributary connectivity) were also compared. CE/ICA results and other criteria including the degree to which plans were complete, effective, efficient, and acceptable were used to tentatively select a plan. Based on the analysis, restoration at Charles Rider Park was excluded from the plan.

A Tentatively Selected Plan that included restoration at five sites was presented in the Draft Integrated Feasibility Report and Environmental Assessment released for public review in June 2019. Comments received from the public and landowners articulated opposition to the plan for two sites: Rondout Creek (Eddyville Dam) and Binnen Kill. Coordination with NYSDEC resulted in these sites being excluded from the Recommended Plan.

The Recommended Plan, or National Ecosystem Restoration Plan, includes restoration at three sites (Figure ES-1):

- Henry Hudson Park, in the Town of Bethlehem in Albany County, on the Hudson River's western shore.
- Schodack Island, which is part of Schodack Island State Park, located approximately three miles south of Castleton-on-Hudson in the Town of Schodack, on the Hudson River's eastern shore.
- Moodna Creek: a sewer utility line, Firth Cliff Dam, and Orr's Mill Dam, in the towns of New Windsor and Cornwall in Orange County. The barriers are located approximately 1.8, 3.0, and 3.7 miles upstream of the creek's confluence with the Hudson River.

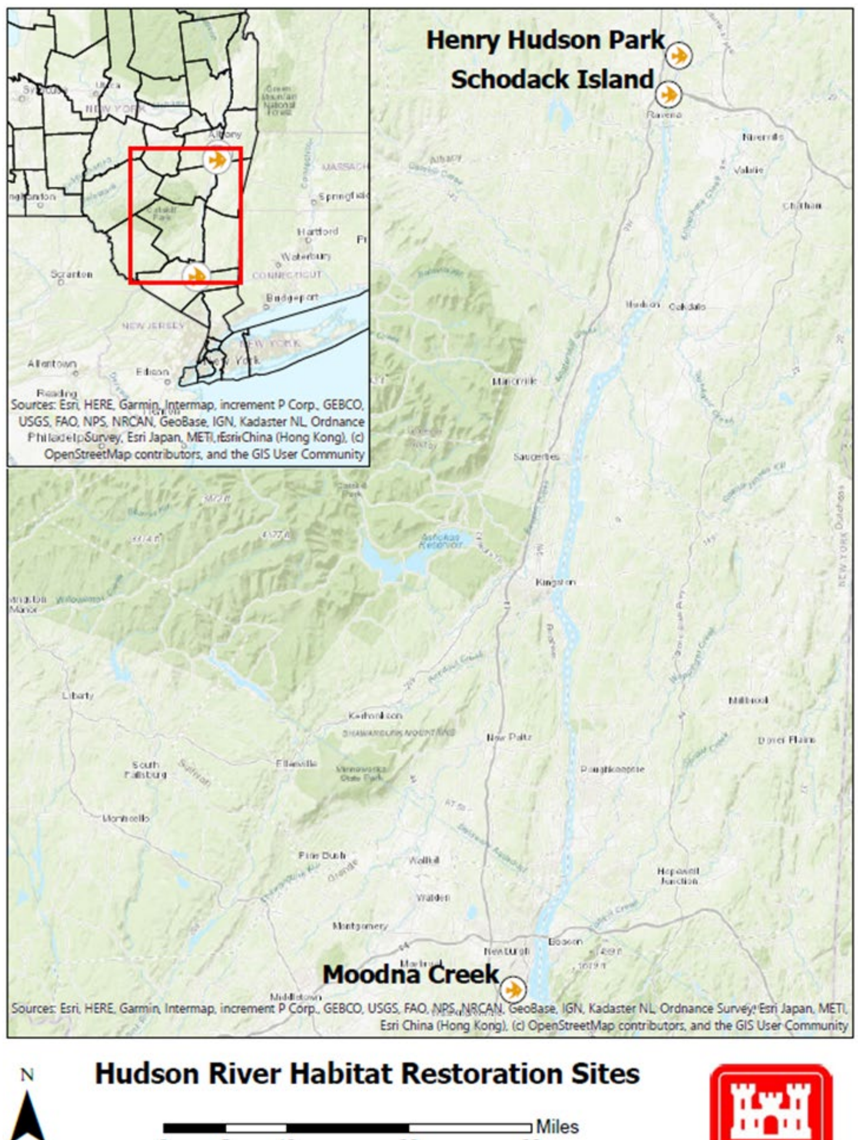

Figure ES-1: Habitat Restoration Sites.

The Recommended Plan would restore a total of approximately 22.8 acres of tidal wetlands, 8.5 acres of side channel and wetland complex, and 1,760 linear feet of living shoreline with 0.6 acres of tidal wetlands. The plan would also reconnect 7.8 miles of tributary habitat to the Hudson River (Table ES-1). The plan would provide a total of 59.2 average annual functional capacity or habitat units. The plan would lessen some of the impacts constructing a federal navigation channel in the Hudson River had on aquatic ecosystems, including the loss and degradation of subtidal, shallow water and side channels, intertidal, and shoreline habitats, as well as the fragmentation of aquatic habitats that occurred as small dams were placed on tributaries to the Hudson River for industrial purposes.

At Henry Hudson Park, the plan would address the impacts of hard-armoring the shoreline and placing dredged material from the navigation channel in wetland areas. The conversion of upland to tidal wetlands along Vloman Kill, the restoration of tidal wetlands at the confluence of Vloman Kill and the Hudson River, and the establishment of a living shoreline along the Hudson River would increase the area and quality of intertidal and shoreline habitat available to fish, amphibians, invertebrates, and birds.

At Schodack Island, the plan would address the impacts of placing dredged material from the navigation channel in tidal wetlands, side channels, and between river islands. Restoring tidal wetlands and reestablishing a side channel connecting the Hudson River with Schodack Creek would restore a mosaic of large river habitats. Side channels provide moderate velocity, high-biodiversity refuges, which serve as nursery, resting and feeding habitat for federally endangered species (shortnose sturgeon and Atlantic sturgeon), American shad, striped bass, and a variety birds, mammals and reptiles.

On Moodna Creek, the plan would address the impacts of small dams and other barriers having been placed at multiple locations on many of the tributaries to the Hudson River. Removing the sewer utility line and Firth Cliff Dam from Moodna Creek, and partially removing Orr's Mill Dam would reconnect an additional 7.8 miles of Moodna Creek with the Hudson River. This would provide spawning, foraging, and resting habitat for migratory fish including anadromous (e.g., American shad, hickory shad, striped bass, alewife, and blueback herring), catadromous (e.g., American eel), and potamodromous (e.g., white sucker, smallmouth bass, white and yellow perch, apottail and golden shiner, carp, northern pike, walleye, shorthead redhorse, and gizzard shad) species. The barrier removals are also expected to improve the quality of in-stream and downstream habitat, by reestablishing sediment, nutrient, and other material transport processes, increasing dissolved oxygen levels, and reducing maximum water temperatures, which would benefit resident fish and other aquatic organisms.

Table ES-1: Recommended Plan Summary.

RESTORATION CATEGORY	SITE	ELEMENT DESCRIPTION OF RECOMMENDED ALTERNATIVES
Shoreline Restoration	Henry Hudson Park	▪ Tidal wetland restoration (3.7 acres) ▪ Hardened bulkhead replaced with a living shoreline (1,760 linear feet of shoreline restoration with 0.6 acres of tidal wetlands)
Large River Mosaic/Side Channels	Schodack Island	▪ Side channel and tidal wetland complex restoration (8.5 acres) ▪ Tidal wetland restoration (19.1 acres)
Tributary Connectivity	Moodna Creek	▪ Removal of a utility crossing (barrier 1) ▪ Removal of Firth Cliff Dam (barrier 2) ▪ Partial removal of Orr's Mill Dam (barrier 3) ▪ Collectively, reconnection of 7.8 miles of habitat
Total		**• 22.8 acres of tidal wetlands in the Hudson River corridor** **• 8.5 acres of side channel and tidal wetland complex** **• 1,760 linear feet of living shoreline with 0.6 acres of tidal wetlands** **• 7.8 miles of tributary habitat reconnected**

The estimated total first cost of the Recommended Plan in FY 2020 (October 2019) price levels is $43,143,000 which includes monitoring costs of $764,285 and adaptive management costs of $980,100. The estimated total fully funded project cost is $62,784,000. The fully funded costs will be the basis for the Design and Project Partnership agreements. In accordance with the cost share provisions in Section 551 (b) of the Water Resources Development Act (WRDA) of 1996, the federal share of the estimated first cost is 75%, or $32,357,143, and the non-federal share is 25%, or $10,785,714. The non-federal costs include the value of lands, easements, rights-of-way, relocations, and dredged or excavated material disposal areas (LERRD), estimated to be $1,347,126. The non-federal sponsor would also be responsible for 100% of the projects' operation, maintenance, repair, rehabilitation, and replacement (OMRR&R) costs, estimated to be a total of $427,879 and average annual OMRR&R costs estimated to be $9,666. Based on a 2.75-percent interest rate and a 50-year period of analysis, the total equivalent average annual costs of the project are estimated to be $1,630,307. Table ES-2 summarizes the benefits, costs, and cost apportionment for each restoration site in the Recommended Plan.

Although the Recommended Plan includes three sites, separate Design and Project Partnership agreements may be executed for each site, depending on non-federal sponsor priorities and available funding. Accordingly, Table ES-2 presents cost apportionment for the Recommended Plan on a per site basis.

Table ES-2: Recommended Plan Benefits, Costs, and Cost Apportionment[1].

SITE	BENEFITS (AAFCU OR AAHU)[2]	AVERAGE ANNUAL COST ($)	ANNUAL UNIT COST ($/UNIT)	TOTAL FIRST COST ($)	FEDERAL COST ($)	NON-FEDERAL COST ($)	TOTAL FULLY FUNDED COST ($)	ANNUAL OMRR&R COST ($)[3]
Henry Hudson Park	2.4 AAFCUs	427,074	179,443	11,228,044	8,421,033	2,807,011	13,725,000	5,125
Schodack Island	8.5 AAFCUs	755,396	88,974	19,848,972	14,886,729	4,962,243	29,296,000	4,541
Moodna Creek	48.4 AAHUs	447,837	9,260	12,065,841	9,049,381	3,016,460	19,764,000	0
ALL	**59.2 HUs**	**1,630,307**	**27,525**	**43,142,857**	**32,357,143**	**10,785,714**	**62,784,000**	**9,666**

[1] Fiscal year 2020 price levels and a discount rate of 2.75% were used for cost estimates.
[2] AAFCUs and AAHUs: Average Annual Functional Capacity Units and Habitat Units
[3] Annual OMRR&R Cost: Annual Operations, Maintenance, Repair, Rehabilitation and Replacement Cost is included in Average Annual Cost but NOT in Total Cost.

Plan formulation for potential restoration sites that were not prioritized in this study may be pursued under the same Hudson River Habitat Restoration study authority or the Continuing Authorities Program (Section 206 or Section 1135). The ability to begin a new study under these authorities depends on the availability of federal funding and the willingness of one or more non-federal sponsors to share study costs and to execute new cost-sharing agreements with USACE.

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Acronyms

AAFCUs – Average Annual Functional Capacity Units

AAHUs – Average Annual Habitat Units

AgACIS – Agricultural Applied Climate Information System

AOP – Aquatic Organism Passage

AM&M – Adaptive Management and Monitoring

CE/ICA – Cost Effectiveness and Incremental Cost Analysis

CEQ – Council on Environmental Quality

CMP – Coastal Management Plan

CSC – Climate Smart Communities

CSOs – Combined Sewer Overflows

CZM – Coastal Zone Management

DA – Design Agreement

EFH – Essential Fish Habitat

EPW – Evaluation of Planned Wetlands

EQ – Environmental Quality

FCI – Functional Capacity Index

FCU – Functional Capacity Units

FCSA – Feasibility Cost Share Agreement

FIRM – Flood Insurance Rate Map

FR/EA – Feasibility Report and Environmental Assessment

FWOP – Future Without Project Conditions

GARFO- Greater Atlantic Regional Fisheries Office

GIGP – Green Innovation Grant Program

GOSR – Governor’s Office of Storm Recovery

HR CRP – Hudson River Comprehensive Restoration Plan

HRHR – Hudson River Habitat Restoration

HTRW – Hazardous Toxic and Radioactive Waste

HU – Habitat Units

LERRD – Lands, Easements, Right-of-Ways, Relocations, and dredge or excavation Disposal areas

LWRP – Local Waterfront Revitalization Program

NAAQS – National Ambient Air Quality Standards

NED – National Economic Development

NEPA – National Environmental Policy Act

NER – National Ecosystem Restoration

NGOs – Non-governmental Organizations

NMFS – National Marine Fisheries Service

NRCS – Natural Resources Conservation Service

NYRCR – New York Rising Community Reconstruction Program

NYSDEC – New York State Department of Environmental Conservation

NYSDOS – New York State Department of State

NYSDOT – New York State Department of Transportation

NWI – National Wetlands Inventory

NWS – National Weather Service

O&M – Operations and Maintenance

OMRR&R – Operations, Maintenance, Repair, Rehabilitation, and Replacement

OSE – Other Social Effects

P&G – Planning and Guidance

PCBs – Polychlorinated biphenyls

PEC – Probable Effect Concentration

PED – Pre-construction Engineering and Design

PPA – Project Partnership Agreement

RCRA – Resource Conservation Recovery Act

RED – Regional Economic Development

SASS – Scenic Areas of Statewide Significance

SCFWH – Significant Coastal Fish and Wildlife Habitats

SPDES – State Pollution Discharge Elimination System

SVOCs – Semi-Volatile Organic Compounds

TEC – Threshold Effect Concentration

TSP – Tentatively Selected Plan

USACE – U.S. Army Corps of Engineers

USCB – U.S. Census Bureau

USFWS – U.S. Fish and Wildlife Service

VOCs – Volatile Organic Compounds

WRDA – Water Resources Development Act

WRRDA – Water Resources Reform and Development Act

WUCT – Watershed-Scale Upstream Connectivity Toolkit

Chapter 1: Introduction

1.1 Overview and Study Area

In this Final Integrated Feasibility Report and Environmental Assessment (FR/EA), the U.S. Army Corps of Engineers (USACE) assesses and recommends solutions to restore degraded significant ecosystem function, structure, and dynamic processes in the Hudson River basin. The FR/EA is the decision document for the Hudson River Habitat Restoration (HRHR) Ecosystem Restoration Feasibility Study, and also documents the compliance of the study and recommended solutions with all applicable environmental requirements, including the National Environmental Policy Act (NEPA). The non-federal sponsors of the study are the New York State Department of Environmental Conservation (NYSDEC) and New York State Department of State (NYSDOS). NYSDEC also plans to be the non-federal sponsor for project implementation (Appendix A).

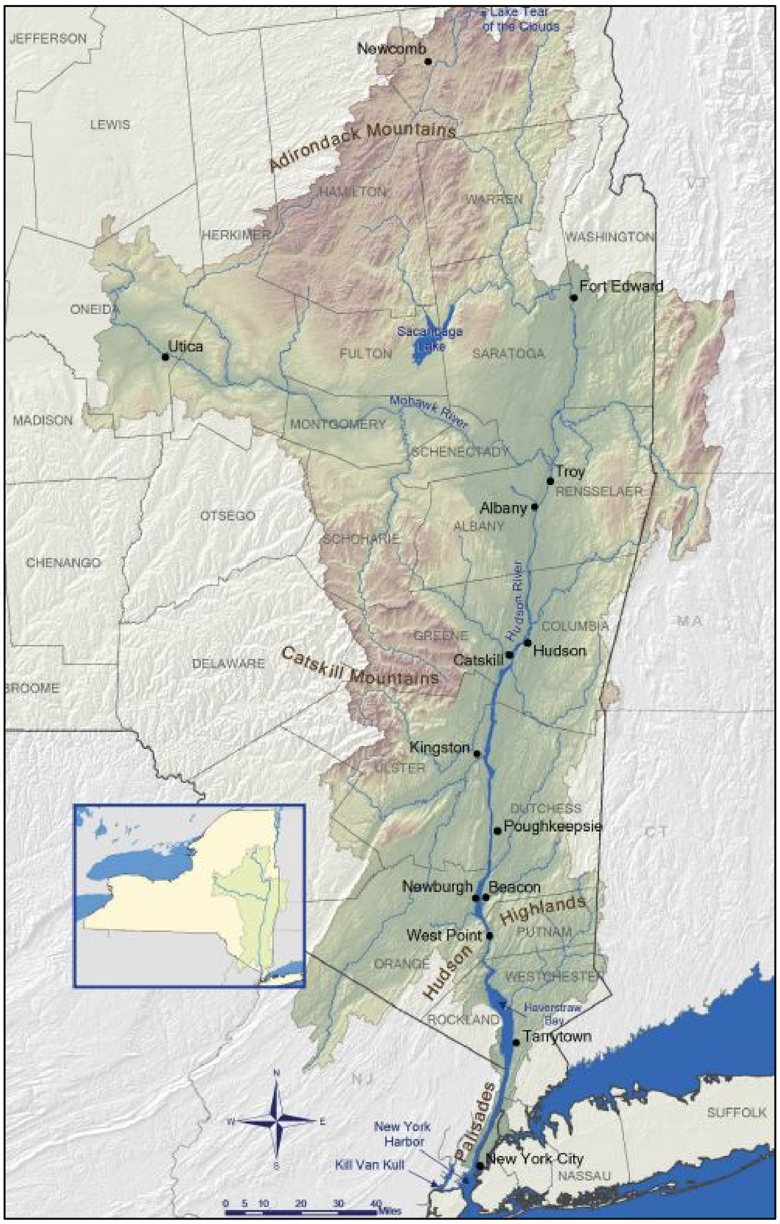


Figure 1-1: Hudson River Basin.

From its origin at Lake Tear of the Clouds in the Adirondack Mountains, in northeastern New York, the Hudson River flows south 315 miles, past New York City, to its outlet in the New York-New Jersey Harbor (Figure 1-1). The river is tidally influenced from the Harbor to Troy, New York, with a saltwater front that is typically detected between West Point and Newburgh, or, during drought conditions, as far upstream as Poughkeepsie. The river's watershed encompasses about 13,400 square miles.

This study aligns with the NYSDEC Hudson River Estuary Habitat Restoration Plan (Miller, 2013), is consistent with the recommendations of the Hudson-Raritan Estuary Comprehensive Restoration Plan (USACE, 2016) and Hudson River Comprehensive Restoration Plan (Partners Restoring the Hudson, 2018), and complements the Hudson-Raritan Estuary Ecosystem Restoration Feasibility Study (USACE, 2020). While this study considers the approximately 125-mile reach of the Hudson River upstream of the Governor Mario M. Cuomo (formerly Tappan Zee) Bridge, to Troy Lock and Dam (Figure 1-2), the Hudson-Raritan Estuary study considers the Hudson River and other water bodies downstream of the bridge, in the area encompassed by a 25-mile radius around the Statue of Liberty National Monument.

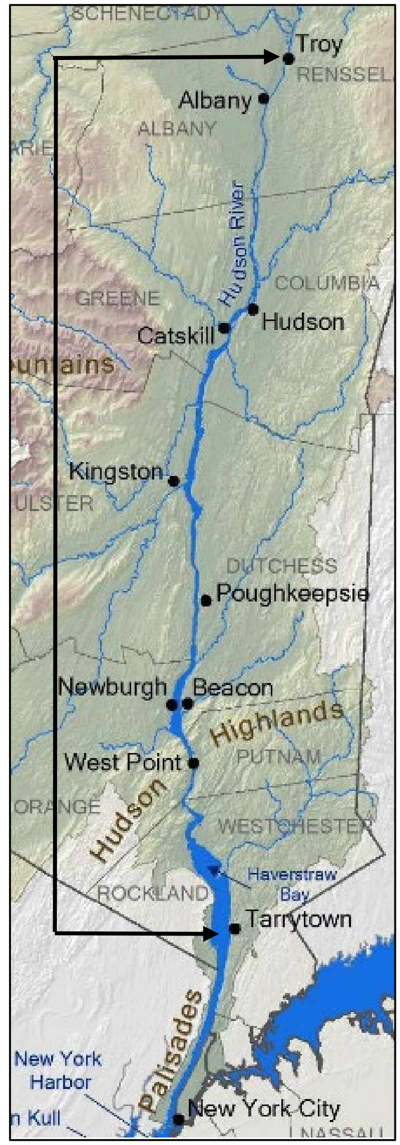


Figure 1-2: Study Area.

1.2 Study Authority and History

A reconnaissance study preceded this feasibility study. The reconnaissance study, which USACE conducted from 1994 to 1996, was authorized by Section 216 of the Rivers and Harbors Act of 1970 and a resolution of the U.S. Senate Committee on Environment and Public Works dated 21 January 1987, which reads:

> *Resolved by the Committee on Environment and Public Works of the United States Senate, that the Board of Engineers for Rivers and Harbors is requested to review previous reports on the Hudson River Channel, New York City to Albany, contained in House Document No. 228, 83rd Congress, 2nd session, dated September 3, 1954, with a view towards improving the existing Federal navigation project, providing anchorages and necessary spur channels.*

The reconnaissance report identified ecosystem restoration problems and opportunities in the Hudson River basin, identified a federal interest in ecosystem restoration in the river basin, and recommended that the study continue into the feasibility phase.

The feasibility study was authorized by Section 551 of the Water Resources Development Act of 1996:

(a) Habitat Restoration.–The Secretary shall expedite the feasibility study of the Hudson River Habitat Restoration, Hudson River Basin, New York, and may carry out not fewer than 4 projects for habitat restoration in the Hudson River Basin, to the extent the Secretary determines such work to be advisable and technically feasible. Such projects shall be designed to–

(1) assess and improve habitat value and environmental outputs of recommended projects;

(2) evaluate various restoration techniques for effectiveness and costs;

(3) fill an important local habitat need within a specific portion of the study area; and

(4) take advantage of ongoing or planned actions by other agencies, local municipalities, or environmental groups that would increase the effectiveness or decrease the overall cost of implementing one of the recommended restoration project sites.

(b) Non-Federal Share. – Non-Federal interests shall provide 25 percent of the cost of each project undertaken under subsection (a). The non-Federal share may be in the form of cash or in-kind contributions.

(c) Authorization of Appropriations. – There is authorized to be appropriated to carry out this section $11,000,000.

USACE executed a Feasibility Cost Sharing Agreement (FCSA) with the non-federal sponsors for the feasibility study, NYSDEC and NYSDOS in 1996, and the study began in 1998. In 2001, the four sites the feasibility study had focused on became unavailable, and the study was put on hold due to lack of consensus on a path forward.

Interest in restoring the Hudson River was renewed in 2012 and the NYSDEC Commissioner Joseph Martens requested that USACE resume the study. A rescoping charrette for the feasibility study was held with USACE, NYSDEC, NYSDOS, and partners in March 2014, and the study was resumed in February 2016. The existing FCSA remained in effect for the study. NYSDEC plans to be the non-federal sponsor for construction.

1.3 Study Partners and Stakeholders

In 2013, anticipating the feasibility study's resumption, *The Nature Conservancy* organized stakeholders, including USACE, NYSDEC, NYSDOS, other state and federal agencies, non-profit and community-based organizations, and research institutes, as the "Partners Restoring the Hudson" (Partners). Together, the Partners developed the Hudson River Comprehensive Restoration Plan, which was released in August 2018. The recommendations in this FR/EA advance that plan's restoration goals, as well as the NYSDEC Hudson River Estuary Action Agenda and NYSDEC Hudson River Estuary Habitat Restoration Plan. The following Partners in addition to USACE and the non-federal sponsors contributed their expertise to this study:

- NYSDEC Hudson River Estuary Program (HREP) Management Advisory Committee
- Hudson River National Estuarine Research Reserve
- Hudson River Valley Greenway
- New York - New Jersey Harbor and Estuary Program
- NOAA Restoration Center
- U.S. Fish and Wildlife Service
- U.S. Environmental Protection Agency (EPA)
- Cornell Cooperative Extension Columbia and Greene Counties
- Cornell Cooperative Extension of Dutchess County
- Historic Hudson River Towns
- Hudson River Boat & Yacht Club Association
- Hudson River Foundation
- Hudson River Watershed Alliance
- Riverkeeper
- Scenic Hudson
- The Nature Conservancy
- Center for International Earth Science Information Network, Columbia University
- Cary Institute of Ecosystem Studies
- Regional Plan Associates

This study's stakeholders are those who live in and visit the study area and others who may be affected by the study's recommendations, as well as the organizations that represent their interests, including federal, tribal, state, and local governments and various non-governmental organizations. The congressional districts in the study area and their representatives are shown in Table 1-1.

Table 1-1: Study Area's Congressional Districts.

SENATORS	REPRESENTATIVES
Chuck Schumer (D)	Nita Lowey (D) 17th District
Kirsten Gillibrand (D)	Sean Maloney (D) 18th District
	Antonio Delgado (D) 19th District
	Paul Tonko (D) 20th District

1.4 Purpose and Need*

USACE's interest in Hudson River restoration stems from the impacts USACE's navigation mission has had on the river's ecosystems, the national significance of those ecosystems, and the potential USACE, working alongside NYSDEC, NYSDOS and other partners, has to measurably improve degraded ecological resources in the river basin.

The population in the Hudson River valley began to grow at the end of the American Revolution. The river has long been a shipping and transportation route, and navigation improvements to the river and the introduction of railroad travel in 1851 accelerated the river valley's development. Early industrial development included brick and cement manufacturing, and those who settled in the valley included vacationers and later, commuters who worked in New York City. USACE became involved in modifying the Hudson River for navigation after the Erie Canal, which linked the Hudson River to the Midwest, was completed in 1825. In 1915, USACE constructed Troy Lock and Dam on the river at Troy, NY, and USACE still maintains a navigation channel in the river from the lock and dam to the harbor.

A total of approximately 4,000 acres of aquatic habitats, including shallow water, intertidal, and wetland habitats, were lost in the upper third of the Hudson River estuary as a result of the navigation improvements that USACE and others made to the Hudson River. Of those, about 3,300 acres were lost to filling, which converted aquatic habitats to upland habitats. The other approximately 700 acres were lost to dredging, which deepened previously shallow waters to more than six feet deep at low tide. More than 85% of the river's islands were eliminated and most of the river's side channels were filled in, resulting in the loss of 71 miles of shoreline. Dredging and filling also occurred along the shores of the Hudson south of Catskill, NY, to accommodate transportation and industrial activities, especially around population centers. Additionally, there are more than 1,600 dams and thousands of culverts in the Hudson River's 90 tributaries, which have significantly reduced available habitat for American eel and other migratory species (Partners Restoring the Hudson, 2018) and serve as impediments to fish passage. The environment, problems, and opportunities in the study area are described in more detail in Chapter 2: Affected Environment and Chapter 3: Plan Formulation.

1.5 Resource Significance

The Hudson River's environmental resources are nationally significant. In accordance with the Economic and Environmental Principles and Guidelines (P&G) for Water and Related Land Resources Implementation Studies (United States Water Resources Council, 1983) and the Planning Guidance Notebook, Engineer Regulation (ER) 1105-2-100, significance is established based on institutional, public, and technical recognition. Examples of institutional, public, and technical recognition that establish the significance of the Hudson River's resources include:

Institutional recognition

- Contains special aquatic sites such as wetlands and vegetated shallows recognized as nationally significant by the Clean Water Act (33 USC 1344)
- Includes exceptionally scarce and declining freshwater tidal marsh as determined by U. S. Fish and Wildlife Service (USFWS) / National Oceanic and Atmospheric Administration (NOAA) status and trends report
- The river is located within the North American Atlantic Flyway, a critical corridor for migrating birds
- The river has received the following national designations:
  - One of 28 Estuaries of National Importance - National Estuary Program (EPA)
  - Hudson River National Estuarine Research Reserve - National Estuarine Research Reserve System - (National Oceanic and Atmospheric Administration [NOAA] National Ocean Service)
  - Hudson River Valley National Heritage Area (National Park Service [NPS])
  - Hudson River - American Heritage River (Executive Order 13061)
  - Hudson River Greenway Water Trail - National Recreation Trail (NPS)
- River restoration is the subject of several regional plans, including the:
  - Hudson River Estuary Action Agenda (NYSDEC)
  - Hudson River Estuary Habitat Restoration Plan (NYSDEC)
  - Hudson River Comprehensive Restoration Plan (Partners Restoring the Hudson)
  - Hudson-Raritan Estuary Comprehensive Restoration Plan

Public recognition

- Communities with land on the waterfront in the study area include 21 villages, 41 towns, and 10 cities bookended by two metropolitan areas in 10 New York counties
- There are plentiful public access sites on the river, providing recreational opportunities for local communities that include hiking, kayaking, swimming and aesthetic views
- Hudson River restoration is supported by the 94 federal and state agencies, non-profit and community-based organizations, and research institutes who collaborated to draft the Hudson River Comprehensive Restoration Plan, and the efforts of the "Partners Restoring the Hudson"

- Hudson River restoration projects contribute to the recovery of fisheries popular with both recreational anglers and commercial fishermen
- The Lower Hudson River was designated a State Important Bird Area by the National Audubon Society

<u>Technical recognition</u>

- Habitat scarcity - The Hudson River contains regionally and globally rare tidal communities including freshwater tidal swamp/tidal marsh/intertidal shore. The Hudson River is also one of only a dozen areas in the northeastern U.S. with more than 500 acres of rare highly productive freshwater tidal marsh and is the only such area in New York State. Significant loss of aquatic habitats, including side channels, shoreline, and tidal wetlands resulted from modifications to the river channel for navigation starting in the 1800s by USACE, as well as the urbanization of the Hudson River valley.
- Habitat connectivity – dams and other barriers disconnected the Hudson River from its tributaries, and the placement of dredged material from the navigation channel in side channels, between river islands, on shorelines, and in wetlands, resulted in the fragmentation of what was a diverse mosaic of tidal and non-tidal freshwater habitats. Side channels and wetlands along the Hudson River provide refuges for a variety of native fish, birds, mammals and reptiles. Access to the river's tributaries from the river, and from the tributaries to the river, is important to migratory fish including anadromous and catadromous species, which use both freshwater and marine habitats, and potamodromous species, which use both small stream and large river habitats.
- Habitat for listed and protected species - species found in the study area include the federally endangered Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus),* shortnose sturgeon *(Acipenser brevirostrum), and* Indiana bat (*Myotis sodalis*); federally threatened northern long-eared bat (*Myotis septentrionalis*), bog turtle (*Clemmys muhlenbergii*), and small whorled pogonia (*Isotria medeoloides*); and state endangered or threatened species including the Karner blue butterfly (*Lycaeides melissa samuelis*), shortnose sturgeon, bog turtle, peregrine falcon (*Falco peregrinus*), black rail (*Laterallus jamaicensis*), Indiana bat, least bittern (*Ixobrychus exilis*), northern harrier (*Circus cyaneus*), bald eagle (*Haliaeetus leucocephalus*), and northern long-eared bat.
- Ecological services - placing fill in the Hudson River's floodplain and installing channel revetments impaired natural floodplain functions like water retention and filtration.

1.6 Prior Reports and Existing Water Resource Projects and Programs

Prior reports on the Hudson River related to ecosystem restoration include:

- Hudson River Habitat Restoration, Hudson River Basin, New York Reconnaissance Report (USACE, 1996)
- Rondout Creek and Wallkill River, Watershed Reconnaissance Report (USACE, 2008)
- Esopus and Plattekill Creeks, Watershed Reconnaissance Report (USACE, 2008)
- Hudson River Estuary Habitat Restoration Plan (Miller, 2013)
- Hudson River Estuary Action Agenda (NYSDEC, 2015a)
- Hudson-Raritan Estuary Comprehensive Restoration Plan (USACE, 2016)
- Hudson River Comprehensive Restoration Plan: Recommendations for the New York–New Jersey Harbor & Estuary Program Action Agenda and the New York State Hudson River Estuary Action Agenda (Partners Restoring the Hudson, 2018).

Existing USACE water resources projects in the study area (Figure 1-3) include:

- Hudson River, New York City to Waterford, New York, Maintenance Dredging
- Hudson River, New York, Operations & Routine Maintenance of Troy Lock & Dam
- Saugerties Harbor, New York, navigation channel
- Rondout Harbor, New York, navigation channel and channel dikes
- City of Kingston Waterfront, Planning Assistance to States
- Wappinger Creek, navigation channel
- Peekskill Harbor, navigation channel
- Tarrytown Harbor, navigation channel
- NY/NJ Harbor and Tributaries Study, coastal storm risk management

Figure 1-3: Existing USACE Water Resource Projects.

Additional Partner Programs include:

- NYSDEC Hudson River Estuary Program
- NYSDEC Hudson River National Estuarine Research Reserve
- NYSDEC Hudson River Fisheries Unit
- The Hudson River Valley Greenway
- The Hudson River Valley National Heritage Area
- American Heritage River
- New York-New Jersey Harbor Estuary Program

The ongoing navigation projects within the study area do not affect this restoration study. Dredged material is currently placed at a disposal facility on Houghtaling Island south of Schodack Island State Park. The study area for the NY/NJ Harbor and Tributaries Study (HATS) extends up the Hudson River to Troy Lock and Dam. As part of its own impact assessment, HATS will consider the effects of coastal storm risk management alternatives in this area. HATS will also consider the use of natural and nature-based features that complement the Recommended Plan. Some of the habitat restoration measures this study evaluated and that were included in the Recommended Plan, such as living shorelines, may provide secondary coastal storm risk management benefits.

1.7 Report Contents

This report describes environmental conditions in the study area, formulation of restoration plans, a Recommended Plan for USACE action, and the environmental and cumulative impacts of that plan. The EA components of the report (Chapters 5 and 6 and Appendix G) were prepared to comply with NEPA requirements. NEPA requires federal agencies to “provide sufficient evidence and analysis for determining whether to prepare an environmental impact statement or a finding of no significant impact” on actions authorized, funded, or carried out by the federal government, to ensure such actions adequately address “environmental consequences, and take actions that protect, restore, and enhance the environment." This report informs decision makers and the public about affected environmental resources and the potential benefits and impacts to those resources that would result from constructing, operating, and maintaining the recommended ecosystem restoration projects.

1.8 USACE Environmental Operating Principles

The USACE Environmental Operating Principles were applied to the study. These principles foster unity of purpose on environmental issues to ensure that conservation, environmental preservation, and restoration are considered in all USACE activities:

1. Foster sustainability as a way of life throughout the organization

2. Proactively consider environmental consequences of all USACE activities and act accordingly
3. Create mutually supporting economic and environmentally sustainable solutions
4. Continue to meet our corporate responsibility and accountability under the law for activities undertaken by USACE, which may impact human and natural environments
5. Consider the environment in employing a risk management and systems approach throughout the life cycles of projects and programs
6. Leverage scientific, economic, and social knowledge to understand the environmental context and effects of USACE actions in a collaborative manner
7. Employ an open, transparent process that respects views of individuals and groups interested in USACE activities

Chapter 2: Existing Environment in the Hudson River Valley*

2.1 Introduction

This chapter discusses the existing environment of the Hudson River valley in an overview from Governor Mario Cuomo Bridge to Troy Lock and Dam. For site-specific existing environmental conditions and impacts, see Chapter 5: Existing Environmental Conditions and Environmental Impacts*. In addition, the site-specific Future Without Project Condition (FWOP) for each category is presented in tables 5-1 through 5-3.

2.2 General Description

The Hudson River's origin is Lake Tear of the Clouds in the Adirondack Mountains at an elevation of 4,322 feet above sea level. From here the river flows southward 315 miles to New York City and the Hudson Raritan Estuary. The Hudson River Valley lies almost entirely within the state of New York, except for its last 22 miles, where it serves as the boundary between New York and New Jersey. Tributaries to the river drain small portions of Connecticut, Massachusetts, New Jersey, and Vermont.

The 125-mile study area concentrates on the environmental habitat restoration problems and opportunities in the Hudson River ecosystem associated with the existing federal channel. The authorized channel extends from New York City, NY upstream to the Federal Lock and Dam at Troy, NY. The river is tidal throughout the study area, with detectable salinity reaching as far north as Poughkeepsie, NY (Hudson River Mile (HRM) 75 – the Battery is HRM 0) during periods of low freshwater discharge.

2.3 Physical Setting

The climate of the study area is characterized by long, cold winters and short warm summers. The mean annual temperature for this region is approximately 40° F. The normal annual temperature during the winter months is about 25° F, and during the summer months it is about 70° F to 75° F. Annual precipitation, in rainfall, for this region is approximately 41 inches. This area receives about 10.5 inches of precipitation during the spring and again in the fall, about 9 inches during the winter, and 11.5 inches during the summer. The mean annual snowfall for the entire Hudson River Basin varies from about 100 inches in the northern regions to about 20 inches in the lower reaches near New York City. Storms occurring in this region are transcontinental and extratropical. The transcontinental storms come from the Gulf of Mexico and the west, often in the spring, while tropical storms generally occur in the fall, from the Atlantic Ocean. Thunderstorms and cloudbursts usually occur during the summer months.

The winds of this region of the Hudson River lie in a belt of prevailing westerlies; however, physiographic features orient a large percentage of the winds in a north-south direction. Direction of the winds during the winter months is from the north and in the summer months from the south. The average wind velocity in the Hudson River Valley is 10 mph. Maximum velocities are experienced during hurricanes, with winds of 75-mph or greater.

The topography of this reach of the Hudson River and its surrounding area is quite different from the basin upstream of the existing federal channel. The stream gradient for this reach of the river is slight, dropping only five feet in 155 miles. Flowing in an almost straight southerly direction, the river basin is bounded on the west by the Catskill Mountains and on the east by the Taconic Mountains. A major topographic feature of the central portion of this region is the Hudson Highlands, the cliffs of which rise directly from the river.

The entire Hudson River drainage basin covers approximately 13,000 sq. mi and includes 3 major sub-basins: Upper Hudson (4,627 sq. mi), Mohawk (3,463 sq. mi) and Lower Hudson (4,940 sq. mi).

2.4 Geological Setting

The Hudson River Valley is a north-south trending linear lowland, extending from New York City to the Adirondack Mountains. The Highlands Gorge in the Peekskill, NY area geographically subdivides the study area into two sections. Both sections are geographically within the Hudson River estuary, but for the purpose of describing the geotechnical setting of the study area the two sections will be called the river valley section and the estuary section. The river valley section extends from Albany to Cornwall-on-the-Hudson, NY. The estuary section extends from Troy Lock and Dam south to the Battery. Although the Hudson River is considered an antecedent stream, many changes in the river's course appear to be controlled by fault zones or by contact with erosion-resistant rocks.

2.4.1 Bedrock

From just south of Albany to Kingston the Hudson River Valley is relatively narrow and steep-walled. The Catskill Mountains lie to the west and the lower Taconic Mountains lie to the east. This section of the river valley is predominantly underlain by Ordovician shale and sandstone with some chert and siltstone. Some Cambrian shale, conglomerate, and limestone are also present.

South of Kingston the valley widens and the river deepens. The Catskill Mountains withdraw to the west. The most common rocks underlying the valley from Kingston to just below Poughkeepsie are Ordovician graywacke, shale, siltstone, chert, and argillite of the Austin Glen, Indian River, Mt. Merino, and Normanskill Formations.

At Cornwall-on-the-Hudson the river valley narrows into a deep steep-sided gorge or fjord with water depths up to 200 feet. Here the river enters the rugged low mountains of the Hudson Highlands. The rocks of the Highlands are predominantly erosion resistant Precambrian and Cambrian metamorphic rocks. Just south of the Highlands, the river passes through the Cortlandt Complex of intrusive rocks.

After passing through the Hudson Highlands the river widens again. As in the Highlands, most of the valley is submerged, forming an estuary. From Stony Point, NY south the river follows the contact between the Triassic rocks of the Newark Basin and the Lower Paleozoic/Precambrian rocks of the Manhattan Prong until it reaches the Hudson Raritan Estuary.

2.4.2 Sediments

Most unconsolidated sediment deposits found in the river valley are the result of glacial and postglacial depositional episodes. Differences in local patterns of deglaciation are responsible for the present location of the various glacial deposits. North of Kingston the river bottom sediments are predominantly sands and sandy silts. A deposit of Quaternary glacial and alluvial deposits conceals the bedrock at Hudson, NY. Clean sands are common in this area. From Saugerties, NY to Kingston the bottom sediments become finer. Between Kingston and Peekskill few streams enter the river and the sediment deposits are generally fine grained. Sediment studies have shown that the river is not carrying coarse grained sediments through the Highlands Gorge. The sediments from Haverstraw Bay to the New Jersey - New York State boundary are clayey silts or sandy clayey silts. From this point south the sediments coarsen appreciably. The coarse fraction of the sediments is probably locally derived, although some may be supplied by the flood tide from New York Bay.

2.5 Water Resources

The Hudson River channel runs nearly straight north and south except for a few sharp bends through the Hudson Highlands. From Troy to Newburgh, the river is generally less than 3/4 mile wide. The river widens at Newburgh Bay, narrows again through the Hudson Highland Gorge, becomes its widest through the shallow bays of Haverstraw Bay and the Governor Mario Cuomo Bridge and remains narrow until it empties into upper New York Harbor at the Battery (Limburg et al., 1986., U.S. of Dept. of Commerce, 1982).

Over the 150 miles from the Troy Lock and Dam to the Battery, New York City, the river gradient is small, only 5 feet, and the river bottom at Albany is at sea level (Limburg et al., 1986, Cooper et al., 1988). This stretch of the river is really a drowned river valley. Intruding sea water flooded the lower river as the last glaciers melted and sea level rose. Tidal freshwater can be found from Troy south to the Poughkeepsie area, however, it is considered saline by regulatory agencies (NOAA Fisheries, NYSDOS) only downstream of Poughkeepsie.

Freshwater flow in the estuary follows a typical seasonal pattern for temperate climates, with the highest flows occurring during the spring and the lowest flows occurring during late summer, early fall, and mid-winter. Approximately 80% of the fresh water in the estuary enters the river upstream of Troy Lock and Dam, with the remaining 20% being introduced through the estuary's tributaries (Limburg et al., 1986). Hudson River tributaries including Stockport Creek, Catskill Creek, Roeliff Jansen Kill, Esopus Creek, Rondout Creek, Moodna Creek and Wappingers Creek are just a few tributaries that contribute significant freshwater and sediment to the system. Freshwater flow into the estuary is partly regulated through releases from the Sacandaga Reservoir, located in the southern Adirondack Mountains. The average annual freshwater flow at the Green Island Gauging Station, just north of Troy is 13,820 cubic feet/second (cfs). Lower Hudson River freshwater flows have been estimated at 19,000 to 20,000 cfs. In the New York Harbor area, additional freshwater enters the system through New York City's sewage treatment plants and the Hackensack, Passaic and Raritan Rivers. The mean tidal flow varies from 425,000 cfs at the Battery to zero at the Troy Lock and Dam, and can be 10 to 100 times greater than the freshwater flow (Limburg et al., 1986).

The tide is semidiurnal, meaning that two high tides and two low tides occur each day. The average tidal range is greatest at the Battery and Troy (4.4 feet) and is least at West Point, NY (2.5 feet; Limburg et al., 1986). Tidal range and flow are affected by freshwater flow, wind, variations in the lunar cycle and ocean storms. While the tidal regime of the estuary essentially reverses the current direction twice each day, strong winds from the south or north can push water into or out of the estuary, obscuring the true tidal regime (Barnthouse et al., 1988).

The currents in the Hudson River are influenced by the same variables that affect the tides. The times of slack water and the velocities and durations of flood and ebb are subject to extensive changes; the times of strengths are less likely to be affected. Near the Troy Lock and Dam, the current does not flood and the velocity of the downstream flow during ebb tide is 0.7 knots. These values are for the summer when the freshwater discharge is at a minimum.

The interaction between salt water and freshwater is a key feature of the estuary. Dense salt water from the ocean flows up the river where it meets less dense fresh water flowing downstream. Where the two mix, a diffuse wedge of intruding salt water forms. This mixing of salt and freshwater creates a salinity gradient measured in parts per thousand (ppt) which can be grouped into three basic salinity zones within the estuary: polyhaline (18-30 ppt), brackish (includes oligo- and mesohaline 0.5-18ppt) and tidal fresh (<0.5ppt; Limburg et al., 1986). The location of the zones varies with daily tides and seasonally. Under average runoff conditions the limit of salt water intrusion can usually be found 50 to 60 miles north of the Battery, between West Point and the Newburgh area. In general, seasonal patterns in freshwater flow cause saline water to move upriver in the summer and early fall and to move southward in the winter and spring. During periods of very high freshwater flow the salt front can be pushed as far south as the Bronx in New York City (HRM 15) while during drought periods the salt front has approached the Poughkeepsie area (HRM 75). Measurable salt water reached Kingston, 100 miles north of the Battery during the 1965-66 drought (Limburg et al., 1986).

Tidal forces, irregularities in the channel's bottom and river depth affect the mixing of salt and fresh water. The resulting condition is a vertical as well as horizontal salinity gradient. Measurements of vertical gradients of salinity show that during low flow conditions, salt water and fresh water are generally well mixed, while under high flow conditions, freshwater tends to override the denser salt water layer. Parallel shallow areas may receive less salt water, have delayed mixing and experience reduced ranges in salinity (Limburg et al., 1986).

Dissolved oxygen tends to be highest during the late winter and early spring months, when the river is coolest and least saline. During summer, warmer waters contain lower levels of dissolved oxygen due to a lower saturation point throughout much of the estuary. In general, oxygen levels drop south of Albany, recover and peak near Saugerties, decrease slightly through the Highlands, then rise again south of Peekskill and are high in Haverstraw Bay and the Tappan Zee. Levels drop past Yonkers and remain low throughout the New York City area due to biological oxygen demand associated with sewage inputs (Limburg et al., 1986). Typical dissolved oxygen levels are between 5 and 14 milligrams/liter (Barnthouse et al., 1988).

The essential nutrients of phosphorus, nitrogen and carbon play important roles in the productivity of aquatic systems and their sources and fates have been closely studied over the years. Phosphorus enters the Hudson estuary from a variety of sources, including natural ones (organic detritus), non-point source runoff, and sewage discharges. Phosphorus inputs are greatest near the mouth of the river due to combined sewer overflows and sewage treatment plant effluent from the greater NY-NJ metropolitan area (Limburg et al., 1986).

The lower estuary easily meets the phosphorous requirements for the growth of algae and microscopic plants that form the base of an important estuarine food chain. Because natural levels of phosphorous are high relative to demand, phosphorus is not a limiting factor for biological productivity, and biological uptake does not control phosphorus levels. In the freshwater portion of the estuary, although dissolved organic and particulate phosphorus remain high throughout the year, the more usable form, phosphate, varies seasonally, with the lowest values occurring in late summer. Phosphate may, at these times, limit net algal growth in the upper portion of the estuary (Cole, et al., 1991, 1992).

Sources of nitrogen for the estuary include precipitation, decomposition of organic matter, surface and groundwater discharge and nitrogen fixation both in water and in sediments. Nitrogen enters the estuary in the forms of ammonia, nitrate, nitrite and organic nitrogen. Nitrogen is lost from the estuary through outflows from the basin, bacterial denitrification, through burial of nitrogen-containing compounds in the sediments and as water flows into the Atlantic Ocean (Limburg et al., 1986).

The availability of organic carbon drives and controls total food chain productivity. Organic carbon inputs into the Hudson estuary include both autochthonous sources (originating within the river) and allochthonous sources (originating outside the river). The relative contribution of various sources to the overall carbon budget varies with seasonal changes in water flow. During periods of high flow, the allochthonous contribution from both the upper and lower Hudson River watershed areas can be three times the contribution from instream phytoplankton and macrophytes (Howarth, et al., 1991). By contrast, phytoplankton, submerged vegetation, contributions from tidal wetlands and sewage become the major sources of organic carbon during the summer, when river flows decrease and watershed inputs decline (Limburg et al., 1986).

2.6 Ecological Communities

The Hudson River contains many distinct ecological communities, or assemblages of interacting plant and animal populations that share a common environment (Reschke, 1990). The communities are part of the estuarine system which includes the deepwater tidal habitats and adjacent tidal wetlands. Adjacent freshwater creeks and upland forest feed into, and are a part of, the Hudson River ecosystem.

An inventory of tidal wetlands in the Hudson River in 2007 documented approximately 7,000 acres between the George Washington Bridge and the head of tide at Troy (NYSDEC, 2015b). The Hudson River is one of only a dozen areas in the northeastern U.S. with more than 500 acres of tidal freshwater marsh and is the only such area in New York State. Tidal freshwater wetlands are highly productive biological communities, characterized by near freshwater conditions (average annual salinity of 0.5 ppt or below except during extended periods of drought), plant and animal communities dominated by freshwater species, and a semi-diurnal lunar tidal fluctuation (Swift, 1987).

Over 16,500 acres in the estuary from Albany-Rensselaer to Rockland-Westchester counties have been inventoried and designated `significant coastal fish and wildlife habitat' by NYSDEC and NYSDOS. In addition, the New York Natural Heritage Program has identified numerous significant sites along the estuary where rare species or natural communities occur.

2.6.1 Fishes

Fish common to the estuary can be grouped according to the habitat in which they reproduce. Anadromous species are marine forms that move inshore to spawn in freshwater but will spend most of their lives in salt water. Important species include: Atlantic sturgeon (*Acinpenser oxyrinchus oxyrinchus*), shortnose sturgeon (*Acipenser brevirostrum*), American shad (*Alosa sapidissima*), striped bass (*Morone saxatilis*), alewife (*Alosa pseudoharengus*), and blueback herring (*Alosa aestivalis*). One species, the American eel (*Anguilla rostrata*), is catadromous, adults spawn at sea and the young mature in the estuary then travel upriver into the tributaries to live as adults. Marine fish, such as Atlantic menhaden (*Brevoortia tyrannus*), bluefish (*Pomatomus saltatrix*), weakfish (*Cynoscion regalis*), winter flounder (*Pseudopleuronectes americanus*), and summer flounder (*Paralichthys dentatus*), hatch and live in the sea but move inshore to feed in low-salinity waters during their first year of life. Resident species include two types: estuarine fishes which are marine but spawn and spend most if not all of their lives in the brackish portion of the estuary, such as white perch (*Morone americana*), bay anchovy (*Anchoa mitchilli*), hogchoker (*Trinectes maculatus*), and tomcod (*Microgadus tomcod*), and freshwater fishes which primarily spend their lives in the freshwater reaches of the river but may spend time in brackish areas as well, such as white bullhead (*Ameiurus catus*), black bass (*Micropterus salmoides*), and brown bullhead (*Ameiurus nebulosus*). The Hudson River is free flowing along the mainstem from the Battery to Troy Lock and Dam; however, more than 1,600 dams and culverts within many of the tributaries serve as barriers for these anadromous and catadromous fish species.

2.6.2 Birds

The Hudson River corridor is part of the Atlantic Flyway, one of four major avian migratory routes in North America. Spring migration occurs along the estuary in February - May; fall migration occurs in September - November. Concentrations of mixed waterfowl can be seen resting and feeding in shallow areas such as Stockport Flats, Tappan Zee, Esopus Meadows, and the flats north of Kingston. Dabbling ducks often congregate in shallows supporting beds of water celery (*Vallisneria americana*). A variety of diving ducks overwinter on open water portions of the estuary, feeding on small fishes such as killifish, shellfish and crustaceans. Herons and egrets commonly feed in sub-tidal shallows during late summer and early fall. Birds of prey are seen circling above the river feeding on fishes and small mammals. The estuary's marshes provide nesting habitat for a limited number of songbirds.

Table 2-1: Common Avian Species in the Hudson River Valley.

Common Name	Scientific Name	Common Name	Scientific Name
Marsh wren	*Cistothorus palustris*	American bittern	*Botaurus lentiginosus*
Red-winged blackbird	*Agelaius phoeniceus*	Spotted sandpiper	*Actitis macularia*
Swamp sparrow	*Melospiza georgiana*	Common snipe	*Gallinago galligano*
Virginia rail	*Rallus limicola*	Greater yellowlegs	*Tringa melanoleuca*
Yellow warbler	*Dendroica petechia*	Belted kingfisher	*Ceryle alcyon*
Song sparrow	*Melospiza melodia*	Eastern kingbird	*Tyrranus tyrannus*
Willow flycatcher	*Empidonax traillii*	Tree swallow	*Tachycineta bicolor*
Common yellowthroat	*Geothylpis trichas*	Grey catbird	*Dumetella carolinensis*
American goldfinch	*Carduelis tristis*	Common grackle	*Quiscalus quiscula*
Mute swan	*Cygnus olor*	Pied-billed grebe	*Podilymbus podiceps*
Canada goose	*Branta canadensis*	Blue-winged teal	*Anas discors*
Mallard	*Anas platyrhynchos*	American bittern	*Botaurus lentiginosus*
American black duck	*Anas rubripes*	Least bittern	*Ixobrychus exilis*
Wood duck	*Aix sponsa*	Virginia rail	*Rallus limicola*
Great Blue heron	*Ardea herodias*	King rail	*Rallus elegans*
Green-backed heron	*Butorides striatus*	Sora	*Porzana carolina*
Least bittern	*Ixobrychus exilis*	Common moorhen	*Gallinula chloropus*
Cerulean warbler	*Setophaga cerulea*	Wood thrush	*Hylocichla mustelina*
Hermit thrush	*Catharus guttatus*	Blue jay	*Cyanocitta cristata*
Yellow-throated vireo	*Vireo flavifrons*	American crow	*Corvus brachyrhynchos*
Red-eyed vireo	*Vireo olivaceus*	Black-capped chickadee	*Poecile atricapillus*
Warbling vireo	*Vireo gilvus*	Tuffted titmouse	*Baeolophus bicolor*
Blue-headed vireo	*Vireo solitarius*	White-breasted nuthatch	*Sitta carolinensis*
Carolina wren	*Thryothorus ludovicianus*	Gray catbird	*Dumetella carolinensis*
American robin	*Turdus migratorius*	Cedar waxwing	*Bombycilla cedrorum*
Eastern bluebird	*Sialia sialis*	Ovenbird	*Seiurus aurocapilla*
Yellow-rumped warbler	*Setophaga coronata*	Northern parula	*Setophaga americana*
Blue-winged warbler	*Vermivora cyanoptera*	Yellow warbler	*Setophaga petechia*
Black-throated blue warbler	*Setophaga caerulescens*	Black and white warbler	*Mniotilta varia*
Black-throated green warbler	*Setophaga virens*	Great crested flycatcher	*Myiarchus crinitus*
Olive-sided flycatcher	Contopus cooperi	Alder flycatcher	*Empidonax alnorum*
Eastern wood-pewee	Contopus virens	Willow flycatcher	*Empidonax traillii*
Acadian flycatcher	Empidonax virescens	Eastern phoebe	*Sayornis phoebe*
Yellow-bellied sapsucker	Sphyrapicus thyroideus	Eastern kingbird	*Tyrannus tyrannus*

2.6.3 Reptiles and Amphibians

The most important habitats for reptiles and amphibians are the tidal marshes and shallows, woodland pools and ponds, and adjacent terrestrial forests. Tidal fluctuation and salinity prevent some species from living in the estuary itself. Reptiles found within the estuary include: snapping turtle (*Chelydra serpentina*)*,* northern map turtle (*Graptemys geographica*), painted turtle (*Chrysemys picta*), spotted turtle (*Clemmys guttata*), common box turtle (*Terrapene Carolina*), wood turtle (*Glyptemys insculpta*), and five-lined skink (*Plestiodon fasciatus*). While amphibians are not abundant in the estuary, freshwater wetland areas provide important breeding habitat for amphibians such as peepers and other tree frogs.

2.6.4 Mammals

Mammals associated with the Hudson River valley include: muskrat (*Ondatra zibethicus*), American mink (*Neovison vison*), North American river otter (*Lontra canadensis*), whitetail deer (*Odocoileus virginianus*), white-footed mouse (*Peromyscus leucopus*), eastern cottontail (*Sylvilagus floridanus*), eastern gray squirrel (*Sciurus carolinensis*), meadow vole (*Microtus pennsylvanicus*), northern shorttail shrew (*Blarina brevicauda*), raccoon (*Procyon lotor*), gray fox (*Urocyon cinereoargenteus*), red fox (*Vulpes vulpes*), Virginia opossum (Didelphis virginiana) and North American beaver (*Castor Canadensis*).

2.6.5 Endangered and Threatened Species

The federal endangered and threatened species that utilize the Hudson River estuary as habitat include the federally endangered Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus),* shortnose sturgeon *(Acipenser brevirostrum),* and Indiana bat (*Myotis sodalis*), and the federally threatened northern long-eared bat (*Myotis septentrionalis*), bog turtle (*Clemmys muhlenbergii*), and small whorled pogonia (*Isotria medeoloides*). State endangered and threatened species include the Karner blue butterfly (*Lycaeides melissa samuelis*), shortnose sturgeon, bog turtle, peregrine falcon (*Falco peregrinus*), black rail (*Laterallus jamaicensis*), Indiana bat, least bittern (*Ixobrychus exilis*), northern harrier (*Circus cyaneus*), bald eagle (*Haliaeetus leucocephalus*), and northern long-eared bat.

2.6.6 Vegetation

Vegetation in the river varies depending on the salinity, depth of water, and currents. Typical submerged aquatic vegetation in the brackish subtidal community consists of native wild celery (*Vallisneria americana*) and clasping pondweed (*Potamogeton perfoliatus)* as well as nonnative Eurasian water milfoil (*Myriophyllum spicatum*) and curly pondweed (*Potamogeton crispus*).

Mudflat plant communities are often characterized with rosette structures (i.e., having leaves in a circular arrangement). The plant communities may include native awl-leaf arrowhead (*Sagittaria subulata*), kidneyleaf mud-plantain (*Heteranthera reniformis*), and soft-stemmed bulrush (*Scirpus validus*), and the non-native spatterdock (*Nuphar advena*).

The freshwater intertidal zone is characterized by native threesquare (*Scirpus americanus*), wild rice (*Zizania spp*.), pickerelweed (*Pontederia cordata*), cattail (*Typha* spp.), jewelweed (*Impatiens capensis*), and spatter dock (*Nuphar advena*), and non-native common reed (*Phragmities spp*.) and purple loosetrife (*Lythrum salicaria*).

Terrestrial vegetation along the Hudson River in undeveloped areas is generally deciduous forest. Extensive areas of the river's shores are forested with oaks (*Quercus* spp.), maples (*Acer* spp.*)*, beeches (*Fagus spp.*), birches (*Betula spp.*), and pines (*Pinaceae* spp). Dry rocky slopes such as the Palisades Ridge and Hudson Highlands support oaks. Areas with deeper soils, generally located in the mid-upper reaches of the estuary, as well as moist ravines down river, support oaks, maples, tulips (*Liriodendroidae* spp.), birches, beeches, and dogwood (*Cornaceae* spp.).

2.7 Human Impacts and Ecosystem Degradation

USACE maintains a federal navigation channel in the Hudson River from Troy Lock and Dam to the New York-New Jersey Harbor, and periodically dredges the channel between Albany and New York City to a depth of 32 feet. There is currently an active dredged material placement area on Houghtaling Island on the southern part of Schodack Island State Park. The modifications that were made to the river for navigation, and the ecological impacts of these modifications, are described in Chapter 3: Plan Formulation, Section 3.1.1, Problems. Other human impacts to the Hudson River and resulting ecosystem degradation are described below.

Numerous population centers of varying sizes are located along the river in the study area. The north end is flanked by the cities of Albany and Troy. Numerous smaller communities are located along both banks of the river to the southern Rockland-Westchester County lines. From here south, the greater New York Metropolitan area, with its estimated population of nearly 8 million people, dominates the shoreline of the estuary. As a result of the large population and need to protect property and land, over 10,100 acres of shoreline are engineered or hardened to limit erosion of sediment into the channel and prevent bank retreat (Partners Restoring the Hudson, 2018). Approximately 53% of the shoreline is engineered within the study area (http://gis.ny.gov/gisdata/inventories/details.cfm?dsid=1136).

Railroad tracks were constructed along both shores of the estuary, on the east to Rensselaer County and on the west to central Ulster County, during the 19th century

(NYSDEC, 1988). The tracks cut off numerous shallow coves and bays at the mouths of tributaries from the river mainstem (Squires, 1992).

The Hudson River provides water for several communities and institutions within the study area. Among the communities which presently withdraw water from the river are the Village of Rhinebeck, NY, the City of Poughkeepsie, and the Highland and Port Ewen Water Districts. A pumping station in Chelsea, New York, which is capable of drawing water from the Hudson River, may be available to augment the water supply by 100 MGD under emergency conditions. The Hudson is also a source of industrial process water or once through cooling systems at power plants, obtained indirectly through municipal systems or from direct withdrawals.

Several major power generating facilities, manufacturing plants, petroleum terminals, cement and aggregate plants, as well as various mining operations, are located along the banks of the river. More recently, several resource recovery facilities that utilize river water for cooling have been built along the river. Many of the river's tributaries were historically dammed for industrial use. The dams eliminated access to spawning habitat for many anadromous fish, notably herring and shad.

Unregulated discharge of polychlorinated biphenyls (PCBs) from two General Electric capacitor manufacturing plants in the non-tidal river above Troy Lock and Dam between 1947 and 1977 contaminated sediments and has resulted in PCB uptake by Hudson Estuary biota, especially striped bass and other commercially and recreationally significant sportfish (Limburg et al., 1986). The EPA concluded that contaminated sediments in the upper Hudson River are a major source of PCBs for the entire river environment at least as far as New York Harbor (EPA, 1997b). The Contaminant Assessment and Reduction Project (CARP) identified the upper freshwater non-tidal portion of the Hudson River Superfund Site, which includes 200 miles of the Hudson River between Hudson Falls and the Battery, to be the dominant external source of PCBs to the New York/New Jersey Harbor Estuary. This portion was contributing about three-quarters of the PCB load below Troy Dam to the Atlantic Ocean, and modeling showed these PCBs were transported throughout the entire estuary, including Newark Bay (Suszkowski and Lodge, 2008). Studies conducted to evaluate the extent of the problem revealed that most of the contaminated sediments were in "hot spots" situated in a 40-mile stretch of the river between the town of Fort Edward and Troy Dam.

In February 2002, the EPA issued a Record of Decision (ROD) for the Hudson River Superfund Site that called for targeted dredging of approximately 2.65 million cubic yards of PCB-contaminated sediments from this 40-mile section of the Upper Hudson River. General Electric removed a total of 2.75 million cubic yards of PCB-contaminated sediments from the river bottom between 2009 and 2015. Monitoring to track the river's recovery and to confirm that cleanup was successful is ongoing (USEPA, 2019). The second five-year review indicated that the dredging was very successful in removing the contaminated sediments that exceeded EPA thresholds and showed that over 99% of the sampled locations are below the surface sediment criteria set in the ROD. The EPA will continue to review monitoring data and fish tissue data in order to make reliable conclusions on the effectiveness of the remedy in the Upper Hudson. In addition, EPA is working closely with NYSDEC to advance assessment of the Hudson River from Troy to the mouth of New York Harbor to determine if additional remedial actions are needed. The USACE will continue to work with both EPA and NYSDEC on future activities.

Sewage plants located along tributaries to the river discharge treated effluent into the water. In the lower estuary, combined sewer overflows (CSOs) discharge untreated effluent that the overflowing system cannot handle during storm events, contributing a pulse of nutrients and toxic materials to the water.

Exotic zebra mussel introduced to the river in 1992 depleted the river’s standing stock of phytoplankton and impacted other successive food chain components, including zooplankton.

The Hudson River is on the 303(d) List of Impaired Waters: Part 2b – Multiple Segment/Categorical Waterbody Segments Impaired due to Fish Consumption Advisories (USEPA, 2016a). The impairment extends up into the river’s tributaries, to the first impassable barrier. The fish consumption advisories (do not eat, or limit consumption) NY State has issued are due to high levels of PCBs in fish in the river.

Despite the fish consumption advisories, the Hudson River is used for commercial and recreational fishing, as well as hunting and trapping along the river banks. The river is also used for boating and swimming, and as an outdoor laboratory for education and research.

Chapter 3: Plan Formulation

Plan formulation is the process of building plans that meet planning objectives and avoid planning constraints. For the Hudson River Habitat Restoration study, plans were formulated by (1) defining problems, opportunities, objectives, and constraints, (2) identifying and screening restoration sites, (3) developing sets of site-specific management measures to address one or more of the planning objectives, (4) combining measures into alternative plans for each site and/or site component, (5) evaluating the plans' costs and benefits, (6) comparing the alternatives at sites or site components, (7) comparing the site alternatives within a restoration type (large mosaics/side channels, shoreline restoration, tributary connectivity), (8) tentatively selecting a plan, and (9) optimizing the tentatively-selected plan based on a) technical, policy, agency, and public reviews and b) feasibility-level design, to (10) recommend a National Ecosystem Restoration (NER) Plan. The NER Plan is the Recommended Plan.

Plans were formulated for this study in accordance with the requirements of the Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (1983); ER 1105-2-100; Civil Works Ecosystem Restoration Policy (ER 1165-2-501); Ecosystem Restoration Supporting Policy Information (Engineer Pamphlet 1165-2-502); and Review Policy for Civil Works (EC 1165-2-217).

Supplementing the following description of the plan formulation process for this study is Appendix C - Plan Formulation.

3.1 Problems, Opportunities, Objectives, and Constraints

This section defines the problems, opportunities, objectives, and constraints that guided plan formulation for this study.

3.1.1 Problems

As described in Chapter 2, human activity has led to the degradation of the Hudson River ecosystem. Developing and maintaining the federal navigation project in the river, and development in the Hudson River valley, in particular, have altered the morphology and hydrology of the Hudson River, its side channels, and floodplain, resulting in the loss of valuable habitat for federally endangered fish species (shortnose sturgeon and Atlantic sturgeon), American shad, and striped bass, as well as many birds, mammals, and reptiles. Certain fish, bird and wildlife populations supported by the Hudson River estuary have declined to critically low levels over the past 70 years (Miller, 2013).

Modifications to the Hudson River for navigation began in 1790. USACE became involved in 1834, when Congress authorized a federal navigation project in the river. USACE currently maintains a federal navigation channel in the river between Troy, NY

(HRM 154.8) and the Battery in New York City (HRM 0). Modifications to the river for navigation in the study area, which extends from Troy Lock and Dam to the Governor Mario M. Cuomo Bridge, have generally included:

- Dams and dikes connecting islands to each other and the mainland and closing side channels
- Stone and timber revetments
- Removal of shoals and sandbars
- Channel deepening (1899: 12 feet, 1931: 27 feet, and 1954: 32 feet)
- Channel widening (up to 400 feet between Troy and Kingston and 600 feet between Kingston and New York City)
- Dredged material placement on and along river shorelines, on and between islands, in side channels, and in the river (creating new islands)
- Troy Lock and Dam
- Saugerties, Rondout, Peekskill, and Tarrytown harbors
- Entrance channels at Catskill and Wappinger creeks

A history of the federal navigation project, including specific alterations that were made to the Hudson River between 1790 and 1954, is contained in the Reconnaissance Report for this study (USACE, 1996). The modifications to the Hudson River that were made for the federal navigation project altered the river's ecosystems in several ways.

Dikes, dams, dredging and the placement of dredged material along river banks changed channel depths (Figure 3-1) and narrowed the river overall. This altered water velocity distributions in the river, disrupting the river's sediment regime, or the transport, supply, and storage of sediments in the river (USACE, 1996).

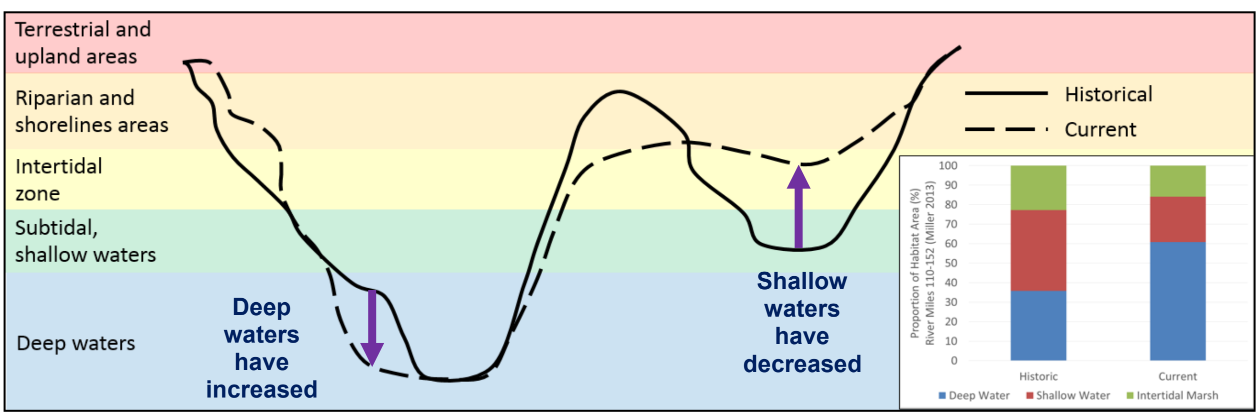


Figure 3-1: Example Historic and Current Cross-Section of the Hudson River.

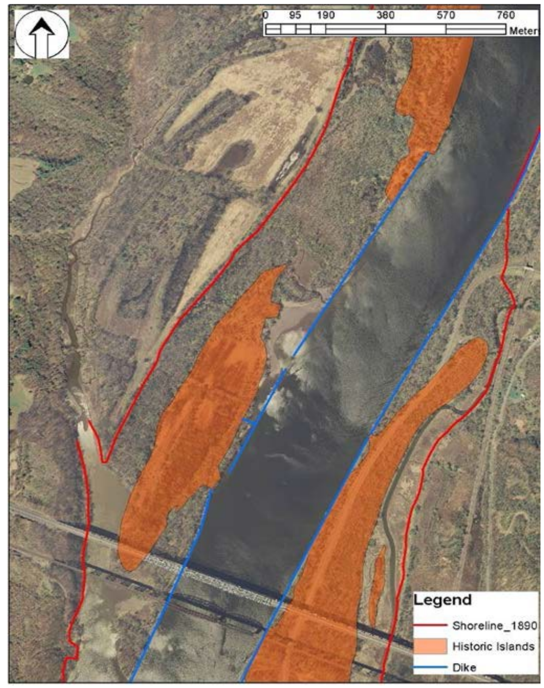


Figure 3-2: Example of Historic Islands Now Part of the Mainland; Castleton, NY (Source: NYSDEC, 2013).

Dikes, dams, and placement of dredged material along river banks, in between islands and the mainland, and in side channels, reduced both areas of open water and the amount of shallow water habitat in and near the river. The hydrologic connectivity between the river and its floodplain was reduced, over 85% of islands were lost (Figure 3-2) and most of the side channels in the upper portion of the study area were filled in. Placing dredged material in shallow water and marshes often induced habitat transitioning to high marsh or upland systems (USACE, 1996).

Dikes, dams, dredged material placement, and revetments changed the river's shoreline. The placement of dredged material in side channels led to the loss of 71 miles of shoreline. Bulkheads and rip-rap were used to harden over 10,100 acres of shoreline (Partners Restoring the Hudson, 2018), which altered or eliminated natural shoreline functions, such as erosion and accretion and the maintenance of a dynamic ecotone between aquatic and riparian areas.

Historical dredging of the federal navigation channel and dredged material placement resulted in negative impacts to over 9,200 acres of habitats in general (Partners Restoring the Hudson, 2018) and the loss of nearly 4,000 acres of shallow water, intertidal, and wetland habitat, including the near-complete elimination of side channels (28 out of 29 side channels) in the upper third of the estuary (Miller et al., 2006 A; Collins and Miller, 2011).

The extent and magnitude of infrastructure building that accompanied the development of the Hudson River valley also led to unintended ecological consequences. Over 1,600 dams were constructed in the Hudson River watershed, including on tributaries to the Hudson River. Disconnecting the river from its tributaries degraded the river's ecosystem, resulting in problems including the: fragmentation of migratory pathways for aquatic organisms such as river herring, sturgeon, and striped bass; disruption of migratory corridors for riparian and upland taxa; and reduced delivery of water, sediment, and nutrients. In addition, constructing railroad tracks along the Hudson River during the 19th century isolated tidal marshes and shallow estuarine coves from the main channel of the Hudson River, reducing the tidal exchange of water, and inhibiting fluxes of particulate materials and nutrients.

Two problem statements for the study area were developed from the problems described above, to guide plan formulation for this study:

1. Intertidal, shallow water, and shoreline habitats connected to the Hudson River have been degraded and reduced in area (e.g., over 9,000 acres of habitat were affected by USACE dredging and dredged material placement, nearly 4,000 acres of shallow water and intertidal habitat have been lost, and 53% of remaining shorelines are hardened).

2. Barriers on Hudson River tributaries have fragmented migration corridors for fish and birds and impaired the exchange of water, sediment, and nutrients.

3.1.2 Opportunities

Opportunities to address problems in the study area include:

- Restoring and/or creating sustainable intertidal, shallow water, and shoreline habitats with hydrologic connectivity to the Hudson River
- Removing barriers on Hudson River tributaries that prevent or impede fish passage and the exchange of water, sediment, and nutrients

Additional opportunities associated with addressing the problems include using natural and nature-based features for coastal storm risk management, providing passive recreation, and providing public education on the historical and importance of the Hudson River.

3.1.3 Future Without Project Conditions

A planning horizon of 100 years comes into play with large scale civil works projects. HRHR is composed of three projects of medium to small size. Performance beyond 50 years was deemed challenging to assess given the resolution of ecological and economic models. While benefits are expected to accrue beyond 50 years, the economic period of analysis and planning horizon were both set at 50 years, from 2027, when the first construction season is assumed to end, to 2076. The terms “period of analysis” and “planning horizon” are used synonymously throughout the report. The future without project condition describes how conditions in the study area will change over the period of analysis if no federal action is taken as a result of this study. The future without project condition is the baseline to which the effects of alternative plans are compared.

The quality and area of some habitats in the Hudson River ecosystem are expected to improve slightly over the 50-year planning horizon. Ongoing, planned, and ad-hoc restoration and conservation projects, including small-scale fish passage projects in the watershed, by government agencies and non-governmental organizations, will result in small habitat gains. Additionally, General Electric’s clean-up of PCBs associated with the Hudson River Superfund Site, completed in 2015, will continue to improve sediment quality in the river and downstream of the areas dredged and capped with monitored natural attenuation. The second five-year monitoring review of the Upper Hudson River remedy determined that the dredging of the Upper Hudson successfully removed contaminated sediments, with over 99% of the sampled locations showing contamination concentrations below the surface sediment criteria set in the Record of Decision. Therefore, overall sediment concentrations throughout the Hudson River will be reduced. Sediment, fish and water will continue to be monitored in the future to determine the additional success of monitored natural attenuation and allow EPA to make reliable conclusions on the effectiveness of the remedy related to protection of human health and the environment (EPA, 2019).

The degradation of the Hudson River ecosystem as a whole is expected to continue due to development, with losses to the area and quality of riparian, wetland, and aquatic habitats. Periodic maintenance dredging of the federal navigation channel will continue; however, dredge material will be properly placed in designated confined disposal facility (e.g., Houghtailing Island). The Hudson River valley will also continue to be developed. Each time it occurs, dredging and/or filling will negatively impact submerged aquatic vegetation beds by changing water depths in the littoral zone, which also impacts water quality. Similarly, continuing shoreline erosion will negatively affect water quality, increasing turbidity and temperature and altering water depths in littoral zones, wetlands, and streams. Additionally, the range of invasive species already present in the Hudson River valley is expected to continue to expand within many of the Hudson River ecosystem's habitats. This will negatively affect the diversity and abundance of native plant, vertebrate, and invertebrate species in the river's ecosystem, with marsh-nesting birds disproportionately affected.

Rising sea levels may exacerbate the loss and degradation indicated above. Analysis indicates a rise of 6 to 36 inches by the year 2077 in the study area. The future without project condition, characterized by extensive reaches of hardened shorelines, reduced shallow water environments, diminished connectivity, and degraded sediment distribution processes will lack the resiliency to adequately adapt to such changes. Areas of wetlands will not be able to migrate due to space constraints. Sediment accretion rates in these wetlands will not be able to keep pace with rising water elevations and shallow waters will deepen, resulting in further habitat loss.

This forecast of how problems and opportunities in the study area are likely to change over the planning horizon is general, and based on observed, known trends. Chapter 5: Existing Environmental Conditions and Environmental Impacts* presents the anticipated future without project conditions for the sites the recommended plan includes. Section 4.6 summarizes the results of a sea level change analysis and nonstationarity and vulnerability assessments for inland hydrology, which are detailed in Appendix B - Engineering. Risk and uncertainty associated with the future without project conditions are discussed in Section 4.8.

3.1.4 Objectives

Ecosystem restoration is one of the primary missions of USACE's Civil Works program. Guidance document ER 1165-2-501 states:

> *The purpose of Civil Works ecosystem restoration activities is to restore significant ecosystem function, structure, and dynamic processes that have been degraded. … The intent of restoration is to partially or fully reestablish the attributes of a naturalistic, functioning, and self-regulating system.*

The federal objectives for ecosystem restoration differ slightly from the objectives for other USACE missions, in that the evaluation and comparison of alternative plans for restoration rely heavily on both monetary and non-monetary metrics. As such, ER 1165-2-501 states:

> *Consistent with the analytical framework established by the P&G, plans to address ecosystem restoration should be formulated and recommended, based on their monetary and non-monetary benefits. These measures do not need to exhibit net national economic development (NED) benefits and should be viewed on the basis of non-monetary outputs compatible with the P&G (Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies) selection criteria.*

The planning objectives, or the desired effects of alternative plans, that were developed based on the aforementioned problems and opportunities to guide plan formulation for this study, are to:

1. Restore <u>a mosaic of interconnected, large river habitats</u>, which together host a diversity of native taxa.
    - Increase the extent and quality of *subtidal, shallow water habitats* (e.g., submerged aquatic vegetation, side channels).
    - Increase the extent and quality of *intertidal habitats (*e.g., freshwater tidal marshes, mud/sand flats).
    - Promote *neighboring shoreline, riparian, and upland habitats* contributing to aquatic ecosystem integrity.
    - Promote a balanced *mosaic of habitat types*.
2. Restore <u>lost ecological connectivity</u> within the Hudson River and its tributaries.
    - Increase the connectivity of spawning, foraging, and resting habitats for *migratory fish* (e.g., shad, herring, eel, and sturgeon).
    - Increase the connectivity of stopover, nesting, and foraging habitat for *migratory and resident birds* from freshwater ecosystems to the ocean.

- Promote actions improving the *transport regime* of water, sediment, and nutrients to the estuary.

3.1.5 Constraints and Other Considerations

Both universal and specific constraints limited the planning process for this study. Universal constraints include legal, regulatory, and policy requirements. Specific constraints (other than resource constraints) that were identified for this study include:

- <u>Navigation:</u> Plans must not significantly impact the federal navigation channel or other existing USACE navigation projects.
- <u>Transportation:</u> Plans must not significantly impact transportation infrastructure or services on, over, or along the Hudson River, including bridges, Amtrak, MetroNorth, and CSX.
- <u>Residential:</u> Plans must not negatively impact existing homes.
- <u>Existing Ecosystem Restoration Projects</u>: Plans must not compromise the function of existing or planned projects.

Other planning considerations included:

- Consistency with Master Plans: Restoration planning should consider and be complementary to municipal, site, and park master plans. Restoration projects should be sited and designed in coordination with stakeholders to also meet local planning objectives.
- Fish Consumption Advisories: Because removing barriers could allow fish with potentially harmful levels of chemical contaminants to enter waters where they are currently not present, for any plans that include barrier removal, NYSDEC will be consulted on the need to expand fish consumption advisories, which are issued by the New York State Department of Health (DOH).

3.1.6 Alignment with State Plans

The NYSDEC Hudson River Estuary Habitat Restoration Plan (Miller, 2013) adapted, and refined for the HRHR Study, restoration objectives identified in USACE's 1996 Hudson River Habitat Restoration Reconnaissance Report and Hudson-Raritan Estuary Comprehensive Restoration Plan (USACE, 2016). The four habitat types the NYSDEC Hudson River Estuary Habitat Restoration Plan identified as priorities for restoration in the study area are intertidal, shallow water, shoreline, and tributary stream habitats. To restore these habitat types, the plan proposed five actions:

- *Protect and conserve existing estuary habitat*, including protection of adjacent shore lands

- *Restore side channels*, including tidal wetlands, vegetated shallow waters, back waters and intertidal habitats
- *Promote and implement construction of fish passage structures, dam removal, and culvert right-sizing and placement* in tributaries to the Hudson
- *Promote and implement use of ecologically enhanced shoreline treatments* where shoreline stabilization is required to protect property or other economic assets
- *Implement programs to control invasive plant species*, including preventing new introductions

Table 3-1 shows how the planning objectives for the HRHR study correspond to the NYSDEC Habitat Restoration Plan's proposed actions.

Table 3-1: Correlating HRHR Objectives and NYSDEC Restoration Plan Actions.

HUDSON RIVER HABITAT RESTORATION OBJECTIVES	CORRESPONDING NYSDEC RESTORATION PLAN ACTIONS
1. Restore <u>a mosaic of interconnected, large river habitats</u> ○ Increase the extent and quality of *subtidal, shallow water habitats* ○ Increase the extent and quality of *intertidal habitats* ○ Promote neighboring *shoreline, riparian, and upland habitats* contributing to aquatic ecosystem integrity ○ Promote a balanced mosaic of habitat types	▪ *Restore side channels*, including tidal wetlands, vegetated shallow waters, back waters and intertidal habitats ▪ *Promote and implement use of ecologically enhanced shoreline treatments* ▪ *Implement programs to control invasive plant species*, including preventing new introductions ▪ *Protect and conserve existing estuary habitat*, including protection of adjacent shore lands
2. Restore <u>lost ecological connectivity</u> within the Hudson River and its tributaries ○ Increase the connectivity of spawning, foraging, and resting habitats for *migratory fish* ○ Increase the connectivity of stopover, nesting, and foraging habitat for *migratory and resident birds* from freshwater ecosystems to the ocean ○ Promote actions improving the *transport regime* of water, sediment, and nutrients to the estuary	▪ *Restore side channels*, including tidal wetlands, vegetated shallow waters, back waters and intertidal habitats ▪ *Promote and implement fish passage*, dam removal, and culvert rightsizing in tributaries to the Hudson

3.2 Site Identification and Screening

3.2.1 Site Identification

In 2015, staff from The Nature Conservancy (TNC), Historic Hudson River Towns, Scenic Hudson, Hudson River Watershed Alliance, with funding from the New York State Energy Research and Development Authority and the Hudson River Estuary Program, facilitated five identical workshops in the Hudson River valley to provide a forum for riverfront communities and counties to identify potential habitat restoration, infrastructure, and access projects. Participants from 25 riverfront communities and all 10 estuary planning offices included city managers, mayors, and representatives of economic development councils, conservation action committees, and non-governmental organizations. In 2017 and 2018, additional opportunities were submitted by government agencies and non-profit organizations participating in the Partners Restoring the Hudson. The communities identified a diverse range of project ideas, from green infrastructure, shoreline restoration, bike paths, and fishing piers, to storm water management, combined sewer outfalls, and waste water treatment plants. Organizations affiliated with the Partners Restoring the Hudson also identified project ideas, ranging from dam and culvert removal to side channel and wetland restoration and additional wastewater treatment. The locations associated with each project idea were used to compile a list of sites.

The restoration sites recommended in the 1996 Hudson River Habitat Restoration Reconnaissance Report were added to the list if those sites had not already been included. The four sites the previous iteration of this study proposed restoring in 2001 were not included as they remained unavailable. Additional potential restoration sites were sought out through a desktop ArcGIS exercise called the Ecological Assessment tool produced by The Nature Conservancy (Partners Restoring the Hudson, 2019b). This tool draws on existing GIS data resources and overlays physical habitat characteristics with quality and threat indicators to identify priority areas for preservation or restoration. The Ecological Assessment tool did not identify any additional sites that had not already been identified. The final list contained 1,800 sites.

Sites with opportunities that could not be addressed through USACE's ecosystem restoration mission and the study authority were removed from consideration for further analysis. As they had been identified, sites were categorized based on the type of opportunity they represented: "habitat restoration," "community infrastructure," and/or "access and education." Many sites had been placed in more than one category. The 1,665 sites that were categorized as "habitat restoration" opportunities were retained for further analysis. The sites that were categorized as "community infrastructure" and/or "access and education" opportunities only were dropped from consideration.

Two-hundred and twelve (212) of the 1,665 "habitat restoration" sites represented opportunities that aligned with the planning objectives developed for this study. Those 212 sites were retained for further analysis.

3.2.2 Site Screening

Site screening was conducted in two stages: preliminary and secondary. Preliminary screening used available information and desktop analyses to shorten the list of potential restoration sites to high-priority sites for which it was likely that acceptable, efficient, effective, and complete alternatives could be developed to meet the planning objectives. Secondary screening included visiting the remaining sites to observe and gather more information about site conditions. The two stages of screening, including the rationale for removing sites from consideration at this time, are described in detail below. The discussion of screening concludes with Figure 3-4, which provides a visual summary of the screening process.

Preliminary Screening

The 212 sites that aligned with the planning objectives for this study were divided into two groups, based on which of the two objectives they most closely aligned with: restoring a mosaic of interconnected, large river habitats ('mosaic habitat/side channels and shoreline restoration sites'), or restoring lost ecological connectivity ('tributary connectivity sites').

Preliminary screening of the 89 mosaic habitat and shoreline restoration sites consisted of screening out sites that met one or more of the following criteria:

- <u>Known contamination</u>: The non-federal sponsor for project implementation must provide clean sites to USACE before construction can begin. The increased costs and time required to clean up sites contaminated with Hazardous, Toxic, or Radioactive Waste (HTRW) present a risk to implementation.
- <u>Landowner has articulated opposition to restoration on his or her property</u>: Although NYSDEC has the authority to exercise eminent domain, the increased legal costs and time required to condemn and acquire lands from an unsupportive or uncooperative landowner present a risk to implementation. Note: none of the five sites screened out based on this criterion represented a unique restoration opportunity.
- <u>Low potential benefits compared to cost of gathering information needed to develop, evaluate, and compare alternatives</u>: For some sites, for which inadequate information was available, potential benefits appeared low in relation to the cost of collecting additional data needed to develop, evaluate, and compare alternatives for that site.

- Lack of complexity or scale: Simple, small sites were considered better candidates for restoration by other actors and/or organizations.
- Funding for restoration already available: At some of the sites, where restoration was planned, other actors and/or organizations had already secured funding.

The remaining 48 mosaic habitat and shoreline restoration sites were prioritized based on whether the sites had potentially been negatively affected by the federal navigation channel. A total of 17 sites were retained for further analysis to be evaluated in this report. Table C-1 in Appendix C – Plan Formulation contains a list of the 89 sites and shows how they were screened down to 17.

The 123 tributary connectivity sites, located on 41 tributaries to the Hudson River, consisted of dams, utility crossings, and culverts. The sites were first grouped by tributary. The tributaries were then screened, based on the potential benefits removing or modifying the barriers on them could provide for migratory fish communities. Indicators of benefits, developed from previous studies (Schmidt 1996, USFWS 1998, Alderson and Rosman, 2012), used to screen the tributaries included:

- Stream length upstream of barrier(s): Stream length upstream of a barrier, to the next barrier or the tributary's headwaters, was used as a proxy for the potential benefits of removing or modifying that barrier. The amount of habitat that could be opened, or connected to the Hudson River mainstem, was assumed to increase proportionally with stream length. The miles of stream upstream of and between barriers were measured using ArcGIS. Tributaries on which barriers prevent access to more miles of stream were ranked higher than tributaries on which barriers prevent access to fewer miles.
- Number of barriers: Tributaries with fewer barriers, relative to the stream length between and upstream of those barriers, were ranked higher than tributaries with more barriers, due to the potential costs of removing or modifying multiple barriers relative to benefits.
- Natural barriers: Because removing or modifying a barrier upstream or just downstream of a natural barrier, such as a natural waterfall or raised bedrock, would provide few benefits, tributaries with a natural barrier near the first barrier upstream of the tributary's confluence with the Hudson River that could be removed or modified were screened out.
- Access by multiple taxa: Tributaries that, if reconnected to the Hudson River, would not benefit multiple species, such as both river herring and American eel[1], were screened out.

[1] River herring (alewife and blueback herring) are anadromous fish that migrate up rivers from the sea to spawn, while eel are catadromous fish that migrate down rivers to the sea to spawn.

Four tributaries, with a total of 21 sites, were prioritized and retained for further analysis at this time. Table C-2 in Appendix C - Plan Formulation shows how the 41 tributaries were screened down to four.

Desktop analyses of the remaining 17 mosaic habitat and shoreline sites resulted in two of the sites being removed from further consideration. One of the planning constraints for this study is that plans must not significantly impact transportation on, over, or along the Hudson River. Greenpoint Conservation Area & North Bay of Hudson, NY was removed from consideration because a culvert that would need to be modified to restore the site is located under MetroNorth railroad. Bear Mountain State Park, where there may have been opportunities for shoreline restoration, was removed because Amtrak runs along the Hudson River at the park.

Among the 15 other mosaic habitat and shoreline sites, there were a number of sites with overlapping footprints or in very close proximity to each other. Considering hydrologic connectivity and the logistics of mobilization, these sites, in the Albany shoreline, Binnen Kill, and Schodack Island areas, were grouped under one site name each, and thereafter known as 'components.' For instance, in the Binnen Kill area, the Binnen Kill habitat restoration, Schermerhorn Island side channel, and Shad Island side channel sites became components of one Binnen Kill site.

Table 3-2 shows the 17 mosaic habitat and shoreline restoration sites and four tributaries that were retained after preliminary screening. Sites and tributaries are listed in the order of their position on the Hudson River, from upstream to downstream. Tributaries are shaded light blue. The two sites that were removed based on the transportation constraint are crossed out. Sites in close proximity to each other that were grouped are listed under their new site name.

Table 3-2: Sites Remaining After Preliminary Screening.

	SITE	RESTORATION CATEGORY	COUNTY
1	Albany Shorelines: Bulkhead Repairs/ Habitat Restoration	Shoreline	Albany
	Mohawk Hudson Hike Bike Trail		
2	Cow Island Dike	Mosaic Habitat	Rensselaer
3	Binnen Kill: Binnen Kill Habitat Restoration	Mosaic Habitat	Albany
	Schermerhorn Island Side Channel		Greene

	SITE	RESTORATION CATEGORY	COUNTY
	Shad Island Side Channel		
4	Henry Hudson Park Shoreline	Shoreline	Albany
5	Schodack Island: Channel/ Island Restoration	Mosaic Habitat	Rensselaer
	Houghtaling Island Side Channel		Columbia
	Schodack Island State Park Shoreline		Rensselaer
	Upper Schodack Island Side Channel		Columbia
6	Rattlesnake Island Dike Side Channel	Mosaic Habitat	Greene
	~~Greenport Conservation Area & North Bay of Hudson, NY~~	~~Mosaic Habitat~~	~~Columbia~~
7	Claverack Creek (Stockport Creek)	Tributary Connectivity	Columbia
8	Roeliff Jansen Kill	Tributary Connectivity	Columbia
9	Charles Rider Park	Shoreline	Ulster
10	Rotary Park	Mosaic Habitat	Ulster
11	Rondout Creek	Tributary Connectivity	Ulster
12	Waryas Park	Shoreline	Dutchess
13	Moodna Creek	Tributary Connectivity	Orange
	~~Bear Mountain State Park~~	~~Shoreline~~	~~Rockland~~

Figure 3-3 is a map showing the location of the 13 sites that remained after preliminary screening.

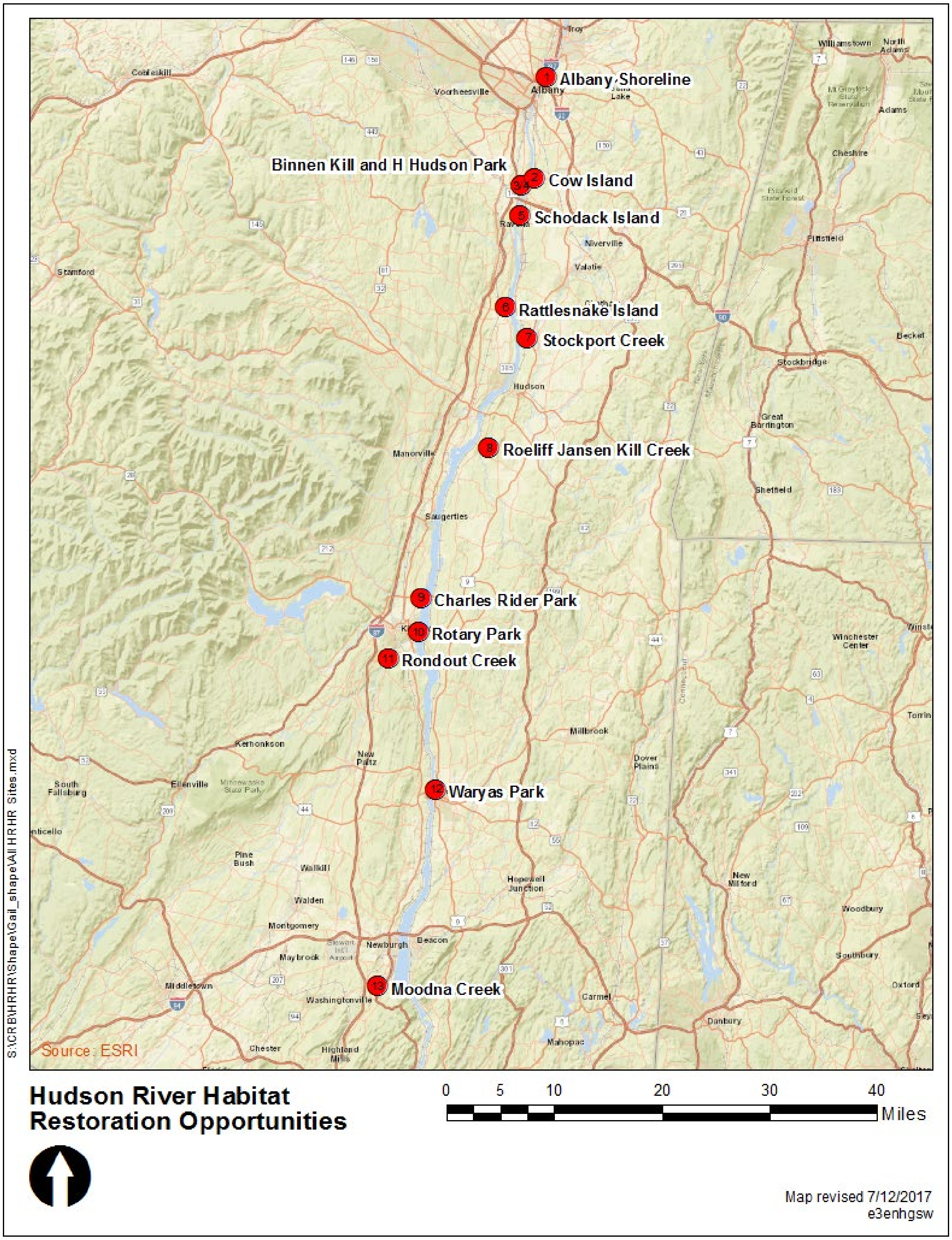


Figure 3-3: Map of Sites Remaining After Preliminary Screening.

Secondary Screening of Sites

The study team visited the remaining 13 sites in September and December 2017, to verify restoration need and potential and to gather preliminary data on site conditions for use in the development of alternatives. Table 3-3 lists sites that were removed from further consideration based on this secondary screening and summarizes the reasons for their removal. For two of the tributaries, the presence of previously unknown natural barriers near the site would significantly diminish or remove the effectiveness of proposed measures since those barriers would continue to block passage even if manmade barriers were removed. For the mosaic habitat and shoreline sites listed, reasons for removal included potential negative consequences of restoration, unanticipated challenges to restoration, and the sites being smaller or in better condition than expected.

Table 3-3: Sites Removed During Secondary Screening.

	SITE	REASON FOR REMOVAL
1	Albany Shoreline	The Hudson River has high energy at the site that causes erosion and scour. The cost to stabilize the river banks with an ecologically restored shoreline and conflicts with the need to preserve park space for patron use would eliminate or significantly diminish the ecological net benefits.
2	Cow Island	Proposed removal of dike may have impacts to the subaquatic vegetation beds.
6	Rattlesnake Island	The NEIWPCC and NYSDEC sponsored report, *Hydrodynamic and Sediment Transport Study of Existing Conditions and Restoration Alternatives at Rattlesnake Island and Coxsackie Cove, Greene County, NY*, found there would be limited benefits from removing the remains of the dike. More costly and likely unjustified measures would need to be implemented to obtain significant benefits (NEIWPCC and NYSDEC, 2018).
7	Stockport Creek, Claverack Creek Dam #4	A natural barrier was identified about 0.6 miles upstream of the dam of interest that limits the ecological benefits realized from dam removal, modification, or the installation of an aquatic organism ladder.
8	Roeliff Jansen Kill Dam	A natural barrier downstream of the dam was identified that prevents migratory fish from reaching the dam location even if removed, modified, or an aquatic organism ladder was installed.
10	Rotary Park	Site was found to be in good condition and did not require restoration.
12	Victor Waryas Park	Removed before visiting the site due to small size and lack of potential ecological benefits.

Figure 3-4 summarizes the screening process the study team used to obtain the final array of six sites for which alternative plans were developed, evaluated, and compared in this feasibility study. The feasibility of restoring sites that were screened out may be considered in future studies, using the same Hudson River Habitat Restoration study authority, or the Continuing Authorities Program.

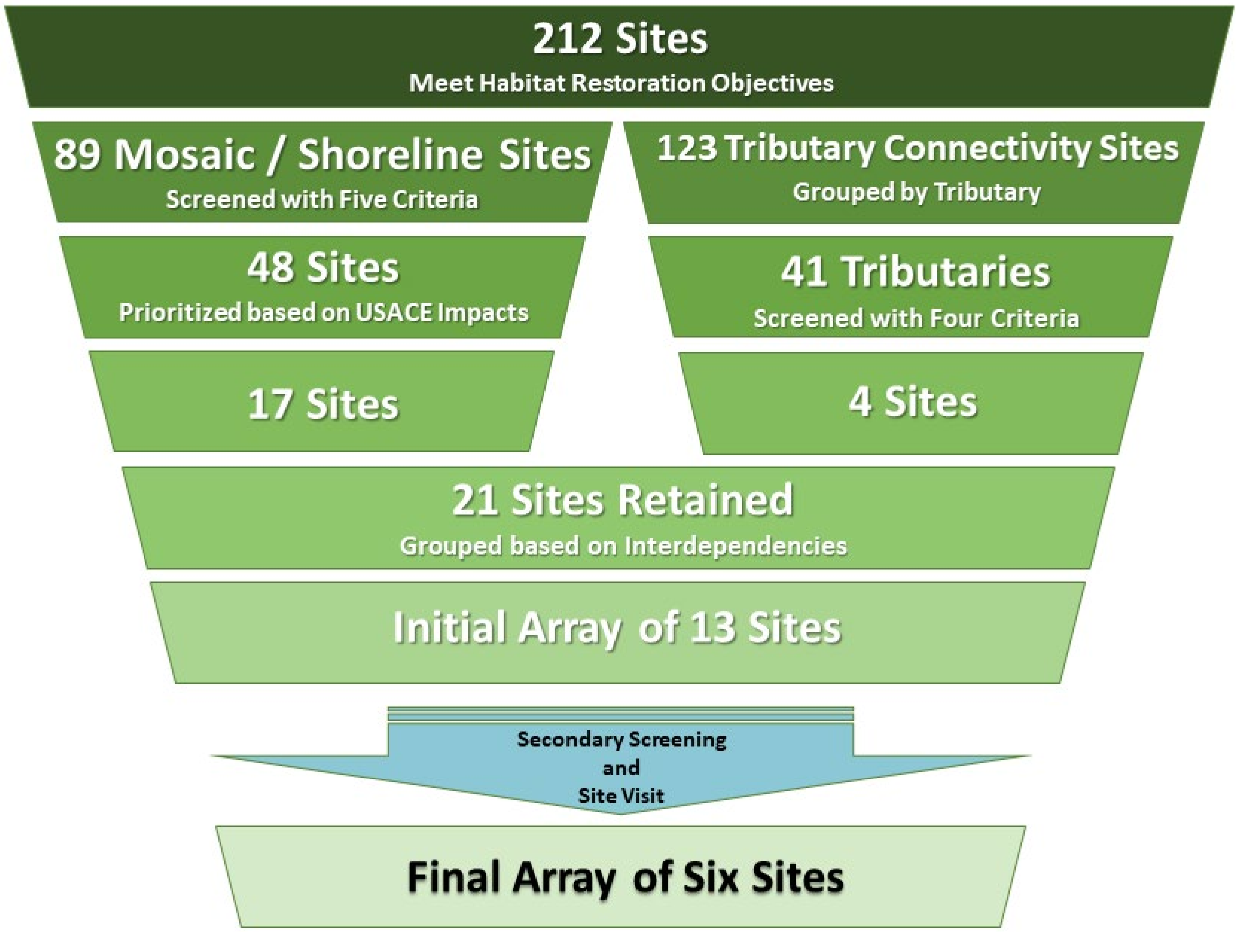


Figure 3-4: Summary of the Site Screening Process.

3.2.3 Final Array of Six Sites

The final array of six sites included Henry Hudson Park, Binnen Kill, Schodack Island, Charles Rider Park, Rondout Creek, and Moodna Creek. Figure 3-5 is a map of the sites. Appendix B - Engineering contains a more detailed site overview map (Figure 1) that shows river stationing, hydro-geomorphic reaches, and the location of three tide gauges in the study area. This section includes brief descriptions of the sites. More detailed site summaries are included in Appendix C - Plan Formulation.

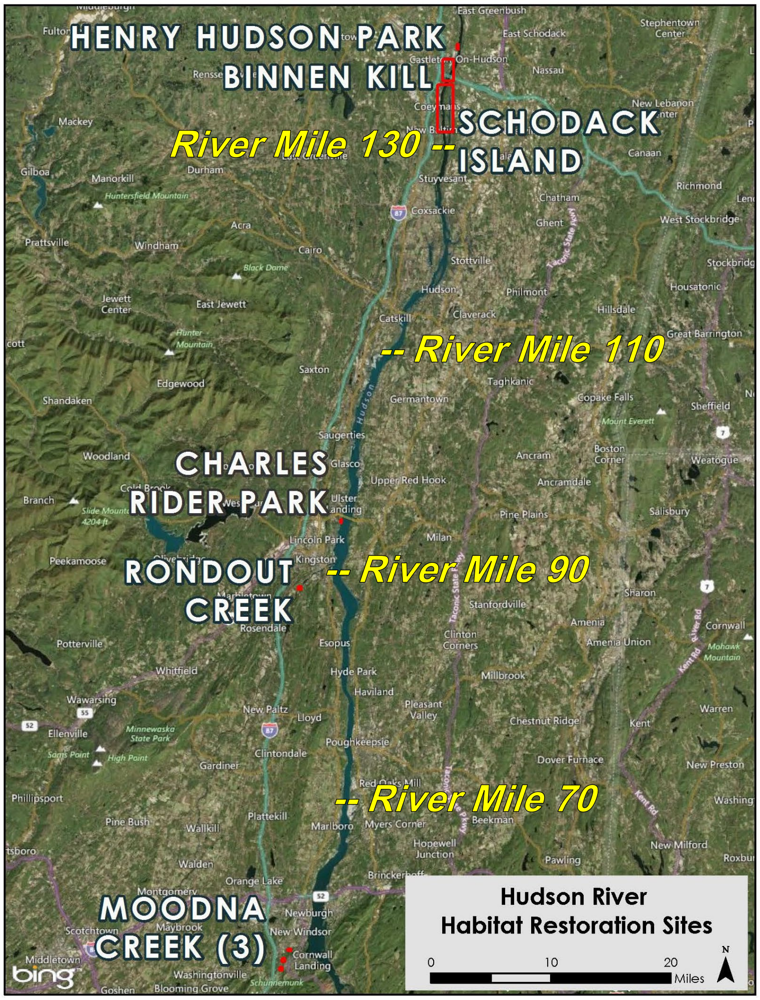


Figure 3-5: Map of Final Array of Sites.

Of the six sites, two – Rondout Creek and Moodna Creek – are tributary connectivity sites. To facilitate the development, evaluation, and comparison of alternative plans, the other four sites were split into two groups: large river mosaic sites, which include Binnen Kill and Schodack Island, and shoreline restoration sites, which include Henry Hudson Park and Charles Rider Park. The differences between large river mosaic sites and shoreline restoration sites pertaining to plan formulation are discussed further in Section 3.3, Alternatives Development.

The following descriptions of the sites are ordered by position on the Hudson River, from upstream to downstream.

Henry Hudson Park, located on the western shore of the Hudson River, is public open space owned by the Town of Bethlehem. The park is the only place in Bethlehem where the public can access the river. The southern section of the shoreline consists of a dilapidated timber cribbing structure, filled with riprap between two timber crib walls, and capped with convex concrete segments. Most of the structure has either partially or completely failed; the crib walls are severely decomposed, the concrete cap has detached and been displaced, and riprap has moved from between the crib walls into the river. In sections of complete structural failure, upland areas show signs of erosion and are inundated during high tides.

The **Binnen Kill** site is located on the western shore of the Hudson River, on the border of the Towns of Bethlehem and Selkirk, NY. The site encompasses approximately 1,000 acres of publicly- and privately-owned lands. In the 1800s, there were islands separated from the mainland by side channels on the eastern edge of the site. Due to dredged material infilling, the islands are now contiguous with the mainland. The Binnen Kill is a tidal freshwater tributary surrounded by a complex of on-site tidal wetlands, upland forests, non-tidal wetlands and swamps, farmland, and farm roads. The original islands, Shad and Schermerhorn, are designated a Significant Coastal Fish and Wildlife Habitat by NY State and include resident and migratory fish spawning and nursery habitat, habitat for protected birds, and rare plant species and communities (NYSDEC, 2017; USFWS, 1997).

The Binnen Kill site includes a variety of vital ecological communities and habitats that have been significantly altered by a combination of natural processes and human action, including farming, in addition to dredged material placement. The Binnen Kill site was divided into two components - North and South - for alternatives development, because the site is large and independent action may be taken at its two ends.

The **Schodack Island** site is part of Schodack Island State Park, which sits off the eastern shore of the Hudson River, approximately 10 miles south of Albany, NY. The park is located in the towns of Schodack, New Baltimore, and Stuyvesant. The area of focus for this study is limited to the southern portion of the park, between the river and Schodack Creek. Schodack Island, which is in fact a peninsula, comprised a series of islands in the late 19th to early 20th centuries, but now forms a contiguous landmass due to dredged material infilling. Schodack Creek is a relic side channel of the Hudson River. NY State has designated the original islands, Schodack Island (North and South) and Houghtaling Island, as well as Schodack Creek, a Significant Coastal Fish and Wildlife Habitat, as well as a Bird Conservation Area. The site is considered ecologically significant because it consists of a large undeveloped floodplain wetland ecosystem with diverse ecological communities, including floodplain forests, freshwater tidal wetlands, tidal creeks, littoral zones, submerged aquatic vegetation beds, emergent marshes, and tidal swamp, which support resident and migratory fish spawning and provide nursery and foraging habitat for protected birds (NYSDEC, 2002; NYSDOS, 2012a-c; USFWS, 1997). The Schodack Island site was divided into three components - North, South, and Pocket Wetlands - for alternatives development, because independent action may be taken in different areas of the large site.

Charles Rider Park, which is located on the western shore of the Hudson River, is a 29.6-acre public open space owned by the Town of Ulster. Approximately 5.5 acres of the park are actively managed while the remaining area is primarily forested. The park's shoreline varies in condition. The northern most portion of the shoreline is part of a small cove, partially protected by large rock material at the cove's mouth. The eastern shoreline consists of dilapidated stone-filled timber cribbing that has predominantly failed. Large boulders have been placed along the shoreline adjacent to existing erosional scour in some locations. These boulders appear to have been placed recently, presumably to stabilize the shoreline. Sparse riprap extends riverward of the timber cribbing, mixed with a natural cobble substrate. Heavily worn bricks and water chestnut seeds are common throughout the shoreline.

Rondout Creek contains the Eddyville Dam, the first aquatic organism passage (AOP) barrier approximately 3.6 miles upstream of the creek's confluence with the Hudson River. The dam lies on the boundary between the towns of Esopus and Ulster in Ulster County. The creek has been designated a Significant Coastal Fish and Wildlife Habitat by NY State and is an important migratory habitat for American eel (IUCN listed endangered), blueback herring (IUCN listed threatened), and alewife, a NOAA Fisheries species of concern. The shortnose sturgeon (International Union for Conservation of Nature [IUCN] threatened; federal and state listed endangered) is found in this section of the Hudson River. Brown trout is stocked in the upper portions of the creek. The Eddyville Dam is classified as a Class A – Low Hazard dam, is currently a barrier to tidal flow, serves as the 'head of tide' on Rondout Creek, and is an impediment for resident and migratory fish.

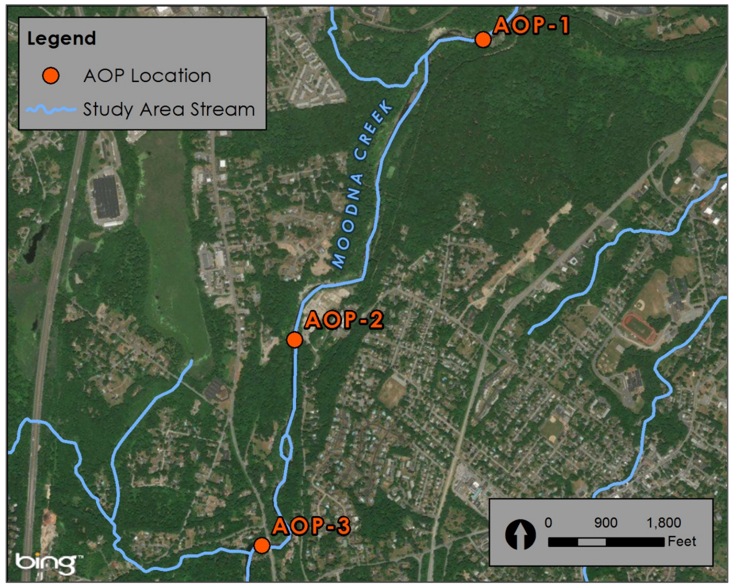
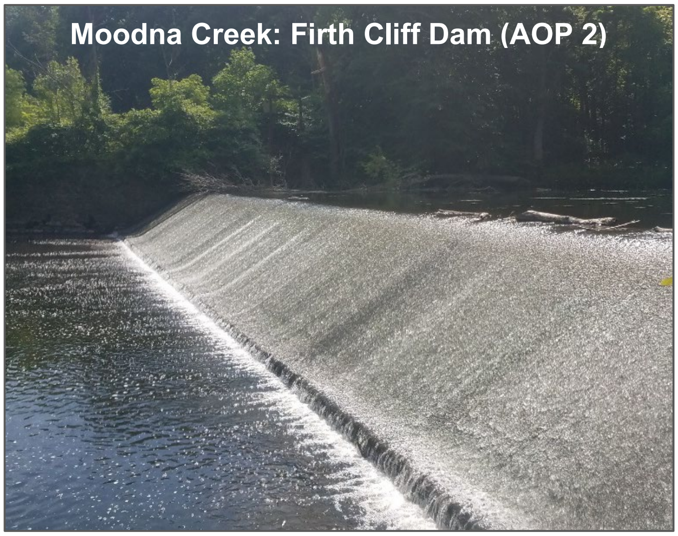
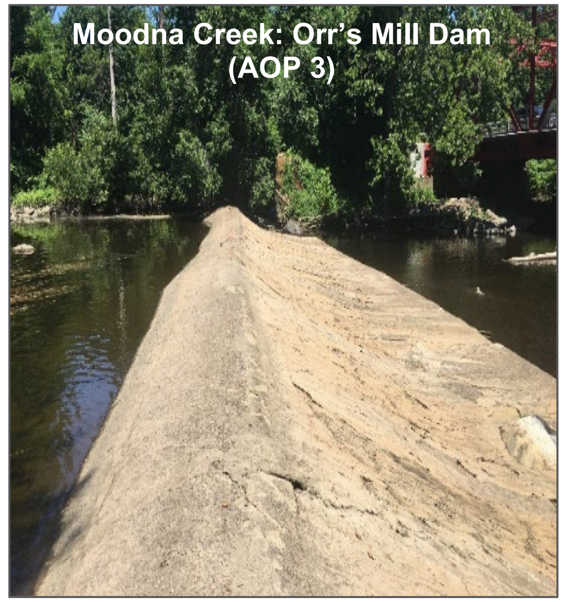


Figure 3-6: Moodna Creek AOP Barriers.

Moodna Creek is a tributary of the Hudson River located in Orange County, NY, approximately 40 miles north of New York City. The creek is used for spawning by anadromous fish such as blueback herring (IUCN listed vulnerable), alewife, a NOAA Fisheries species of concern, and others. The area is also known to be used for breeding by least bitterns (NY State listed threatened). Depending on the location of the salt front in the Hudson River, bluefish (IUCN listed vulnerable) may feed in the creek. Moodna Creek has three AOP barriers, including: a sewer utility line (AOP 1), the Firth Cliff Dam (AOP 2), and Orr's Mill Dam (AOP 3), which are approximately 1.8, 3, and 3.7 miles upstream of the Hudson River confluence, respectively (Figure 3-6). The utility line, which is approximately 5 ft wide, is encased in concrete and forms a weir that creates a vertical drop of water approximately 2 ft high at normal flows. The Firth Cliff Dam, which is 9 ft high, is classified as a Class A - Low Hazard Dam and is owned by the Moodna Creek Development, Ltd., which is affiliated with the former textile manufacturing factory known originally as Firth Carpet Company and now Majestic Weaving. The Orr's Mill Dam, which is 10 ft high, is a concrete encased cobble/boulder filled crib structure with metal rails running across the crest and down the spillway. The Orr's Mill Dam has been characterized as being in a state of disrepair, structurally unsound, and "could fail at any time," based on prior NYSDEC inspections. The three barriers to, or opportunities for, enhanced tributary connectivity on Moodna Creek (AOP 1, AOP 2, and AOP 3) were considered components of the Moodna Creek site for alternatives development.

Moodna Creek: Utility Line (AOP 1)





3.3 Alternatives Development

In February and April 2018, three design charrettes were held with NYSDEC, to determine field data requirements, management measures, and potential alternatives for the six sites in the final array of sites. Detailed field investigations were conducted in July 2018. For the mosaic habitat and shoreline restoration sites (Binnen Kill, Schodack Island, Henry Hudson Park, and Charles Rider Park), the study team collected shoreline profiles, channel cross-sections, water levels using tide gauges, and input for Evaluation of Planned Wetlands (described in Section 3.4.1, Alternative Benefits). For the tributary connectivity sites (Rondout Creek and Moodna Creek), the study team inspected the utility line and dams, explored any associated reservoirs, and collected historical information about the structures. The data collected in July 2018 was used to determine baseline conditions at the sites and to aid in alternatives development.

The identification of management measures, which are features or activities that can be implemented at a specific geographic site to address one or more planning objectives, was informed by the field investigations and derived from a variety of sources. Sources for management measures included the Hudson River Habitat Restoration Reconnaissance Study, prior public scoping process, and U.S. Army Engineer Institute of Water Resources (IWR) Management Measures Digital Library for Ecosystem Restoration. Table 3-4 provides a sample of the management measures that were used alone or in combination to develop alternatives for the sites associated with the planning objectives.

Table 3-4: Objectives and Management Measures.

<table>
<tr><th></th><th colspan="3">MOSAIC HABITAT AND SHORELINE RESTORATION</th><th>TRIBUTARY CONNECTIVITY</th></tr>
<tr><td>OBJECTIVES</td><td colspan="3">Restore a mosaic of interconnected, large river habitats, which together host a diversity of native taxa</td><td>Restore lost ecological connectivity within the Hudson River and its tributaries</td></tr>
<tr><td rowspan="2">SUB-OBJECTIVES</td><td>Increase the extent and quality of subtidal, shallow water habitats (e.g., submerged aquatic vegetation, side channels)</td><td>Increase the extent and quality of intertidal habitats (e.g., freshwater tidal marshes, mud/sand flats)</td><td>Promote neighboring shoreline, riparian, and upland habitats contributing to aquatic ecosystem integrity</td><td rowspan="2">- Increase the connectivity of spawning, foraging, and resting habitats for migratory fish (e.g., shad, herring, eel, and sturgeon)
- Increase the connectivity of stopover, nesting, and foraging habitat for migratory and resident birds from freshwater ecosystems to the ocean
- Promote actions improving the transport regime of water, sediment, and nutrients to the estuary</td></tr>
<tr><td colspan="3">Promote a balanced mosaic of habitat types</td></tr>
<tr><td>MEASURES</td><td>Side channel excavation, dredging, re-contouring</td><td>Excavation, dredging, re-contouring, invasive species removal, bank stabilization, wetland re-vegetation</td><td>Berm or dike removal or modification, modify bank armor, bank stabilization and vegetation, channel modification</td><td>Dam removal, culvert modification, Aquatic Organism Passage (AOP) structures</td></tr>
</table>

To facilitate the development of alternatives, the mosaic habitat and shoreline restoration sites were split into ‘large river mosaics’ and ‘shoreline restoration’ sites. Binnen Kill and Schodack Island, the large river mosaic sites, once included diverse mosaics of subtidal, intertidal, shoreline, and riparian habitats unique to the Hudson

River ecosystem. Critical side channel and wetland habitats were lost at these sites as a result of USACE constructing and maintaining a federal navigation channel in the Hudson River. Charles Rider and Henry Hudson parks, the shoreline restoration sites, are characterized by active bank erosion and shoreline retreat along the Hudson River mainstem. Riparian and wetland habitats at these sites were lost as a result of dredged material placement.

Twenty-three alternatives were developed for the six sites, to meet planning objectives and avoid constraints while reasonably maximizing ecosystem restoration benefits. Multiple alternatives were developed for each site or site component (i.e., the North and South components of the Binnen Kill site; the North, South, and Pocket Wetlands components of the Schodack Island site; the Henry Hudson Park site; the Charles Rider Park site; the Rondout Creek site; and the three AOP components of the Moodna Creek site). The measures that compose alternatives were selected to enhance the habitat value for the life stage or stages of the species most likely to be found at a site.

Each alternative includes a “base” measure - that is, a key measure addressing the critical needs of the study area for a balance of more, better-quality shallow water, intertidal, and shoreline habitats, and increased tributary-river connectivity for fish, birds, and the exchange of water, nutrients, and sediment. Alternatives that did not include a base measure would not be considered complete, acceptable, efficient, or effective.

The study team used professional judgment to incrementally add one or more measures to the base measure at a site or site component. These incremental additions increased the amount of habitat restored or created at a site or site component. Preliminary costs and benefits were used to identify alternatives that provide high levels of benefits relative to the costs. The combination of measures to develop alternatives, including the addition of increments to base measures, is further described in Section 3.4, Evaluation and Comparison of Alternatives.

To account for the effects of sea level change (SLC), conceptual-level grading plans were prepared for the sites. For the low level of design at this stage of plan formulation, it was assumed that the intermediate scenario of SLC would apply over the planning horizon. The NOAA tide gauge at Sandy Hook was referenced and the level of SLC for the period of analysis was derived using the USACE Online Sea Level Change Curve Calculator. The absolute magnitude of sea level (MSL) change for years 20 and 50 were then applied to the local tidal data and used as the basis of design for each site. For each site, the project base year used in the SLC analysis was the first year following construction. More information about risk and uncertainty related to SLC is contained in Section 4.8. The results of a SLC analysis of the Recommended Plan that considered the low, intermediate, and high SLC scenarios is contained in Section 4.6.

Table 3-5 shows, for each of the 23 alternatives that were developed, what categories of measures (e.g., wetland restoration) the alternative consists of, and the associated acreage of habitat restored or created. Appendix C - Plan Formulation, contains site summaries with descriptions of the alternatives for each site, as well as concept plans for all of the alternatives. Feasibility-level design plans for the alternatives included in the Recommended Plan may be found in Chapter 4: Recommended Plan.

Table 3-5: Alternatives Summary.

<table>
<tr><th>SITE</th><th>COMP-ONENT</th><th>ALTER-NATIVE</th><th>ALTERNATIVE DESCRIPTION[1]</th></tr>
<tr><td colspan="4">LARGE RIVER MOSAICS</td></tr>
<tr><td rowspan="6">BINNEN KILL</td><td rowspan="4">North</td><td>1</td><td>1-Wetland Restoration, 89.94 AC
2-AOP Crossing Enlargement, 0.27 AC</td></tr>
<tr><td>2</td><td>1-Wetland Restoration, 43.77 AC
2-Forested Wetland Restoration, 15.52 AC
3-Emergent Wetland Restoration, 4.29 AC
4-Emergent Wetland Restoration & Channel Restoration, 41.88 AC
5-AOP Crossing Removal, 0.27 AC</td></tr>
<tr><td>3</td><td>1-Wetland Restoration, 89.94 AC</td></tr>
<tr><td>4</td><td>1-Wetland Restoration, 43.77 AC
2-Forested Wetland Restoration, 15.52 AC
3-Emergent Wetland Restoration, 4.29 AC
4-Emergent Wetland Restoration & Channel Restoration, 41.18 AC</td></tr>
<tr><td rowspan="2">South</td><td>1</td><td>1-Wetland Restoration, 13.85 AC
2-Tidal Wetland Restoration East, 7.19 AC
3-Tidal Wetland Restoration West, 0.28 AC
5-Side Channel and Riparian Corridor Restoration, 14.85 AC</td></tr>
<tr><td>2</td><td>1-Wetland Restoration, 13.85 AC
2-Tidal Wetland Restoration East, 7.19 AC
3-Tidal Wetland Restoration West, 0.28 AC
4-Road Crossing
5-Side Channel and Tidal Wetland Corridor Restoration, 27.02 AC</td></tr>
<tr><td rowspan="3">SCHODACK ISLAND</td><td rowspan="2">North</td><td>1</td><td>1-Tidal Wetland Restoration North, 1.80 AC
2-Tidal Wetland Restoration & Conversion to Side Channel Connection, 2.31 AC
3-Road Crossing
4-Side Channel and Riparian Corridor Restoration, 2.82 AC
5-Tidal Wetland Restoration South, 15.69 AC</td></tr>
<tr><td>2</td><td>1-Tidal Wetland Restoration North, 1.80 AC
2-Tidal Wetland Restoration & Conversion to Side Channel Connection, 2.31 AC
3-Road Crossing
4-Side Channel and Tidal Wetland Corridor, 9.09 AC
5-Tidal Wetland Restoration South, 15.69 AC</td></tr>
<tr><td>South</td><td>1</td><td>1-Side Channel and Riparian Corridor Restoration, 1.45 AC
2-Road Crossing
3-Tidal Wetland Restoration, 2.77 AC</td></tr>
</table>

SITE	COMP-ONENT	ALTER-NATIVE	ALTERNATIVE DESCRIPTION[1]
		2	1-Side Channel and Tidal Wetland Corridor Restoration, 3.80 AC 2-Road Crossing 3-Tidal Wetland Restoration, 2.77 AC
	Pocket Wetlands	1	1-Tidal Wetland Restoration A, 3.61 AC 2-Non-Tidal Wetland Restoration B, 1.48 AC 3-Tidal Wetland Restoration C, 2.01 AC 4-Tidal Wetland Restoration D, 3.85 AC
SHORELINE RESTORATION			
HENRY HUDSON PARK	–	1	1-Western Tidal Wetland Restoration, 3.59 AC 2-Vegetated Riprap Restoration, 0.43 AC 3-Cove Tidal Wetland Restoration, 0.18 AC
		2	1-Northern Tidal Wetland Restoration, 0.41 AC 2-Pocket Wetland Restoration, 0.09 AC 3-Western Tidal Wetland Restoration, 3.59 AC 4-Southern Tidal Wetland Restoration, 1.28 AC
CHARLES RIDER PARK	–	1	1-Interstitial Rock Planting Restoration, 0.12 AC 2-Northern Tidal Wetland Restoration, 0.29 AC 3-Southern Tidal Wetland Restoration, 0.70 AC
TRIBUTARY CONNECTIVITY			
RONDOUT CREEK	–	1	Technical Fishway Construction
		2	Dam Removal
		3	Dam Notching
MOODNA CREEK	**AOP 1**	1	Sewer Pipe Removal
		2	Roughened Rock Ramp
	AOP 2	1	Dam Removal
		2	Technical Fishway Construction
	AOP 3	1	Dam Removal
		2	Partial Dam Removal/Notching

[1] Alternative number corresponds to concept plan alternative numbers presented in (Figures 4-1 through 4-8; Engineering and Plan Formulation appendices).

3.4 Evaluation and Comparison of Alternatives

In order to evaluate the alternatives presented in Table 3-5, the study team forecasted the environmental benefits of each alternative and estimated how much each alternative would cost to implement. The benefits and costs were then used as inputs for a Cost Effectiveness and Incremental Cost Analysis (CE/ICA), in which alternatives were compared to tentatively select a National Ecosystem Restoration plan.

3.4.1 Alternative Benefits

Ecosystem restoration projects provide benefits to people and the environment that cannot easily be quantified. For example, healthy ecosystems can support biodiversity, resilience, stability, sustainability, and materials cycling, among others. In planning ecosystem restoration projects, USACE uses non-monetary indicators of benefits in cost-effectiveness analysis and incremental analysis, rather than economic benefit-cost analysis. To calculate the non-monetary benefits of the restoration alternatives, two models were used: Evaluation of Planned Wetlands (EPW) and Watershed-Scale Upstream Connectivity Toolkit (WUCT). These benefits were computed based on temporal trajectories and compared to the future-without project condition to determine the ecological lift. Ecological improvement, or lift, is presented as average annual functional capacity units (AAFCUs) for EPW or habitat units (AAHUs) for WUCT. Detailed descriptions of the environmental benefits of each alternative are presented in Appendix D – Habitat Evaluation/ Ecosystem Benefits and a summary of the ecosystem benefit analysis is presented in Table 3-6 for each alternative. The calculation of AAFCUs and AAHUs is presented in the CE/ICA Appendix F.

Evaluation of Planned Wetlands (EPW) was used to quantify benefits for large-scale mosaic and shoreline restoration sites. EPW is a rapid assessment procedure, certified for regional use in July 2016, which provides a method for determining the capacity of a wetland to perform certain ecological and watershed functions by evaluating elements of major wetland functions. EPW evaluates functional categories including shoreline bank erosion, sediment stabilization, water quality, wildlife, and fish (Bartoldus 1994, Bartoldus et al., 1994). EPW scores were calculated for each component/site alternative. Functions of the existing wetlands and uplands slated for restoration were characterized to assess the current functional capacity, establishing a baseline to determine the anticipated increase in functional capacity as a result of implementing the project as proposed. The five functional categories were averaged to obtain a functional capacity index (FCI), which was subsequently multiplied by project area (in acres) to obtain a quality-weighted area metric (functional capacity units [FCUs]).

The Watershed-Scale Upstream Connectivity Toolkit (WUCT) was developed by Engineering Research and Development Center (ERDC) and certified for National use on 29 October 2018. WUCT was utilized for the AOP sites and focuses on upstream movement of migratory organisms such as fish and is intended for application at the watershed scale. The WUCT combines three data sources to estimate quality-weighted, accessible habitat at the watershed scale. The algorithm is based on three primary inputs:

- Habitat Quantity: The area of upstream habitat was computed as the distance from a dam to the next upstream barrier multiplied by the tributary width.
- Habitat Quality: Habitat quality was assessed relative to upstream watershed condition using Colorado State's Environmental Resources Assessment and Management System modeling platform for rapid watershed assessment (https://erams.com/documentation/wrap/).
- Passability: Passability to aquatic species was estimated based on prior research studies elsewhere in the region (Franklin et al. 2012), meta-analyses of fishway efficacy across multiple taxa (Noonan et al. 2011, Bunt et al. 2012), and professional judgment based on two taxa serving as representative keystone species: river herring and American eel.

Both models were applied at four time intervals for all alternatives including future without project (FWOP): Year 0 (TY0-baseline conditions), Year-2 (TY2-an as built/post construction period reflecting initial ecological response), Year 20 (TY20- incorporates 19 full growing seasons and estimates long term outcomes), and Year-50 (TY50- end of the planning horizon). Ecological benefits were annualized by computing the time-averaged benefits distributed over the entire planning horizon (known as average annual functional capacity units, AAFCUs or average annual habitat units, AAHUs). Alternatives were compared using the net benefits (or "ecological lift") over the future without project condition (i.e., Lift = AAFCUAlt – AAFCUFWOP).

The EPW benefits evaluations for the large mosaic and shoreline restoration sites accounted for how SLC is expected to increase areas of open water, decrease areas of vegetated wetland, and change wetland community types at each site over the planning horizon, for all alternatives including no action or the FWOP condition. As explained in Section 3.3, the absolute magnitude of sea level (MSL) change for years 20 and 50, assuming the intermediate SLC scenario, was used as the basis for site design. To predict wetland community acreages in Year-50 for the benefits evaluation, the expected Mean Tide Line (MTL) and the Mean Higher High Water line (MHHW or Spring High Tide) for the intermediate SLC scenario were found with the USACE Online Sea Level Change Curve Calculator. The MTL and MHHW elevations were then compared to surveyed cross sections and available topographic data to remap the extent of wetland communities. Predictions for the FWOP conditions in Year-50 also included the expansion of invasive species colonies into wetland areas, based on experience with similar restoration projects in the region. The evaluations showed that SLC alone is unlikely to affect the functional capacity of Binnen Kill North, would decrease the functional capacity of three areas of the Schodack Island Pocket

Wetlands, and would slightly increase the functional capacity of Binnen Kill South, Charles Rider Park, Henry Hudson Park, Schodack Island North, Schodack Island South, and one area of the Schodack Island Pocket Wetlands. Compared to taking no action, however, the projected functional uplift from the proposed restoration activities is clear. The numerical differential is supported by the understanding that invasive-dominated wetlands offer impaired functionality and upland communities offer zero wetland functionality when compared to healthy and diverse wetland systems. More details on the benefits evaluation and results are included in Appendix D: Habitat Evaluation and Ecosystem Benefits.

3.4.2 Alternative Costs

Preliminary first cost estimates for the alternatives included planning engineering and design costs, real estate costs, cultural resources surveys and mitigation costs, construction costs, construction management costs, monitoring and adaptive management costs, and contingencies:

- Planning engineering and design costs (Account 30) developed for each site consisted of the costs of all activities associated with the planning, engineering and design effort, including costs related to regulatory compliance, field data collection, and the preparation of design plans, documentation, and specifications.
- Real estate costs (Account 01) developed for each site assumed that fee title and temporary easements would be acquired per ER 1105-2-100 Sec. 3-5(b)(9) and ER 405-1-12. Land acquisition and incidental costs (i.e., appraisals, land surveys, title services, etc.) were included.
- Construction costs (Account 06) were developed in MCACES, Second Generation (MII) using the appropriate Work Breakdown Structure (WBS). Construction cost estimates were developed from available estimated quantities for the alternatives, using cost resources such as RSMeans, historical data from similar construction features, and MII Cost Libraries.
- Construction management costs (Account 31) were estimated as a percentage of the construction costs (14.5%) or adjusted upward to ensure appropriate funding was available for construction oversight for lower cost projects.
- Project contingencies were developed for each site using an Abbreviated Risk Analysis (ARA) provided by the Cost MCX and ranged from 18% to 35%.

Costs for the operation, maintenance, repair, rehabilitation, and replacement (OMRR&R) of alternatives were also estimated, for use in the calculation of the alternatives' average annual costs.

First costs, interest during construction, monitoring, adaptive management, and OMRR&R costs were used to calculate average annual costs over the 50-year period of analysis. All costs were amortized at a FY2019 interest rate of 2.875% (Economic Guidance Memo 19-01). Interest during construction was computed based on estimated construction durations. Monitoring and adaptive management costs were amortized over a five-year period. OMRR&R costs were amortized over a 10-year period.

Table 3-6 presents the preliminary cost estimates for each alternative including first costs, average annual costs, and annual OMRR&R costs. Appendix E - Cost Engineering provides details on how cost estimates were prepared and Appendix F - CE/ICA shows how cost estimates were annualized.

Table 3-6: Summary of Benefits and Costs for each Component/Site Alternative.

Site	Comp-onent	Altern-ative	Alternative Description (Habitat Type and Measures)	Net Benefits (AAFCU-HU)[1,2]	Total First Cost ($)[3]	Total Average Annual Cost ($)[4]	Total OMRR&R Cost ($)[6]
Binnen Kill	North	1	1-Wetland Restoration, 89.94 AC 2-AOP Crossing Enlargement, 0.27 AC	5.2	28,928,554	1,233,669	118,211
		2	1-Wetland Restoration, 43.77 AC 2-Forested Wetland Restoration, 15.52 AC 3-Emergent Wetland Restoration, 4.29 AC 4-Emergent Wetland Restoration & Channel Restoration, 41.88 AC 5-AOP Crossing Removal, 0.27 AC	20.8	35,719,261	1,534,710	148,049
		3	1-Wetland Restoration, 89.94 AC	5.2	27,396,882	1,167,621	111,326
		4	1-Wetland Restoration, 43.77 AC 2-Forested Wetland Restoration, 15.52 AC 3-Emergent Wetland Restoration, 4.29 AC 4-Emergent Wetland Restoration & Channel Restoration, 41.18 AC	20.8	35,193,651	1,512,712	145,896
	South	1	1-Wetland Restoration, 13.85 AC 2-Tidal Wetland Restoration East, 7.19 AC 3-Tidal Wetland Restoration West, 0.28 AC 4-Road Crossing 5-Side Channel and Riparian Corridor Restoration, 14.85 AC	2.0	20,118,939	853,720	77,552
		2	1-Wetland Restoration, 13.85 AC 2-Tidal Wetland Restoration East, 7.19 AC 3-Tidal Wetland Restoration West, 0.28 AC 4-Road Crossing 5-Side Channel and Tidal Wetland Corridor Restoration, 27.02 AC	12.7	22,136,946	945,843	85,556

Site	Comp-onent	Altern-ative	Alternative Description (Habitat Type and Measures)	Net Benefits (AAFCU-HU)[1,2]	Total First Cost ($)[3]	Total Average Annual Cost ($)[4]	Total OMRR&R Cost ($)[6]
Schodack Island	North	1	1-Tidal Wetland Restoration North, 1.80 AC 2-Tidal Wetland Restoration & Conversion to Side Channel Connection, 2.31 AC 3-Road Crossing 4-Side Channel and Riparian Corridor Restoration, 2.82 AC 5-Tidal Wetland Restoration South, 15.69 AC	3.2	13,457,575	568,677	45,836
		2	1-Tidal Wetland Restoration North, 1.80 AC 2-Tidal Wetland Restoration & Conversion to Side Channel Connection, 2.31 AC 3-Road Crossing 4-Side Channel and Tidal Wetland Corridor, 9.09 AC 5-Tidal Wetland Restoration South, 15.69 AC	7.1	19,256,797	822,106	73,636
	South	1	1-Side Channel and Riparian Corridor Restoration, 1.45 AC 2-Road Crossing 3-Tidal Wetland Restoration, 2.77 AC	0.9	7,835,830	323,161	21,062
		2	1-Side Channel and Tidal Wetland Corridor Restoration, 3.80 AC 3-Tidal Wetland Restoration, 2.77 AC	1.7	9,715,454	405,123	30,278
	Pocket Wetlands	1	1-Tidal Wetland Restoration A, 3.61 AC 2-Non-Tidal Wetland Restoration B, 1.48 AC 3-Tidal Wetland Restoration C, 2.01 AC 4-Tidal Wetland Restoration D, 3.85 AC	2.0	9,072,622	376,249	30,727
Henry Hudson Park (1760 linear feet of shoreline)	-	1	1-Western Tidal Wetland Restoration, 3.59 AC 2-Vegetated Riprap Restoration, 0.43 AC 3-Cove Tidal Wetland Restoration, 0.18 AC	2.2	8,873,209	368,870	29,783
		2	1-Northern Tidal Wetland Restoration, 0.41 AC 2-Pocket Wetland Restoration, 0.09 AC 3-Western Tidal Wetland Restoration, 3.59 AC 4-Southern Tidal Wetland Restoration, 1.28 AC	2.9	15,221,511	638,516	59,173

Site	Comp-onent	Altern-ative	Alternative Description (Habitat Type and Measures)	Net Benefits (AAFCU-HU)[1,2]	Total First Cost ($)[3]	Total Average Annual Cost ($)[4]	Total OMRR&R Cost ($)[6]
Charles Rider Park	-	1	1-Interstitial Rock Planting Restoration, 0.12 AC 2-Northern Tidal Wetland Restoration, 0.29 AC 3-Southern Tidal Wetland Restoration, 0.70 AC	0.2	3,585,451	146,099	9,830
Rondout Creek	-	1	Technical Fishway Construction	7.1	4,221,080	183,602	25,000
		2	Dam Removal	127.4	3,932,388	157,659	8,429
		3	Dam Notching	70.8	4,634,670	188,411	12,882
Moodna Creek - AOP 1	-	1	Sewer Pipe Removal	2.8	1,695,631	69,227	5,000
		2	Roughened Rock Ramp	2.2	1,858,694	75,409	5,000
Moodna Creek - AOP 2	-	1	Dam Removal	7.5	5,317,614 (3,621,983)	214,789 (145,562)	7,664
		2	Technical Fishway Construction	3.1	5,745,026 (4,049,395)	246,779 (177,552)	25,000
Moodna Creek - AOP 3	-	1	Dam Removal	48.4	9,597,544 (4,279,930)	387,122 (172,333)	9,523
		2	Partial Dam Removal/Notching	48.4	8,993,274 (3,675,660)	363,771 (148,982)	10,000

[1] Net AAFCU-HU: Average Annual Functional Capacity Unit - Habitat Unit
[2] Net HUs presented for Moodna AOPs 2 and 3 Alternatives represent total maximum HUs including barrier removals at downstream AOPs.
[3] Total First Cost for Moodna AOPs 2 and 3 Alternatives include costs for barrier removal at AOP 1 (costs in parentheses represent cost for Alternative action only).
[4] Total Average Annual Cost for AOPs 2 and 3 Alternatives include average annual cost for barrier removal at AOP 1 (costs in parentheses average/annual cost for that AOP action only).
[6] Total OMRR&R Cost: Operations and Maintenance Repair and Rehabilitation also included in Total Average Annual Cost and NOT include Project Cost. Costs are 100% non-federal funds for up to 10 years after ecological success has been determined.

3.4.3 Cost Effectiveness and Incremental Cost Analysis

Cost-effectiveness and incremental cost analyses (CE/ICA) are analytical tools for assessing the relative benefits and costs of ecosystem restoration actions and informing decisions. Benefits and costs (Table 3-6) are assessed prior to these analyses using ecological models and cost engineering methods, respectively. CE/ICA may then be conducted at the site scale to compare alternatives at a single location (e.g., no action vs. dam removal vs. fish ladder vs. bypass) or at the system scale to compare relative merits of multiple sites (e.g., no sites vs. Site-A only vs. Site-B only vs. Site-A and Site-B). Within the USACE, the Institute of Water Resources' Planning Suite is the primary toolkit for conducting CE/ICA (http://www.iwr.usace.army.mil/Missions/Economics/IWR-Planning-Suite/).

Cost-effectiveness analysis provides a mechanism for examining the efficiency of alternative actions. For any given level of investment, the agency wants to identify the plan with the greatest return-on-investment (i.e., the most environmental benefits for a given level of cost or the least cost for a given level of environmental benefit). An "efficiency frontier" identifies all plans that efficiently provide benefits on a per cost basis. Incremental cost analysis sequentially compares each cost-effective plan to all larger cost-effective plans to reveal changes in unit cost as output levels increase and eliminates plans that do not efficiently provide benefits on an incremental unit cost basis. Incremental cost analysis is ultimately intended to inform decision-makers about the consequences of increasing unit cost when increasing benefits (i.e., each unit becomes more expensive). Plans emerging from incremental cost analysis efficiently accomplish objectives relative to unit costs and are typically referred to as "best buys."

For each alternative, net benefits were computed over the future without project (FWOP) condition to reflect the change in ecological condition associated with the restoration costs. Notably, EPW and WUCT outputs remain separate throughout these analyses since sites will only be compared within a given type of restoration (i.e., "like with like" comparison).

CE/ICA can be applied multiple ways when examining a multi-site restoration project. First, recommendations can be made at the site-scale and combined logically with other recommended actions to develop different "portfolios" of projects (e.g., Alt-A at Site-1 and Alt-C at Site-2). Second, all permutations of sites and alternatives can be assessed to develop project portfolios. Here, CE/ICA was applied using both approaches (Appendix F) with the logic that greater confidence may be placed in a recommendation arrived at through competing methods. The following sections only presents CE/ICA for combinations of actions within a restoration type (e.g., mosaic sites) because recommendations were identical using both methods.

The USACE Planning Guidance Notebook (USACE 2000) directs plan selection by stating, "Selecting the National Ecosystem Restoration (NER) plan requires careful consideration of the plan that meets planning objectives and constraints and reasonably maximizes environmental benefits while passing tests of cost effectiveness and incremental cost analyses, significance of outputs, acceptability, completeness, efficiency, and effectiveness." Three questions derived from this language were used when interpreting CE/ICA and identifying a recommended alternative, specifically:

- Does this alternative/plan meet the planning objectives?
    - "meets planning objectives and constraints"
- Which alternative/plan has the lowest unit cost (i.e., $/AAFCU or $/AAHU)?
    - "reasonably maximize environmental benefits"
- Which alternative reasonably maximizes environmental benefits in light of non-linearities in cost-benefit data, incremental cost associated with additional investment, cost affordability, and benefits not captured by ecological models?
    - "passing the tests of cost effectiveness and incremental cost analyses"

The Planning Guidance Notebook also states that, "Neither cost effectiveness analysis nor incremental cost analysis include a 'one plan' selection rule similar to the '[National Economic Development] plan' selection rule for [National Economic Development] evaluations. In the absence of such a decision-making rule, neither analysis dictates what choice to make. However, the information developed by both analyses can inform decision making by progressively proceeding through the available levels of output to ask whether the next level is 'worth it'; that is, whether the environmental benefit of the additional output in the next level is worth its additional cost." This implies that incremental cost per incremental benefit provides a key metric, and incremental cost analysis is used here as the primary mechanism for structuring decision-making.

3.4.3.1 Large River Mosaic Sites

Binnen Kill and Schodack Island both represent large river mosaic restoration sites, and recommendations were developed for this restoration type in isolation of other types (i.e., shoreline, connectivity). System-scale plans were developed examining all possible combinations of sites, components, and alternatives. Mosaic plans represent 270 combinations and are consecutively numbered (i.e., MOS1 – MOS270). For each plan, a time series of ecological benefits was forecast with EPW (Figure 3-7 A), benefits of each plan were annualized over the 50-year horizon (Figure 3-7 B), annualized benefits were compared with annualized cost in cost-effectiveness analysis (Figure 3-7 C), and cost-effective plans were subjected to incremental cost analysis (Figure 3-7 D). Based on these analyses, the following system-wide plans for large river mosaic restoration were examined as the final array:

- MOS1 = No action in any sites or components
    - Unit Cost = $0 / AAFCU

  - No action alternative.
- MOS5 = Binnen Kill North-Alternative 4
  - Unit Cost = $72,657 / AAFCU (Incremental Cost / Incremental Unit = $72,657 / AAFCU)
  - No side channels included.
  - Does not meet side channel restoration sub-objective.
- MOS15 = Binnen Kill North-Alternative 4 + Binnen Kill South-Alternative 2
  - Unit Cost = $73,324 / AAFCU (Incremental Cost / Incremental Unit = $74,417 / AAFCU)
  - Side channels are only included at Binnen Kill.
  - Does not meet side channel restoration sub-objectives.
- **MOS45** (**Tentatively Selected NER Plan for 'Mosaic' Sites**) = Binnen Kill North-Alternative 4 + Binnen Kill South-Alternative 2 + Schodack Island North-Alternative 2
  - Unit Cost = $80,824 / AAFCU (Incremental Cost / Incremental Unit = $116,446 / AAFCU)
  - Side channels are included at both Binnen Kill and Schodack Island.
  - Meets planning objectives.
  - Of plans meeting planning objectives, this alternative has the lowest unit cost and lowest incremental unit cost.
- MOS180 = Binnen Kill North-Alternative 4 + Binnen Kill South-Alternative 2 + Schodack Island North-Alternative 2 + Schodack Island Wetlands-Alternative 1
  - Unit Cost = $85,964 / AAFCU (Incremental Cost / Incremental Unit = $192,948 / AAFCU)
  - Meets planning objectives.
  - Moderate unit cost, but increase in incremental unit cost was very high and was not deemed "worth it" given MOS45's value.
- MOS268 = Binnen Kill North-Alternative 2 + Binnen Kill South-Alternative 2 + Schodack Island North-Alternative 2 + Schodack Island South-Alternative 1 + Schodack Island Wetlands-Alt1
  - Unit Cost = $91,901 / AAFCU (Incremental Cost / Incremental Unit = $244,050 / AAFCU)
  - Meets planning objectives.
  - High unit cost.

- MOS270 = Binnen Kill North-Alternative 4 + Binnen Kill South-Alternative 2 + Schodack Island North-Alternative 2 + Schodack Island South-Alternative 2 + Schodack Island Wetlands-Alternative 1
    - Unit Cost = $92,378 / AAFCU (Incremental Cost / Incremental Unit = $2,199,800 / AAFCU)
    - Meets planning objectives.
    - High unit cost and extremely large incremental cost.

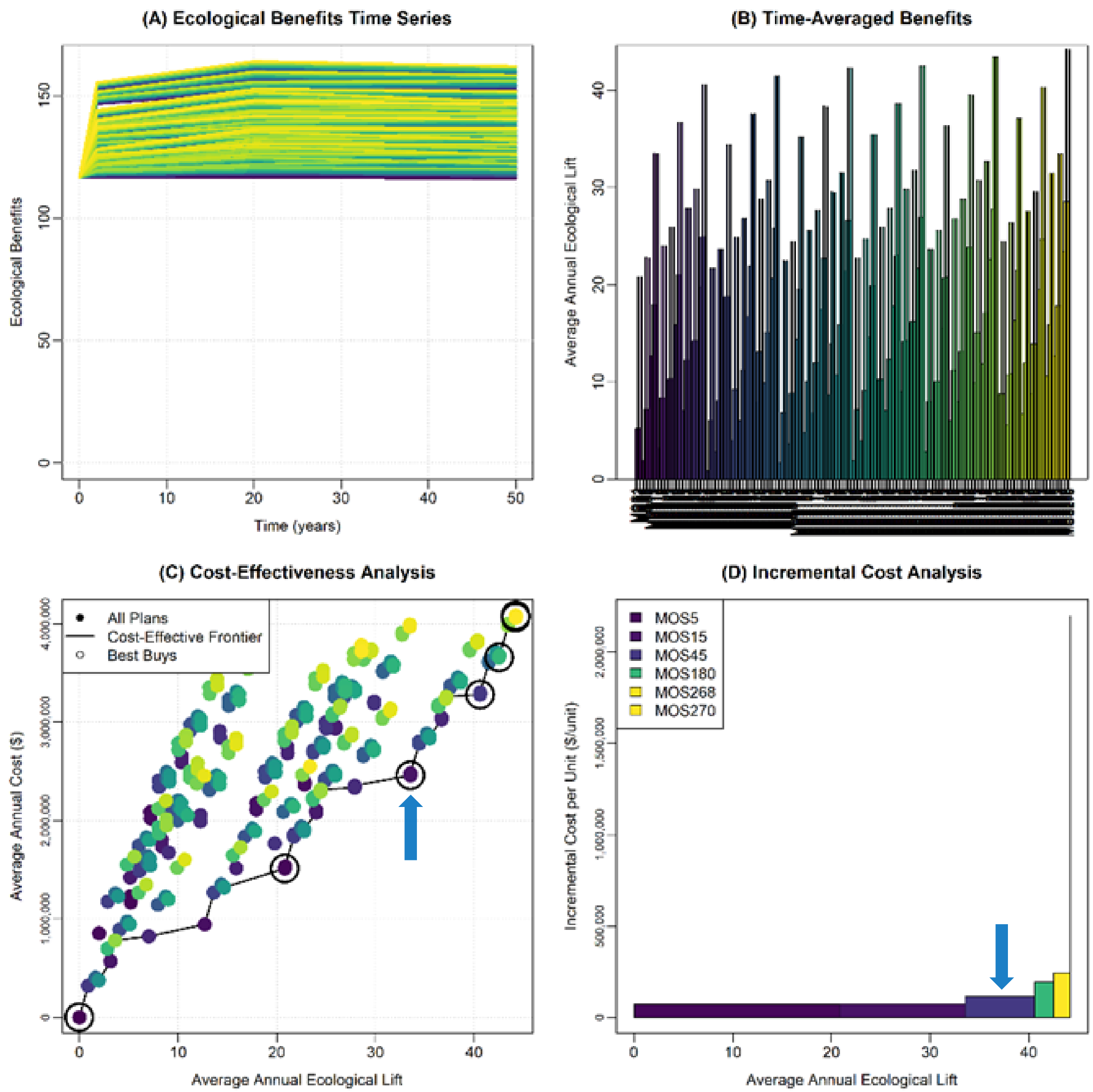


Figure 3-7: CE/ICA Results for Mosaic Sites.

System-wide alternative plan MOS45 was selected for further consideration at Binnen Kill and Schodack Island because it had the lowest unit cost *of plans that meet the planning objectives* (restoring side channels). The restoration of shallow water habitat through the restoration of side channels at both Binnen Kill and Schodack Island was an important objective due to the complete loss of side channels and extensive loss of shallow water habitat resulting from historic USACE activities. This system-wide alternative plan consists of the following components:

- Binnen Kill North Alternative 4: wetland restoration, emergent wetland restoration and side channel restoration and forested wetland restoration;
- Binnen Kill South Alternative 2: wetland restoration, tidal wetland restoration, side channel and tidal wetland corridor restoration and road crossing; and
- Schodack Island North Alternative 2: tidal wetland restoration and conversion to side channel connection, side channel and tidal wetland corridor restoration.

3.4.3.2 Shoreline Restoration Sites

Henry Hudson and Charles Rider both represent relatively small shoreline restoration sites, and recommendations were developed for this restoration type in isolation of other types (i.e., mosaic, connectivity). System-scale plans were developed examining all possible combinations of sites and alternatives. Shoreline restoration plans represent 6 combinations and are consecutively numbered (i.e., SHO1 – SHO6). For each plan, a time series of ecological benefits was forecast with EPW (Figure 3-8 A), benefits of each plan were annualized over the 50-year horizon (Figure 3-8 B), annualized benefits were compared with annualized cost in cost-effectiveness analysis (Figure 3-8 C), and cost-effective plans were subjected to incremental cost analysis (Figure 3-8 D). The following system-wide plans for shoreline restoration were examined as the final array:

- SHO1 = No action in any sites.
    - Unit Cost = $0 / AAFCU
    - No action alternative.
- SHO2 (**Tentatively Selected NER Plan for 'Shoreline' Sites**) = Henry Hudson-Alternative 1 and no action at Charles Rider Park
    - Unit Cost = $74,176 / AAFCU (Incremental Cost / Incremental Unit = $74,176 / AAFCU)
    - Lowest unit cost and incremental unit cost of the best buys.
- SHO3 = Henry Hudson-Alternative 2 and no action at Charles Rider Park
    - Unit Cost = $76,982 / AAFCU (Incremental Cost / Incremental Unit = $86,606 / AAFCU)

- Large increase in incremental unit cost not deemed "worth it" due to small increase in project footprint (i.e., 2.88 AAFCUs vs. SHO2's 2.23 AAFCUs).

- SHO6 = Henry Hudson-Alternative 2 and Charles Rider-Alternative 1
  - Unit Cost = $80,602 / AAFCU (Incremental Cost / Incremental Unit = $124,050 / AAFCU)
  - Highest unit cost and largest incremental cost.

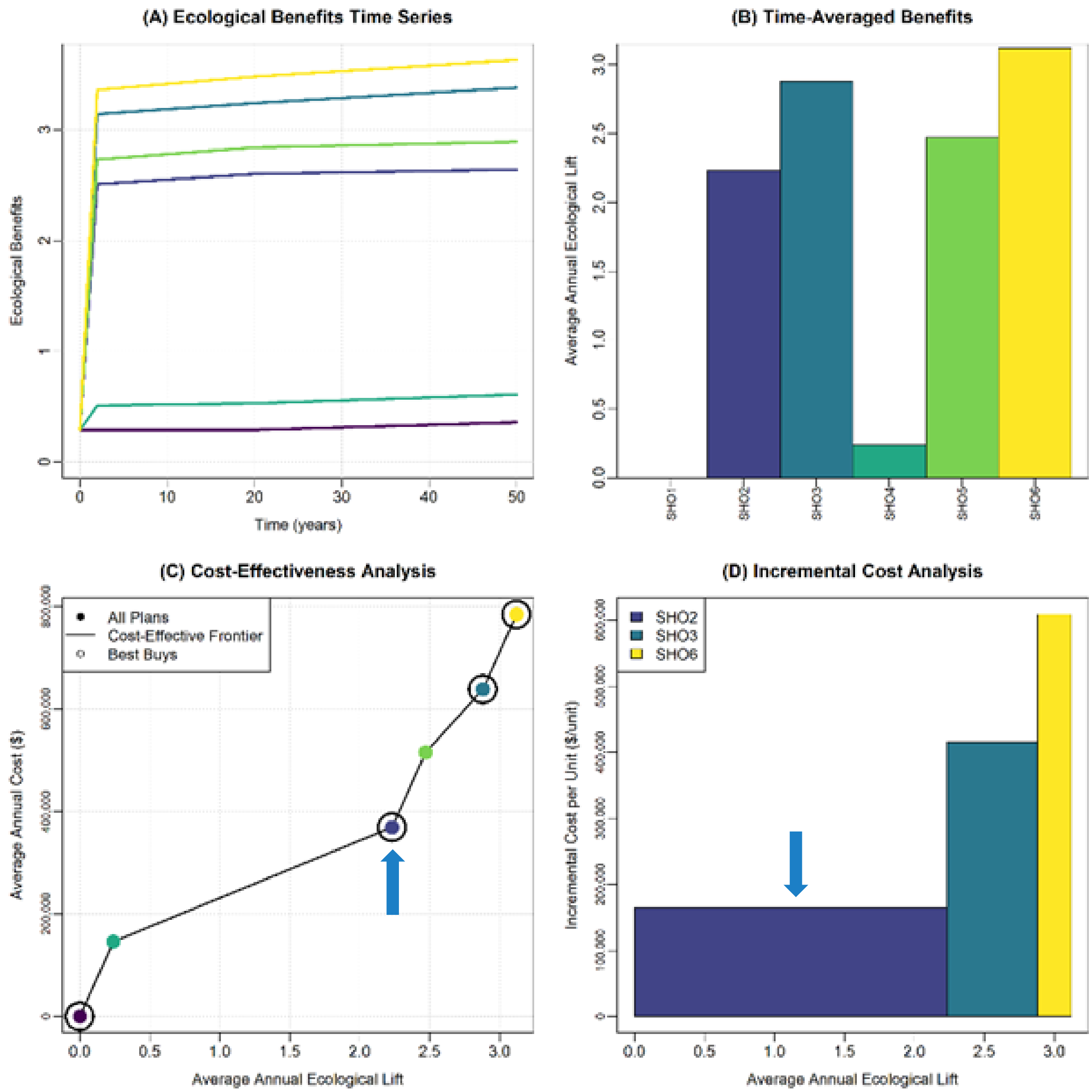


Figure 3-8: CE/ICA Results for Shoreline Restoration Sites.

System-wide alternative plan SHO2 was selected for further consideration for shorelines because it has the lowest unit cost per benefit while meeting the planning objectives. This system-wide alternative plan consists of no action, or the Future-Without Project Scenario (FWOP), for Charles Rider Park, and Alternative 1 at Henry Hudson Park (vegetated riprap and tidal wetland restoration).

3.4.3.3 Tributary Connectivity Sites

Rondout and Moodna Creek sites represent tributary connectivity sites, and recommendations were developed for this restoration type in isolation of other types (i.e., mosaic, shoreline). Connectivity projects on Moodna are highly dependent upon activities at downstream sites and represent non-separable elements. System-scale plans were developed examining all possible combinations of sites, components, and alternatives. Tributary connectivity plans represent 108 combinations and are consecutively numbered (i.e., CON1 – CON108). For each plan, a time series of ecological benefits was forecast with WUCT (Figure 3-9 A), benefits of each plan were annualized over the 50-year horizon (Figure 3-9 B), annualized benefits were compared with annualized cost in cost-effectiveness analysis (Figure 3-9 C), and cost-effective plans were subjected to incremental cost analysis (Figure 3-9 D). The following “best buy” plans were examined as the final decision array:

- CON1 = No action at any sites
    - Unit Cost = $0 / AAFCU
    - No action alternative.
- CON3 = Rondout-Alternative 2
    - Unit Cost = $1,238 / AAHU (Incremental Cost / Incremental Unit = $1,238 / AAHU)
    - Dam removal at Rondout Creek only.
- CON91 (**Tentatively Selected NER Plan for ‘Connectivity’ Sites**) = Rondout-Alternative 2 + Moodna AOP 1-Alternative 1 + Moodna AOP 2-Alternative 1 + Moodna AOP 3-Alternative 2
    - Unit Cost = $2,967 / AAHU (Incremental Cost / Incremental Unit = $7,522 / AAHU)
    - Full or partial removal of all barriers.
    - The increased incremental cost over CON3 is “worth it,” given the reconnection of more than seven miles of ecologically valuable tributary habitat associated with the Moodna Creek sites. Overall, this plan is a good value for a large amount of environmental benefits ($2,967 / AAHU for 175 AAHUs). Even in light of a six-fold increase in incremental unit

cost, the ecological value of a reconnected tributary is very high in a region with scarce tributary connectivity from historic dam construction.

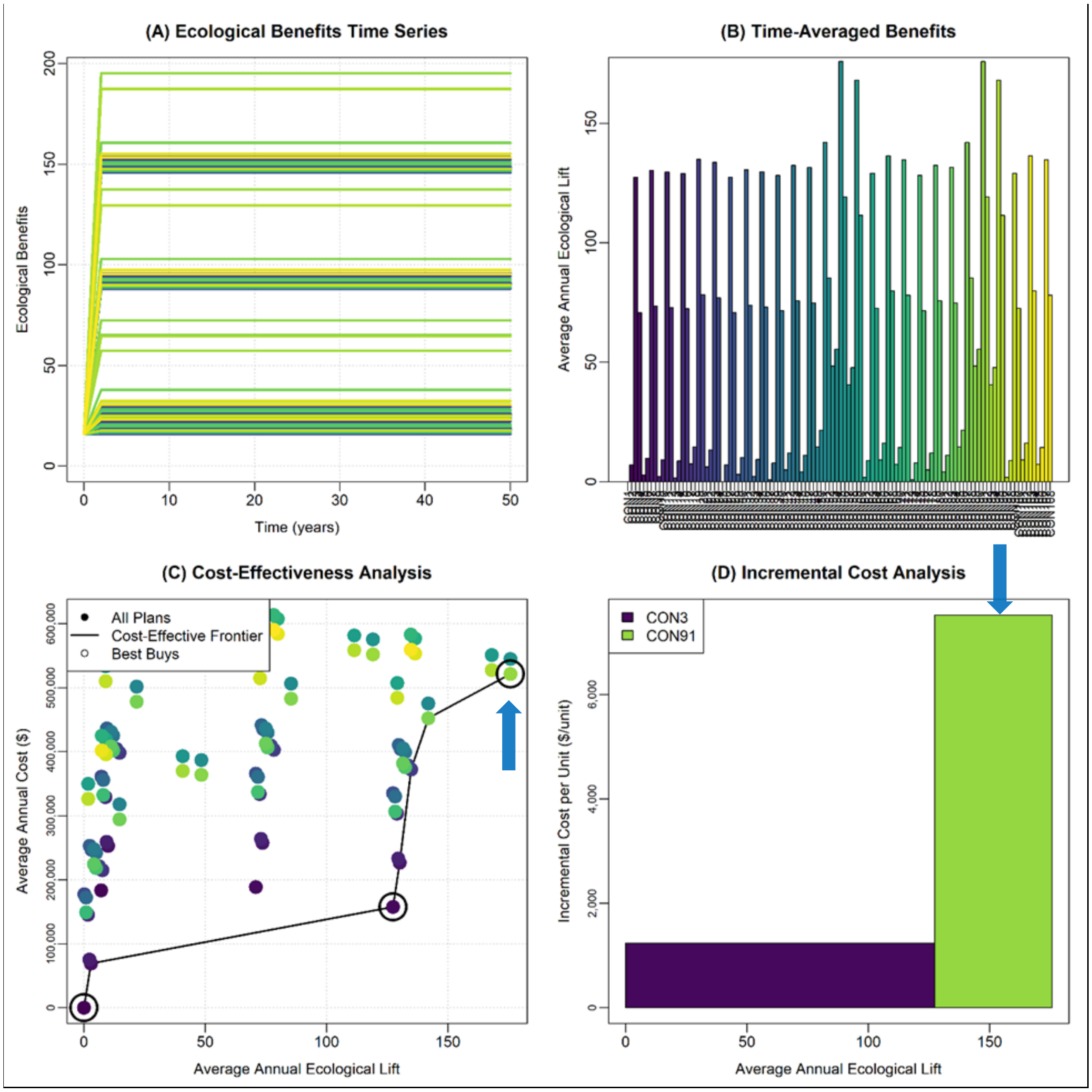


Figure 3-9: CE/ICA for Tributary Connectivity Sites.

System-wide alternative plan CON91 was recommended. Actions are recommended for both tributaries in order to meet the planning objectives and reasonably maximize benefits by reconnecting two of the 90 tributaries blocked within the Hudson River watershed at low unit cost. A total of 17 additional miles (9 miles at Rondout and 7.8 miles along Moodna Creek) of high-quality spawning habitat would benefit important migratory fish species including American shad, striped bass, alewife, blueback herring, and American eel. This system-wide plan consists of the Rondout Alternative 2 (full removal), Moodna AOP 1 Alternative 1 (full removal), Moodna AOP 2 Alternative 1 (full removal) and Moodna AOP 3 Alternative 2 (partial removal).

3.4.4 The Four P&G Criteria

The Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (P&G) (US Water Resources Council, 1983) requires that plan formulation consider four criteria: **completeness**, **effectiveness**, **efficiency**, and **acceptability**.

Completeness is the extent to which alternatives provide and account for all necessary investments or other actions to ensure the realization of the planned effects. This may require relating the alternatives to other types of public or private plans if the other plans are crucial to realization of the contributions to the objective.

- For the benefits of the 23 alternatives that were formulated and those included in the tentatively selected plan to be realized, no unusual actions or planning would be required. The implementation of the alternatives would follow USACE's standard implementation process for General Investigations projects. The planning objectives were developed to align with the state's existing plans for Hudson River restoration, as described in Section 3.1.6. and coordination with NYSDEC during the study assured support for the formulated alternatives.

Effectiveness is the extent to which alternatives alleviate the specified problems and achieve the specified opportunities.

- Planning objectives were developed to alleviate the problems and achieve opportunities available in the study area, and all action alternatives were developed to achieve one or more of the planning sub-objectives. The extent to which alternatives and combinations of alternatives met planning objectives was used to interpret the CE/ICA results and to tentatively select a plan, as described in Section 3.4.3.

Efficiency is the extent to which an alternative plan is the most cost-effective means of alleviating the specified problems and realizing the specified opportunities, consistent with protecting the Nation's environment.

- CE/ICA was used to tentatively select a cost-effective plan that meets one or more of the planning objectives, as described in Section 3.4.3.

Acceptability is the workability and viability of the alternative plan with respect to acceptance by State and local entities and the public and compatibility with existing laws, regulations, and public policies.

- The study team developed alternatives that are compliant with existing laws, regulations, and policies. The draft FR/EA was reviewed for policy and legal compliance within USACE and by other federal and state agencies with regulatory authority that applies to USACE projects. The final FR/EA will be similarly reviewed.

- The formulated alternatives were expected to be acceptable to the public and local communities. Hudson River restoration is popular, as evidenced by the large number of stakeholders that participated in the development of the Hudson River Comprehensive Restoration Plan (Partners Restoring the Hudson, 2018) as discussed in Section 1.3. To manage the risk of developing unacceptable alternatives, preliminary site screening and landowner outreach were conducted prior to the development of alternatives (Section 4.8). Unfortunately, significant landowner concerns associated with the alternatives developed for two sites in the tentatively selected plan were not discovered until after the release of the draft FR/EA for public reviews. As described in Section 3.5.2, based on coordination with one of the study non-federal sponsors (NYSDEC), these sites were dropped from the plan before feasibility-level design occurred.

3.5 Tentatively Selected Plan Optimization

3.5.1 Tentatively Selected Plan

The Tentatively Selected Plan identified in Section 3.4.3 included the sites and alternatives in Table 3-7. No action would be taken at Charles Rider Park.

Table 3-7: Tentatively Selected Plan.

SITE	TENTATIVELY SELECTED PLAN
BINNEN KILL	North: Alternative 4 • Wetland restoration (43.8 acres) • Forested wetland restoration (15.5 acres) • Emergent wetland restoration (4.3 acres) • Emergent wetland restoration & channel restoration (41.9 acres) South: Alternative 2 • Side channel and tidal wetland corridor restoration (27 acres) • Tidal wetland restoration (21.3 acres)
SCHODACK ISLAND	North: Alternative 2 • Side channel and tidal wetland corridor (9.1 acres) • Tidal wetland restoration (19.8 acres)
HENRY HUDSON PARK	Alternative 1 • Tidal wetland restoration (3.6 acres) • Replacement of the eroding hardened shoreline with a vegetated riprap living shoreline
RONDOUT CREEK	Alternative 2: Eddyville Dam removal (9 miles of upstream habitat)
MOODNA CREEK	AOP 1: Alternative 1: Utility pipe removal AOP 2: Alternative 1: Firth Cliff Dam removal AOP 3: Alternative 2: Orr's Mill Dam partial removal (Collectively, 7.8 miles of upstream habitat)

3.5.2 Removal of Sites

A draft version of this Integrated Feasibility Report and Environmental Assessment, presenting the Tentatively Selected Plan, was released for public review in June 2019. Based on public comments received, Binnen Kill and Rondout Creek and the tentatively selected restoration alternatives for those sites were not included in the Recommended National Ecosystem Restoration Plan.

Although some public comments supportive of the plan to remove Eddyville Dam from Rondout Creek were received, many more of the comments received on the plan expressed concerns and/or opposition. The dam owner opposed the plan, and approximately 60 other community members who were in direct communication with him opposed the plan or had serious concerns. Keane&Beane Attorneys at Law represented the dam owner and community members. Additional comments or letters opposing the dam were received from 17 owners of land adjacent to the project site, the Town of Esopus, and D&H Canal Historical Society. Several of those who commented opposing dam removal stated they would support another formulated alternative for Rondout Creek – a fishway. However, because the average annual costs of a fishway are about $26,000 higher than for removing Eddyville Dam, for only a fraction of the lift (7.07 AAFCUs compared to 127.4 AAFCUs), a fishway could not be included in the NER Plan per ER 1105-2-100 paragraph 2-3.f.(2). Due to public concerns and opposition, NYSDEC was unwilling to support removing Eddyville Dam and Rondout Creek was not included in the Recommended Plan.

Although significant support for the plan for Binnen Kill was received from Scenic Hudson, the owner of a portion of the project area and other landowners opposed the plan. The owner of a northern parcel of the project site stated that the planned restoration would be incompatible with his plans to use his land for farming, and two owners of land adjacent to where the plan for Binnen Kill South would have restored a side channel expressed concerns that the side channel would increase the risk of their cornfields flooding. These landowners expressed that they were unwilling to provide the real estate interests required for project implementation. The project footprint and benefits were so reduced by the deletion of these areas from the plan that Binnen Kill site could not be included in the NER Plan following the updated CE/ICA, and Binnen Kill was not included in the Recommended Plan.

3.5.3 Feasibility-Level Design

The sites in the Recommended NER Plan include Henry Hudson Park, Schodack Island, and Moodna Creek. Feasibility-level design for the recommended alternatives for these sites consisted of the following:

- Detailed designs and appropriate cross-sections were developed for each site.
- Grading plans and planting plans with plant lists were prepared for Schodack Island and Henry Hudson Park.
- Preliminary habitat vegetation zones were correlated to tidal datums for Schodack Island and Henry Hudson Park.
- Side channel cross-sections and details of the road crossing were developed for Schodack Island.
- Qualitative assessment was conducted to anticipate changes in hydraulic conditions at each AOP site along Moodna Creek based on general topography, and anticipated channel form and post-hydraulic conditions following the removal of each barrier.

- Qualitative assessment was conducted to anticipate transport of impounded sediment following the removal of each barrier along Moodna Creek. This assessment was based on previous sediment probing and visual inspection of sediment character collected during field work performed in 2018.
- Detailed designs for Moodna Creek AOPs were prepared based on results from the qualitative hydraulic assessment resulting in improved condition plans.
- Quantity take-offs were updated.
- Costs and benefits were updated for each optimized feasibility level design as described in Section 4.2 and Section 4.3.

3.5.4 Updated CE/ICA Results

CE/ICA using the updated costs and benefits confirmed the Recommended NER Plan. Table 3-8 summarizes changes in the ecological lift, average annual costs, and unit costs of each site as well as percent change in unit cost. The unit cost at Schodack Island decreased due to increases in benefits and decreases in costs. A decline in unit cost increases the competitiveness of this site. As such, this site is assumed to be even more competitive and was easily confirmed as part of the Recommended Plan. Unit costs increased at Henry Hudson Park and Moodna Creek sites, but these increases are acceptable for the following site-specific reasons. Notably, increases in costs and benefits should be considered relative to other project uncertainties (e.g., contingency estimates ranging from 10-32%, ecological model outputs, sea level change, etc.).

- Henry Hudson Park: Benefits increased at this location as a result of design optimization, but costs increased substantially as well. This site and alternative were originally selected based on incremental cost analysis over the next “Best Buy,” which was Alternative 2 at Henry Hudson Park with an incremental cost of $221,000. As such, this site and alternative would still be considered not only a “Best Buy,” but also preferred relative to other potential shoreline restoration actions on an incremental basis. See Section 3.4.3 for additional details about the prior incremental analysis.
- Moodna Creek: Unit cost increased substantially at these three dams, but unit cost remains extremely low and the regional ecological value of three barrier removals in series is high.

Table 3-8: Summary of Initial and Optimized Benefits and Costs.

SITE	INITIAL LIFT (AAFCU)	FINAL LIFT (AAFCU)	INITIAL ANNUAL COST ($)	FINAL ANNUAL COST ($)[1]	INITIAL UNIT COST ($/AAFCU)	FINAL UNIT COST ($/AAFCU)	CHANGE IN UNIT COST (%)
Schodack Island	7.06	8.49	822,106	755,396	116,446	88,974	- 23.6
Henry Hudson	2.23	2.38	368,870	427,074	165,413	179,443	+ 8.5
Moodna Creek	48.36	48.36	363,771	447,837	7,522	9,260	+ 23.1
ALL	57.65	59.23	1,554,747	1,630,307	26,969	27,525	+ 2.1

[1] **Design changes since draft FR/EA resulting in cost increases and/or decreases:**

Schodack Island: Cost *decrease* due to: a) decreased volume of excavated soil and placement and b) use of standard-size culvert:
a) Proposed wetland corridor and side channel designed at higher elevations, with corridor designed for a scrub shrub wetland community rather than a low and high marsh wetland community.
b) Road crossing culvert width increased.
Cost *increase* due to: inclusion of land value in real estate cost; increased excavation along the Hudson River and Schodack Creek channel connections; and off-site disposal of excavated material.

Henry Hudson: Cost *increase* due to off-site disposal of excavated material and inclusion in land value in real estate costs.

Moodna Creek: For AOP1, cost *decrease* due to change in sanitary sewer decommission approach
For AOP2 & AOP3, cost *decrease* due to change in water control method. Real estate costs also increased for all Moodna sites; as well as inflating costs from 2019 to 2020 price levels resulting in an overall net increase.

Chapter 4: Recommended Plan*

The Recommended Plan is the National Ecosystem Restoration (NER) Plan. This chapter describes the plan and its implementation. The NER Plan includes habitat restoration at Henry Hudson Park and Schodack Island on the Hudson River, and on Moodna Creek, a tributary of the Hudson River. Figure 4-1 shows where the restoration sites are located in the study area. Table 4-1 summarizes the alternatives the plan includes and the number of acres or river miles of habitat that the plan would restore.

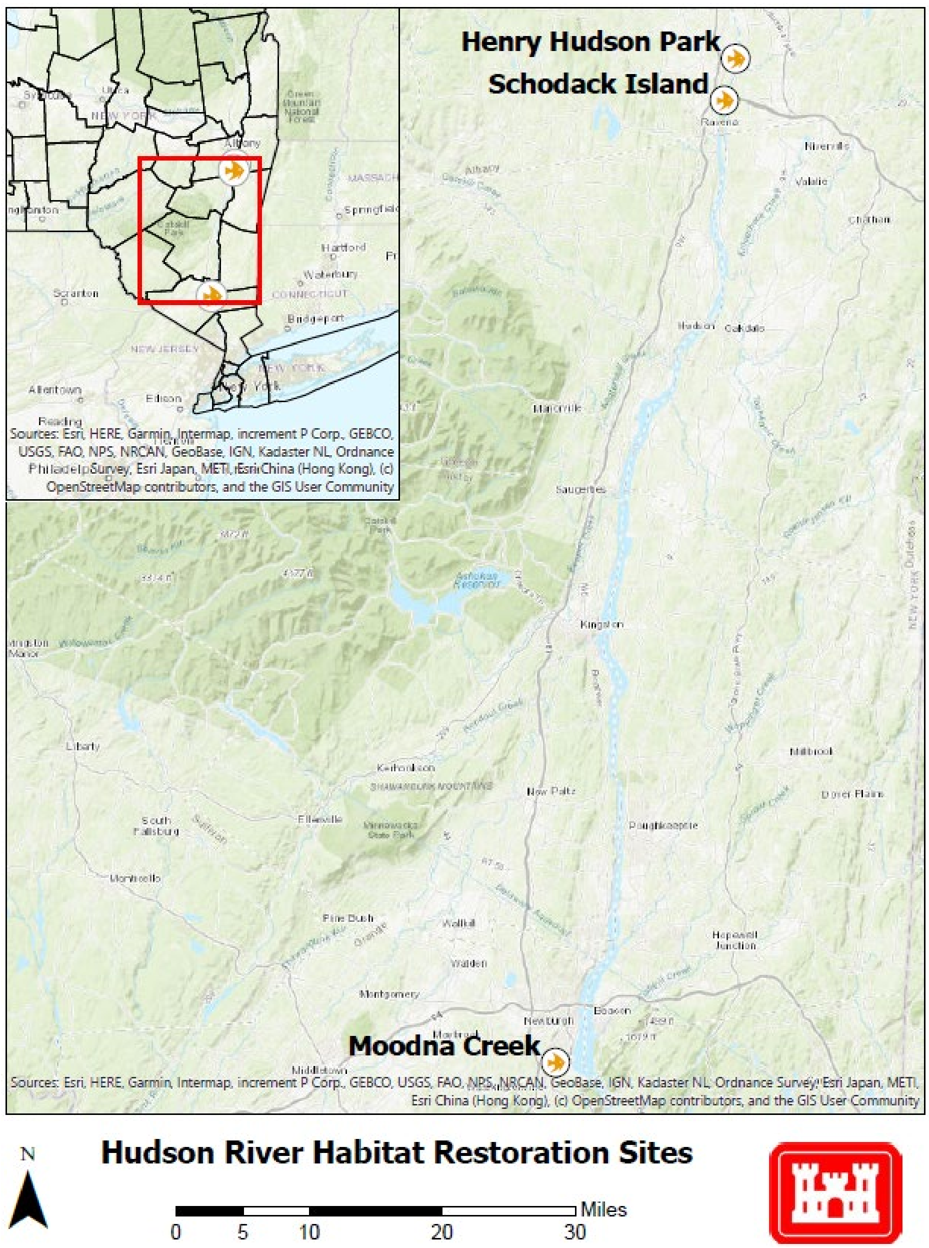


Figure 4-1: Map of Sites in the Recommended Plan.

Table 4-1: NER Plan Alternatives and Habitat Restoration Acres and Miles.

SITE	RECOMMENDED PLAN
HENRY HUDSON PARK	Alternative 1 • Tidal wetland restoration (3.7 acres) • Replacement of the eroding hardened shoreline with a living shoreline (1,760 linear feet of shoreline with 0.6 acres of tidal wetlands)
SCHODACK ISLAND	North: Alternative 2 • Side channel and tidal wetland complex restoration (8.5 acres) • Tidal wetland restoration (19.1 acres)
MOODNA CREEK	AOP 1: Alternative 1 • Utility pipe removal AOP 2: Alternative 1 • Firth Cliff Dam removal AOP 3: Alternative 2 • Orr's Mill Dam partial removal (Collectively, 7.8 miles of upstream habitat)
TOTAL	**• 22.8 acres of tidal wetlands in the Hudson River corridor** **• 8.5 acres of side channel and tidal wetland complex** **• 1,760 linear feet of living shoreline with 0.6 acres of tidal wetlands** **• 7.8 miles of tributary habitat reconnected**

4.1 Restoration Sites in the Plan

This section describes the recommended plan for each site and includes concept plans. The Engineering Appendix contains grading and planting plans and Relative Sea Level Change (RSLC) analyses. Construction sequencing is presented in Section 4.7 and specific details for construction implementation will be determined during the Preconstruction Engineering and Design phase.

4.1.1 Henry Hudson Park

At Henry Hudson Park on the western shore of the Hudson River in Bethlehem, New York, the plan includes the restoration of tidal wetlands and a living shoreline providing habitat and stability (Figure 4-2). Construction of the plan for Henry Hudson Park is estimated to take 16 months. The general construction approach includes site clearing and invasive plant species removal; installation of water control features; earthwork including excavation and grading; removal of 36,000 cubic yards of soil off-site; import of soil; and installation of stabilization structures followed by native plantings. Construction of the restoration features and areas presented below may occur simultaneously depending on project phasing and construction crews.

Western Tidal Wetland Restoration

Approximately 3.6 acres of existing upland will be restored to tidal wetland (Figure 4-3). Soils would be excavated to an average depth of five feet below existing grade to achieve tidal wetland hydrology. The soils within the wetland area would be amended as necessary and planted with native vegetation. The shoreline would also be stabilized with rock to dissipate erosive forces. Target ground elevations would be set to allow daily tidal flushing. Excavated soil would be disposed of off-site at a nearby disposal facility.

Shoreline Wetland Restoration

Approximately 0.6 acres of tidal wetlands and 1,760 linear feet of shoreline would be restored (Figure 4-4). The portion of land available for shoreline restoration at the Park is limited due to the adjacent park amenities, and the bank slopes are generally steep and require stabilization to transition from the shoreline edge to river channel bottom. Due to these conditions, it was necessary to provide a hard-armoring approach using vegetated riprap while balancing the goal to maximize ecological benefits. To breach the transition from the river channel bottom to shoreline edge, reinforcement of the existing timber cribbing toe protection is proposed. Along the Hudson River shoreline, the existing timber cribbing would remain. The cribbing would be reinforced with 12-inch riprap. The selected rock sizing is consistent with existing material in observed stable bank areas. The concrete cap would be removed and replaced with riprap and graded to achieve a 1V:3H slope. The area of land landward of the reinforced cribbing would be backfilled with soil and planted with native vegetation. Additionally, stabilization boulders would be placed at the wetland-upland interface. The boulders would be approximately three to four feet in diameter which is similar in size to boulders on-site that appear to be currently stabilizing the shoreline. These modifications to the structure would not significantly encroach upon the park’s upland areas.

Cove Tidal Wetland Restoration

Approximately 0.2 acres of existing mudflat would be stabilized and restored to tidal wetland (Figure 4-5). Along the northern bank on the Vloman Kill, 20-inch coir log toe protection would be installed at the toe of the slope around the existing mudflat. This diameter coir log was selected to allow six inches to be embedded into the existing substrate and at least 12 inches above grade to retain the substrate, assuming that the coir log would flatten by approximately two inches during installation. Riprap consisting of 36-inch diameter boulders would be installed at the top of slope to stabilize existing scour. These boulders would be embedded a minimum of six inches into the ground. This diameter rock was selected because it is consistent with the size of existing material in stable bank areas. Native wetland vegetation would be planted within the intertidal area.

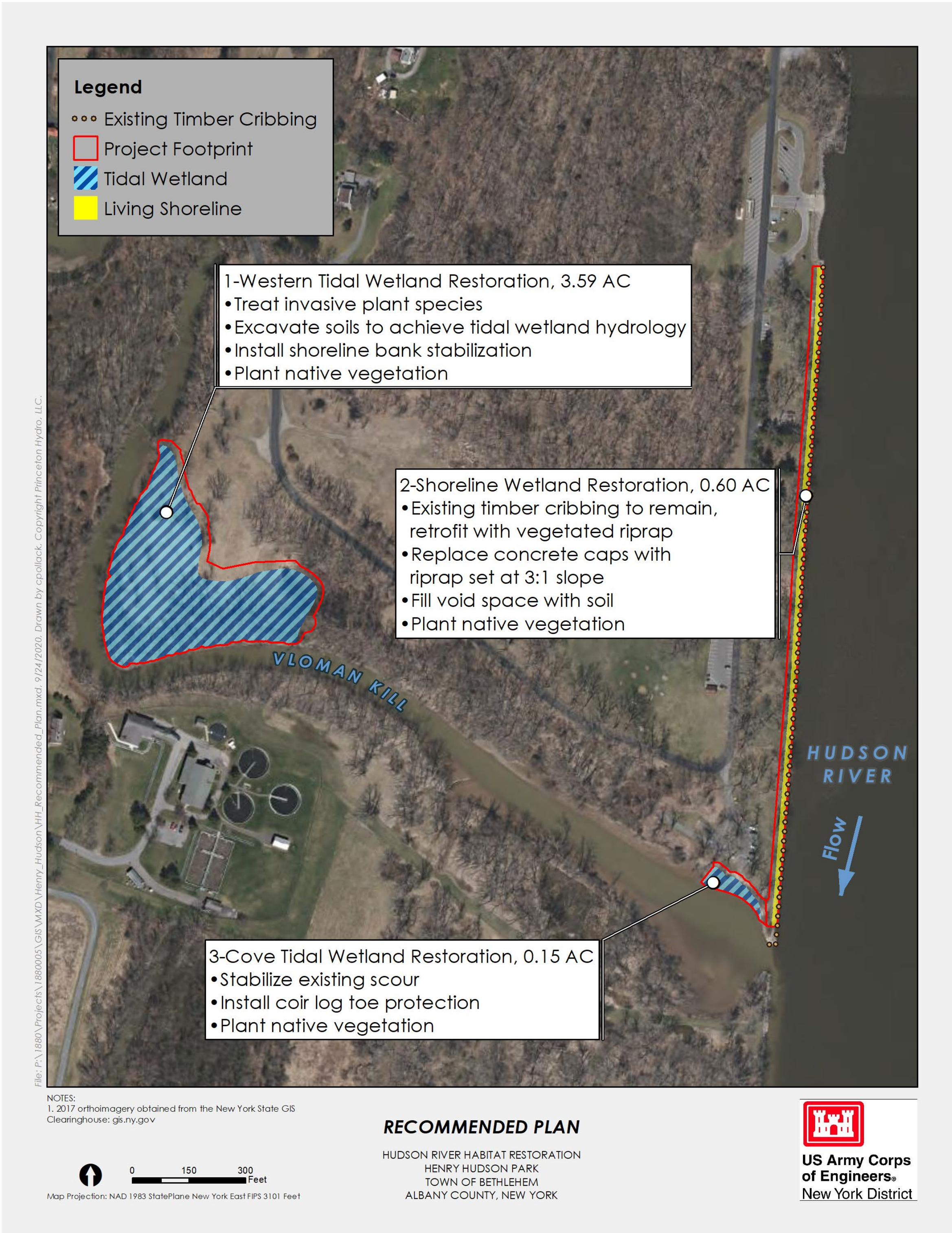


Figure 4-2: Recommended Plan at Henry Hudson Park on the Hudson River in Bethlehem, NY.

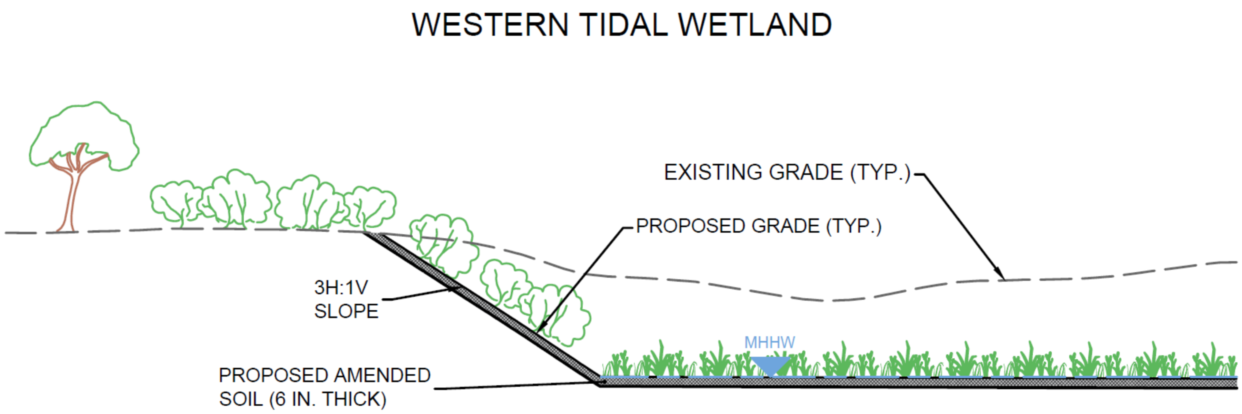


Figure 4-3: Henry Hudson Park Western Tidal Wetland Cross-Section (Typical).

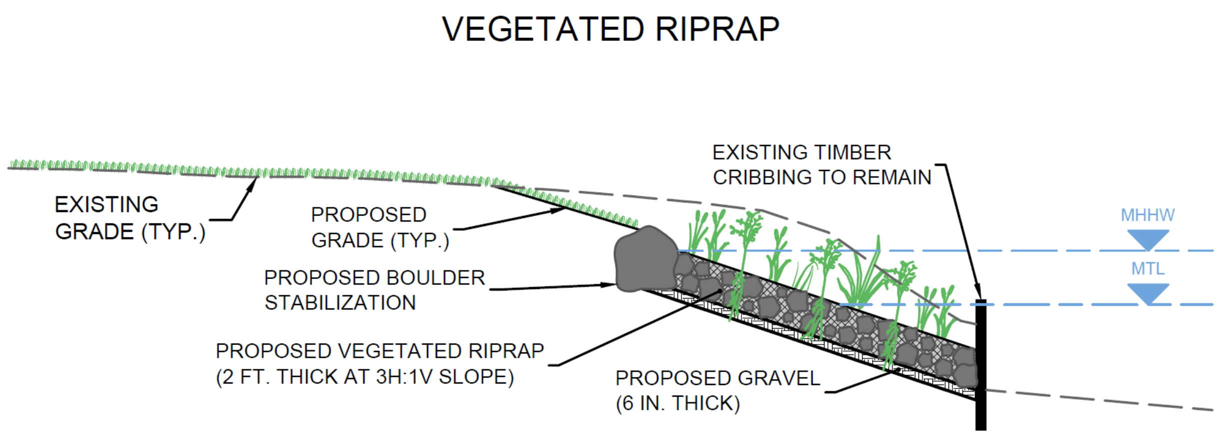


Figure 4-4: Henry Hudson Park Shoreline Cross-Section (Typical).

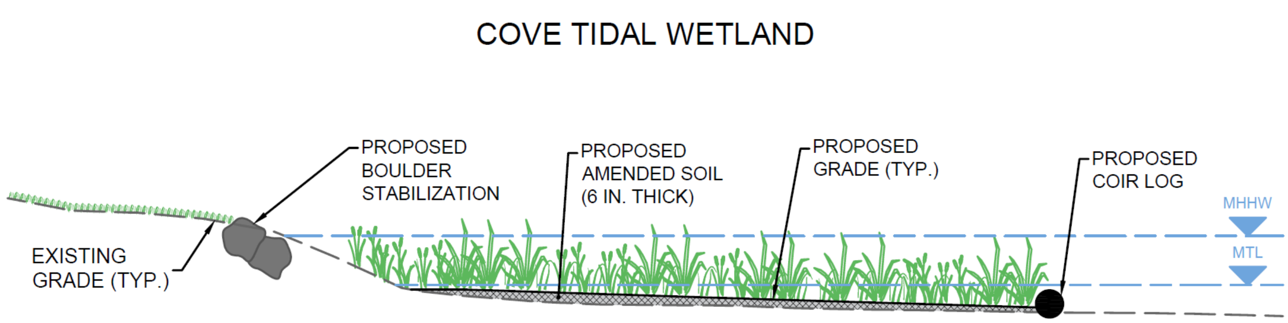


Figure 4-5: Henry Hudson Park Cove Tidal Wetland Cross-Section (Typical).

4.1.2 Schodack Island

At Schodack Island on the eastern shore of the Hudson River in Schodack, New York, the plan consists of tidal wetland restoration and side channel restoration with a tidal wetland complex (Figure 4-6). Construction of the plan for Schodack Island is estimated to take two years. The general construction approach includes installation of soil erosion/sediment control features and a temporary work access road; site clearing and invasive plant species removal; installation of water control features; earthwork including excavation and grading of the side channel and wetlands; removal of 85,000 cubic yards of excess soil off-site; installation of site amenities (including removing or modifying existing aquatic organism crossings, floodplain connections and/or culverts); and installation of native plantings. Construction of the restoration features and areas presented below may occur simultaneously depending on project phasing and construction crews.

Tidal Wetland Restoration North

Approximately 2.8 acres of existing tidal habitat, dominated by invasive species such as common reed, would be treated with an approved aquatic herbicide (assumed two seasons) and planted with native plant species.

Tidal Wetland Restoration & Conversion to Side Channel Connection

Approximately 0.8 acres of existing tidal habitat, dominated by invasive species such as common reed, would be treated and planted with native plant species. Additionally, grading would occur to convert wetland to a side channel connection point, which would facilitate the conveyance of flow. The shoreline would be stabilized as necessary to accommodate new flows.

Side Channel and Tidal Wetland Corridor Restoration

Approximately 7.6 acres of side channel and wetland corridor would be restored (Figure 4-7). A side channel would be excavated in areas of historic fill placement to hydrologically reconnect the upstream end of Schodack Creek with the Hudson River. Currently, Schodack Creek is only connected to the Hudson River at its downstream end. The channel would convey flow during low tide and higher water levels providing refuge to aquatic species during increased river velocities. A 400-foot tidal wetland corridor would be established adjacent to the channel. To accommodate local vehicular access to the southern portion of the island, the channel would be spanned by a road crossing with a rectangular reinforced box culvert (Figure 4-8). The existing ski trail would also be redirected to this road crossing. The channel would have a 20-foot width and an invert elevation of -2.00 feet and transition to tidal wetland, based on 2027 tide levels, which would range in elevation from elevation 1.5 to 4.00 feet and then transition to riparian vegetation. The tidal wetland would be dominated by a scrub/shrub wetland community. The riparian vegetation would transition to existing grade at a maximum slope of 3 feet horizontal to 1 foot vertical.

Excavated soil from each restoration area would be disposed of at the dredged material placement site on Houghtaling Island, New Baltimore, NY.

Tidal Wetland Restoration South

Approximately 16.2 acres of existing tidal habitat, dominated by invasive species such as common reed, would be treated. Minor grading would expand the existing tidal channel to accommodate increased flows with the proposed side channel connection. Fringe wetlands would be graded as necessary to stabilize the wetland and native vegetation would be planted.

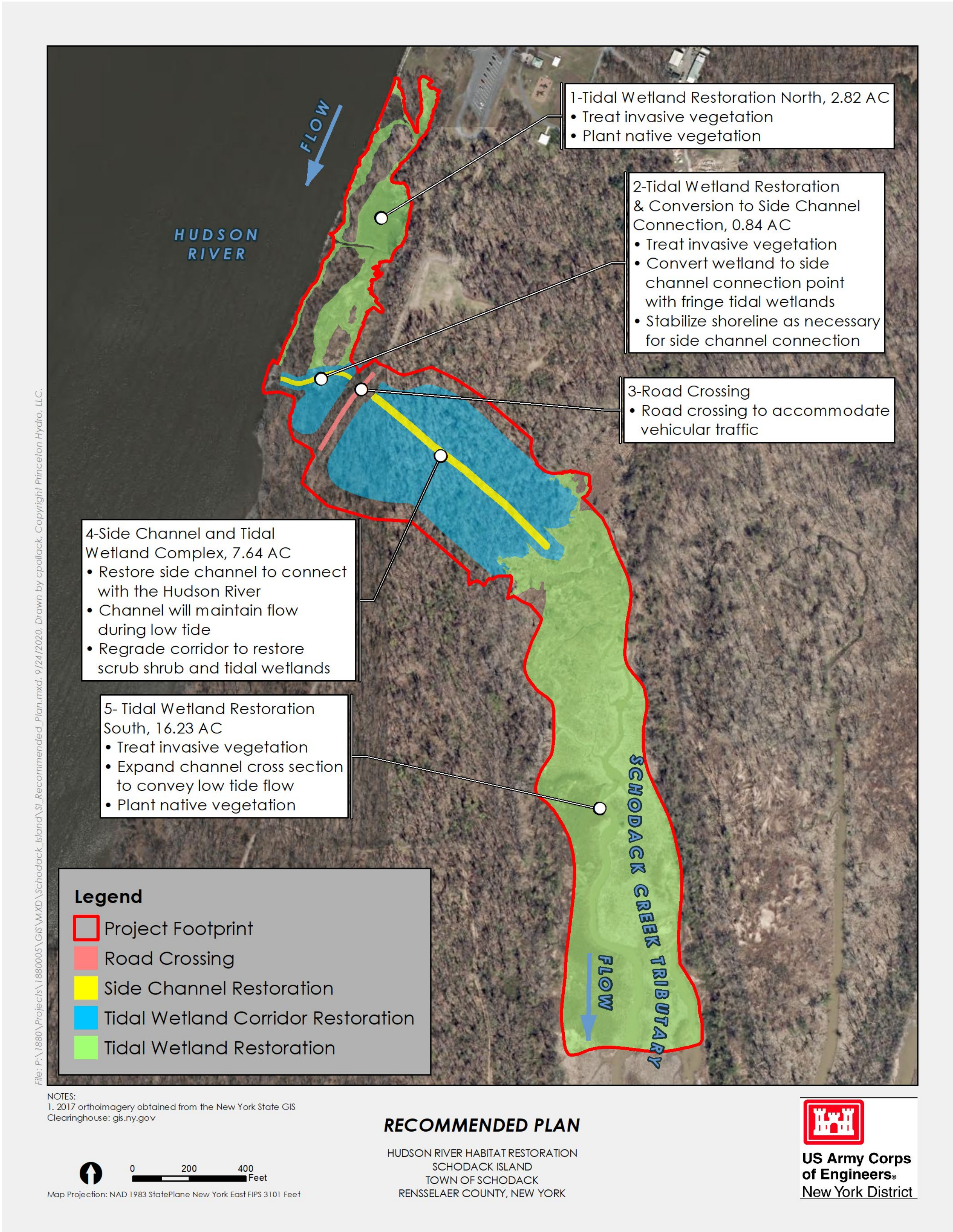


Figure 4-6: Recommended Plan at Schodack Island on the Hudson River in Schodack, NY.

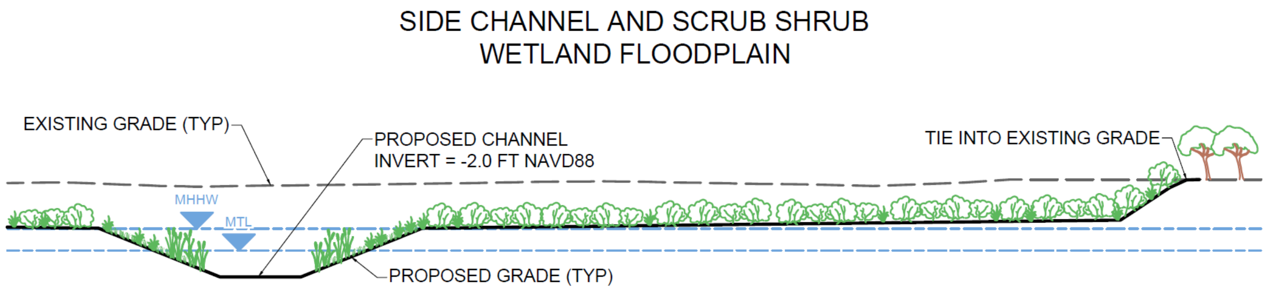


Figure 4-7: Schodack Island Side Channel Cross-Section (Typical).

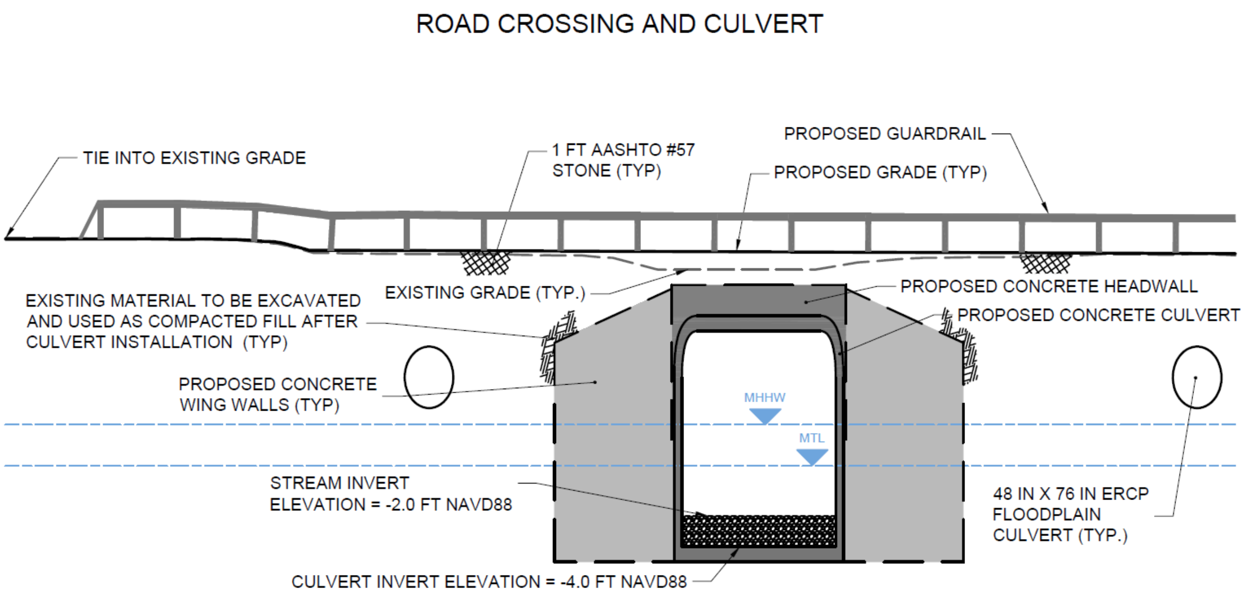


Figure 4-8: Schodack Island Road Crossing and Culvert Cross-Section.

4.1.3 Moodna Creek

On Moodna Creek, a tributary of the Hudson River in Orange County, New York, the plan includes removal of the sewer utility line (Aquatic Organism Passage Site [AOP] 1), removal of Firth Cliff Dam (AOP 2), and breach of Orr's Mill Dam (AOP 3). The plan would collectively reconnect 7.8 miles of habitat. Construction of the plan for Moodna Creek is estimated to take 15 months overall, and would proceed sequentially from upstream to downstream, starting with AOP 1 (3 months), proceeding to AOP 2 (6 months), and ending with AOP 3 (6 months). The general construction approach for all three AOPs includes installation of soil erosion and sediment control features; installation of temporary work area roads; site clearing; installation of water control features and in-water access ramps and pads; demolition of barriers; installation of in-stream structures (boulders); and stabilization of banks and surrounding areas (as necessary).

AOP 1 - Utility Removal

For AOP 1, the sewer utility line in New Windsor, the recommended plan (Figure 4-9) entails decommissioning the dormant utility line and removing the section that crosses Moodna Creek. This removal would result in the reconnection of 1.2 miles of river habitat. The sanitary sewer line is an 18-inch ductile iron pipe (DIP); an approximately 100-foot-long section spans the channel and is contained in a concrete encasement approximately five feet wide and five feet deep. The recommended approach to decommissioning the line includes accessing the existing manhole on the floodplain to the northwest (i.e. river left bank), and sealing-off the incoming sanitary line with concrete or similar means. On the river right bank, where the utility descends steeply from the inactive railroad bed at the top of the slope, the recommended approach to decommissioning this sewer line is to break the existing line at the base of the slope and mechanically plug and cap the line with a concrete thrust block. The sewer line at the upslope manhole will also be mechanically plugged.

A total of 175 feet of sewer line (100-foot concrete encased section and the 75-foot section under floodplain soils leading to the existing manhole) would be excavated and disposed of offsite. Full removal of the utility line at the channel crossing is proposed as it is the alternative that most effectively restores fish passage through the site, and also eliminates the structure that is currently exposed, undermined by subsurface flow, and at risk for damage or rupture. Preliminary hydraulic modeling for the proposed conditions of the recommended plan indicates that removal of the sewer utility line would lower water surface elevations by 0.8 feet in the 1% Annual Chance Flood (or a storm similar in scale to Irene or Lee), 1.0 feet in the bankfull flow (or a precipitation event of moderate size), and 1.6 feet in the median annual flow, which is more typical of everyday conditions. See Appendix B - Engineering, Attachment B: Qualitative Assessment of Hydraulic and Sediment Conditions.

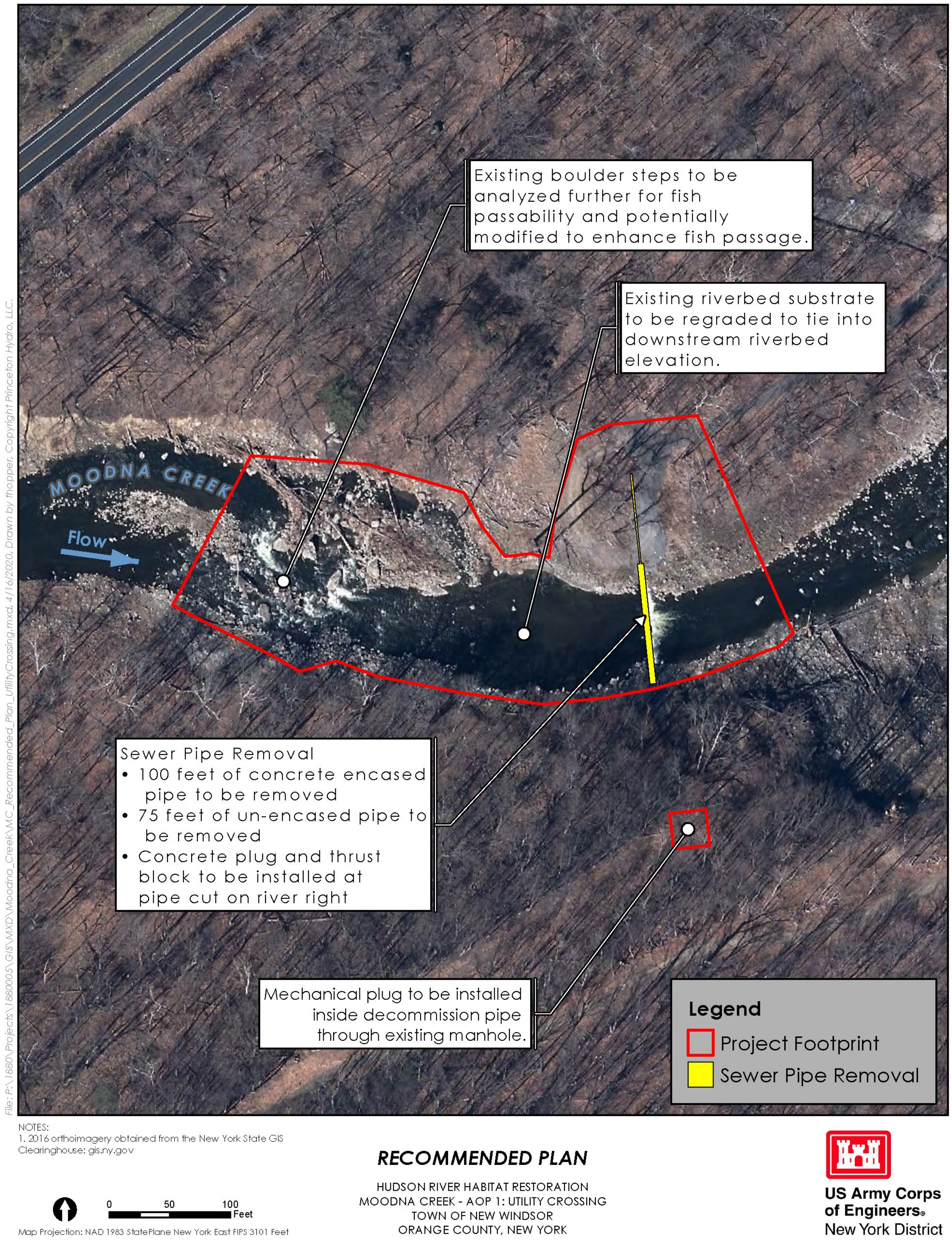


Figure 4-9: Recommended Plan at Moodna Creek, AOP 1 – Utility Crossing in New Windsor, NY.

Moodna Creek AOP 2 - Dam Removal

For AOP 2, Firth Cliff Dam, the recommended plan (Figure 4-10) entails demolition and removal of the approximately 9-foot high, 180-foot wide, concrete spillway to the full vertical extent. This removal would result in the reconnection of 0.6 miles of river habitat. Concrete debris would be broken up and re-used on-site for channel and bank stabilization. The abutments attached to the valley wall on river left and the building foundations on river right may be left in place pending observations from a more detailed site investigation. Approximately 1,300 feet upstream of the dam, a pronounced boulder riffle indicates the upstream limit of the impoundment and would serve as a natural grade control that would limit the upstream extent of any channel adjustment in the event of dam removal. The well-vegetated banks and narrow valley walls indicate little potential for lateral channel adjustment or meandering.

In general, the geomorphic response to dam removal would follow a predictable trajectory: (i) initial water-lowering, (ii) impounded sediment evacuates from the impoundment as a head-cut moves upstream from the dam and then widens to the full span of the channel, and (iii) temporary deposition of coarse-grained sediment in the downstream reaches. By the end of the first growing season, herbaceous, annual plants would begin to occupy the newly-exposed upper banks; perennial species would begin to dominate by the end of the second growing season.

The assessment of the transport of impounded sediment, which included approximating equilibrium profile, impounded sediment volume, and watershed sediment yield, indicates that the impounded sediment volume is negligible (4-10%) relative to the annual watershed sediment yield. While sediment sampling and chemical analysis would be performed as part of the Preconstruction Engineering and Design phase, the passive release of this quantity of impounded sediment is not anticipated to have adverse impacts on downstream aquatic biota, habitats, structures, or properties based on a preliminary analysis.

This plan is anticipated to restore a free-flowing reach of river with increased dissolved oxygen content and moderated water temperatures. Full fish passage conditions are very likely to re-form; removal of the dam would reconnect two previously disconnected river reaches and restore passage for some resident species and American Eel. In addition, this dam removal is anticipated to restore the natural transport of bedload sediment, which in turn could rejuvenate benthic habitat conditions for aquatic invertebrates downstream, and partially offset any vertical channel degradation that has occurred in the decades and centuries since dam construction. Preliminary hydraulic modeling for the proposed conditions of the recommended plan indicates that removal of the dam and subsequent riverbed adjustments would lower water surface elevations by 5.8 feet in the 1% Annual Chance Flood (or a storm similar in scale to Irene or Lee), 7.3 feet in the bankfull flow (or a precipitation event of moderate size), and 8.1 feet in the median annual flow, which is more typical of everyday conditions. See Appendix B - Engineering, Attachment B: Qualitative Assessment of Hydraulic and Sediment Conditions.

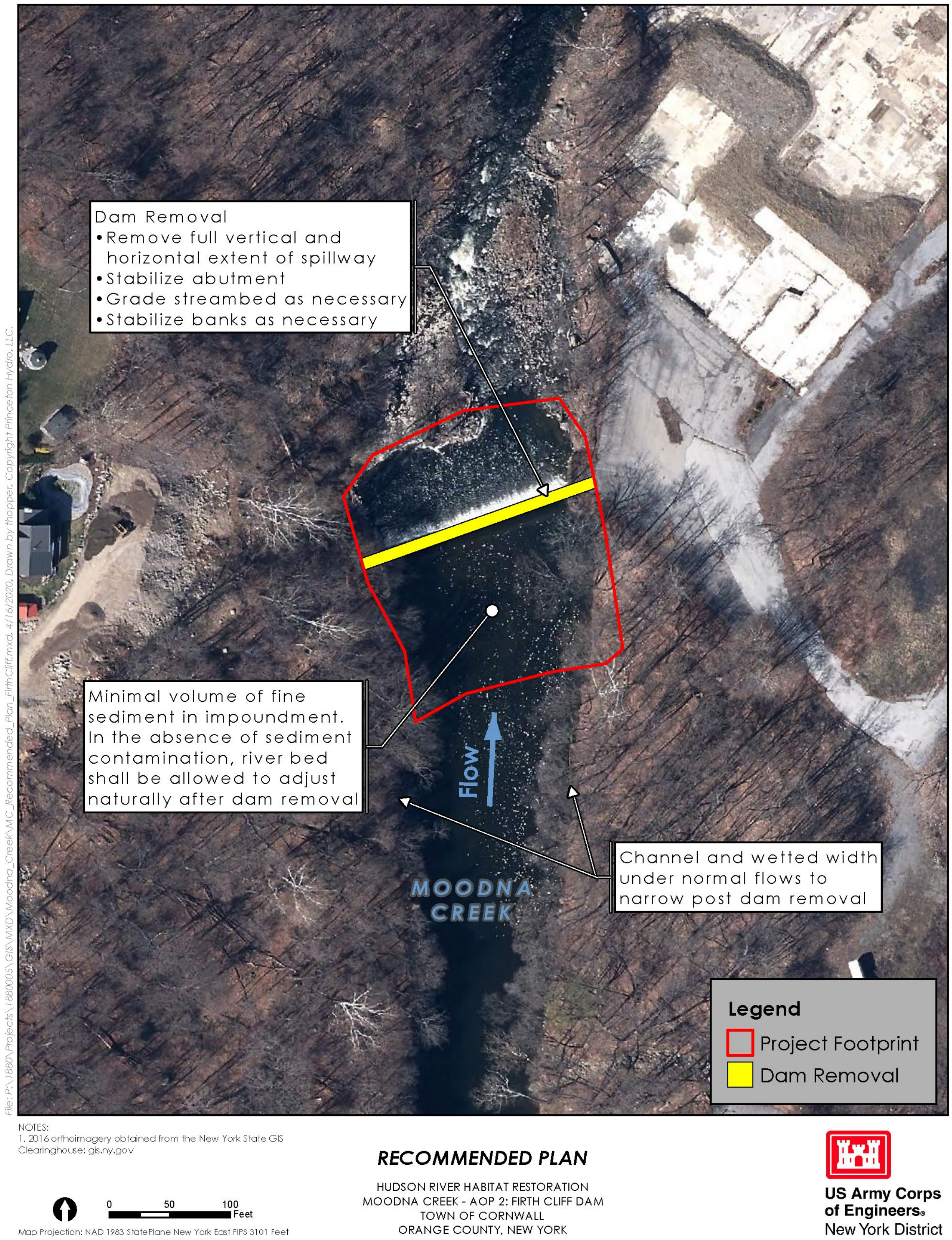


Figure 4-10: Recommended Plan at Moodna Creek, AOP 2 - Firth Cliff Dam in Cornwall, NY.

AOP 3 - Dam Breach

For AOP 3, Orr's Mill Dam, the recommended plan (Figure 4-11) entails breaking through the approximately 10-foot high, 100-foot wide spillway concrete crest and underlying cobble/boulder-filled timber crib structure, removing the vertical extent of a central portion of the spillway, and leaving the side portions in place. This removal would result in the reconnection of 6 miles of river habitat. Concrete debris would be broken up and re-used on-site for channel and bank stabilization. The ends of the spillway could be stabilized at their base with placed boulders, while the upper portions could be left open for visibility of the spillway's interior construction. This plan effectively removes the dam, but retains a portion of the spillway in place as a physical marker of the former dam; however, similar to current conditions, the remaining spillway would be subject to slow deterioration due to weathering and river conditions (freeze/thaw, ice floes, scour, abrasion, debris impact, etc.).

The pronounced accumulation of boulders behind the dam, which may shift in position during construction and after dam breach, has the potential to form a steep (5% slope) boulder cascade or reveal natural bedrock falls (although no historic record of a natural waterfall has been identified). However, the more likely, and conservative, estimate for a potential post-dam breach equilibrium slope extends approximately 325 feet upstream of the spillway crest at 1.6 percent resulting in a cobble-boulder riffle. Approximately 900 feet upstream of the dam, a large boulder riffle exists that would likely serve as grade control if channel adjustment extends to that point.

The re-formation of a cobble-boulder riffle would likely restore passage to a range of fish and other aquatic organisms in Moodna Creek. However, the emergence of a bedrock falls or formation of a steep boulder cascade may not provide full passage for fish; and in this case, some active re-grading and re-positioning of boulders may be recommended to facilitate fish passage while maintaining grade control. If in situ boulders are insufficient to maintain a stable grade change and/or fish passage conditions, the recommended plan also includes supplementing this reach with large boulders. The small cobble dominated tributary which flows under a residence and joins Moodna Creek approximately 250 feet upstream of the dam, may require grade control to prevent undermining of the over-lying house.

The assessment of the transport of impounded sediment, which included approximating equilibrium profile, impounded sediment volume, and watershed sediment yield, indicates that the impounded sediment volume is negligible (4-10%) relative to the annual watershed sediment yield. While sediment sampling and chemical analysis is strongly recommended in a subsequent project phase to assess sediment quality, the passive release of this quantity of impounded sediment is not anticipated to have adverse impacts on downstream aquatic biota, habitats, structures, or properties.

This plan is anticipated to remove the stagnant backwater conditions that occur during low flows and base flows, and to restore a free-flowing reach of river with increased dissolved oxygen content and moderated water temperatures. In addition, this dam breach is anticipated to restore the natural transport of bedload sediment, which in turn could rejuvenate benthic habitat conditions for aquatic invertebrates downstream, and offset any vertical channel degradation that has occurred in the decades and centuries since dam construction. Preliminary hydraulic modeling for the proposed conditions of the recommended plan indicates that breach of the dam and subsequent riverbed adjustments would lower water surface elevations by 3.5 feet in the 1% Annual Chance Flood (or a storm similar in scale to Irene or Lee), 7.3 feet in the bankfull flow (or a precipitation event of moderate size), and 9.1 feet in the median annual flow, which is more typical of everyday conditions. See Appendix B - Engineering, Attachment B: Qualitative Assessment of Hydraulic and Sediment Conditions.

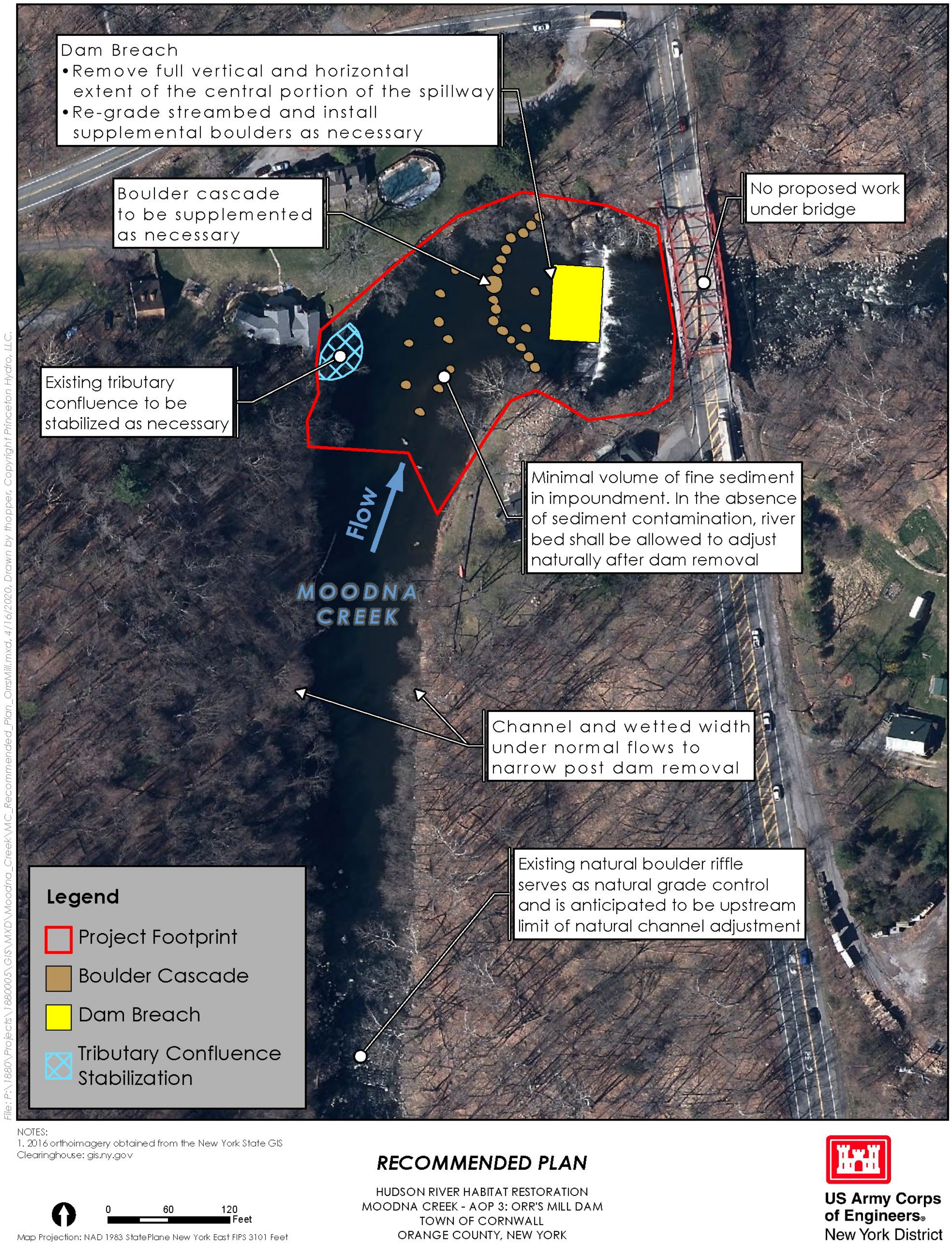


Figure 4-11: Recommended Plan at Moodna Creek, AOP 3 – Orr's Mill Dam in Cornwall, NY.

4.2 Plan Costs

The preliminary cost estimates used to tentatively select a plan (Section 3.4.2) were updated for the Recommended Plan following plan optimization. Final cost estimates for the Recommended Plan (Table 4-2) used the FY2020 (October 2019) interest rate of 2.75% (Economic Guidance Memorandum 20-01), and contingencies ranging from 22% to 26% based on a Cost Schedule Risk Analysis (CSRA). Cost estimates for required real estate (Section 4.7.2 and Appendix I); cultural resources preservation (Chapter 5 and Appendix G5); preconstruction engineering and design (Section 4.7.1); construction (Section 4.7.3); construction management; monitoring and adaptive management (Section 4.7.4 and Appendix H); and operation, maintenance, repair, replacement, and rehabilitation (Section 4.7.5 and Appendix B) were all updated. Appendix E - Cost Engineering explains in detail how the costs of the Recommended Plan were estimated.

The estimated total first cost of the Recommended Plan is $43,143,000. The first cost is the cost of the plan at the current (October 2019/FY20) price level. The estimated total fully funded cost of the Recommended Plan is $62,784,000. The fully funded costs are the first costs escalated to the midpoint of construction for each project according to the construction schedules in Section 4.7.3. The fully funded costs do not include OMRR&R costs.

Table 4-2: Recommended Plan Cost Estimates (October 2019/FY 20 Price Level).

SITE	CONSTRUCTION DURATION (months)	TOTAL FIRST COST ($)	FULLY FUNDED COST ($)	MONITORING & ADAPTIVE MGMT COST ($)	AVG ANNUAL COST ($)	TOTAL OMRR&R COST ($)	ANNUAL OMRR&R COSTS ($)
Henry Hudson	16	11,228,044	13,724,838	308,893	427,074	232,315	5,125
Schodack Island	24	19,848,972	29,295,514	993,918	755,396	195,565	4,541
Moodna AOP1	3	2,202,265	3,654,005	72,259	81,545	0	0
Moodna AOP2	6	4,526,819	7,419,124	72,259	168,407	0	0
Moodna AOP3	6	5,336,757	8,690,832	297,056	197,885	0	0
Moodna Total	15	12,065,841	19,763,961	441,574	447,837	0	0
TOTAL	**55**	**43,142,857**	**62,784,313**	**1,744,385**	**1,630,307**	**427,879**	**9,666**

4.3 Plan Benefits

The Recommended Plan meets the planning objectives to restore a mosaic of interconnected, large river habitats and to restore lost ecological connectivity within the Hudson River and its tributaries. The large river mosaic and connectivity benefits of the plan were calculated as 10.87 AAFCUs and 48.36 AAHUs, respectively. Appendix D - Benefits shows how FCUs and HUs were calculated. The plan improves the Hudson River lessening some of the deleterious impacts that navigation had on aquatic ecosystems, including the loss and degradation of subtidal, shallow water and side channels, intertidal, and shoreline habitats, as well as the fragmentation of aquatic habitats that occurred as small dams were placed on tributaries to the Hudson River for industrial purposes.

At Henry Hudson Park, the plan would address the impacts of hard-armoring the shoreline and placing dredged material from the navigation channel in wetland areas. The conversion of upland to 3.59 acres of tidal wetlands along Vloman Kill, the restoration to 0.15 acres of tidal wetlands at the confluence of Vloman Kill and the Hudson River, and the restoration of 0.60 acres of tidal wetlands along 1,760 linear feet of living shoreline of the western shore of the Hudson River would increase the area and quality of intertidal and shoreline habitat available to fish, amphibians, invertebrates, and birds. The living shoreline, consisting of vegetated rip-rap, would also address active bank erosion in this reach of the river, to provide and protect stable restored shoreline habitat.

At Schodack Island, the plan would address the impacts of placing dredged material from the navigation channel in tidal wetlands, side channels, and between river islands. Restoring 19.05 acres of tidal wetlands and reestablishing a 400-feet long, 20-feet wide, 8.48-acre side channel and wetland corridor connecting the Hudson River with Schodack Creek would restore a mosaic of interconnected subtidal, shallow water, intertidal, and shoreline, riparian, and upland habitats. Side channels provide moderate velocity, high-biodiversity refuges, which serve as nursery, resting and feeding habitat for federally endangered species (shortnose sturgeon and Atlantic sturgeon), American shad, striped bass, and a variety of birds, mammals and reptiles (Miller, 2013).

On Moodna Creek, the plan would address the impacts of small dams and other barriers having been placed at multiple locations on many of the tributaries to the Hudson River. Removing a 2-feet high sewer utility line that crosses Moodna Creek in New Windsor, removing the 9-feet high Firth Cliff Dam, which impounds Moodna Creek in Cornwall, and breaching the 10-feet high Orr’s Mill Dam in Cornwall, would reconnect 7.8 miles of Moodna Creek with the Hudson River. The sewer utility line is not being used and the small dams, estimated to have been constructed in the mid-to-late 1800s for the former Townsend and Orr’s mills, provide no flood risk management benefits.

Removing these barriers, while retaining visual markers of Orr's Mill Dam for historical value would provide spawning, foraging, and resting habitat for migratory fish.

Anadromous fish (e.g., American shad, hickory shad, striped bass, alewife, and blueback herring) would be able to reach nursery grounds for their larval and juvenile life stages. Because Moodna Creek is a relatively small tributary, tree canopy coverage from the stream banks offers protection from predation by birds; additionally, the tributary's small size may limit access by larger predator fish species. Catadromous fish (e.g., American eel) in Moodna Creek would be able to reach marine habitats via the Hudson River to live out their adult life stages. The plan would also benefit potamodromous fish (e.g., white sucker, smallmouth bass, white and yellow perch, apottail and golden shiner, carp, northern pike, walleye, shorthead redhorse, and gizzard shad) that utilize both smaller stream and larger river habitats for their life stages.

In addition to benefiting migratory fish species, restoring the free flow of water where barriers on Moodna Creek are removed is expected to improve the quality of in-stream and downstream habitats, by reestablishing sediment, nutrient, and other material transport processes, increasing dissolved oxygen levels, and reducing maximum water temperatures. These improvements would benefit resident fish and other aquatic organisms. Removing the sewer utility line and dams may also benefit public safety. Preliminary hydraulic modeling shows removing the structures would not increase flood risk but would rather lower water levels in the creek.

4.4 Plan Significance

The Hudson River's environmental resources are institutionally, publicly, and technically recognized as significant, as described in Section 1.5. The Recommended Plan will benefit significant resources as outlined in Table 4-3. The Recommended Plan is not expected to adversely affect significant resources, as described in Chapter 5: Existing Environmental Conditions and Environmental Impacts.

The magnitude of habitat loss - the loss of over 4,000 acres of aquatic habitats and 71 miles of shoreline, the filling-in of most of the river's side channels, and the severity of habitat fragmentation – with more than 1,600 dams and thousands of culverts placed on the Hudson River's 90 tributaries – in the Hudson River ecosystem make it imperative to take action to realize even small gains in restoring the River's significant resources now. If action is not taken, the ecosystem's unique and scarce habitats, on which so many species, including federally and state listed and protected species, depend, are at risk of remaining scarce and degraded.

The Recommended Plan is consistent with and will support several local and regional natural resource protection, preservation and restoration plans including the NYS Office of Parks Recreation and Historic Preservation's 2020 New York State Comprehensive Outdoor Recreation Plan (SCORP) and the Schodack Island Master Plan (1995). The plan is consistent with the New York State Department of Environmental Conservation's Hudson River Estuary Action Agenda and the New York State Hudson River Habitat Restoration Plan, which identifies side channel, shoreline and tributary restoration as priority restoration actions for the Hudson River and its tributaries. The plan is also consistent with the Partners Restoring the Hudson's Hudson River Comprehensive Restoration Plan.

Table 4-3: Recommended Plan Benefits Relative to Significant Resources

RESTORATION TYPE	NER PLAN	BENEFITS TO SIGNIFICANT RESOURCES
Mosaic Habitat and Shoreline Restoration	Schodack Island and Henry Hudson Park Restoration: • 8.5 acres of side channel and wetland corridor • 0.6 acres of tidal wetlands along 1,760 feet of living shoreline • 22.8 acres of tidal wetlands	• Habitat Scarcity – Restoration of freshwater tidal wetland habitat communities, shoreline habitat, and side channels, will address the significant loss and degradation of these habitats resulting from deepening and straightening the river and dredged material placement along the river, in side channels, between river islands, and in wetlands. Habitat loss included the loss of over 4,000 acres of aquatic habitats, the loss of 71 miles of shoreline, the filling-in of 28 of 29 side channels from below Schodack Island (river mile 130) to Troy Lock and Dam, and a more-than 60% reduction of shallow water habitat from Roeliff Jansen Kill near Catskill (river mile 110) to the dam. • Habitat Connectivity – Connectivity between the river and freshwater tidal wetland habitat communities will be restored, including through side channel restoration. These habitats were fragmented due to the placement of dredged material fill. • Restored habitats will provide foraging, resting, and nursery grounds for fish, birds, mammals, amphibians, and reptiles. • Habitat will be improved in federally designated Atlantic and shortnose sturgeon critical habitat, for important coastal migratory fish species, such as: striped bass, river herring, and American shad, for state listed least bittern and black rail, and by removing invasive vegetation species.

RESTORATION TYPE	NER PLAN	BENEFITS TO SIGNIFICANT RESOURCES
Tributary Connectivity	Moodna Creek - AOP 1: Utility pipe removal - AOP 2: Firth Cliff Dam removal - AOP 3: Orr's Mill Dam partial removal • 7.8 miles of tributary habitat reconnected to the river	• Habitat Scarcity – Removal of barriers on Moodna Creek will provide access to scarce small freshwater stream habitat from the Hudson River. • Connectivity – Removal of barriers will restore the flow of water and exchange of sediment, nutrient and other materials within the stream and between the stream and river, which will improve habitat quality in the stream and at the confluence of the stream and river. • Migratory fish species will be able to travel between the stream, river, and ocean for different stage of their life cycles. • Habitat will be improved for important migratory fish species including anadromous (e.g., American shad, hickory shad, striped bass, alewife, and blueback herring), catadromous (e.g., American eel), and potamodromous (e.g., white sucker, smallmouth bass, white and yellow perch, apottail and golden shiner, carp, northern pike, walleye, shorthead redhorse, and gizzard shad) species. NYSDEC has designated the tidal portion of Moodna Creek as a 'Significant Anadromous Fish Concentration Area' and a Significant Coastal Fish and Wildlife Habitat. Alewife and blueback herring, both of which ideally spawn in upstream habitats, are designated Species of Concern by NOAA Fisheries and a status review has been initiated for listing as an Endangered Species. Alewife prefer smaller tributaries such as Moodna Creek.

4.5 The Four P&G Accounts

The Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (P&G) (US Water Resources Council, 1983) requires evaluation of alternative plans for the following four accounts:

National Economic Development (NED): Per the P&G and ER 1105-2-100, the prime federal goal in water and related land resources planning is to contribute to national economic development, consistent with protecting the nation's environment, in accordance with national environmental statutes, applicable executive orders, and other federal planning requirements. Contributions to national economic development (national economic development outputs) are increases in the net value of the national output of goods and services, expressed in monetary units, and are the direct net benefits that accrue in the planning area and the rest of the nation.

Ecosystem restoration projects differ from traditional USACE planning studies in that ecological benefits typically are not expressed in monetary terms. For all project purposes except ecosystem restoration, the national economic development account displays changes in the economic value of the national output of goods and services, expressed in monetary units. For this study, there is no evaluation for national economic development, as benefits of the alternative plans are not monetized and no measurable economic benefits would accrue.

Regional Economic Development (RED): This account registers changes in the distribution of regional economic activity that result from each alternative plan. Chapter 5 provides a detailed assessment of the potential economic effects that would result from implementing the Recommended Plan.

The Recommended Plan would result in both short- and long-term social and economic benefits for the regional economy. Construction activities would generate jobs, and it is assumed that the majority of the workforce would be from the local area. In the short term, this employment would contribute to local earnings, induced spending for goods and services, and tax revenues. Implementing the recommended plan would give local community groups and educational institutions opportunities to participate in the restoration efforts, providing valuable educational experiences that would bolster environmental education.

At the scale of the HRHR study area, improvements to the environment, notably cleaner water and greater abundance and diversity of desirable terrestrial wildlife, fish, and vegetation, potentially would stimulate the local economy by increasing activities such as fishing, hiking, boating, and bird watching, and tourism in general. Improved quality of life would strengthen the desirability of living in the region and maintain, if not increase, property values. Increased shoreline stabilization may reduce municipal expenditures, including those for emergency services. Ongoing restoration and monitoring activities would give local community groups and educational institutions opportunities to participate, providing valuable educational experiences. These restoration projects provide long-term stimulation of the local economy and provision of educational opportunities.

Environmental Quality (EQ): This account displays non-monetary effects on significant natural and cultural resources. The expected environmental quality effects of implementing the alternatives are primarily beneficial, although there would be short-term adverse effects during construction. Chapter 5 provides a detailed assessment of the potential environmental quality effects that would result from implementing the Recommended Plan. In the long term, environmental quality will be greatly enhanced by construction of the projects.

Other Social Effects (OSE): This account registers effects that are not covered in the NED, RED, and EQ accounts. This would include effects on the community, health and safety, displacement, energy conservation, environmental justice, and other non-monetary effects. The expected social effects of implementing the Recommended Plan are primarily beneficial (improved outdoor activities based on increased fish and wildlife populations such as fishing, hunting, and bird watching) although there would be short-term adverse effects during construction such as decreased access, noise, and dust in the local vicinity.

4.6 Resilience and Sustainability

As part of plan formulation, USACE considers how the Recommended Plan contributes to resiliency of affected ecological communities and affects the sustainability of environmental conditions in the affected area. Resiliency is defined in the February 2013 USACE-NOAA Infrastructures Systems Rebuilding Principles white paper as the ability to adapt to changing conditions and withstand and rapidly recover from disruption due to emergencies. Sustainability is defined as the ability to continue, in existence or a certain state, or in force or intensity, without interruption or diminution.

The Recommended Plan will increase the resiliency and sustainability of the Hudson River study area by establishing habitat that will be more resilient to relative sea level change (RSLC), restoring system dynamics and processes to more sustainable and self-regulating regimes, and improving anadromous and catadromous species reproduction through the removal of three barriers to fish passage and greatly increased access to 7.8 miles of high quality tributary habitat. The Recommended Plan represents a resilient, sustainable ecosystem solution that integrates multiple habitat features that can adapt to changes and can recover after a major disturbance naturally. The sites included in the Recommended Plan were identified as important restoration opportunities that should be restored to address long-term regional ecosystem degradation trends. The Recommended Plan addresses the most feasible and highest priority sites for USACE participation in the near-term and complements ongoing and future restoration work. The Recommended Plan will work in concert with completed restoration work by others, in addition to ongoing and future projects to improve the sustainability of the Hudson River Valley ecosystem.

The increase in spatial extent and biodiversity encourages resiliency with the implementation of the Recommended Plan. The addition of diverse native species, novel physical features, and functional redundancy into the ecosystem will allow restored areas to better adapt to changing conditions and withstand and rapidly recover from disruption. This is important as climate change, sea level change, water quality degradation, the introduction and proliferation of invasive species, and other stressors continue to influence the region.

Recognizing the federal government’s commitment to ensure no inducement of development in the floodplain, pursuant to Executive Order 11988, the implemented Recommended Plan will ensure that development within the floodplain of each project site will not occur. The non-federal sponsor’s ownership of the restoration sites will result in the protection from the threat of development on project lands, easements, and rights-of-way or the addition of facilities which might reduce the outputs produced by the ecosystem restoration features or interfere with the project's proper function.

4.6.1 Relative Sea Level Change

The design and implementation of ecosystem restoration projects requires consideration of the effects of climate change, including global sea level rise. The foundation for coordinated action on climate change preparedness and resilience across the federal government was established by Executive Order 13514 of October 5, 2009 and the Interagency Climate Change Adaptation Task Force led by the Council on Environmental Quality (CEQ). In October 2011, the Task Force developed a National Action Plan that provided an overview of the challenges a changing climate presents for the management of the nation's freshwater resources. Climate preparedness and resilience actions have also been established by USACE, as demonstrated by the annual release of the Climate Change Adaptation Plan, prepared under the direction of the USACE Committee on Climate Preparedness and Resilience. USACE established an overarching USACE Climate Change Adaptation Policy Statement and a governance structure to support mainstreaming adaptation in 2011 following the release of the Executive Order. ER 1100-2-8162, Incorporating Sea Level Change in Civil Works Programs, and EP 1100-2-1, Procedures to Evaluate Sea Level Change: Impacts, Responses and Adaptation, provide USACE with guidance for planning for and adapting its civil works projects and programs.

A sea level change (SLC) analysis was conducted in accordance with EP 1100-2-1 (June 2019) and ER-1100-2-8162 (June 2019). Low, intermediate and high rates of sea level change were calculated. The complete SLC analysis can be found in Attachment C of the Engineering Appendix and calculates an increase in water surface elevations of 6 to 36 inches for the study area by the year 2077. The results of this analysis informed the designs of all alternatives (where appropriate) as well as the EPW analyses of baseline and projected with and without project conditions. These results complement SLC studies conducted by the City of Albany. The NY State Energy Research and Development Authority (NYSERDA) has also investigated sea level change concluding that water surface elevations along the NY coastlines have increased at an average rate of 1.2 inches per decade since 1900, and that Hudson River water surface elevations at the City of Albany could possibly increase between 8 and 18 inches by the year 2080.

For the Recommended Plan, both the designs and the SLC analysis of those designs were updated using all three SLC curves to reflect a future planned construction date and planting elevation ranges that incorporate projected Mean Tide Level (MTL) for that date. Designs were developed in accordance with Engineer Construction Bulletin (ECB)-2018-2. For each tidal site analyzed (Schodack Island and Henry Hudson Park), an accretion level of 4.0 mm/yr was used to project future conditions (Year 20 and Year 50) for the intermediate and high curve. An accretion level of 3.5 mm/yr was used for the low curve. The accretion rates are based on studies that have been conducted in the Hudson River area. The rates were chosen using engineering judgment and considered to be reasonable and conservative. Both rates are less than the annualized SLC rates and the difference between the accretion rates and SLC rates become greater as time goes forward given the fact that the accretion rates are treated as static while the rate of SLC change is increasing.

Project designs were developed so as to yield immediate benefits that were sustainable over the project duration, with minimized loss of habitat or benefit. The designs successfully incorporate resiliency by providing a measure of elevation capital at each site and by maximizing the ability of salt marsh habitats to migrate landward and vertically. Elevation capital simply refers to the vertical distance between estimated MTL (at the time of construction) and the lower edge of the planting range. This vertical distance essentially delays the onset of SLC-driven salt marsh deterioration for many years, depending on the rate of SLC. Such considerations will continue to guide the design development process as critical details such as optimized flood plain elevations and channel cross-section morphology will be greatly refined during the Preconstruction Engineering and Design phase. Designs were, and will continue to be, developed to augment both resiliency and adaptability, where critical habitats are afforded the opportunity to migrate in response to rising water surface elevations and natural processes are harnessed to promote adaptability.

Both sites perform well under all three sea level change curves. At Henry Hudson Park, while the balance between upper and lower tidal wetlands varies between each scenario, the total area of tidal wetlands (upper + lower) is expected to remain constant or expand under all SLC projections for both Year 20 and Year 50. The greatest percent change compared to design area is predicted to occur in the upland herbaceous area under the high curve scenario, which is predicted to decrease to 29% of its design area by Year 50. At Schodack Island, predicted habitat zone area changes are expected to vary greatly depending on the habitat zone and SLC scenario. The total area of wetlands (scrub shrub + upper + lower) is, however, expected to expand under low and intermediate curve projections for both Year 20 and Year 50 and decrease only slightly under high curve projections. As noted above, a fuller analysis and discussion of projected SLC induced habitat change can be found in Attachment C of the Engineering Appendix.

The impact of sea level rise driven changes to the salinity regime in the Hudson River were considered. The HRHR sites where SLC driven changes to the Hudson River salinity gradient could potentially be of concern, Schodack Island and Henry Hudson Park, are located between river miles 133 to 137. The salt front for the Hudson River generally ranges from Mile 27 to Mile 67. During a drought in 1991 saltwater intrusion reached up to Mile 75, and this is generally considered to be the northernmost extent of saltwater intrusion. While studies investigating the impacts of sea level change on Hudson River wetlands are available, no studies that specifically investigated the impact of sea level change on salinity intrusion for the Hudson River were found. Modeling studies that investigate this issue for rivers throughout the world generally calculate changes in the range of one to five miles. Based on the location of the HRHR restoration sites, sea level rise driven changes to salinity intrusion are not considered a concern for the HRHR restoration sites.

4.6.2 Inland Hydrology: Nonstationarity and Vulnerability

The project sites were evaluated for both hydrologic nonstationarity and vulnerability to climate change. Detailed discussions of both can be found in Attachment D of the Engineering Appendix.

Stationarity is the assumption that the statistical characteristics of hydrologic time series data are consistent through time, and it is this consistency that forms the basis of design for ecosystem restoration projects. Due to the recent impacts of climate change, including more extreme changes in temperature and precipitation, the premise of stationarity can no longer be assumed.

USACE's ECB 2018-14, Guidance for Incorporating Climate Change Impacts to Inland Hydrology in Civil Works Studies, Designs, and Projects, and ETL 1110-2-3 (April 2017), Guidance for Detection of Nonstationarities in Annual Maximum Discharges, require the evaluation of nonstationarity to determine the sustainability of a recommended plan with respect to climate change. USACE's online Nonstationarity Detection (NSD) Tool was used to detect nonstationarities in annual instantaneous peak streamflow data series at USGS stream gages throughout the project area. The USGS Hudson River gage at Green Island was used to evaluate nonstationarity for the Henry Hudson Park and Schodack Island sites. As there are no gages located within Moodna Creek, three nearby USGS gages at Wallkill River, Wappinger Creek and Rondout Creek served as proxies to evaluate the Moodna Creek project locations.

No strong statistical trends in nonstationarity were detected at the Hudson River gage; however, two of the three gages serving as proxies to Moodna Creek met the criteria for "strong" nonstationarity. Further sensitivity analyses should be conducted during the Preconstruction Engineering and Design phase of the study to help guide the final designs of the Moodna Creek sites.

Vulnerability of a project site to climate change is evaluated by using USACE's online Vulnerability Analysis (VA) tool. This tool evaluates various business lines under wet and dry scenarios. The Flood Risk Management and Ecosystem Restoration business lines were evaluated for the HUC 0202 (Upper Hudson River) in which the project sites are located. The results of the tool indicate that the watershed is not vulnerable to climate change under either of the business lines; however, the indicator most affecting the vulnerability score under the Flood Risk Management business line is the cumulative flood magnification factor, which tries to predict how flood flow will change in the future, and the indicator most affecting the vulnerability score under the Ecosystem Restoration Business Line is the percent of freshwater plant communities that are at risk of future extinction within the watershed. These concerns should be incorporated into the project design such that their effects due to climate change are mitigated to the extent possible.

4.7 Plan Implementation

The implementation of the Recommended Plan will occur in two phases: Preconstruction Engineering and Design (PED), and construction. Prior to beginning each phase, USACE will execute an agreement for that phase with a non-federal sponsor. NYSDEC plans to be the non-federal sponsor for both PED and construction. The Recommended Plan includes three sites: Henry Hudson Park, Schodack Island, and Moodna Creek, and separate agreements may be executed for each site. That is, the recommended plan for each site may be considered its own project. As such, this section presents cost apportionment and schedules on a per site, or project, basis.

For each project, a Design Agreement will be executed prior to the start of the PED phase, and a Project Partnership Agreement will be executed prior to the start of the construction phase. In conjunction with the agreements, a project management plan will be prepared to obtain agreement within the project team and between USACE and the non-federal sponsor on goals and expectations, particularly regarding scope, quality, safety, costs, schedule, and communications.

4.7.1 Preconstruction Engineering and Design

For the preparation of site-specific cost estimates, and during the course of risk management (Section 4.8), the following preliminary list of activities to be conducted during the PED phase were identified:

- Property and utility investigations: Parcel ownership, property boundaries and utility survey, needed to confirm acquisition requirements and refine real estate and relocation costs
- Data collection: Topography, bathymetry, tidal gauging, bio-benchmarking (with a reference site) to establish habitat vegetation zones correlated to tidal datums, wetland delineation, and soils testing needed to support civil and ecological design
- Hydraulic and hydrologic analysis and modeling: Riverine and sedimentation studies needed to optimize design features, investigate potential scour and erosion, bank failure risk (Moodna Creek), refine construction cost estimates, confirm areas of environmental benefits, confirm results of preliminary hydraulic modeling, which showed that the project would not induce flooding, and predict/minimize actions for operations and maintenance

- Geotechnical analyses: Foundation design, analysis of settlement and seepage of project features and identification of disposal and borrow sites, needed to finalize design features and refine cost estimates
- HTRW sampling: Soil and sediment sampling to determine contaminant concentrations in project areas, to check whether remediation will be required prior to construction
- Cultural Resources surveys
- Regulatory compliance and permits
- Coordination with NOAA Fisheries and USFWS on their plan recommendations
- Preparation of Plans and Specifications (30, 60, 90, 100 percent)
- Value Engineering
- Updated Monitoring and Adaptive Management Plan
- Draft Operations, Maintenance, Repair, Replacement, and Rehabilitation Manual

4.7.2 Real Estate Requirements

The non-federal sponsor is responsible for acquiring all the Lands, Easements, Right-of-Ways, Relocations, and dredged or excavated material Disposal areas (LERRD) required for the construction, operation and maintenance of the project. USACE must certify that the non-federal sponsor has acquired all required real estate for a project before construction of that project can begin. The non-federal sponsor will provide a copy of all easements and deeds recorded with their respective county to USACE.

The non-federal sponsor is responsible for all direct and indirect LERRD costs. LERRD costs that are found to be reasonable, allowable, and allocable may be applied towards a non-federal sponsor's required project cost-share (Section 4.7.6). To claim credit, the non-federal sponsor should retain and submit to USACE for review all receipts, invoices and other supporting documents for LERRD costs incurred. The total value of LERRD required to implement the Recommend Plan has been estimated at $1,347,126.

Table 4-4 shows the real estate requirements for each site and component of the Recommended Plan. The plan requires the acquisition of a total of approximately 38.1 acres of land. Of these, the non-federal sponsor, NYSDEC, owns 32.61 of the required acres, through the New York State Office of Parks, Recreation and Historic Preservation (NYS Parks). An additional 15.6 acres of land, which have no designated tax parcel identification number, include submerged lands under the jurisdiction of the New York State Department of General Services (OGS) and road rights-of-way under the jurisdiction of the State Department of Transportation. The non-federal sponsor has been coordinating with NYS Parks, NYS OGS and the Town of Bethlehem on the Recommended Plan and intends to execute an Agreement (e.g., Memorandum of

Agreement, Local Sub-Agreement to the PPA or signatory as a non-federal party to the PPA) to make those State and Municipal lands available for the project.

Table 4-4: Real Estate Requirements for the Recommended Plan.

		Required Acres			Number of Parcels		
Project Site	**Site Component**	**Fee**	**Temporary Easements**	**Total**	**Private**	**Public[1]**	**Total**
Schodack Island	North	±32.61	0	±32.61	0	3	3
Henry Hudson Park	-	±5.46	±0.63	±6.09	1	5	6
Moodna Creek	AOP 1	0	±3.89	±3.89	7	3	10
	AOP 2	0	±1.85	±1.85	3	0	3
	AOP 3	0	±2.61	±2.61	2	1	3
	Totals:	***±38.07***	***±8.98***	***±47.05***	***13***	***12***	***25***

[1] Includes areas without designated tax identification numbers.

The plan does not require the relocations of persons or businesses under Public Law 91-646 or the Uniform Relocation Assistance and Real Property Acquisition Policies Act and does not require the physical relocation of any public utilities or facilities. More information on the real estate requirements of the Recommended Plan is included in Appendix I - Real Estate Plan.

4.7.3 Construction Schedule and Sequences

A construction schedule for the three sites: Henry Hudson Park, Schodack Island, and Moodna Creek, was developed in coordination with the non-federal sponsor (NYSDEC). NYSDEC requested that the projects be implemented sequentially and not in parallel due to appropriations and agency priorities. It was further requested that the initial construction schedule be conservative with regard to overall sequencing and construction starts. NYSDEC is committed to these restoration efforts and the overall schedule and sequencing will be accelerated if and when possible. This resulted in a window of construction within a ten year timeframe. The schedule is presented in Table 4-5 and Appendix E - Cost Engineering.

Table 4-5: Recommended Plan Construction Schedule.

Activity	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041
Design Agreement																			
Preconstruction Engineering Design																			
Project Partnership Agreement																			
Construction																			
Monitoring and Adaptive Management																			

Legend:
Henry Hudson Park
Schodack Island Park
Moodna Creek - AOPs

General construction sequences for the projects were identified for the preparation of fully funded cost estimates and are presented below. More information about the sequences, including assumptions, is available in Appendix E - Cost Engineering. Phasing for design and construction activities will be updated as-needed during each project's PED phase.

The general construction sequence for the mosaic habitat and shoreline restoration projects at Schodack Island and Henry Hudson Park is:

1. Mobilization
2. Installation of soil erosion and sediment control features
3. Installation/modification of temporary work access road(s) and crossings, where applicable
4. Site clearing, including removal of existing vegetation and invasive species treatment, where applicable
5. Installation of water control features, where applicable
6. Earthwork; including excavation, grading, and import of select amended soils, where applicable
7. Installation of site amenities or shoreline stabilization structures; including removing or modification of existing AOP crossings, floodplain connections, and/or culverts, or the import of soil and bank stabilization boulders
8. Installation of herbivory fencing
9. Installation of plants and seed
10. Demobilization

The general construction sequence for the tributary connectivity project at Moodna Creek is:

1. Mobilization
2. Installation of soil erosion and sediment control features
3. Installation of temporary work access road(s)
4. Site clearing, including removal of existing vegetation, where applicable
5. Installation of water control features
6. Installation of in-water access ramps and pads
7. Demolition of barrier, including excavation and export of material, as applicable
8. Installation of in-stream structures, including import and transport of boulders
9. Stabilization of banks and surrounding areas, as necessary
10. Demobilization

4.7.4 Monitoring and Adaptive Management Plan

Appendix H is the Monitoring and Adaptive Management Plan for the projects. The plan includes monitoring protocols for side channels, tidal wetlands, stream crossings, shoreline, barrier removals, dam breach, boulder cascade, and tributary stabilization. Each monitoring protocol includes success and failure criteria and identifies adaptive management procedures to follow in failure conditions. The plan also contains the cost estimates for the monitoring and adaptive management for each site, and the additional site-specific monitoring and management items, procedures, and assumptions that were used to develop the estimates. The Monitoring and Adaptive Management Plan will be reviewed and updated during the PED phase of each project. Any changes to the plan that are inconsistent with the plan appended to this report will be coordinated with USACE Headquarters in accordance with Section 2039 of WRDA 2007.

USACE and the non-federal sponsor will conduct monitoring and adaptive management until USACE determines that the projects have met ecological success criteria, for up to ten years. Per Section 1010 of the Water Resources Reform and Development Act of 2014, the non-federal sponsor will be fully responsible for any monitoring and adaptive management of the projects occurring more than ten years after construction is complete. Based on USACE New York District's previous experience with restoration, the study team anticipates the projects will achieve success within five years after construction is complete. Further justification of the selected time frame is provided in Appendix H. The estimated total monitoring and adaptive management cost for the Recommended Plan is $2,152,714, and the average annual monitoring and adaptive management cost of the plan is $59,607. Table 4-2 shows the estimated total monitoring and adaptive management costs for each project, and average annual costs for each project that include monitoring and adaptive management.

4.7.5 Operation, Maintenance, Repair, Replacement, and Rehabilitation

Operations, Maintenance, Repair, Replacement, and Rehabilitation (OMRR&R) for the projects is the non-federal sponsor's responsibility. OMRR&R will begin when monitoring and adaptive management conclude. For non-structural, non-mechanical components of ecosystem restoration projects, the non-federal sponsor's responsibility for OMRR&R ends ten years after ecological success has been determined, per USACE implementation guidance for Section 1161 of the Water Resources Development Act of 2016. For structural or mechanical components, such as the rip-rap at Henry Hudson Park's shoreline and the culvert at Schodack Island, the non-federal sponsor is responsible for up to 50 years of OMRR&R.

OMRR&R for the projects is expected to be minimal, and some features in the project areas that the plan will not modify are already being maintained by local entities. Assumptions used to prepare OMRR&R cost estimates included that, in the 50-year period following construction, each project would be inspected annually, the project at

Henry Hudson Park would require one repair and rehabilitation action, and the culvert at Schodack Island would require annual clearing. The study team also assumed that maintenance would include debris removal after major storm events. Costs for these activities were estimated based on the cost estimates for similar activities in the Monitoring and Adaptive Management Plan (Appendix H) and project MII files for (Appendix E - Cost Engineering). The estimated total OMRR&R cost for the Recommended Plan is $427,879, and the average annual OMRR&R cost of the plan is $9,666. Table 4-2 shows the estimated total OMRR&R costs for each project, and average annual costs for each project that include OMRR&R.

The assumptions used to prepare OMRR&R cost estimates during the feasibility phase will be revisited in the PED phase for each project. A draft OMRR&R manual will be prepared during the PED phase for each project, and a final OMRR&R manual will be provided to the non-federal sponsor when construction is complete.

4.7.6 Cost Sharing and Non-Federal Partner Responsibilities

The authority for the feasibility study, Section 551 of the Water Resources Development Act of 1996, specified a 75% federal and 25% non-federal cost-share for "each project undertaken." The authorization for construction from Congress will confirm that this is the cost-share for implementing the Recommended Plan. The cost-share in the new authorization will apply to both the PED and construction phases.

Table 4-6 shows costs apportionment for the projects, assuming a 75% federal and 25% non-federal cost-share. The table includes the estimated value of required LERRD, annual OMRR&R costs, and both first and fully funded costs for each project. As discussed in Section 4.7.2, the non-federal sponsor may claim credit for its LERRD costs and put that credit towards its share of the costs. OMRR&R, as discussed in Section 4.7.5, is the non-federal sponsor's responsibility.

The total estimated first cost for the Recommended Plan is $43,142,857; of which $32,357,143 is the federal cost and $10,785,714 is the non-federal cost. The first cost will serve as the basis for the construction authorization. The total estimated fully funded cost for the Recommended Plan is $62,784,000. The fully funded cost estimates will be used as the basis for the Design and Project Partnership agreements executed for the PED and construction phases and internal determination reports.

Table 4-6: Cost Apportionment.

SITE	FIRST COST ($)				FULLY - FUNDED COST ($)	ANNUAL OMRR&R ($)
	FEDERAL ($)	NON-FEDERAL ($)		TOTAL ($)		
		TOTAL	LERRD			
Henry Hudson Park	8,421,033	2,807,011	301,646	11,228,044	13,725,000	5,125
Schodack Island	14,886,729	4,962,243	578,594	19,848,972	29,296,000	4,541
Moodna Creek	9,049,381	3,016,460	466,886	12,065,841	19,764,000	0
ALL	**32,357,143**	**10,785,714**	**1,347,126**	**43,142,857**	**62,784,000**	**9,666**

In addition to providing its share of the costs of the PED and construction phases, acquiring LERRD, and OMRR&R, the non-federal sponsor is responsible for remediating any HTRW that is discovered in the project areas prior to construction. Other necessary items of cooperation USACE must receive from the non-federal sponsor to implement the Recommended Plan are specified in list form in Chapter 8. The Water Resources Development Act of 1986 (Public Law 99-662) and various administrative policies provide the basis for this division of responsibilities. The final division of specific responsibilities will be formalized in the agreements for the PED and construction phases.

4.7.6.1 Non-Federal Sponsor's Financial Capability

The non-federal sponsor, the NYSDEC, has committed to provide its share of total project costs, as well as all LERRD required for the projects including LERRD that is excluded from reimbursement. Non-federal sponsor Self-Certification of Financial Capability forms have been provided.

4.8 Risk and Uncertainty

Throughout the feasibility phase, the study team identified and managed risk and uncertainty. Known risks were entered in a risk register and strategies to manage those risks were selected based on anticipated consequences, their likelihood, and uncertainty. Significant risks identified in the study and their management strategies are discussed in this section. The risks are labeled according to when the risk was or will be present during the feasibility or study phase ('Study'), the implementation or PED and construction phases ('Implementation'), or once the project is complete and its outcomes can be assessed ('Outcome').

- **Relative Sea Level Change (RSLC) and Nonstationarity in Inland Hydrology Trends (Study, Outcome)** - The intermediate RSLC scenario was used to develop alternatives and to evaluate the benefits of alternatives over the 50-year planning horizon. A RSLC Analysis of the Recommended Plan that considered all three RSLC scenarios was conducted during feasibility-level design. An analysis of inland hydrology trends, performed during the feasibility-level design phase, indicated no or only mild nonstationarity on the Hudson River. While analysis of the proxies at Moodna Creek indicate “strong” nonstationarity, the risks to the project’s performance are judged to be minimal. It is, however, recommended that further sensitivity analyses should be conducted during the PED phase. Rather than defining thresholds and adaptation strategies that could be implemented when those thresholds are reached, resiliency was built into the alternatives, including the Recommended Plan. Section 4.6 summarizes and Appendix B - Engineering details the results of the RSLC and inland hydrology analyses that were conducted as part of feasibility-level design.

- **Hydrologic and Hydraulic Conditions (Study, Implementation)** - To reduce the costs and duration of the study, detailed hydrological and hydraulic (H&H) analyses, including discharge, velocity, and wave action calculations, were postponed until the PED phase of the project. Assumptions about H&H conditions, based on imprecise available information, observations and data gathered during site visits, and engineering judgment were used to formulate alternatives. Comments received on the draft FR/EA prompted the study team to conduct qualitative assessments of the impacts of implementing the Recommended Plan on water levels and sediment transport around the barriers that would be removed from Moodna Creek during feasibility-level design. The assessment showed no negative impacts. If unanticipated H&H conditions are discovered during PED, it could increase the costs and duration of PED.
- **Tidal Datums (Study, Implementation, Outcome)** - Tide gauge data collected for the development of feasibility-level designs was of limited duration. This introduced uncertainty into the design elevations and excavation quantities. Longer-term tide data, as well as biobenchmarking, should be collected for Schodack Island and Henry Hudson Park during the PED phase, to better refine tidal datums and site-specific vegetation community ranges. Designs should be adjusted as necessary to incorporate any elevation changes. Sea level rise projections were based on the NOAA long-term gauge at the Battery, NY, more than 100 miles south of the project locations. These projections did not consider any degree of attenuation and this too should be further investigated during the PED phase.
- **Low Level of Design (Study, Implementation)** - Feasibility-level designs for the Recommended Plan were developed based on limited data and data analysis with respect to site conditions, including not just H&H as discussed above, but also geotechnical conditions. More extensive field data collection and data analysis will occur in the PED phase, to develop more detailed designs. One of the assumptions in the feasibility-level designs is that the existing timber cribbing at Henry Hudson Park is sound enough to function for the limited time required to install and establish a living shoreline composed of rip-rap, soil, and vegetation

along the Hudson River. This assumption was based on a visual inspection of the shoreline. During the PED phase, the site will be inspected again to confirm this remains the case. While it is unlikely the timber cribbing will significantly deteriorate in the years prior to construction - if it does, compromised sections could be replaced or reinforced, or the design could be adapted to incorporate an alternative that would temporarily stabilize the shoreline while vegetation becomes established. The consequences of requiring replacement or reinforcement of timber cribbing or an alternative would be an increase to the project cost. Additional costs for placement of rock were included in the estimated OMRR&R costs in case the timber cribbing is compromised.

- **Cost Estimates (Study, Implementation)** – The cost estimates prepared during the feasibility phase, for the alternatives and the Recommended Plan, were based on relatively low levels of design. During PED, quantities will change as designs are refined, different site conditions than expected could be discovered, material and fuel prices could fluctuate unexpectedly, and locations and costs for borrow and disposal sites could change. Risk and uncertainty associated with the cost estimates were managed through cost contingencies developed through an Abbreviated Risk Analysis, for the alternatives, and through a Cost and Schedule Risk Analysis, for the Recommended Plan.
- **Real Estate Acquisition (Study, Implementation)** - The amenability of private landowners to ecosystem restoration projects requiring their land or cooperation was uncertain when the study began. Landowner opposition could block a project, or, at the very least, make it cost more and take longer to implement. Although NYSDEC has the authority to condemn private property, the agency expressed a strong preference to not exercise this authority for any projects recommended by this study. A large number of sites with restoration opportunities that are unlikely to require the use of eminent domain are available in the study area. Riverkeeper and NYSDEC conducted landowner outreach prior to alternative formulation and again, prior to the release of the draft FR/EA. To minimize the risks associated with formulating alternatives unacceptable to landowners, five mosaic habitat and shoreline restoration sites, none of which represented a unique restoration opportunity, were screened out during preliminary site screening. Despite outreach efforts, comments received on the draft FR/EA revealed restoration at two sites in the tentatively selected plan was unacceptable to landowners, and therefore, to the non-federal sponsor. As a result, those sites, Rondout Creek and Binnen Kill, were not included in the Recommend Plan, as discussed in Section 3.5.1. The remaining risks for implementing the Recommended Plan associated with landowner support are low for Henry Hudson Park and Schodack Island, and slightly higher for Moodna Creek. The required lands at Henry Hudson Park and Schodack Island are publicly owned by the Town of Bethlehem and the State of New York (local sponsor), respectively, that are supportive of restoration and the Recommended

Plan. The private landowners from whom temporary easements will be required to implement the barrier removals on Moodna Creek have so far been cooperative and supportive of the Recommended Plan. The non-federal sponsor will continue to coordinate with these landowners.

- **Hazardous Toxic and Radioactive Waste (Study, Implementation)** - There is a low risk that Hazardous Toxic and Radioactive Waste (HTRW) may be present at one or more of the sites in the Recommended Plan. A literature search and site visits revealed no HTRW concerns in the project area. HTRW is not expected to be an issue for Schodack Island or Henry Hudson Park since dredged material from the navigation channel was placed on those sites prior to industrialization. In response to comments received on the draft FR/EA, a qualitative sediment transport assessment was conducted for Moodna Creek during feasibility-level design. The volume of sediment impounded behind the barriers the Recommended Plan would remove was found to be low, and negligible relative to the annual watershed sediment yield. Despite the low risk, sediment and soil surveys will be conducted during the PED phase to check whether contaminant concentrations are low to negligible, as expected, or whether remediation will be required. Any necessary remediation would be the non-federal sponsor's responsibility and would need to be accomplished prior to construction. The presence of HTRW in the project area would delay project implementation.
- **Cultural Resources (Study, Implementation)**

  \- The District carried out a cultural resources assessment for the study to identify previously documented cultural resources in the study area, identify archaeologically sensitive areas and to determine the need for additional surveys during the PED phase. The report is entitled *Preliminary Historical and Archaeological Assessment for the Hudson River Habitat Restoration Project, Hudson River Basin, New York* (Scarpa 2019). The report and PA were coordinated with the New York State Historic Preservation Office (SHPO), the Stockbridge Munsee Band of Mohican Indians, the Delaware Nation, and the Delaware Tribe of Indians for review and comment. The NYSHPO concurred with the approach of preparing a Programmatic Agreement (PA) early on in the study. Costs for additional investigations and potential mitigation to implement the PA were estimated for each site using existing information. Additional cultural resources surveys identified in Appendix G5 and the PA will be carried out during the PED phase and will determine the need for and type of mitigation required, in consultation with the NYSHPO, and other consulting parties as needed.

  \- All costs incurred by USACE for actions associated with historic preservation, including, but not limited to, the identification and treatment of historic properties, and the mitigation of adverse effects, will be included in construction costs. These costs, not including the costs for data recovery, are cost-shared in accordance with other project costs. Data recovery costs are a full federal costs and are not cost-shared and are subject to a cap of 1% of the total federal project cost. Data recovery costs in excess of 1% are subject to review and a waiver in accordance with ER 1105-2-100. Based upon current estimates, data recovery costs for this project will not exceed the 1% cap.

- **Environmental Conditions (Study, Implementation, Outcome)** - Assumptions about fish and wildlife resources and other environmental conditions in the study and project areas were based on literature searches and databases, observations and data gathered during one site visit in the summer of 2018, professional knowledge and experience, and coordination with state and federal agencies. Zoning, planning, or other regulatory changes implemented in the coming years could require new permits or approvals to be attained, which could delay project implementation. Environmental compliance activities will continue to manage risks associated with uncertain environmental conditions and impacts.
- **Native Plant Establishment (Study, Outcome)** - Native plantings may not establish as expected. Predation from herbivorous animals and insects can be reasonably estimated based on baseline surveys of the existing flora and fauna. However, weather also plays a large role in the success of new plantings. Periods of drought or early frost may alter the survival percentage of plantings. Although historical records can help to predict the best possible location and timing of new plantings, single unforeseen events may lead to failure. In addition, increased temperatures due to climate change could affect plant establishment. Increased or decreased runoff volumes and velocities, water levels, and sedimentation rates resulting from climate change could also affect plant establishment. Assumptions about native plant establishment influenced the benefits evaluation. If native plant establishment takes longer or is successful in a smaller area than anticipated, the plan's actual benefits may be lower than predicted. The Monitoring and Adaptive Management Plan (Appendix H), which will be reviewed and updated during the PED phase as designs for the Recommended Plan are refined, will manage risks associated with native plant establishment, and concerns associated with potential changes to H&H conditions will be incorporated into the project design to mitigate climate change impacts to the extent possible. Adaptive management procedures for native plant establishment include replanting and modifications to plant species.
- **Invasive Species Removal (Study, Outcome)** - The complete eradication of invasive species in a project area is challenging, and the risks of reinvasion are higher when native species have not yet established. Assumptions about invasive species removal influenced the benefits evaluation. If invasive species removal takes longer or is successful in a smaller area than anticipated, the plan's actual benefits may be lower than predicted. The Monitoring and Adaptive Management Plan (Appendix H), which will be reviewed and updated during the PED phase as designs for the Recommended Plan are refined, will manage the risks associated with invasive species removal. Adaptive management

procedures for invasive species removal include manual pulling or herbicide application as needed.

- **Benefits Evaluation (Study)** - Models were used to evaluate the benefits of the alternatives and the Recommended Plan and to select the Recommended Plan. The main risk associated with benefits evaluation is that the models used resulted in the selection of alternatives that are inferior to other alternatives when the full range of alternative benefits is considered, because of what these models emphasize or how they were applied. To manage this risk, certified models appropriate for the habitat types the Recommended Plan would restore, EPW and WUCT, were used to evaluate benefits.
- **Construction Schedule (Study, Implementation)** - Construction of the three projects in the Recommended Plan is anticipated to occur sequentially, according to the schedule in Section 4.7.2. The construction schedule influenced the benefits evaluation, fully-funded cost estimates, CE/ICA, and RSLC analysis. Environmental conditions in the project areas may change before construction begins, with increased uncertainty the longer before construction begins. Ownership of the structures on Moodna Creek, the project scheduled third to be constructed, may also change. The PED activities preceding construction, outlined in Section 4.7.1, will account for changes to environmental conditions and ownership and address any changes to NEPA compliance and permitting. NYSDEC requested that a conservative construction schedule be used for the study, but may be amenable to accelerating the project implementation schedule, depending on available funding and agency priorities.

Chapter 5: Existing Environmental Conditions and Environmental Impacts*

Sections 1500.1(c) and 1508.9(a)(1) of the National Environmental Policy Act (NEPA) of 1969, as amended (42 United States Code 4321 et seq.) require federal agencies to "provide sufficient evidence and analysis for determining whether to prepare an environmental impact statement or a finding of no significant impact" on actions authorized, funded, or conducted by the federal government to insure such actions adequately address "environmental consequences, and take actions that protect, restore, and enhance the environment." This chapter provides an assessment of the potential environmental impacts that would result from implementing the Recommended Plan presented in Chapter 4 of this integrated FR/EA for the Hudson River. Table 4-1 and Figures 4-1 through 4-6 (Chapter 4), show the principal restoration measures applied under the Recommended Plan at each site to achieve the planning objectives. This chapter also supplements the ecosystem benefits outlined in Chapters 3 and 4 for each project.

As this study includes recommendations for construction of restoration opportunities that are designed at a feasibility level of detail, as well as possible new phase future spin-off studies for restoration opportunities, a qualitative evaluation of impacts resulting from the restoration measures associated with the Recommended Plan is discussed in this chapter. This chapter also serves as the baseline for the impact analysis and cumulative impacts of implementing the Recommended Plan are discussed in Chapter 6.

5.1 Recommended Plan – Overview

The expected environmental impacts of implementing the Recommended Plan would be overwhelmingly beneficial to the flora and fauna of the Hudson River, and beneficial to the public living in the surrounding study area. Implementation of the Recommended Plan would be a substantial first step in the large-scale restoration of the Hudson River Estuary. Implementation of the Recommended Plan would realize habitat restoration and expansion of available habitat for a host of fauna, including anadromous and catadromous species. Secondary benefits would include, but not be limited to, the following:

- Immediate and long-term improvements to water quality and storage of floodwaters;
- Removal of large swathes of invasive species;
- Improved sediment loading and water quality from dam removals;
- Short-term job creation during construction; and
- Educational and "hands on" restoration opportunities for the public and students of the region (for Henry Hudson Park and Schodack Island sites).

Impacts can be short-term or long-term. In general, short-term impacts are those that would occur only with respect to a particular discontinuous activity or for a finite period, or only during the time required for construction activities. Long-term impacts are those that are more likely to be persistent and chronic. Impacts of a proposed action can be positive or negative. A positive impact is one having beneficial outcomes on an environmental resource. A negative impact is one having adverse, unfavorable, or undesirable outcomes. A single action might result in positive impacts on one environmental resource and negative impacts on another.

Implementation of the Recommended Plan would result in some short-term, negative impacts to the affected environment; however, these impacts would be temporary and localized. All restoration measures would be implemented in accordance with regulatory agency stipulations and construction contractors would employ best management practices (BMPs) at all times—e.g., use of silt curtains and adherence to sediment and erosion control plans.

5.2 No Action Alternative (Future Without Project Condition)

The no action alternative, which is synonymous with the future without project condition (FWOP), would be the state of the site under the anticipated future condition if no action were implemented by USACE as a result of this study. The no action alternative provides a basis upon which a comparison of the potential impacts associated with implementing the Recommended Plan can be made. The impacts from the No Action Alternative represents the FWOP condition throughout the planning horizon compared to the existing conditions.

5.3 Assessment by Site (Tables 5-1, 5-2, and 5-3)

The existing conditions, FWOP, and environmental impacts of the Recommended Plan are presented in:

- Table 5-1, for Schodack Island,
- Table 5-2, for Henry Hudson Park, and
- Table 5-3, for Moodna Creek.

Table 5-1: Existing Conditions and Environmental Impacts to the Schodack Island Site.

RESOURCE	SCHODACK ISLAND	
	Condition	**Description**
Physical Setting	Background	Schodack Island State Park sits off the eastern shore of the Hudson River approximately 10 miles south of Albany, New York. The park is located in the Town of Schodack (Rensselaer County), the Town of New Baltimore (Columbia County), and the Town of Stuyvesant (Greene County). The restoration site (hereafter referred to as "the site") where proposed actions would be implemented, is limited to an approximately 400 foot wide corridor within Schodack Island State Park between The Hudson River and Schodack Creek, just south of the park's boat launch parking area. The restoration site is entirely within the Town of Schodack, Rensselaer County portion of Schodack Island State Park Prior to the 20th century, the area that would become the park originally consisted of Upper Schodack Island, Lower Schodack Island, and Houghtaling Island, as well as several smaller islands (NYS GIS Clearinghouse, 2018). The area known as Schodack Creek along the east side of the islands was in fact a branch of the Hudson River. The Muitzes Kill flowed from the east into the Hudson at the northern end of Upper Schodack Island, where Schodack Creek split off from the main flow of the Hudson River. Beginning in the late 19th to early 20th century, dikes were constructed along the western edge of the islands (Friends of Schodack Island State Park, 2018). Dredging of the Hudson River deepwater channel began in the 1920s. Dredge spoils placed in the area caused the original islands to merge into a single landmass of approximately 2,000 acres (NYSDOS, 2012). This peninsula is connected to the eastern shore of the Hudson River at its upstream end and extends approximately seven miles downstream. Schodack Creek, along the east side of the peninsula, no longer has an upstream connection to the Hudson River. The Muitzes Kill as well as several small streams along the eastern shore now feed it, before joining the Hudson River at the downstream end of the peninsula. The peninsula is now primarily occupied by Schodack Island State Park, including a boat launch, campground, and network of unpaved roads and trails. The south end, on what was originally Houghtaling Island, is occupied by a United States Army Corps of Engineers (USACE) dredge spoil disposal site in active use (USACE, 2014). The northern end of the Park is crossed by a railroad bridge and a highway bridge for Route 912M, both spanning the Hudson River. A set of railroad tracks are adjacent to the east side of Schodack Creek.
Geology and Physiography	Existing Conditions	The site is within the Hudson-Mohawk Lowlands physiographic region. The Hudson River flows from the southeastern Adirondacks, through a 15-20 mile wide lowland area, which is bounded by the Helderberg Plateau and the Catskill Mountains to the west, and the Taconic Mountains to the east. This section of the Hudson River Valley consists of a narrow inner valley with adjacent terraces approximately 100-200 feet high, bordered by gently rolling terrain and low hills. The valley is underlain by weak sedimentary rock, primarily formed during the Cambrian and Lower Ordovician periods (NYS DOT, 2013). Specifically, the Schodack Island site is mapped as the Normanskill Formation, which

RESOURCE	SCHODACK ISLAND	
	Condition	Description
		characterized as dark green to black argillaceous shale containing calcareous and chert beds (Laberge Group, 2011). Post-deposition, the Normanskill shale was folded into a series of hills and valleys trending north-south (NYSDOS, 1995). In general, the surficial geology of the region is heavily influenced by its history of glaciation, including glacial till and lacustrine sediment deposited during the most recent glacial advance and retreat 70,000 to 16,000 years ago. The Hudson River has since reworked these sediments, and the site is currently mapped as alluvium (NYS Museum, 1991). Additionally, the area has been influenced by dredging, and deposited dredged material have filled in the areas between islands that historically existed at the site (Friends of Schodack Island State Park, 2018).
	FWOP	The No Action Alternative would have no impact on geology or physiography.
	Recommended Plan	Construction activities under the Recommended Plan (Plan) would occur at shallow depths. Therefore, the Plan would have no impact on geology or physiography.
Topography	Existing Conditions	As discussed above, the area of the Hudson River Valley consists of a low-lying inner valley, bordered by steep slopes to terraces 100-200 feet high. The site is located within the inner valley on a peninsula that was previously multiple islands formed from alluvium. Based on a 2011–2012 LiDAR (Light Detection and Ranging) dataset developed by the New York State Department of Environmental Conservation (NYSDEC), the topography of the site is generally low-lying, with the highest elevations on the western edge reaching 22 feet. Portions of the dredge disposal area at the south end of the site reach as high as 50 feet (NYSDEC, 2011 - 2012).
	FWOP	Under the No Action Alternative, the site would/ could to be susceptible to topographic change by erosion due to wave and tidal action, and the projected increase in storm frequency and intensity with climate change (NYSDEC, 2018b).
	Recommended Plan	Excavation and regrading under the Plan would result in permanent alterations to on-site topography. Approximately nine acres of land would be excavated to restore a side channel/tidal wetland corridor between Schodack Creek and the Hudson River. Regrading would also occur on existing wetlands on either end of the proposed corridor to facilitate water flow through the new hydrological connection. Implementing the Plan would result in major beneficial impacts to site topography by removing dredged material fill and restoring the historic connection between Schodack Creek and the Hudson River.
Soils	Existing Conditions	Soils data and soils descriptions for Schodack Island Park were acquired from the National Resources Conservation Service (NRCS) Web Soil Survey for Rensselaer, Columbia, and Greene Counties, New York. The majority of the Park was mapped as one of eight soils: Udorthents (sandy), Limerick silt loam, Udipsamments (dredged), Medisaprists-Hydraquents (tidal marsh), Fluvaquents-Udifluvents complex, Saprists and Aquents (ponded), Middlebury silt loam, and Hamlin silt loam (NRCS, Web Soil Survey). **Udorthents, sandy**, are composed of very gravelly loamy sand, typically dredged from the Hudson River. These soils are deep, excessively drained, with very high hydraulic conductivity.

RESOURCE	SCHODACK ISLAND	
	Condition	**Description**
		Limerick silt loam soils are found in depressions on floodplains and are composed of silt loam derived from alluvium that is dominantly silt and very fine sand. These soils are deep, poorly drained, and rated as hydric. **Udipsamments, dredged**, are made up of very deep, level areas of well drained sand and gravel, formed from soil material pumped from the Hudson River. Typically, sandy material containing up to 35% gravel is deposited in layers up to 10 feet thick on top of the original soil. **Medisaprists-Hydraquents, tidal marsh**, are a complex of organic Medisaprists composed of deep layers of organic muck over silt loam and mineral Hydraquents, which are made up of silty clay loam over silt loam. They are both found in flat areas in marshes, are rated as hydric, and are very poorly drained. **Fluvaquents-Udifluvents complex** soils are found in flat areas on floodplains. Fluvaquents are formed from silt loam over gravelly silt loam, located in low areas that flood frequently. They are poorly drained and rated as hydric. Udifluvents are found in slightly higher areas and are composed of gravelly fine sandy loam over gravelly sandy loam. They are moderately well drained, with a typical depth to water of 36-72 inches, and are not rated as hydric. Both are formed from alluvium with a highly variable texture and have variable profiles. **Saprists and Aquents, ponded,** are a complex of organic Saprists composed of deep layers of organic muck over fine sandy loam and mineral Aquents, which are made up of mucky silt loam over gravelly loamy sand. They are both found in flat areas in swamps and marshes, are rated as hydric, and are very poorly drained. **Middlebury silt loam** is a moderately well drained soil found on flat floodplains, and it is composed of silt loam, sandy loam, and gravelly fine sand. This soil is derived from loamy alluvium predominantly from areas of shale and sandstone with some lime-bearing material. It is not rated as hydric. **Hamlin silt loam** is a nearly level, very deep and well-drained soil found on floodplains along the Hudson River. It is formed from silty alluvium from areas of siltstone, shale, and limestone. Typical depth to the water table is 36-72 inches, and it is not considered hydric. The surface layer is typically dark brown silt loam, underlain by layers of dark grayish brown silt loam.
	FWOP	Under the No Action Alternative, the soils would be subject to minor adverse impacts from soil erosion due to wave and tidal action, and the projected increase in storm frequency and intensity with climate change (NYSDEC, 2018b).
	Recommended Plan	In the short-term, the Plan would result in negligible adverse impacts on soil resources due to soil erosion during the construction phase of the project. Erosion and sediment control practices would be implemented to minimize soil erosion and the deposition of sediment into surface waters. An Erosion

RESOURCE	SCHODACK ISLAND	
	Condition	**Description**
		and Sediment Control Plan would be prepared and approved before any construction activities would commence. In the long-term, implementing the Plan would result in minor beneficial impacts to soil resources through the restoration of wetlands, which reduce shoreline erosion by stabilizing sediments and absorbing and dissipating wave energy (Hammer, 1992).
Climate and Weather	Existing Conditions	A National Weather Service (NWS) station is located approximately 7.8 miles west of the site, at the Alcove Dam. Records for this station are available between 1942 and 2018, via the Agricultural Applied Climate Information System (AgACIS). Records at this station indicate that between 1942 and 2018, Average monthly temperatures ranged for 21.1°F in January to 69.5°F in July (AgACIS, 2018). Average annual precipitation was 39.74 inches, with monthly averages ranges from 2.18 inches in February to 3.89 inches in June. Average annual snowfall was 29.5 inches, primarily occurring between December and March. The average number of days with 0.10 inches of precipitation or more was 76 days per year; such precipitation days occurred at a roughly equally rate per month (5-8 days per month).
	FWOP	The No Action Alternative would have no impact on the climate or weather at the site.
	Recommended Plan	The Plan would have no impact on the climate or weather at the site.
Climate Resiliency	Existing Conditions	According to the Intergovernmental Panel on Climate Change's (IPCC) Special Report 15, released in October of 2018, human activities have caused approximately 1.0° C (1.8° F) of global warming above pre-industrial levels, causing many land and ocean ecosystems to change. The same report also stated that, "model-based projections of global sea level rise (relative to 1986-2005) suggest an indicative range of 0.26 to 0.77 m (0.85 to 2.5 ft.) by 2100 for 1.5° C (1.8° F)of global warming… Increasing warming amplifies the exposure of small islands, low-lying coastal areas and deltas to the risks associated with sea level rise for many human and ecological systems, including saltwater intrusion, flooding and damage to infrastructure" (IPCC, 2018). Climate projections developed by New York State indicate a future increase in temperatures, precipitation, sea levels, and severity of flooding (NYSDEC, 2018b). The State's average annual temperature is expected to increase approximately four to six degrees Fahrenheit by mid-century and as much as 11 degrees Fahrenheit by 2100. The total annual precipitation is expected to increase as much as 11% by mid-century and 18% by 2100. Since 1900, sea level in the lower Hudson has risen 13 inches. Sea level rise along the Hudson River is projected to continue. The Hudson River is projected to rise a minimum of nine additional inches by 2050, with mid-range projections of approximately 10 to 20 inches by 2050. These changing climatic factors will likely alter flooding patterns in the Hudson River. It is projected that today's 1% storm will become 20 to 50% more likely by 2020 and as much as 610% more likely by 2100. Given its location along the Hudson River

RESOURCE	SCHODACK ISLAND	
	Condition	Description
		Shoreline, Schodack Island will likely be significantly affected by any changes in climate and hydrology patterns. Neither Rensselaer County nor the Town of Schodack are participants in the NYS Climate Smart Communities Program (New York State, 2018).
	FWOP	Under the No Action Alternative, predicted sea level rise and increasing storm frequency and intensity may result in moderate adverse impacts to the site (NYSDEC, 2018b).
	Recommended Plan	Implementing the Plan would result in a moderate beneficial impact to climate resiliency by increasing flood storage along the Hudson River floodplain through the conversion of uplands to tidal wetlands, and excavation of a side channel/tidal wetland corridor between Schodack Creek and the Hudson River. This would enhance the site's capacity to hold larger floodwater volumes associated with climate change (NYSDEC, 2018b).
Floodplains	Existing Conditions	The Rensselaer County portion of the site lies completely within the one percent floodplain (A13 Zone) with a base flood elevations of 15.2 to 17.2 feet (NAVD88), as shown on the FEMA Flood Insurance Rate Map (FIRM), effective as of August 15, 1984 (FIRM Panel No.: 3611690012A and 3611690014A)(FEMA, 1984a)(FEMA, 1984b). The Greene County portion of the site lies completely within the one percent floodplain (A Zone), as shown on the Flood Insurance Rate Map (FIRM), effective as of May 16, 2008 (FIRM Panel No.: 36039C0110F) (FEMA, 2008). Base flood elevations were not determined in this zone. A United States Geological Survey (USGS) stream gage is located approximately 6 miles upstream of the project area on right bank of the Hudson River at the Port of Albany (NWIS Site No.: 01359165) (USGS, 2018). Records for this gage begin on September 30, 2016. The gage is under continuous operation as of December 5, 2018. During this period, the maximum water elevation was 7.41 feet (NAVD88) on April 7, 2017 and the minimum water elevation was -4.20 feet on February 14, 2017. A USGS Short-Term Network (STN) Monitoring site is located across the Hudson River from the project site in Coeymans (STN Site No.: NYALB07392) (USGS, 2012). After Hurricane Sandy in 2012, a high water mark was recorded at elevation of approximately 10.2 feet (NAVD88) at this site.
	FWOP	Under the No Action Alternative, the site would continue to be subject to flooding given its location within the Hudson River's one percent floodplain. New York State projects that the one percent storm may be 1.5 to 3.3 inches higher by 2100 (NYSDEC, 2018b), resulting in negligible adverse impacts to the sites.
	Recommended Plan	Under the Plan, the site would remain within the Hudson River's one percent floodplain. Implementing the Plan would result in a moderate beneficial impact to floodplains by increasing flood storage along the Hudson River floodplain during precipitation events through the conversion of uplands to tidal wetlands, and excavation of a side channel/tidal wetland corridor between Schodack Creek and the Hudson River.

RESOURCE	SCHODACK ISLAND	
	Condition	**Description**
Surface Waters	Existing Conditions	Located within the Middle Hudson Watershed (HUC-8 No.: 02020006), the Hudson River and Schodack Creek are the primary surface water bodies at the site (NYS GIS Clearinghouse, 2018). The Hudson River forms the western boundary of the site, while Schodack Creek delineates the eastern boundary. The Hudson River has a drainage area of approximately 8,690 square miles (USGS Streamstats, Accessed December 2018) to the confluence with Schodack Creek. The Federal Lock and Dam located in Troy, approximately 18 miles upstream in part controls water levels in the Hudson River. This dam marks the upstream extent of tidal influence in the Hudson River. The Schodack Creek drainage area is a small subset of the Hudson River drainage area, with an area of approximately 31.5 square miles (USGS Streamstats). The majority of the drainage comes from the Muitzes Kill, which flows, into the northern end of Schodack Creek, while the remainder comes from small creeks along its eastern boundary.
	FWOP	Under the No Action Alternative, the Hudson River and Schodack Creek would continue to constitute the site's only surface water bodies. The projected sea level rise of 1.07 feet by 2075 would slightly increase the extent of the intertidal zone on the site. Therefore, the No Action Alternative would have minor impacts on surface waters.
	Recommended Plan	Implementing the Plan would result in moderate impacts to the site's surface waters. Surface water area on the site would be expanded due the excavation of a side channel/tidal wetland corridor between Schodack Creek and the Hudson River.
Water Quality	Existing Conditions	Schodack Creek and the Hudson River are both classified as Class C water bodies, which support fisheries and are suitable for non-contact recreation (6 CRR-NY X B Article 10- Lower Hudson River Drainage Basin Series). The Hudson River in Albany County is on the 2016 USEPA 303(d) list as "impaired" due to fish consumption advisories from sediment contaminated with polychlorinated biphenyls (PCBs) (USEPA, 2016).
	FWOP	Under the No Action Alternative, soil erosion on the site, due to wave and tidal action, and the projected increase in storm frequency and intensity with climate change (NYSDEC, 2018b) would increase turbidity in the Hudson River and Schodack Creek, resulting in negligible adverse impacts to water quality
	Recommended Plan	In the short-term, implementing the Plan would result in negligible adverse impacts on water due to increases in turbidity during the construction phase of the project. Erosion and sediment control practices would be implemented to minimize the deposition of sediment into surface waters. The risk of potential fuel spills and machinery leakage would be minimized by restricting maintenance, refueling, and storage of construction equipment to an upland staging area. In the long term, implementing the Plan would result in moderate beneficial impacts to water quality through the restoration of an approximately nine-acre side channel/tidal wetland corridor, and restoration of approximately 19.8 acres of tidal wetland. Wetlands improve local water quality through their ability to efficiently fix nitrogen, store phosphorous, retain sulfur, promote sediment deposition,

RESOURCE	SCHODACK ISLAND	
	Condition	**Description**
		and immobilize and decrease the bioavailability of metals in inundated sediments (Gosselink, Odum & Pope, 1974; Mitsch & Gosselink, 1993; Novotny & Olem, 1994; Carter 1997).
Regional Hydrogeology and Groundwater	Existing Conditions	In general, aquifers in the Hudson Valley are unconfined and related to thick layers of sediment glacially deposited over bedrock. The New York State Department of Conservation Division of Water, Bureau of Water Resources Management, has identified one aquifer at the Schodack Island site. This aquifer is described as an unconfined, high yield aquifer with a yield of greater than 100 gallons per minute. The aquifer is composed of sand and gravel deposits with high transmissivity and a saturated thickness greater than 10 feet. The mapped aquifer generally follows the footprint of the Hudson River and associated alluvium deposits and overlaps with the western edge of the site. However, this aquifer was mapped at a 1:250,000 scale, based on published surficial and bedrock geology maps, and the boundaries of this aquifer indicate the general location only (NYS GIS Clearinghouse, 2018). To the east of the Hudson River in Rensselaer and Columbia counties, there are several unconfined aquifers including a regional aquifer within the Schodack and Kinderhook terrace deposits. This aquifer was formed from glacially derived sediment deposited in a north to south strip approximately 3-5 miles east of the Hudson River. In some areas, the aquifer has a yield greater than 100 gallons per minute. Though not directly connected to the Hudson River, this aquifer is a source of water to the Muitzes Kill, and ultimately drains to Schodack Creek and the Hudson River (Reynolds, 1999).
	FWOP	The No Action Alternative would have no impact on the hydrogeology or the groundwater.
	Recommended Plan	Implementing the Plan may result in minor impacts on local shallow groundwater flows due to alterations to topography and surface water flow.
Tidal Influences	Existing Conditions	The Hudson River Environmental Conditions Observing System (HRECOS) monitoring station and tide gauge are located on-site at the main boat launch on the Hudson River. At this station, the low and lower low tide levels are -1.42 and -1.63 feet, (NAVD88), respectively; while the high and higher high tide levels are 3.47 and 3.80 feet (NAVD88), respectively. As part of this Hudson River Habitat Restoration Feasibility Study, two water level gauges were installed by the Project Development Team in Schodack Creek on the east side of the peninsula at approximately 2.7 miles and 4.2 miles upstream of the confluence with the Hudson River. Data collected from June to November of 2018 showed water surface levels ranging from below 0 feet in elevation to greater than 5 feet in elevation (NAVD88). Tide levels were similar at both locations and were similar to the levels recorded at the HRECOS gauge on the west side of Schodack Island, indicating little tidal variability between the Hudson River and monitored portions of Schodack Creek.
	FWOP	Sea level rise is projected to occur in the tidal Hudson River and Schodack Creek, which would shift the intertidal areas landward of their current extents. According to Scenic Hudson's Sea Level Rise Mapper, the waters of the Hudson River and Schodack Creek, during mean higher high tide, would begin to inundate the site's low-lying areas under 12 inches of sea level rise and completely inundate these areas under 30 inches of sea level rise (Scenic Hudson, 2018). The projected sea level rise of

RESOURCE	SCHODACK ISLAND	
	Condition	**Description**
		1.07 feet by 2075 would slightly increase the extent of the intertidal zone on the site. Therefore, the No Action Alternative would have minor impacts on tidal influences.
	Recommended Plan	The Plan would result in moderate beneficial impacts to tidal influence by restoring historically tidal areas that were filled with dredged materials. Intertidal areas of the site will increase by approximately nine acres through the excavation of a side channel/tidal wetland corridor between Schodack Creek and the Hudson River.
Land Use and Zoning	Existing Conditions	Schodack Island State Park is within the Town of Schodack and Town of New Baltimore protected open space. This open space consists of extensive forest and wetland areas throughout the southern and central portions of the island, and a recreational area, which includes an access road, playgrounds, parking lots, and camping grounds in the northern portion of the island. This open space is owned and operated by the State of New York. Land uses in the vicinity of the site contain a mix of forested land and low-density residential properties. The southern end of Schodack Island (approximately 1.5 miles long) is not a part of the State Park. This section is owned and operated by the federal government as a dredged material disposal area. Historically, there was not a single contiguous island in this area but a complex of islands and side channels within the Hudson River. Since European colonization, the historic islands underwent a variety of land uses including timber production, ice harvesting, industry, and agriculture. The channels were filled and islands connected through the placement of dikes and dredged material in the 1920s, resulting in a peninsula between the Hudson River and Schodack Creek and a relic side channel (Huey et al., 1997). The site is located entirely Town of Schodack Residential/Agricultural (RA) zoning district. This zone is regulated under Chapter 219 of the Schodack municipal code. This districts generally zones for low-density residential or agricultural-oriented development. Habitat restoration is not explicitly regulated under the town's municipal zoning code. Given that the site is protected as state park land, it is unlikely any residential or agricultural development will occur on the site in the foreseeable future. Pursuant to §24-0501 of the New York State Freshwater Wetlands Act (Article 24 of the New York Environmental Conservation Law), the towns of New Baltimore and Schodack have fully accepted responsibility with regard to activities subject to regulation under the Act within officially designated freshwater wetlands.
	FWOP	The No Action Alternative would have no impact on the land use or zoning at the site. Given the site's status as a protected open space, it is unlikely that the area would be significantly developed in the future outside of recreational land uses.
	Recommended Plan	Implementing the Plan would have no impact on the land use or zoning at the site.

RESOURCE	SCHODACK ISLAND	
	Condition	**Description**
Economics	Existing Conditions	Schodack Island State Park is located in upstate New York in the Saratoga/Capital District, the metropolitan area surrounding the state's capital city, Albany. The park spans portions of Rensselaer, Greene, and Columbia counties. The riverfront area within the site is generally undeveloped. The only developed area is the Village of Castleton-on-Hudson, in the Town of Schodack, which sits approximately in the center of the waterfront area. According to the Town of Schodack Comprehensive Plan, a quarter of the town's working residents are employed in the following industries: educational, health, and social services (Laberge Group, 2011). Ecotourism is an important economic driver in this region, as the natural and scenic resources draw millions of visitors to New York's recreation areas (USFWS, 2006). Many people come from out of town to pursue wildlife-associated recreation, outdoor sporting, angling, hunting, and wildlife watching, bringing with them business for local restaurants, hotels, shops, etc. According to a report by the United States Fish and Wildlife Service (USFWS), 3.8 million people watch birds and other wildlife in New York State, generating approximately $1.6 billion in ecotourism revenue every year. In 2006, there was a total of $716 million in hunting-related expenditures in the state of New York (USFWS, 2006).
	FWOP	The No Action Alternative would have no impact on local economic conditions.
	Recommended Plan	Implementing the Plan may have some incidental economic impacts on local economic conditions. Ecotourism, outdoor recreation, fishing, job creation from construction, and boating may increase because of the improved conditions.
Socio-Economics	Existing Conditions	According to the US Census Bureau (USCB) American Community Survey 5-year survey for 2013-2017, the population in the Town of Schodack, NY is an estimated 12,794 people, and is predominantly white (USCB, 2013-2017). The median age in the Town of Schodack, NY is approximately 44.1 years of age and median household income is $79,740. An estimated 5,324 occupied housing units are present within the town, with a majority of structures being built in 1939 or earlier (1,273structures). Approximately 93.5% of the population are high school graduates or higher while 31.4% of the population have a bachelor's degree or higher. The estimated number of companies in the Town of Schodack is 1,053. The civilian employed population 16 and over is an estimated 6,865 people. Of this employed population, an estimated 2,789 people work in management, business, science, and arts occupations, 990 people in service occupations, 1,859 in sales and office occupations, 491 in natural resources, construction, and maintenance occupations, and 736 in production, transportation, and material moving occupations.
	FWOP	The No Action Alternative would have no impact on local socio-economic conditions.
	Recommended Plan	Implementing the Plan may have some incidental positive socio-economic impacts. Ecotourism, outdoor recreation, fishing, educational opportunities, job creation from construction, and boating may increase because of the improved conditions.

RESOURCE	SCHODACK ISLAND	
	Condition	**Description**
Environmental Justice	Existing Conditions	According to the New York State Department of Environmental Conservation's Maps & Geospatial Information System (IGST) Tools for Environmental Justice data set, the site is not located within an Environmental Justice area (NYSDEC, 2018c).
	FWOP	There are no environmental justice populations in proximity to this site. Therefore, the No Action Alternative would have no impact on environmental justice populations.
	Recommended Plan	There are no environmental justice populations in proximity to this site. Therefore, implementing the Plan would have no impact on environmental justice populations.
Coastal Zone Management	Existing Conditions	The Hudson River, downstream of the Federal Lock and Dam in Troy, New York, is a designated Coastal Area, subject to regulation under the federal Coastal Zone Management Act and managed under the New York Coastal Management Program. The landward boundary of the coastal area is typically 1,000 feet inland from the shoreline. The New York State Department of State (NYSDOS) has designated Schodack Island, Houghtaling Island, and Schodack Creek as a Significant Coastal Fish and Wildlife Habitat. Based on an evaluation by the New York State Department of Environmental Conservation (NYSDEC), this area is considered significant because it consists of a large undeveloped floodplain wetland ecosystem with diverse ecological communities, including floodplain forest, freshwater tidal wetlands, tidal creek, littoral zones, emergent marshes, and tidal swamp. Schodack Creek provides spawning, nursery, and feeding habitat for migratory and resident fish species, including white perch (*Morone americana*), American shad (*Alosa sapidissima*), blueback herring (*Alosa aestivalis*), largemouth bass (*Micropterus salmoides*), smallmouth bass (*Micropterus dolomieui*), shortnose sturgeon (*Acipenser brevirostrum*), American eel (*Anguilla rostrata*), and alewife (*Alosa pseudoharengus*). The Muitzes Kill additionally provides a spawning area for spottail shiners (*Notropis hudsonius*). Submerged aquatic vegetation provides food and cover for fish and macroinvertebrates and contributes to dissolved oxygen in the water. The wetland and upland areas also support various bird species and other wildlife.
	FWOP	The No Action Alternative would have no impact on any areas regulated under the New York Coastal Zone Management Program. State and/or municipal entities may initiate a project at the site in the future. Any state agency action performed at the site (i.e. direct undertaking, financial assistance, or permitting) would require review by the Coastal Zone Management Program to ensure consistency with coastal policies established in Department of State regulations 19 NYCRR Part 600.
	Recommended Plan	Proposed actions under the Plan would occur in areas regulated under the New York Coastal Zone Management Program. The Plan would be consistent with the overall objectives of the Coastal Management Program. In particular, implementing the Plan would promote Coastal Policy 7, through the restoration of a Significant Coastal Fish and Wildlife Habitat, and Coastal Policy 44, through the restoration of approximately 19.8 acres, and restoration of approximately 2.64 acres of tidal wetland, resulting in moderate beneficial impacts on coastal resources.

RESOURCE	SCHODACK ISLAND	
	Condition	**Description**
Wetlands	Background	Specific wetland communities were identified in July 2018 using Evaluation of Planned Wetlands (EPW). Wetland communities existing, future without project conditions (year 50) and forecasted (years 2, 20 and 50) following implementation of the Recommended Plan are detailed in Appendix D.
	Existing Conditions	The USFWS National Wetland Inventory (NWI) map indicates the presence of both freshwater emergent wetlands and freshwater forested/shrub wetlands at the Schodack Island site. The Hudson River and Schodack Creek are mapped as riverine environments. Additionally, the NYSDEC's Hudson River Estuary Program has mapped tidally influenced wetlands as a separate effort in 2007 based off aerial photographs. This dataset overlaps the NWI inventory and indicates the presence of multiple types of tidal environments including: submerged aquatic vegetation, wooded swamp, unvegetated flats, scrub shrub wetland, cattail (*Typha angustifolia)* dominated, common reed (*Phragmites australis)* dominated, intertidal mix, and open water. These are primarily mapped along the east side of the site along Schodack Creek (NYSDEC, 2007).
	FWOP	Under the No Action Alternative, sea level rise is projected to occur in the tidal Hudson River and Schodack Creek, which would shift intertidal areas landward of their current extents. As this shift occurs, some of the site's existing non-tidal wetlands would become inundated by daily tides and eventually convert to tidal-wetland habitat. Therefore, while there would be no impact to the extent of wetlands on the site as the plant communities of those wetlands would likely shift.
	Recommended Plan	In the short-term, construction activities associated with implementing the Plan would result in moderate adverse impacts to existing wetlands due to site clearing, grading, and the movement of personnel and equipment across the site during construction. These areas would be restored and replanted as necessary post-construction. In the long-term, implementing the Plan would result in major beneficial impacts to wetlands through the restoration of an approximately nine-acre side channel/tidal wetland corridor and restoration of approximately 19.8 acres of tidal wetland.
Vegetation	Background	Specific wetland/vegetation communities were identified in July 2018 using EPW. Wetland/vegetation communities existing, future without project conditions (year 50) and forecasted (years 2, 20 and 50) following implementation of the Recommended Plan are detailed in Appendix D.
	Existing Conditions	The Schodack Island site contains a variety of ecological communities including floodplain forests, wooded swamp, scrub shrub wetlands, and emergent wetlands (NYSDOS, 2012). All community descriptions were acquired from Ecological Communities of New York State, 2nd Edition (Edinger et al., 2014). Floodplain forests in the Hudson River valley typically contain plants such as silver maple (*Acer saccharinum*), box elder (*Acer negundo*), sycamore (*Platanus occidentalis*), green ash (F*raxinus pensylvanicus*), cottonwood (*Populus deltoides*), slippery elm (*Ulma nigra*), black walnut (*Juglans nigra*), multiflora rose (*Rosa multiflora*), Virginia creeper (*Parthenocissus cinquefolia*), poison ivy (T*oxicodendron radicans*), spicebush (*Lindera benzoin*), and American hornbeam (*Carpinus*

RESOURCE	SCHODACK ISLAND	
	Condition	Description
		caroliniana). In particular, invasive species such as mugwort (*Artemisia vulgaris*) were dominant in the forest understory. Wooded swamps typically contain trees and shrubs including green ash, black ash (*Fraxinus nigra*), red maple (*Acer rubrum*), slippery elm, alders (*Alnus spp.*), spicebush, arrowwood (*Vibernum dentatum*), dogwoods (*Cornus spp.*), Virginia creeper, and poison ivy. Common herbaceous species include rice cutgrass (*Leersia oryzoides*), sensitive fern (*Onoclea sensibilis*), spotted jewelweed (*Impatiens capensis*), and skunk cabbage (*Symplocarpus foetidus)*. Scrub shrub wetlands may contain alder (*Alnus incana*), red osier dogwood (*Cornus sericea*), silky dogwood (*Cornus amomum*), or willows (*Salix spp.*). Also common are meadowsweet (*Spiraea spp.*), gray dogwood (*Cornus racemosa*), swamp azalea (*Rhododendron viscosum*), highbush blueberry (*Vaccinium corymbosum*), and spicebush (*Lindera benzoin*). Emergent wetlands are characterized by cattails (*Typha spp.*), sedges (*Carex spp.*), marsh fern (*Thelypteris palustris*), spike rushes (*Eleocharis spp.*), bulrushes (*Scirpus spp.*), and sweetflag (*Acorus americanus*). The invasive common reed (*Phragmites australis*) is also common.
	FWOP	Under the No Action Alternative, sea level rise is projected to occur in the tidal Hudson River and Schodack Creek, which would shift intertidal areas landward of their current extents. As this shift occurs, some of the site's existing non-tidal wetlands would become inundated by daily tides and eventually convert to tidal-wetland habitat. Therefore, while there would be no impact to the extent of vegetation on the site, the vegetation communities would likely shift.
	Recommended Plan	In the short-term, construction activities associated with implementing the Plan would result in moderate adverse impacts to vegetation due to site clearing, grading, and the movement of personnel and equipment across the site during construction. These areas would be restored and replanted as necessary post-construction. Tree protection and high visibility fencing would be installed during construction to reduce the risk of unnecessary damage to trees and other vegetation. In the long-term, implementing the Plan would result in a moderate beneficial impact on vegetation due to the restoration of 19.8 acres of wetland. Non-native invasive vegetation would be replaced with native vegetation. Additionally, approximately nine acres of upland vegetation would be replaced by an equivalent area of wetland vegetation as a result of wetland restoration.
Shellfish	Existing Conditions	No information regarding the presence, absence, or composition of shellfish communities on the site is readily available. Typically, there are fresh water clams, mussels, and invasive zebra mussels in this habitat.
	FWOP	Under the No Action Alternative, the site’s existing ratio of intertidal and upland area would change slightly with projected sea level rise. The net increase in the extent of intertidal areas with projected sea level rise would result in negligible beneficial impacts to shellfish, as more areas become accessible to shellfish inhabitation.

RESOURCE	SCHODACK ISLAND	
	Condition	**Description**
	Recommended Plan	In the short-term, temporary reductions in water quality due to construction activities associated with implementing the Plan would result in negligible adverse impacts to shellfish, if present. In the long-term, improvements to water quality and the expansion of intertidal areas on the site would result in minor beneficial impacts to shellfish, as more areas become accessible to shellfish inhabitation.
Finfish	Existing Conditions	The site is in vicinity designated as 'Significant Anadromous Fish Concentration Area' by the NYSDEC Environmental Resource Mapper (NYSDEC, Environmental Resource Mapper*)*. Schodack Island in its entirety is also designated as a Significant Coastal Fish and Wildlife Habitat under the New York State Coastal Management Program, known as 'Schodack and Houghtaling Islands and Schodack Creek'. According to the Coastal Fish and Wildlife Rating Form (NYDOS, 2012) associated with this designated habitat, Schodack Creek functions as a biologically productive backwater area that generally supports larger populations of fish, plankton, and rooted plants than the Hudson River. The area contains a multitude of aquatic habitats including mudflats, littoral zones, submerged aquatic vegetation beds, and wetlands, which are important in various life stages of many fish species. Schodack Creek is a significant spawning nursery and feeding area for American shad (*Alosa sapidissima*), white perch (*Morone americana*), alewife (*Alosa pseudoharengus*), blueback herring (*Alosa aestivalis*), largemouth bass (*Micropterus salmoides*), smallmouth bass (*Micropterus dolomieui*), American eel (*Anguilla rostrata*) and other freshwater fish species.
	FWOP	Under the No Action Alternative, the site's existing ratio of intertidal and upland area would change slightly with projected sea level rise. The net increase in the extent of intertidal areas with projected sea level rise would result in negligible beneficial impacts to finfish, as more areas become accessible to finfish inhabitation.
	Recommended Plan	In the short-term, temporary reductions in water quality due to construction activities associated with implementing the Plan would result in negligible adverse impacts to finfish, if present. In the long-term, improvements to water quality, the expansion of intertidal areas on the site, and restoration of the historic connection between Schodack Creek and the Hudson River would result in major beneficial impacts to finfish, as more areas become accessible to fish inhabitation. The side channel/tidal wetland corridor would also provide a velocity refuge for fish during storm events.
Benthic Resources	Existing Conditions	According to Hudson River Estuary Program Benthic Mapping Project (NYSDEC, 2006), the bottom sediment of Schodack Creek is comprised of >90% mud (silt and clay mix) and is part of a thickly lain, depositional sediment region. The bottom sediment of the Hudson River in this area is comprised of muddy sand (sand with >10% mud) and gravelly sand (sand with >10% gravel) along the shoreline. The Hudson River shoreline along the northern and southern portion of Schodack Island is primarily part of a thickly lain,

<table>
<tr><th rowspan="2">RESOURCE</th><th colspan="2">SCHODACK ISLAND</th></tr>
<tr><th>Condition</th><th>Description</th></tr>
<tr><td rowspan="3"></td><td></td><td>depositional sediment region. The central portion of the Island, where the land separating the Hudson River and Schodack Creek is the thinnest, is within an erosional, non-depositional, sediment area.

The site contains a varied mix of benthic morphology including tidal creeks, freshwater intertidal mud flats, and submerged aquatic vegetation beds predominantly dominated by water celery (Vallisneria americana).</td></tr>
<tr><td>FWOP</td><td>Under the No Action Alternative, the site's existing ratio of intertidal and upland area would change slightly with projected sea level change. The net increase in the extent of intertidal areas with projected sea level change would have negligible beneficial impacts to benthic resources.</td></tr>
<tr><td>Recommended Plan</td><td>Under the Plan, the conversion of approximately nine acres of upland habitat to intertidal habitat on the site would increase the extent of benthic habitat, and therefore provide minor beneficial impacts to benthic resources.</td></tr>
<tr><td rowspan="3">Reptiles and Amphibians</td><td>Existing Conditions</td><td>No information regarding the presence, absence, or composition of reptile or amphibian communities on the site is readily available. According to the Coastal Fish and Wildlife Rating Form associated with the designated SCFWH (NYSDOS, 2012), Shad and Schermerhorn Islands supports a variety of amphibians and reptiles including northern map turtle (Graptemys geographica), painted turtle (Chrysemys picta), mudpuppy (Necturus maculosus), American toad (Bufo americanas), bullfrog (Rana catesbeiana), and green frog (Rana clamitans).</td></tr>
<tr><td>FWOP</td><td>Under the No Action Alternative, the site's existing ratio of intertidal and upland area would change slightly with projected sea level rise. The net increase in the extent of intertidal areas with projected sea level rise would have mixed impacts on reptiles and amphibians, resulting in negligible beneficial impacts to intertidal reptile and amphibian species and negligible adverse impacts to non-tidal wetland reptile and amphibian species.</td></tr>
<tr><td>Recommended Plan</td><td>In the short-term, temporary disturbances to vegetation and reductions in water quality due to construction activities associated with implementing the Plan would result in negligible adverse impacts to reptiles and amphibians, if present.

In the long-term, improvements to water quality and the conversion of approximately nine acres of upland habitat to intertidal habitat on the site would result in minor beneficial impacts to intertidal reptile and amphibian species and minor adverse impacts to upland reptile and amphibian species.</td></tr>
<tr><td>Birds</td><td>Existing Conditions</td><td>According to the USFWS Migratory Bird Program, the project area is located within the North America Atlantic Flyway for migratory birds, which is a critical corridor for migrating birds (USFWS, 2018). Schodack Island State Park contains a multitude of bird habitats, including freshwater tidal marsh, freshwater tidal marsh swamp, freshwater intertidal mudflats, and intertidal shorelines. Schodack Island State Park has been designated a State Important Bird Area (IBA) by the National Audubon Society (National Audubon Society, 2018), and the New York State Bird Conservation Area Program similarly classifies Schodack Island State Park as a Bird Conservation Area (BCA) (NYSDEC, 2002). According to the National Audubon Society and New York State Bird Conservation Area Program, the Island</td></tr>
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RESOURCE	SCHODACK ISLAND	
	Condition	**Description**
		contains a concentration of wading birds, supports the roosting and perching of Osprey and Bald Eagle, contains a Great Blue Heron rookery with over 50 breeding pairs, and has been inhabited by Cerulean Warblers since 1965, including 18 Cerulean Warblers in 1997. Bald Eagles are federally protected under the Bald and Golden Eagle Protection Act (16 U.S.C. 668). According to the eBird database, managed by Cornell Lab of Ornithology, as of January 8, 2019, 173 species of birds have been documented within Schodack Island State Park (eBird, 2012). The most common species that have been observed on the site include Canada Goose (*Branta canadensis*), Tree Swallow (*Tachycineta bicolor),* American Tree Sparrow (*Spizella arborea),* American Robin (*Turdus migratorius),* Dark-eyed Junco (*Junco hyemalis),* and White-throated Sparrow (*Zonotrichia albicollis)* As mentioned previously, the project area is within the designated Significant Coastal Fish and Wildlife Habitat of ‘Schodack and Houghtaling Islands and Schodack Creek’ under the New York State Coastal Management Program. According to the Coastal Fish and Wildlife Rating Form associated with this designated habitat (NYDOS, 2012), wetland areas around Schodack and Houghtaling Islands and Schodack Creek serve as nesting habitats for a variety of bird species such as Green Heron (*Butorides virescens*), Mallard (*Anas platyrhynchos*), Black Duck (*Anas rubripes*), Spotted Sandpiper (*Actitis macularia*), American Woodcock (*Scolopax minor*), Marsh Wren (*Cistothorus palustris*), and Swamp Sparrow (*Melospiza georgiana*). Upland habitats on the islands support Ruffed Grouse (*Bonasa umbellus*) and the area’s floodplain forests contain unusual concentrations of nesting Wood Thrush (*Hylocichla mustelina*) and Cerulean Warblers (*Vermivora pinus*). During spring and fall migrations (March-May and September-November, generally), Schodack and Houghtaling Islands and Schodack Creek receive considerable use by concentrations of waterfowl, raptors, shorebirds, and passerines, including American Bittern (*Botaurus lentiginosus*), Cerulean Warbler (*Vermivora pinus*). Osprey (*Pandion haliaetus*) occur on Lower Schodack Island regularly during spring migration.
	FWOP	Under the No Action Alternative, the site’s existing ratio of intertidal and upland area would change slightly with projected sea level rise. The net increase in the extent of intertidal areas with projected sea level rise would have mixed impacts on birds, resulting in negligible beneficial impacts to tidal shorebirds and negligible adverse impacts to non-tidal shorebirds.
	Recommended Plan	In the short-term, temporary disturbances to vegetation and reductions in water quality due to construction activities associated with implementing the Plan would result in negligible adverse impacts to birds, if present. In the long-term, improvements to water quality and the conversion of approximately nine acres of upland habitat to intertidal habitat on the site would result in minor beneficial impacts to shorebirds and minor adverse impacts to upland bird species.

RESOURCE	SCHODACK ISLAND	
	Condition	**Description**
Mammals	Existing Conditions	No information regarding the presence, absence, or composition of mammals on the site is readily available. It is likely that the extensive and varied natural areas contained within Schodack Island State Park provide habitat for numerous mammalian species.
	FWOP	Under the No Action Alternative, the site's existing ratio of intertidal and upland area would change slightly with projected sea level rise. The net increase in the extent of intertidal areas with projected sea level rise would have mixed impacts on mammals, resulting in negligible beneficial impacts to intertidal mammalian species (i.e. raccoons and sea otter) and negligible adverse impacts to non-tidal wetland mammalian species (i.e. beavers, mink, opossum, and otter).
	Recommended Plan	In the short-term, temporary disturbances to vegetation and reductions in water quality due to construction activities associated with implementing the Plan would result in negligible adverse impacts to mammals, if present. In the long-term, improvements to water quality and the conversion of approximately nine acres of upland habitat to intertidal habitat on the site would result in minor beneficial impacts to aquatic mammalian species and minor adverse impacts to upland mammalian species.
Federal Species of Concern	Existing Conditions	The USFWS iPac system identified the threatened northern long-eared bat (*Myotis septentrionalis*) and the endangered Indiana bat (*Myotis sodalis*) as potentially occurring at the site. The northern long-eared bat is a medium-sized bat found across much of the eastern and north-central United States and is found statewide in New York. The northern long-eared bat predominantly overwinters in hibernacula that include caves and abandoned mines. During the summer, this species typically roosts singly or in colonies underneath bark or in cavities or crevices of both live trees and snags. Northern long-eared bats are also known to roost in human-made structures such as buildings, barns, sheds, and under eaves of windows (USFWS, 2014a). The Indiana bat is small, weighing only one-quarter of an ounce. In flight, it has a wingspan of 9 to 11 inches. The fur is dark-brown to black. It is found throughout New York. Indiana bats hibernate during winter in caves or, occasionally, in abandoned mines. After hibernation, Indiana bats migrate to their summer habitat in wooded areas where they usually roost under loose tree bark on dead or dying trees. There are no reports of the northern long-eared bat or Indiana bat at the site. Coordination with Greater Atlantic Regional Fisheries Office (GARFO) identified the shortnose sturgeon and Atlantic sturgeon as potentially occurring at the site.
	FWOP	The No Action Alternative would have no effect on federal species of concern at the site.
	Recommended Plan	The site is suitable summer habitat for Indiana and northern long-eared bats. The project will remove trees suitable as bat habitat. To avoid impacts to bats, the District will remove trees greater than 3 inches density at breast height (dbh) October 1 – March 31 or survey for bats prior to tree removal. If bats are observed during the surveys, removal will be deferred to October 1 – March 31 or the District

RESOURCE	SCHODACK ISLAND	
	Condition	Description
		will reinitiate consultation with USFWS. With these measures in place, the District has determined the project may affect, but is not likely to adversely affect Indiana and long-eared bats. Confirmation with USFWS is in progress. Implementation of the Plan is anticipated to have minor positive benefits to both shortnose and Atlantic sturgeons, as it will provide habitat in the side channel for foraging and safety. There will be minor construction activities occurring along the Hudson River and Schodack Island to restore the side channel. Where these activities will occur on the shore is generally not sturgeon habitat; however, the activities may cause temporary increases in water turbidity. The District has determined that the project will not likely adversely affect Atlantic and shortnose sturgeon. NOAA Fisheries concurs with the District's determination.
State Species of Concern	Existing Conditions	The NYSDEC identified the endangered shortnose sturgeon (*Acipenser brevirostrum*) and threatened bald eagle (*Haliaeetus leucocephalus*) as potentially occurring at the site. Reports on eBird show bald eagles circling overhead at the site. There are no reports of shortnose sturgeon at the site.
	FWOP	The No Action Alternative would have no impact on state species of concern at the site.
	Recommended Plan	Implementation of the Plan is anticipated to have positive benefits to the shortnose sturgeon, as it will provide habitat in the side channel for foraging and safety. Surveys for bald eagles will occur prior to construction. If bald eagles are found near the construction site coordination with NYSDEC will determine the path forward, which will include but not limited to no construction during the breeding season.
Designated Critical Habitat	Existing Conditions	The USFWS has not designated any critical habitat in the site. The GARFO has identified the site as critical habitat for the Atlantic sturgeon.
	FWOP	The no action alternative will have no impact on Atlantic sturgeon critical habitat.
	Recommended Plan	Implementation of the Plan would have positive impacts to Atlantic sturgeon critical habitat, as it will provide more habitat with the restoration of the side channel.
Essential Fish Habitat	Existing Conditions	Utilizing NMFS's essential fish habitat (EFH) designation and the EFH Mapper, the Schodack Island site is potential essential fish habitat for various life stages of summer flounder (*Paralichthys dentatus*), winter flounder (*Pseudopleuronectes americanus*), little skate (*Leucoraja erinacea*), Atlantic herring (*Clupea harengus*), red hake (Urophycis chuss), windowpane flounder (*Scophthalmus aquosus*), winter skate (*Leucoraja ocellata*), and clearnose skate (*Raja eglanteria*). Kiviat & Samanns (2017) fish survey found none of the above species.
	FWOP	Under the No Action Alternative, the site's existing ratio of intertidal and upland area would change slightly with projected sea level rise. The net increase in the extent of intertidal areas with projected sea level rise would result in negligible beneficial impacts to EFH, as more areas become accessible to finfish inhabitation.
	Recommended Plan	In the short-term, temporary reductions in water quality due to construction activities associated with implementing the Plan would result in negligible adverse impacts to EFH species, if present.

RESOURCE	SCHODACK ISLAND	
	Condition	Description
		In the long-term, improvements to water quality, the expansion of intertidal areas on the site, and restoration of the historic connection between Schodack Creek and the Hudson River would result in beneficial impacts to EFH, as more areas become accessible to fish inhabitation. The side channel/tidal wetland corridor would also provide a velocity refuge for fish during storm events. In consultation with NOAA Fisheries, they provided conservation measures that the District will follow during construction (Appendix G1).
Cultural Resources	Existing Conditions	There are no archaeological sites or historic properties documented at the site. However, historic maps and firsthand accounts identify a Mahican Indian Village Site (08313.000238) at this location on the historic Island of Mull's Plaat. The existence of the site has not been confirmed through archaeological investigations but the Village is documented on several historic maps of the area and historical accounts. In addition to this there is a history of ice harvesting in the area and several ice houses have been documented on the Island. The archaeological and historical record and the results of previous cultural resources surveys at other locations within Schodack Island suggest that there is potential for both prehistoric and historic sites to exist within the dry and elevated areas of the study area especially within the vicinity of the historic islands.
	FWOP	Under the No Action Alternative no historic properties would be affected/No effect or Impact.
	Recommended Plan	A review of previous surveys and other background data indicates that there is potential for prehistoric and historic archaeological sites to exist within the project area. The proposed excavation of soil to restore a side channel and for the restoration of wetlands as well as the possible soil disturbance related to the construction of a new road crossing has the potential to adversely effect historic properties and archaeological sites located within the project site. Geotechnical surveys of the APE will be helpful in determining the potential for the proposed project to reach depths below dredge material deposits and additional surveys including limited subsurface testing is recommended once plans are further developed to determine the presence or absence of archaeological sites within the APE. Additional areas identified for staging and access should also be evaluated for impacts to cultural resources. A Programmatic Agreement signed July 6, 2020 outlines the steps that the Corps will take to carry out the remaining Section 106 responsibilities including conducting additional surveys, consulting with interested parties, determining adverse effects, and if necessary, mitigation for adverse effects (See Appendix G-5).
Air Quality	Existing Conditions	The USEPA Green Book provides detailed information about area National Ambient Air Quality Standards (NAAQS) designations, classifications, and nonattainment statuses (USEPA, 2018). The site is located in a region classified as "in attainment" for all pollutants tracked under the NAAQS including ozone (O_3), particulate matter (PM10 & PM2.5), sulfur dioxide (SO_2), lead (Pb), carbon monoxide (CO), and nitrogen dioxide (NO_2). There are no major sources of air pollutants (Title V facilities) on or in proximity to the site. Current on-site trucking activities may contribute to local air pollution, but the effect is likely insignificant.

RESOURCE	SCHODACK ISLAND	
	Condition	**Description**
	FWOP	There are no significant sources of air pollution present on the site. Therefore, the No Action Alternative would have no impact on air quality.
	Recommended Plan	In the short-term, negligible adverse impacts on local air quality from construction vehicles would occur temporarily during the construction period, which would have a projected duration of approximately two years. Temporary impacts associated with construction emissions would be mitigated through the implementation of air quality best management practices. Ultra-low sulfur diesel fuel would be used for all construction-related vehicles and non-road construction equipment, limiting SOx emissions. Fugitive dust control measures such as speed limit reductions, water or other dust suppressant application, and regular vehicle rinsing would be managed according to proper standards and procedures. In the long-term, implementing the Plan would have no impact on air quality.
Noise	Existing Conditions	The site currently consists of dense forested parkland and hiking trails. Potential sources of existing noise pollution on the site may include trucking activities, during times when dredged material is being transported for disposal at the southern tip of Schodack Island. Other local sources of noise pollution may include boating activities along the Hudson River and around the Port of Coeymans, which is located just across the river from the site.
	FWOP	There are no significant sources of noise pollution present on the site. Therefore, the No Action Alternative would have no impact on noise levels.
	Recommended Plan	In the short-term, minor adverse impacts on local noise levels from construction activities would occur temporarily during the construction period, which would have a projected duration of approximately two years. Construction activities would be limited to times of the day specified by local noise and construction ordinances. In the long-term, implementing the Plan would have no impact on local noise levels.
Recreation	Existing Conditions	What was to become Schodack Island State Park was first acquired by the New York State Office of Parks, Recreation, and Historic Preservation in the 1970s, and was originally known as Castleton Island State Park. It remained undeveloped until the early 2000s (Huey *et al.,* 1997). Schodack Island State Park was opened in 2002 and was initially a day-use only park. In 2013, plans were proposed to add camping facilities to the park, representing the first new campground constructed by the New York State Office of Parks, Recreation and Historic Preservation in approximately 35 years. The campsites were made available to the public in 2016 (Huey *et al.,* 1997). Prior to its designation as a State Park, Schodack Island was relatively inaccessible (National Audubon Society, 2018). Currently, eight miles of multi-use trails wind through a variety of ecological communities. In addition, the park has 66 campsites for use, an improved bike trail, volleyball nets, horseshoe, and a kayak and canoe launch site. Interpretive signage highlights the park's historic and environmental significance. According to a blog revolving around activities in the town of Schodack, many recreation events are

RESOURCE	SCHODACK ISLAND	
	Condition	Description
		hosted at the Schodack Island State Park, including a Winterfest with cross-country ski racing, snow shoeing, nature hikes, ice-skating, and dogsledding (Schodack Scene, 2015). In addition to being a state park, Schodack Island has also been designated a State Estuary. As noted previously, a portion of the park shelters a BCA that is home to Bald Eagle and Cerulean Warbler, and Great Blue Heron rookery. Osprey also roost and forage in the BCA. The western side of the Island, along the Hudson River shoreline, is predominately floodplain forest, and is of particular importance in regard to its use by bald eagles. These species, and others noted above, draw bird watchers to the island. Hunting is allowed in Schodack Island State Park for those holding a valid NYS hunting license, archery license, muzzle loading license, and/or turkey permit as required by Environmental Conservation Law. In addition, hunters must also be issued a special permit by the park itself (NYS Parks Recreation, and Historic Preservation, 2018).
	FWOP	The No Action Alternative would have no impact on the recreation at the site.
	Recommended Plan	In the short-term, minor adverse impacts to recreation would occur during the construction phase of the project. While none of the park's recreational facilities would be closed during the construction phase, increases in local noise levels and reduced aesthetics associated with construction activities may hinder recreational activities. In addition, there would likely be areas temporarily inaccessible to the public during construction for safety reasons. In the long-term, implementing the Plan would result in minor beneficial impacts to the site's recreational resources. The restoration of intertidal wetland would support fish and bird populations, expanding recreational opportunities for fishing and bird watching.
Aesthetics and Scenic Resources	Existing Conditions	The site is located within a designated Scenic Area of Statewide Significance (SASS), specifically the Columbia-Greene North SASS, in the CGN-4 Islands subunit (NYSDOS, 1993). According to the Scenic Area Study associated with this SASS (NYSDOS, 1993), the Islands subunit is included in the Columbia-Greene North SASS because "...it links distinctive subunits. The subunit constitutes the middle ground and background of views to the Hudson River from distinctive subunits on both the west and east banks of the Hudson, including views from the trains on the eastern shore and from NY Routes 61 and 9J…" As a SASS, Policy 24 of the Coastal Management Program requires that state agencies must ensure proposed actions "prevent impairment of scenic resources of statewide significance." (NYSDOS, 2017). Activities, which could impair or degrade scenic quality, include the modification of natural landforms, removal of vegetation, removal of existing structures, and the addition of structures that diminish scenic quality.
	FWOP	The No Action Alternative would have no impact on aesthetics and scenic resources.

RESOURCE	SCHODACK ISLAND	
	Condition	**Description**
	Recommended Plan	In the short-term, minor adverse impacts to aesthetic and scenic resources would occur during the construction phase of the project due to the presence of heavy equipment, material piles, staging areas, traffic control signs, disturbed land, and high visibility fencing. In the long-term, implementing the Plan would result in minor beneficial impacts to the site's aesthetic and scenic resources through the restoration of wetland habitat.
Hazardous, Toxic, and Radioactive Waste (HTRW)	Existing Conditions	In September 1984, the U. S. Environmental Protection Agency (USEPA) listed the Hudson River, Identification Number NYD980763841 on the CERCLA National Priorities List (NPL). A review of the databases yields no other sites within or near the Schodack Island site.
	FWOP	The No Action Alternative would have no impact on HTRW.
	Recommended Plan	There is no identified HTRW at the site; therefore, implementation of the Plan will not be impacted by HTRW.
Transportation and Other Infrastructure	Existing Conditions	Schodack Island State Park is located off NY-9J, a motor-vehicle road that is also a bicycle route. There is no other infrastructure within the park boundary.
	FWOP	The No Action Alternative would have no impact on transportation or infrastructure.
	Recommended Plan	In the short-term, minor adverse impacts to local traffic conditions would occur during the construction phase of the project due to the transport of material and heavy equipment. In the long-term, implementing the Plan would involve the construction of a road crossing over the proposed side channel tidal wetland connection. However, this road crossing would replace an existing access road and therefore have no impact on transportation and site access.

Table 5-2: Existing Conditions and Environmental Impacts to the Henry Hudson Park Site.

RESOURCE	HENRY HUDSON PARK	
	Condition	Description
Physical Conditions	Background	Henry Hudson Park is a public open space located on a 64.2-acre property on the west shore of the Hudson River, owned by the Town of Bethlehem, Albany County, New York. The park serves as the only public access location to the Hudson River within the Town of Bethlehem. Lyons Road traverses the park connecting it to other local residential roads and to NY Route 144 - River Road. The park is bound to the east by the Hudson River, and Vloman Kill traverses the southern portion of the park draining to the Hudson River. The area of the park to the south of Vloman Kill is inaccessible by foot from the main area of the park. The Henry Hudson Park shoreline is approximately 2,680 feet in length and approximately 600 feet from the Hudson River's main navigation channel (Ocean and Coastal Consultants, 2011). Approximately 15 acres of the park is managed as recreational open space, including parking areas, a pavilion, boat launches for motorized craft, kayaks, canoes and other hand-powered craft, picnic areas, a softball field, a playground, a volleyball court, and a floating fishing platform. The remaining area is primarily undisturbed, including upland forest and vegetated areas adjacent to Vloman Kill. The recreational area of the park is located immediately adjacent to Lyons Road, and in the area between Lyons Road and the Hudson River. This area is relatively flat, ranging in elevation from approximately 7 to 9 feet (NAVD88), and is primarily turf with large shade trees interspersed. In general, narrow widths, extensive shoals, and a relatively steep river bottom resulting in higher water velocities characterize this reach of the Hudson River. The channel has been highly modified due to dredging of the deepwater navigational channel in the 19th and 20th centuries. Shorelines have also been modified from dredged sediment disposal as well as rock and timber cribs used to contain dredge spoils (Allen et al., 2006). At Henry Hudson Park, the site shoreline was built up beginning in the 1860's from dredged materials that were placed and contained with timber cribs containing riprap stone. Based on historic topographic surveys, the site was underwater until 1925, when the navigation channel was dredged to a depth of 27 feet, later deepened to 32 feet in 1954 (Ocean and Coastal Consultants, 2011). The park’s shorelines vary in condition. The northern section of the Hudson River shoreline is lined with riprap. The riprap in this section is in good condition and no significant signs of erosion are present. This section also contains a boat ramp which, based on historic aerial imagery, was constructed between 1994 and 2004. The southern section of the Hudson River shoreline consists of a dilapidated timber cribbing structure built in the 1920s, filled with riprap between two timber crib walls, and capped with convex concrete segments. The majority of the structure has either partially or completely failed. The crib walls are severely decomposed, the concrete cap has detached and displaced, and riprap has moved from between the crib walls into the river. In sections of complete structural failure, upland areas show signs of erosion and are inundated during high tides. The

RESOURCE	HENRY HUDSON PARK	
	Condition	**Description**
		cribbing structure extends southward and terminates along the mouth of Vloman Kill, sheltering a small cove. This cove contains an unvegetated, tidal mudflat area showing signs of erosion. The restoration site (hereafter referred to as “the site”), where proposed actions would be implemented, is limited to the Park’s Hudson River shoreline area, and a 3.5-acre riparian area on the river left side of Vloman Kill approximately 1,900 feet upstream from its confluence with the Hudson River.
Geology and Physiography	Existing Conditions	The site is within the Hudson-Mohawk Lowlands physiographic region. The Hudson River flows from the southeastern Adirondacks, through a 15- to 20-mile-wide lowland area, which is bounded by the Helderberg Plateau and the Catskill Mountains to the west, and the Taconic Mountains to the east. This section of the Hudson River Valley consists of a narrow inner valley with adjacent terraces approximately 100-200 feet high, bordered by gently rolling terrain and low hills (NYSDOT, 2013). The valley is underlain by weak sedimentary rock, primarily formed during the Cambrian and Lower Ordovician periods. Specifically, the Henry Hudson site is mapped as underlain by the Austin Glen Formation, which consists of highly folded, interbedded greywacke sandstone and shale that formed in a deep marine setting from the erosion of pre-existing sedimentary rocks (NYS Museum, 1995). In general, the surficial geology of the region is heavily influenced by its history of glaciation, including glacial till and lacustrine sediment deposited during the most recent glacial advance and retreat 70,000 to 16,000 years ago. The Hudson River has since reworked these sediments, and the site is currently mapped as alluvium (NYS Museum, 1991).
	FWOP	The No Action Alternative would have no impact on geology or physiography.
	Recommended Plan	Construction activities under the Plan would occur at shallow depths. Therefore, the Plan would have no impact on geology nor physiography.
Topography	Existing Conditions	As discussed above, the area of the Hudson River Valley consists of a low-lying inner valley, bordered by steep slopes to terraces 100-200 feet high. The site is located within the inner valley on a river terrace close in elevation to the Hudson River. Based on a 2011–2012 LiDAR (Light Detection and Ranging) dataset developed by the New York State Department of Environmental Conservation (NYSDEC), the topography of the site is generally low-lying and gently sloping, with the majority of the site sitting at an elevation of less than 10 feet (NAVD88) (NYSDEC, 2011 - 2012).
	FWOP	Under the No Action Alternative, the shoreline at the site would continue to be susceptible to topographic change by erosion due to wave and tidal action, the continued deterioration of existing shoreline structures, and the projected increase in storm frequency and intensity with climate change (NYSDEC, 2018b).
	Recommended Plan	Excavation and re-grading under the Plan would permanently alter on-site topography. Overall, implementing the Plan would result in moderate impacts to topography. Topographic changes along the shoreline would be minimal. The existing concrete cap would be removed and replaced with

RESOURCE	HENRY HUDSON PARK	
	Condition	**Description**
		vegetated riprap and graded to achieve a 1V:3H slope. These modifications would enhance the shoreline's stability by dissipating erosive forces. More extensive topographic changes would occur in the proposed western tidal wetland restoration along the Vloman Kill. Approximately 3.6 acres of existing upland would be excavated to an average depth of five feet below existing grade to achieve tidal wetland hydrology.
Soils	Existing Conditions	Soils data and soils descriptions for the Henry Hudson Park were acquired from the National Resources Conservation Service (NRCS) Web Soil Survey for Albany County, New York. The park was mapped as two soil types: Udipsamments, dredged and Teel silt loam (NRCS, Web Soil Survey). **Udipsamments, dredged** soils are made up of deep, level areas of well-drained sand and gravel, formed from soil material pumped from the Hudson River. Typically, sandy material containing up to 35% gravel is deposited in layers up to 10 feet thick on top of the original soil. They are well drained, with a typical depth to water table of greater than 80 inches. **Teel silt loam** soils are very deep, moderately well drained soils found on floodplains of major streams, formed from silty alluvium. The seasonal high-water table for these soils is 18 to 24 inches from February to April and is occasionally flooded from November to May. It is not classified as hydric.
	FWOP	Under the No Action Alternative, the soils along the site's shoreline would be subject to moderate adverse impacts from soil erosion due to wave and tidal action, the continued deterioration of existing shoreline structures, and the projected increase in storm frequency and intensity with climate change (NYSDEC, 2018b).
	Recommended Plan	In the short-term, the Plan would result in negligible adverse impacts on soil resources due to soil erosion during the construction phase of the project. Erosion and sediment control practices would be implemented to minimize soil erosion and the deposition of sediment into surface waters. An Erosion and Sediment Control Plan would be prepared and approved before any construction activities would commence. In the long term, implementing the Plan would result in moderate beneficial impacts to soil resources through the placement of riprap and restoration of wetlands, which reduce shoreline erosion by stabilizing sediments and absorbing and dissipating wave energy (Hammer, 1992).
Climate and Weather	Existing Conditions	A National Weather Service (NWS) station is located approximately 10 miles southwest of the site, at the Alcove Dam. Records for this station are available between 1942 and 2018, via the Agricultural Applied Climate Information System (AgACIS). Records at this station indicate that between 1942 and 2018, average monthly temperatures ranged for 21.1°F in January to 69.5°F in July (AgACIS, 2018). Average annual precipitation was 39.74 inches, with monthly averages ranges from 2.18 inches in February to 3.89 inches in June. Average annual snowfall was 29.5 inches,

RESOURCE	HENRY HUDSON PARK	
	Condition	Description
		primarily occurring between December and March. The average number of days with 0.10 inches of precipitation or more was 76 days per year; such precipitation days occurred at a roughly equally rate per month (5-8 days per month).
	FWOP	The No Action Alternative would have no impact on the climate or weather at the site.
	Recommended Plan	Implementing the Plan would have no impact on the climate or weather at the site.
Climate Resiliency	Existing Conditions	According to the Intergovernmental Panel on Climate Change (IPCC) Special Report released in October of 2018, human activities have caused approximately 1.0°C of global warming above pre-industrial levels, causing many land and ocean ecosystems to change. The same report also stated that, "model-based projections of global sea level rise (relative to 1986-2005) suggest an indicative range of 0.26 to 0.77 m by 2100 for 1.5°C of global warming… Increasing warming amplifies the exposure of small islands, low-lying coastal areas and deltas to the risks associated with sea level rise for many human and ecological systems, including saltwater intrusion, flooding and damage to infrastructure" (IPCC, 2018). Climate projections developed by New York State indicate a future increase in temperatures, precipitation, sea levels, and severity of flooding (NYSDEC, 2018b). The State's average annual temperature is expected to increase approximately four to six degrees Fahrenheit by mid-century and as much as 11 degrees Fahrenheit by 2100. The total annual precipitation is expected to increase as much as 11% by mid-century and 18% by 2100. Since 1900, sea level in the lower Hudson has risen 13 inches. Sea level rise along the Hudson River is projected to continue; the Hudson River is projected to rise a minimum of nine additional inches by 2050, with mid-range projections of approximately 10 to 20 inches by 2050. These changing climatic factors will likely alter flooding patterns in the Hudson River; it is projected that today's 1% storm will become 20% to 50% more likely by 2020 and as much as 610% more likely by 2100. Given its location along the Hudson River Shoreline, Henry Hudson will likely be significantly affected by any changes in climate and hydrology patterns. Both Albany County and the Town of Bethlehem are participants in the NYS Climate Smart Communities Program, an interagency initiative of New York State, which aims to engage and educate local governments in New York State, provide a robust framework to guide their climate action efforts, and recognize their achievements through a certification program (New York State, 2018). While neither governing body has implemented the required climate programs and policies to achieve certification from the program, both have been designated as Registered Climate Smart Communities after committing to such programs and policies via passing a Climate Smart Community pledge as a formal resolution. The Town of Bethlehem has established a Local Waterfront Advisory Committee to aid in the development of a Local Waterfront Revitalization Plan (LWRP). The LWRP is still in development as

RESOURCE	HENRY HUDSON PARK	
	Condition	Description
		of January 2019. A draft LWRP references Henry Hudson Park as a municipal asset that is vulnerable to the projected sea level rise (Town of Bethlehem, 2018). The final LWRP is expected to include a master plan for Henry Hudson Park and develop waterfront revitalization policies.
	FWOP	Under the No Action Alternative, predicted sea level rise, and increasing storm frequency and intensity may result in moderate adverse impacts to the site (NYSDEC, 2018b).
	Recommended Plan	Stabilization of the shoreline under the Plan would result in a minor beneficial impact to climate resiliency by enhancing the shoreline's resistance to greater erosive forces associated with climate change.
Floodplains	Existing Conditions	The site lies completely within the one percent floodplain (AE Zone) with a base flood elevation of 18 feet (NAVD88), as shown on the Flood Insurance Rate Map (FIRM), effective as of March 16, 2015 (Firm Panel No.: 36001C0317D) (FEMA, 2015). Additionally, the shoreline portion of the site, within approximately 30 feet of the Hudson River, is within the regulatory floodway. No habitable structures lie within the floodplain in vicinity the site. A United States Geological Survey (USGS) stream gage is located approximately 6 miles upstream of the project area on right bank of the Hudson River at the Port of Albany (NWIS Site No.: 01359165) (USGS, 2018). Records for this gage begin on September 30, 2016 and the gage is under continuous operation as of December 5, 2018. During this period, the maximum water elevation was 7.41 feet (NAVD88) on April 7, 2017, and the minimum water elevation was -4.20 feet on February 14, 2017. A USGS Short-Term Network (STN) Monitoring site is located approximately one mile downstream of the project site in Castleton-on-Hudson (STN Site No.: NYCOL07401) (USGS, 2012). After Hurricane Sandy in 2012, a high-water mark was recorded at elevation of approximately 10 feet (NAVD88) at this site.
	FWOP	Under the No Action Alternative, the site would continue to be subject to flooding given its location within the Hudson River's one percent floodplain. New York State projects that the one percent storm may be 1.5 to 3.3 inches higher by 2100 (NYSDEC, 2018b), resulting in negligible adverse impacts to the site's floodplain.
	Recommended Plan	Under the Plan, the site would remain within the Hudson River's one percent floodplain. Excavation along the northern banks of Vloman Kill, associated with tidal wetland restoration, would slightly increase local flood storage during precipitation events, resulting in negligible beneficial impacts to the site's floodplain.
Surface Waters	Existing Conditions	Located within the Middle Hudson Watershed (HUC-8 No.: 02020006), the Hudson River and Vloman Kill are the primary surface water bodies at the site, with the Moordener Kill entering the Hudson River directly across from the site. The Hudson River forms the eastern boundary of the site, while Vloman Kill delineates the southern boundary. The Hudson River has a drainage area of approximately 8,530 square miles to the Henry Hudson site (USGS Streamstats, Accessed

RESOURCE	HENRY HUDSON PARK	
	Condition	**Description**
		December 2018). The federal Troy Lock and Dam in part controls water levels in the Hudson River located in Troy, approximately 18 miles upstream. This dam marks the upstream extent of tidal influence in the Hudson River. The Vloman Kill drainage area is a small subset of the Hudson River drainage area, with an area of approximately 30.6 square miles (USGS Streamstats).
	FWOP	Under the No Action Alternative, the Hudson River would continue to constitute the site's only surface water body. The projected sea level rise of 1.07 feet by 2075 would not inundate Henry Hudson Park. Therefore, the No Action Alternative would have no impact on surface waters.
	Recommended Plan	Implementing the Plan would result in minor impacts to the site's surface waters. Surface water area on the site would be expanded due to excavation along the northern banks of Vloman Kill, associated with tidal wetland restoration.
Water Quality	Existing Conditions	Vloman Kill and the Hudson River are both classified as Class C water bodies, which support fisheries and are suitable for non-contact recreation (6 CRR-NY X B Article 10- Lower Hudson River Drainage Basin Series). The Hudson River in Albany County is on the 2016 EPA 303(d) list as "impaired" due to fish consumption advisories from sediment contaminated with polychlorinated biphenyls (PCBs)(USEPA, 2016).
	FWOP	Under the No Action Alternative, the shoreline at the site would continue to be susceptible to soil erosion due to wave and tidal action, and the continued deterioration of existing shoreline structures. Soil erosion along the shoreline would increase turbidity in the Hudson River, resulting in negligible adverse impacts to water quality.
	Recommended Plan	In the short-term, implementing the Plan would result in negligible adverse impacts on water quality due to increases in turbidity during the construction phase of the project. Erosion and sediment control practices would be implemented to minimize the deposition of sediment into surface waters. The risk of potential fuel spills and machinery leakage would be minimized by restricting maintenance, refueling, and storage of construction equipment to an upland staging area. In the long-term, implementing the Plan would result in minor beneficial impacts to water quality through the reduction of soil erosion along the shoreline and the restoration of approximately 3.7 acres of tidal wetland. Wetlands improve local water quality through their ability to efficiently fix nitrogen, store phosphorous, retain sulfur, promote sediment deposition, and immobilize and decrease the bioavailability of metals in inundated sediments (Gosselink, Odum & Pope, 1974; Mitsch & Gosselink, 1993; Novotny & Olem, 1994; Carter 1997).
Regional Hydrogeology and Groundwater	Existing Conditions	In general, aquifers in the Hudson Valley are unconfined, and related to thick layers of sediment glacially deposited over bedrock. The New York State Department of Conservation Division of Water, Bureau of Water Resources Management (NYS GIS Clearinghouse, 2018), has identified one aquifer at the Henry Hudson site. This aquifer is described as an unconfined, high yield aquifer with a yield of greater than 100 gallons per minute. The aquifer is composed of sand and gravel deposits, with high transmissivity and a saturated thickness greater than 10 feet. The mapped aquifer generally follows the footprint of the Hudson River and associated alluvium deposits and

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	Condition	**Description**
		overlaps with the western edge of the site. However, this aquifer was mapped at a 1:250,000 scale based on published surficial and bedrock geology maps and the boundaries of this aquifer indicate the general location only.
	FWOP	The No Action Alternative would have no impact on the hydrogeology or the groundwater.
	Recommended Plan	Implementing the Plan would have no impact on the hydrogeology or the groundwater.
Tidal Influences	Existing Conditions	A NOAA tide station is located in the Hudson River at the City of Albany, approximately 7.5 miles upstream of the site (Station: 8518995, Albany, Hudson River) (NOAA, 2011). At this station, the low and lower low tide levels are -1.59 and -1.81 feet (NAVD88), respectively; while the high and higher high tide levels are 3.4 and 3.78 feet (NAVD88), respectively.
	FWOP	Sea level rise is projected to occur in the tidal Hudson River, which would shift the intertidal areas landward of their current extents. According to Scenic Hudson's Sea level Rise Mapper, during mean higher high tide and under 30 inches of sea level rise, the waters of the Hudson River and Vloman Kill would begin to inundate the recreational areas of Henry Hudson Park. In addition, under 60 inches of sea level rise; Vloman Kill would completely inundate this area (Scenic Hudson, 2018). However, the projected sea level rise of 1.07 feet by 2075 would not inundate Henry Hudson Park. Therefore, the No Action Alternative would have no impact on tidal influences.
	Recommended Plan	Implementing the Plan would result in minor impacts to tidal influence by increasing the intertidal areas of the park by approximately 3.7 acres through the excavation along the northern banks of Vloman Kill, associated with tidal wetland restoration.
Land Use and Zoning	Existing Conditions	Henry Hudson Park is within the Town of Bethlehem protected open space. This open space consists of upland forest, riparian habitat, and a recreational area, which includes an access road, playground, baseball field, parking lots, and maintained turf. This open space is owned and operated by the Town of Bethlehem. Land uses in the vicinity of the site contain a mix of forested land and low-density residential properties. A water treatment plant is also located adjacent to the site, across the Vloman Kill. Historically, the site was part of the Hudson River's open water. According to a Shoreline Stabilization Study prepared for the Town of Bethlehem (Ocean and Coastal Consultants, 2011), the site was constructed from dredged material in the 1860s. The site is located within the Town of Bethlehem's Rural Riverfront (RR) zoning district. This zone is regulated under Chapter 128 of the Bethlehem municipal code. This district generally zones for low-density residential, or agricultural-oriented development. Habitat restoration is not explicitly regulated under the town's municipal zoning code. Pursuant to §24-0501 of the New York State Freshwater Wetlands Act (Article 24 of the New York Environmental Conservation Law), the towns of Bethlehem have fully accepted responsibility with

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	Condition	**Description**
		regard to activities subject to regulation under the Act within officially designated freshwater wetlands.
	FWOP	The No Action Alternative would have no impact on the land use or zoning at the site. Given the site's status as a protected open space, it is unlikely that the area would be significantly developed in the future, outside of recreational land uses.
	Recommended Plan	Implementing the Plan would have no impact on the land use or zoning at the site.
Economics	Existing Conditions	The Town of Bethlehem has made a strong commitment to fostering economic development and diversification of the Town's tax base. The policy basis for this commitment is clear in the Town's 2005 Town Comprehensive Plan. In 2011, the Bethlehem 20/20 Committee prepared the Economic Development Strategy that included several elements to guide economic development initiatives. Several of these initiatives have been addressed or are ongoing as a result of the hiring of an Economic Development Coordinator in 2014 (Town of Bethlehem, 2018). Ecotourism is an important economic driver in this region, as the natural and scenic resources draw millions of visitors to New York's recreation areas (USFWS, 2006). Many people come from out of town to pursue wildlife-associated recreation, outdoor sporting, angling, hunting, and wildlife watching, bringing with them business for local restaurants, hotels, shops, etc. According to a report by the United States Fish and Wildlife Service (USFWS), 3.8 million people watch birds and other wildlife in New York State, generating approximately $1.6 billion in ecotourism revenue every year (USFWS, 2006).
	FWOP	Under the No Action Alternative, Henry Hudson Town Park would continue to serve as an open space to local residences. However, the shoreline of the park would continue to degrade over time, and the park's recreational functions may become compromised as a result. Reduced recreational capacity over time would likely lower the parks economic value and reduce its local economic benefits, resulting in a minor adverse impact on local economic conditions.
	Recommended Plan	Implementing the Plan may have some incidental economic impacts on local economic conditions. Ecotourism, outdoor recreation, fishing, and boating may increase as a result of the improved conditions.
Socio-Economics	Existing Conditions	According to the U.S. Census Bureau (USCB) American Community Survey 5-year survey for 2013-2017 (USCB, 2013-2017), the population in the Town of Bethlehem, NY is an estimated 33,656 people, and is predominantly white. The median age in the Town of Bethlehem, NY is approximately 42.8 years of age and median household income is $96,384. An estimated 14,485 occupied housing units are present within the town, with a majority of structures being built in 1990 to 1999 (2,154 structures). Approximately 97.0% of the population are high school graduates or higher while 58.6% of the population have a bachelor's degree or higher. The estimated number of companies in the Town of Bethlehem is 3,119. The civilian employed population 16 and over is an estimated 18,384 people.

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	Condition	Description
		Of this employed population, an estimated 10,719 people work in management, business, science, and arts occupations, 1,957 people in service occupations, 3,927 in sales and office occupations, 863 in natural resources, construction, and maintenance occupations, and 918 in production, transportation, and material moving occupations. The closest airport to the study area is a small, private, single runway airport (South Albany Airport-4b0) which is located approximately 4 miles northwest of the site. The natural features in the recommended alternative are outside the minimum separation criteria set forth in the FFA Advisory Circular 150/5200-33B and the Memorandum of Agreement with the FAA and therefore would not be expected to introduce hazardous wildlife attractants to the airport.
	FWOP	The No Action Alternative would have no impact on local socio-economic conditions.
	Recommended Plan	Implementing the Plan may have some incidental positive socio-economic impacts. Ecotourism, outdoor recreation, fishing, educational opportunities, job creation from construction, and boating may increase because of the improved conditions.
Environmental Justice	Existing Conditions	According to the New York State Department of Environmental Conservation's Maps & Geospatial Information System (IGST) Tools for Environmental Justice data set, the site is not located within an Environmental Justice area (NYSDEC, 2018c).
	FWOP	There are no environmental justice populations in proximity to this site. Therefore, the No Action Alternative would have no impact on environmental justice populations.
	Recommended Plan	There are no environmental justice populations in proximity to this site. Therefore, implementing the Plan would have no impact on environmental justice populations.
Coastal Zone Management	Existing Conditions	The entire Hudson River downstream of the Federal Lock and Dam in Troy, New York, is a designated Coastal Area. Coastal areas are subject to regulation under the federal Coastal Zone Management Act, and managed under the New York Coastal Management Program. The landward boundary of the coastal area is typically 1,000 feet inland from the shoreline. Henry Hudson Park is adjacent to an area designated as a Significant Coastal Fish and Wildlife Habitat (SCFWH) under the New York State Coastal Management Program, known as 'Shad and Schermerhorn Islands'. Vloman Kill serves as a shared boundary between the park and the designated SCFWH (NYSDOS, 2012). The Town of Bethlehem is in the process of developing a LWRP, currently in draft stage (Town of Bethlehem, 2018), which provide more detailed implementation of the state Coastal Zone Management Program. Upon approval of the LWRP, state and federal actions within the town would be required to be consistent, to the maximum extent practicable, with the approved LWRP, and the town would become eligible for waterfront revitalization grants.

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	Condition	Description
	FWOP	The No Action Alternative would have no impact on any areas regulated under the New York Coastal Zone Management Program. State and or municipal entities may initiate a project at the site in the future. Any state agency action performed at the site (i.e. direct undertaking, financial assistance, or permitting) would require review by the Coastal Zone Management Program to ensure consistency with coastal policies established in Department of State regulations 19 NYCRR Part 600.
	Recommended Plan	Proposed actions under the Plan would occur in areas regulated under the New York Coastal Zone Management Program. The proposed actions would be consistent with the overall objectives of the Coastal Management Program. In particular, implementing the Plan would promote Coastal Policy 44 through the restoration of approximately 3.7 acres of freshwater tidal wetland, resulting in minor beneficial impacts on coastal resources.
Wetlands	Background	Specific wetland communities were identified in July 2018 using Evaluation of Planned Wetlands (EPW). Wetland communities existing, future without project conditions (year 50) and forecasted (years 2, 20 and 50) following implementation of the Recommended Plan are detailed in Appendix D.
	Existing Conditions	The USFWS National Wetland Inventory (NWI) map indicates the presence of both freshwater emergent wetlands and freshwater forested/shrub wetlands at the Henry Hudson site. The Hudson River and Vloman Kill are mapped as riverine environments. Additionally, the NYSDEC's Hudson River Estuary Program has mapped tidally influenced wetlands as a separate effort in 2007 based off aerial photographs (NYSDEC, 2007). This program did not identify any tidally influenced wetlands at the Henry Hudson site.
	FWOP	Under the No Action Alternative, sea level rise is projected to occur in the tidal Hudson River, which would shift wetlands landward of their current extents. Intertidal wetlands would become permanently flooded resulting in loss of wetland vegetation, however current landward extend of wetlands would extent into the upland resulting in new wetlands and wetland vegetation.
	Recommended Plan	In the short-term, construction activities associated with implementing the Plan would have no impact on any wetlands. In the long term, the Plan would result in moderate beneficial impacts to wetlands through the restoration of approximately 3.7 acres of tidal wetland habitat.
Vegetation	Background	Specific wetland/vegetation communities were identified in July 2018 using Evaluation of Planned Wetlands (EPW). Wetland/vegetation communities existing, future without project conditions (year 50) and forecasted (years 2, 20 and 50) following implementation of the Recommended Plan are detailed in Appendix D.
	Existing Conditions	Approximately 15 acres of the park is managed as recreational open space, containing turf areas, picnic areas, playgrounds, and athletic fields. The remaining area is primarily undisturbed, and has been mapped as emergent wetlands, scrub shrub wetlands, forested wetland, upland deciduous

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	Condition	Description
		forest, and upland evergreen forest (NYS GIS Clearinghouse, 2018). All community descriptions were acquired from Ecological Communities of New York State, 2nd Edition (Edinger et al., 2014). Emergent wetlands are characterized by cattails (*Typha spp*.), sedges (*Carex spp*.), marsh fern (*Thelypteris palustris*), spike rushes (*Eleocharis spp*.), bulrushes (*Scirpus spp*.), and sweetflag (*Acorus americanus*). The invasive common reed (*Phragmites australis*) is also present (Edinger et al., 2014). Scrub shrub wetlands may contain alder (*Alnus incana*), red osier dogwood (*Cornus sericea*), silky dogwood (*Cornus amomum*), or willows (*Salix spp.*). Also common are meadowsweet (*Spiraea spp*.), gray dogwood (*Cornus racemosa*), swamp azalea (*Rhododendron viscosum*), highbush blueberry (*Vaccinium corymbosum*), and spicebush (*Lindera benzoin*). Forested wetlands typically contain trees and shrubs including green ash (F*raxinus pensylvanicus*), black ash (*Fraxinus nigra*), red maple (*Acer rubrum*), slippery elm, alders (*Alnus spp.*), spicebush, arrowwood (*Vibernum dentatum*), dogwoods (*Cornus spp.*), Virginia creeper (*Parthenocissus cinquefolia*) and poison ivy (T*oxicodendron radicans*). Common herbaceous species include rice cutgrass (*Leersia oryzoides*), sensitive fern (*Onoclea sensibilis*), spotted jewelweed (*Impatiens capensis*), and skunk cabbage (*Symplocarpus foetidus)*. Deciduous and evergreen forests commonly contain trees such as sugar maple, red maple, yellow birch (*Betula alleghaniensis*), black birch (*Betula lenta*), red oak (*Quercus rubra*), American beech (*Fagus grandifolia*), white ash (*Fraxinus americana*), chestnut oak (*Quercus montana*), white oak (*Quercus alba*), white pine (*Pinus strobus*), red pine (*Pinus resinosa*), and eastern hemlock (*Tsuga canadensis*).
	FWOP	Under the No Action Alternative, sea level rise is projected to occur in the tidal Hudson River, which would shift intertidal areas landward of their current extents. As this shift occurs, some of the trees proximate to the sites shoreline may be lost due to increasing groundwater saturation, resulting in negligible adverse impacts to vegetation.
	Recommended Plan	In the short-term, construction activities associated with implementing the Plan would result in minor adverse impacts to vegetation due to site clearing, grading, and the movement of personnel and equipment across the site during construction. These areas would be restored and replanted as necessary post-construction. Tree protection and high visibility fencing will be installed during construction to reduce the risk of unnecessary damage to trees and other vegetation. In the long-term, implementing the Plan would result in a moderate beneficial impact to vegetation due to the conversion of approximately 0.2 acres of mudflat to tidal wetland at the confluence of Vloman Kill, and the addition of vegetated riprap along the Hudson River shoreline. Additionally, some areas of mowed turf grass and non-native invasive vegetation would be replaced with native vegetation as part of the tidal wetland restoration along the northern banks of Vloman Kill.

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	Condition	**Description**
Shellfish	Existing Conditions	No information regarding the presence, absence, or composition of shellfish communities on the site is readily available. Typically, there are fresh water clams, mussels, and invasive zebra mussels in this habitat.
	FWOP	The No Action Alternative would have no impact on shellfish or their habitat.
	Recommended Plan	In the short-term, temporary reductions in water quality due to construction activities associated with implementing the Plan would result in negligible adverse impacts to shellfish, if present. In the long-term, improvements to water quality and the expansion of intertidal areas on the site would result in negligible beneficial impacts to shellfish, as more areas become accessible to shellfish inhabitation.
Finfish	Existing Conditions	Henry Hudson Park is adjacent to the area designated as a SCFWH under the New York State Coastal Management Program, known as 'Shad and Schermerhorn Islands'. According to the Coastal Fish and Wildlife Rating Form (NYSDOS, 2012) associated with this SCFWH, Shad and Schermerhorn Islands contains habitats serving as a nursery area for blueback herring (*Alosa aestivalis*), American shad (*Alosa sapidissima*), striped bass (*Morone saxatilis*) as well as spawning and feeding areas for resident freshwater species in the Hudson River, including white perch (*Morone americana*). Given Henry Hudson Park's proximity to this area, these species may also occur in the waters surrounding the park, especially in sheltered Vloman Kill.
	FWOP	The No Action Alternative would have no impact on finfish or their habitat.
	Recommended Plan	In the short-term, temporary reductions in water quality due to construction activities associated with implementing the Plan would result in negligible adverse impacts to finfish, if present. In the long-term, improvements to water quality and the expansion of intertidal areas on the site would result in negligible beneficial impacts to finfish, as more areas become accessible to fish inhabitation. The removal of all three structures would, collectively, reconnect 7.8 miles of high-quality spawning habitat and would benefit important migratory fish species including American shad, striped bass, alewife, blueback herring, and American eel.
Benthic Resources	Existing Conditions	According to Hudson River Estuary Program Benthic Mapping Project (NYSDEC, 2006), the bottom sediment of Vloman Kill is comprised of sandy mud (mud with >10% sand). The bottom sediment of the Hudson River in this area is comprised of muddy sand (sand with >10% mud) along the shoreline, and is part of a thickly lain, depositional sediment region.
	FWOP	The No Action Alternative would have no impact on benthic resources.
	Recommended Plan	Under the Plan, the conversion of approximately 3.7 acres of upland habitat to intertidal habitat would increase the extent of benthic habitat, and therefore provide minor beneficial impacts to benthic resources.
Reptiles and Amphibians	Existing Conditions	According to the Coastal Fish and Wildlife Rating Form associated with the designated SCFWH (NYSDOS, 2012), Shad and Schermerhorn Islands supports a variety of amphibians and reptiles

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	Condition	**Description**
		including northern map turtle (*Graptemys geographica*), painted turtle (*Chrysemys picta*), mudpuppy (*Necturus maculosus*), American toad (*Bufo americanas*), bullfrog (*Rana catesbeiana*), and green frog (*Rana clamitans*). Given Henry Hudson Park's proximity to this area, these species may also occur in the waters and wetlands within the park, especially in the sheltered Vloman Kill.
	FWOP	The No Action Alternative would have no impact on reptiles, amphibians, or their respective habitats.
	Recommended Plan	In the short term, temporary disturbances to vegetation and reductions in water quality due to construction activities associated with implementing the Plan would result in negligible adverse impacts to reptiles and amphibians, if present. In the long-term, improvements to water quality and the conversion of approximately 3.7 acres of upland habitat to intertidal habitat on the site would result in minor beneficial impacts to intertidal reptile and amphibian species and minor adverse impacts to upland reptile and amphibian species.
Birds	Existing Conditions	According to the USFWS Migratory Bird Program, the project area is located within the North America Atlantic Flyway for migratory birds, which is a critical corridor for migrating birds (USFWS, 2018). According to the eBird database, managed by Cornell Lab of Ornithology, as January 8, 2019, 155 species of birds have been documented within Henry Hudson Park (eBird, 2012). The most common species that have been observed on the site include brant (*Branta bernicla*), common grackle (*Quiscalus quiscula*), Canada goose (*Branta canadensis*), American robin (*Turdus migratorius*), American crow (*Corvus brachyrhynchos*), and red-winged blackbird (*Agelaius phoeniceus*). According to the Coastal Fish and Wildlife Rating Form associated with the designated SCFWH (NYSDOS, 2012), Shad and Schermerhorn Islands support the breeding and foraging of ruffed grouse (*Bonasa umbellus*), American bittern (*Botaurus lentiginosus*), and many passerine bird species. Given Henry Hudson Park's proximity to this area, these species may also occur in the Park.
	FWOP	The No Action Alternative would have no impact on birds or their habitat.
	Recommended Plan	In the short-term, temporary disturbances to vegetation and reductions in water quality due to construction activities associated with implementing the Plan would result in negligible adverse impacts to birds, if present. In the long-term, improvements to water quality and the conversion of approximately 3.7 acres of upland habitat to intertidal habitat on the site would result in minor beneficial impacts to shorebirds and minor adverse impacts to upland bird species.

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	Condition	**Description**
Mammals	Existing Conditions	According to the Coastal Fish and Wildlife Rating Form associated with the designated SCFWH (NYSDOS, 2012), Shad and Schermerhorn Islands supports mammal species including white-tailed deer (*Odocoileus virginianus*) and eastern cottontail (*Sylvilagus floridanus*). Given Henry Hudson Park's proximity to this area, these species may also occur in the park.
	FWOP	The No Action Alternative would have no impact on mammals or their habitat.
	Recommended Plan	In the short term, temporary disturbances to vegetation and reductions in water quality due to construction activities associated with implementing the Plan would result in negligible adverse impacts to mammals, if present. In the long-term, improvements to water quality and the conversion of approximately 3.7 acres of upland habitat to intertidal habitat on the site would result in minor beneficial impacts to aquatic mammalian species and minor adverse impacts to upland mammalian species.
Federal Species of Concern	Existing Conditions	The USFWS iPac system identified the threatened northern long-eared bat (*Myotis septentrionalis*) as potentially occurring at the site. There are no reports of northern long-eared bats at the site. Coordination with GARFO identified the shortnose sturgeon and Atlantic sturgeon as potentially occurring at the site.
	FWOP	The No Action Alternative would have no effect on federal species of concern.
	Recommended Plan	There are no known hibernaculum within ¼ mile of the site. There is no plan to remove large trees, habitat for the bats. With these two measures in place, the District has determined that the project will have no effect to northern long-eared bats through the implementation of the Plan. Implementation of the Plan would have positive benefits to both sturgeon species, as it may provide habitat in the shoreline with the rocky habitat and the restoration of the wetlands. Implementation of the Plan is anticipated to have no impacts to both shortnose and Atlantic sturgeons. In accordance with the NLAA Program, GARFO PRD concurs with USACE's determination that the action complies with all applicable PDC and is not likely to adversely affect listed species or critical habitat.
State Species of Concern	Existing Conditions	The NYSDEC identified the endangered shortnose sturgeon (*Acipenser brevirostrum*) and threatened bald eagle (*Haliaeetus leucocephalus*) as potentially occurring at the site. Report on eBird show Bald Eagles circling overhead at the site. There are no reports of shortnose sturgeon at the site.
	FWOP	The No Action Alternative would have no impact on state species of concern.
	Recommended Plan	During construction of the Plan, any sturgeon that may be near the site would be able to vacate the area and would not be impacted. There may be positive benefits to the sturgeon with the rocky habitat and the restoration of the wetlands. Bald eagles observed at site are presumably flyovers. However, prior to construction a survey for bald eagle nesting will be conducted. If a nesting bald eagle is observed within ¼ mile of the construction, the District will coordinate with the USFWS and

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	Condition	Description
		the NYSDEC on how to proceed. With these measures in place, the implementation of the Recommended Plan will not impact any state species of concern.
Designated Critical Habitat	Existing Conditions	The USFWS has not designated any critical habitat in the site. The GARFO has identified the site as critical habitat for the Atlantic sturgeon.
	FWOP	The No Action Alternative would have no impact on Designated Critical Habitat.
	Recommended Plan	Implementation of the Plan would have positive impacts to Atlantic sturgeon critical habitat, as it will provide more habitat with the restoration of the rocky habitat and wetlands.
Essential Fish Habitat	Existing Conditions	Utilizing NMFS's essential fish habitat (EFH) designation and the EFH Mapper, the site is potential essential fish habitat for various life stages of summer flounder (*Paralichthys dentatus*), winter flounder (*Pseudopleuronectes americanus*), little skate (*Leucoraja erinacea*), Atlantic herring (*Clupea harengus*), red hake (Urophycis chuss), windowpane flounder (*Scophthalmus aquosus*), winter skate (*Leucoraja ocellata*), and clearnose skate (*Raja eglanteria*). There are no reports of the above EFH species at the site.
	FWOP	Under the No Action Alternative, the site's existing ratio of intertidal and upland area would change slightly with projected sea level rise. The net increase in the extent of intertidal areas with projected sea level rise would result in negligible beneficial impacts to EFH, as more areas become EFH.
	Recommended Plan	In the short term, temporary reductions in water quality due to construction activities associated with implementing the Plan would result in negligible adverse impacts to EFH, if present. In the long-term, improvements to water quality and the expansion of intertidal areas on the shoreline Hudson River and the Vloman Kill would result in minor beneficial impacts to EFH, as more areas become accessible to fish inhabitation. The side tidal wetland habitat would also provide a velocity refuge for fish during storm events. In consultation with NOAA Fisheries, they provided conservation measures that the District will follow during construction (Appendix G1).
Cultural Resources	Existing Conditions	There are three prehistoric archaeological sites and eight historic archaeological sites documented within one mile of the site. Evidence of a Native American presence in the area has been well documented in the archaeological record and through early historical accounts. The Bethlehem Ancestral Repatriation Site (00102.000892) is a Native American burial that was recovered just 0.2 miles south of the site. The presence of several previously documented historic and prehistoric archaeological sites in the vicinity suggests that the area was utilized heavily both in precontact and contact periods and therefore there is a moderate potential for archaeological sites to exist within undisturbed areas at the site. The shoreline of Henry Hudson Park has been built up through the years with dredge material and therefore the shoreline has a low potential of containing archaeological remains, however, there is moderate potential for deeply buried prehistoric archaeological sites to exist below the dredge material. Though the shoreline contains deep

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	Condition	Description
		deposits of dredge material, the wetland area along the Vloman Kill most likely has not been filled to the same extent and is considered sensitive for both prehistoric and historic archaeological remains.
	FWOP	Under the No Action Alternative no historic properties would be affected/No effect or Impact.
	Recommended Plan	The presence of several previously documented historic and prehistoric archaeological sites in the vicinity suggests that the area was utilized heavily both in precontact and contact periods. Considering that the shoreline portion of the study area contains deep dredge material deposits, the potential for historic archaeological remains to exist within the area of proposed shoreline stabilization measures is low. The 3.6 acre proposed wetland area along the bank of the Vloman Kill, however, is believed to have a moderate to high potential for historic and prehistoric remains due to its proximity to a river confluence and the discovery of several historic and prehistoric sites in the vicinity. A pedestrian survey and archaeological testing is recommended for the proposed wetland area to determine the presence or absence of archaeological sites and a geomorphological study is recommended to understand the depositional profile of the shoreline. Additionally, as plans are developed, additional areas including staging and access areas should be subject to a cultural resources assessment. A Programmatic Agreement signed July 6, 2020 outlines the steps that the Corps will take to carry out the remaining Section 106 responsibilities including conducting additional surveys, consulting with interested parties, determining adverse effects, and if necessary, mitigation for adverse effects (See Appendix G-5).
Air Quality	Existing Conditions	The USEPA Green Book provides detailed information about area National Ambient Air Quality Standards (NAAQS) designations, classifications, and nonattainment statuses (USEPA, 2018). The site is located in a region classified as "in attainment" for all pollutants tracked under the NAAQS including ozone (O_3), particulate matter (PM10 & PM2.5), sulfur dioxide (SO_2), lead (Pb), carbon monoxide (CO), and nitrogen dioxide (NO_2). There are no major sources of air pollutants (Title V facilities) on or in proximity to the site. Current on-site boating activities may contribute to local air pollution, but the effect is likely insignificant. The LWRP also noted that the Dinmore Road Wastewater Treatment Plant located immediately south of the Henry Hudson Park can detract from the experience at the park, particularly on weekends and holidays; offensive odor emissions associated with the treatment process can cause a nuisance to the enjoyment of the park (Town of Bethlehem, 2018).
	FWOP	There are no significant sources of air pollution present on the site. Therefore, the No Action Alternative would have no impact on air quality.
	Recommended Plan	In the short-term, negligible adverse impacts on local air quality from construction vehicles would occur temporarily during the construction period, which would have a projected duration of approximately one year. Temporary impacts associated with construction emissions would be mitigated through the implementation of air quality best management practices. Ultra-low sulfur

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	Condition	**Description**
		diesel fuel would be used for all construction-related vehicles and non-road construction equipment, limiting SOx emissions. Fugitive dust control measures such as speed limit reductions, water, or other dust suppressant application, and regular vehicle rinsing would be managed according to proper standards and procedures. In the long-term, Implementing the Plan would have no impact on air quality. The Plan would slightly increase vegetation cover on the site, but not at a level that would significantly alter local air quality.
Noise	Existing Conditions	The site currently consists of recreational parkland. Land in vicinity of the site is largely undeveloped but include some low-density residences and a water treatment plant. Potential sources of existing noise pollution on the site may include recreational activities, such as baseball and boating activities around the site's boat launches. A small, single runway airport (South Albany Airport-4b0) is also located approximately 4 miles northwest of the site; planes passing above the site to or from this airport may also contribute to local noise pollution.
	FWOP	There are no significant sources of noise pollution present on the site. Therefore, the No Action Alternative would have no impact on noise levels.
	Recommended Plan	In the short-term, minor adverse impacts on local noise levels from construction activities would occur temporarily during the construction period, which would have a projected duration of approximately one year. Construction activities would be limited to times of the day specified by local noise and construction ordinances. In the long-term, implementing the Plan would have no impact on local noise levels.
Recreation	Existing Conditions	The Henry Hudson Park has many recreation facilities including a boat launch for motorized craft, a boat launch for kayaks, canoes, and other hand-powered craft, picnic areas with grills, a softball field, a playground, a volleyball court, horseshoes area, a gazebo, a pavilion, and an accessible fishing area all for public, recreational use (Town of Bethlehem, 2015). A handicap accessible floating fishing platform structure is available in the spring through fall seasons; in the winter, the platforms are taken out of the water and stored on land to protect them from damages due to the harsh winter conditions along the Hudson River (Ocean and Coastal Consultants, 2011). Large vessel wakes have caused damage to docks and bulkheads along the shoreline of the park in the past (Ocean and Coastal Consultants, 2011). The motorized boat launch is located at the north end of the park and is operated in cooperation with NYSDEC. On the south end of the park, with access on the Vloman Kill, is a boat launch designed for kayaks, canoes, and other hand-powered boats. The park's boat launch is the only public boat launch site in the Town of Bethlehem, and one of only three Hudson River public boat launch sites in Albany County (NYSDEC, 2018a). The park also has the largest parking capacity of any of Albany County's public Hudson River boat launch sites, able to accommodate approximately 35 vehicles and trailers.

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	Condition	**Description**
		The Town's draft LWRP generally describes Henry Hudson Park as a valuable recreational resource, providing the community with opportunities to fish, launch boats, picnic, recreate, and enjoy scenic view (Town of Bethlehem, 2018).
	FWOP	As previously stated, under the No Action Alternative the site would remain vulnerable to the deterioration of existing shoreline structures and may be subject to the effects of climate change such as sea level rise. These factors could comprise the site's recreational facilities, resulting in a minor adverse impact to recreational resources.
	Recommended Plan	In the short-term, minor adverse impacts to recreation would occur during the construction phase of the project. While none of the park's recreational facilities would be closed during the construction phase, increases in local noise levels and reduced aesthetics associated with construction activities may hinder recreational activities. In addition, there would likely be areas temporarily inaccessible to the public during construction for safety reasons. In the long-term, implementing the Plan would result in minor beneficial impacts to the site's recreational resources. Stabilization of the shoreline would reduce the risk of erosive forces impacting the park's recreational infrastructure and the restoration of approximately 3.7 acres of intertidal wetland would support fish and bird populations, expanding recreational opportunities for fishing and bird watching.
Aesthetics and Scenic Resources	Existing Conditions	The Town of Bethlehem's LWRP identified Henry Hudson Park, being the primary local access point to the Hudson River, as a scenic resource (Town of Bethlehem, 2018). The site is not designated as a Scenic Areas of Statewide Significance (SASS) under the New York Coastal Management Program. However, Policy 25 of the Coastal Management Program requires that state agencies must ensure proposed actions in the coastal zone "Protect, restore or enhance natural and man-made resources which are not identified as being of statewide significance, but which contribute to the overall scenic quality of the coastal area." (NYSDOS, 2017). Activities, which could impair or degrade scenic quality, include the modification of natural landforms, removal of vegetation, removal of existing structures, and the addition of structures that diminish scenic quality.
	FWOP	Under the No Action Alternative, the site's shoreline would be subject erosion and the continued deterioration of existing shoreline structures due to wave and tidal action resulting in a minor adverse impact to the shoreline's aesthetics.
	Recommended Plan	In the short-term, minor adverse impacts to aesthetic and scenic resources would occur during the construction phase of the project due to the presence of heavy equipment, material piles, staging areas, traffic control signs, disturbed land, and high visibility fencing. In the long-term, implementing the Plan would result in minor beneficial impacts to the site's aesthetic and scenic resources through the replacement of the dilapidated concrete capping along the shoreline with vegetated riprap.

RESOURCE	HENRY HUDSON PARK	
	Condition	**Description**
Hazardous, Toxic, and Radioactive Waste (HTRW)	Existing Conditions	In September 1984, the U. S. Environmental Protection Agency (USEPA) listed the Hudson River, Identification Number NYD980763841on the CERCLA National Priorities List (NPL) A review of the databases yields no other sites within or near the Henry Hudson Park site. There may be remnant agricultural chemicals at the site, as some areas have been used for agriculture since 1940 and older forms of pesticides can result in lead, arsenic, and other contamination.
	FWOP	The No Action Alternative would have no impact on HTRW.
	Recommended Plan	There are no identified HTRW at the site; therefore, implementation of the Plan will not be impacted by HTRW.
Transportation and Other Infrastructure	Existing Conditions	Lyons Road loops through Henry Hudson Park, serving as the park's main access road. The park's closest major roadway connections are State Route 114 and Interstate 87. The Town's draft LWRP recommends pedestrian and bicyclist accommodations, such as reduced speed limits and enhanced road crossing, along Route 114 to support access to Henry Hudson Park (Town of Bethlehem, 2018). As mentioned above, a small, single runway airport (South Albany Airport-4b0) is also located approximately 4 miles northwest of the site. As previously discussed, Henry Hudson Park serves as the town's primary public access to the Hudson River Waterfront. The Town's draft LWRP recommends a policy of encouraging and enhancing the access to the Hudson River via the Henry Hudson Park (Town of Bethlehem, 2018).
	FWOP	The No Action Alternative would have no impact on transportation or infrastructure.
	Recommended Plan	In the short-term, minor adverse impacts to local traffic conditions would occur during the construction phase of the project due to the transport of material and heavy equipment. The proposed restoration site is close to the federal channel making it, and construction vessels, susceptible to wake and or surge damage. During construction, coordination with the First Coast Guard District (Sector New York) will be required for publication in the Local Notice to Mariners before starting operations and if needed, request the movement of any federal channel marker buoys. In the long-term, implementing the Plan would have no impact on transportation or infrastructure.

Table 5-3: Existing Conditions and Environmental Impacts to the Moodna Creek Site.

RESOURCE	MOODNA CREEK	
	Conditions	**Description**
Physical Setting	Background	Three proposed restoration sites lie along Moodna Creek, in Orange County, New York. These restoration sites (hereafter referred to as AOP1, AOP2, and AOP3), where proposed actions would be implemented, are each limited to a barrier structure and its adjacent waters. AOP1, AOP2, and AOP3 lie approximately 1.8, 3.0, and 3.7 miles upstream, respectively, from the confluence of Moodna Creek and the Hudson River. AOP1 lies on the border between the towns of Cornwall and New Windsor. AOP1 contains a concrete encased, decommissioned sewer line, which forms a weir that creates a vertical drop of water approximately 2 feet in height. A deep scour hole is present on the downstream side of this structure. AOP2 lies within the Town of Cornwall and contains a dam structure known as Firth Cliff Dam, which stands 9 feet high, and 162 feet long. This dam once provided hydro mechanical power to a former textile-manufacturing factory, which has since been demolished. The remains of this industrial property lie adjacent to the AOP2 site, on river right. Due to the narrow riverine impoundment and steep confining valley walls, this dam impounds mainly bedload sediment (sand, gravel, cobble, and boulder); most finer grain sizes (silt and clay), pass through to downstream reaches. AOP3 lies within the Town of Cornwall and contains a dam structure known as Orr's Mill Dam, which stands 10 feet tall and 18 feet long. The Orr's Mill Dam is located directly upstream of the State Route 32 crossing. The dam is in poor condition as suggested by the cracks and holes in its spillway.
Geology and Physiography	Existing Conditions	Moodna Creek is located at the transition between the Hudson-Mohawk Lowlands and Hudson Highlands physiographic provinces. The lowlands area situated to the north of Moodna Creek is underlain by weak sedimentary rock, primarily formed during the Cambrian and Lower Ordovician periods (NYSDOT, 2013). This area is mapped as the Normanskill Formation, which is characterized as dark green to black argillaceous shale containing calcareous and chert beds (NYS Museum, 1995). Post-deposition, the Normanskill shale was folded into a series of hills and valleys trending north-south (Laberge Group, 2011). The Hudson Highlands to the south of Moodna Creek are rugged mountainous terrain with ridges and valleys trending northeast to southwest. Bedrock is dominantly crystalline and has been metamorphosed. These rocks were originally emplaced during the Proterozoic period and have been since undergone several episodes of deformation associated with continental collisions, including extensive folding and metamorphism (NYSDOT, 2013). The area to the south of Moodna Creek is mapped as various granitis, gneisses, and paragneisses (NYS Museum, 1995). Additionally, the surficial geology of the region is heavily influenced by its history of glaciation, including glacial till and lacustrine sediment deposited during the most recent glacial advance and retreat 70,000 to 16,000 years ago. Moodna Creek itself is mapped as alluvium, with surrounding areas mapped primarily as

RESOURCE		MOODNA CREEK
	Conditions	**Description**
		till and includes areas of outwash sand and gravel, lacustrine deltas, and kame deposits (NYS Museum, 1991).
	FWOP	The No Action Alternative would have no impact on geology or physiography.
	Recommended Plan	Construction activities under the Plan would occur at shallow depths. Therefore, the Plan would have no impact on geology or physiography.
Topography	Existing Conditions	Moderate gradient, cobble-boulder riffles and rapids, extended pools, and narrow floodplains confined by steep, erodible valley walls generally characterize the main stem of Moodna Creek. As discussed above, the creek is located in an area where the lower relief and broader floodplains of the Hudson Valley lowlands are transitioning to the more rugged topography and narrow valleys of the Hudson Highlands. AOP1 is at an elevation of approximately 50 feet (NAVD88), with AOP2 and AOP3 at an elevation of 117 and 163 feet, respectively (NYSDEC, 2011 - 2012).
	FWOP	Under the No Action Alternative, the site could to be susceptible to topographic change by erosion due to wave and tidal action, and the projected increase in storm frequency and intensity with climate change (NYSDEC, 2018a).
	Recommended Plan	Implementing the Plan would result in minor impacts to the topography of each site. At all sites, direct manipulation of riverbed and bank topography, in addition to the placement of boulders in the case of AOP1 and AOP3, would occur to stabilize channels and allow potential fish passage under altered flow conditions after barrier removal. Passive topographic changes to the riverbed may also occur over time under altered hydraulic conditions.
Soils	Existing Conditions	Soils data and soils descriptions for the Moodna Creek site were acquired from the National Resources Conservation Service (NRCS) Web Soil Survey for Orange County, NY. The three barriers at the Moodna Creek site are associated with six different soil types: Mardin gravelly silt loam, Middlebury silt loam, Otisville, Hoosic gravelly sandy loam, Swartswood, and the Udifluvents-Fluvaquents complex (frequently flooded) (NRCS, Web Soil Survey). **Mardin gravelly silt loam** soils are very deep, moderately well drained soils formed from loamy till on glaciated uplands. They have a dense fragipan starting at a depth of 14 to 26 inches, and typically have a perched water table during wet periods. **Middlebury silt loam** is a moderately well drained soil found on flat floodplains, and is composed of silt loam, sandy loam, and gravelly fine sand. This soil is derived from loamy alluvium predominantly from areas of shale and sandstone with some lime-bearing material. It is not rated as hydric. The **Otisville** series are very deep, excessively drained soils consisting of gravelly sandy loam over very gravelly sand. These soils are formed on outwash plains and terraces, from sandy and gravelly glaciofluvial deposits, and have high permeability.

RESOURCE		MOODNA CREEK
	Conditions	Description
		Hoosic gravelly sandy loam soils are formed from sandy and gravelly glaciofluvial deposits on deltas, outwash plains, and terraces. They are very deep and somewhat excessively well drained, with rapid permeability. The **Swartswood** series are deep, well-drained soils consisting of gravelly loam over gravelly fine sandy loam. They are found on hills and till plains and are formed rom till derived primarily from gray and brown quartzite, conglomerate, and sandstone. **Udifluvents-Fluvaquents complex** soils are found in flat areas on floodplains. Fluvaquents are formed from silt loam over gravelly silt loam, located in low areas that flood frequently. They are poorly drained and rated as hydric. Udifluvents are found in slightly higher areas and are composed of gravelly fine sandy loam over gravelly sandy loam. They are moderately well drained, with a typical depth to water of 24-72 inches, and are not rated as hydric. Both are formed from alluvium with a highly variable texture and have variable profiles.
	FWOP	Under the No Action Alternative, the soils may be subject to minor adverse impacts from soil erosion due to the projected increase in storm frequency and intensity with climate change (NYSDEC, 2018b).
	Recommended Plan	In the short-term, the Plan would result in negligible adverse impacts on soil resources due to soil erosion during the construction phase of the project. Erosion and sediment control practices would be implemented to minimize soil erosion and the deposition of sediment into surface waters. An Erosion and Sediment Control Plan would be prepared and approved before any construction activities would commence. In the long-term, The Plan would have no impact on soils at the sites.
Climate and Weather	Existing Conditions	A National Weather Service (NWS) station is located approximately 6.5 miles southwest of the site, in West Point, New York. Records for this station are available between 1890 and 2018 via the Agricultural Applied Climate Information System (AgACIS). Records at this station indicate that between 1890 and 2018, average monthly temperatures ranged for 27.8°F in January to 74.5°F in July (AgACIS, 2018). Average annual precipitation was 47.07 inches, with monthly averages ranges from 3.09 inches in February to 4.35 inches in July. Average annual snowfall was 38.3 inches, primarily occurring between December and March. The average number of days with 0.10 inches of precipitation or more was 79 days per year; such precipitation days occurred at a roughly equally rate per month (6-8 days per month).
	FWOP	The No Action Alternative would have no impact on the climate nor weather at any of the three sub-sites.
	Recommended Plan	The Plan would have no impact on the climate nor weather at the sites.
Climate Resiliency	Existing Conditions	According to the Intergovernmental Panel on Climate Change's (IPCC) Special Report 15, released in October of 2018, human activities have caused approximately 1.0° C (1.8° F) of global warming above pre-industrial levels, causing many land and ocean ecosystems to change. The same report also stated that, "model-based projections of global sea level rise (relative to 1986-2005) suggest an indicative range of 0.26

RESOURCE		MOODNA CREEK
	Conditions	Description
		to 0.77 m (0.85 to 2.5 ft.) by 2100 for 1.5° C (1.8° F)of global warming… Increasing warming amplifies the exposure of small islands, low-lying coastal areas and deltas to the risks associated with sea level rise for many human and ecological systems, including saltwater intrusion, flooding and damage to infrastructure” (IPCC, 2018). Climate projections developed by New York State indicate a future increase in temperatures, precipitation, sea levels, and severity of flooding (NYSDEC, 2018a). The State’s average annual temperature is expected to increase approximately four to six degrees Fahrenheit by mid-century and as much as 11 degrees Fahrenheit by 2100. The total annual precipitation is expected to increase as much as 11% by mid-century and 18% by 2100. Since 1900, sea level in the lower Hudson has risen 13 inches. Sea level rise along the Hudson River is projected to continue; The Hudson River is projected to rise a minimum of nine additional inches by 2050, with mid-range projections of approximately 10 to 20 inches by 2050. These changing climatic factors will likely alter flooding patterns in the Hudson River; it is projected that today’s 1% storm will become 20 to 50% more likely by 2020 and as much as 610% more likely by 2100. Orange County is a participant in the NYS Climate Smart Communities Program, an interagency initiative of New York State, which aims to engage and educate local governments in New York State, provide a robust framework to guide their climate action efforts, and recognize their achievements through a certification program (New York State, 2018). The county’s implementation of climate programs and policies, including commitments to reduce vulnerability to natural hazards, conserve natural habitats, and support green infrastructure, have led the county to be awarded with a ‘silver certified’ status by the NYSDEC office of climate change.
	FWOP	Under the No Action Alternative, increasing storm frequency and intensity may result in moderate adverse impacts to the sites (NYSDEC, 2018b).
	Recommended Plan	Implementing the Plan may result in a beneficial impact to climate resiliency by reducing flood elevations upstream of AOP2 and AOP3, mitigating the effects of increasing precipitation and storm intensity associated with climate change (NYSDEC, 2018a). Detailed hydrologic and hydraulic analysis would be required to affirm the extent and magnitude of this effect. This will occur during the next phase of the project.
Floodplains	Existing Conditions	All three sites lie primarily within one percent floodplain (AE Zone) and partially in the 0.2 percent floodplain (X Zone) as shown on Flood Insurance Rate Maps (FIRM), effective as of August 3, 2009 (FIRM Panel No.: 36071C0333E and 36071C0341E) (FEMA, 2009a)(FEMA, 2009b). AOP 1 and AOP 2 also lie within the regulatory floodplain. Base flood elevations range from 53 to 59 feet (NAVD88) at AOP 1, 119 to 124 feet (NAVD88) at AOP 2, and 162 to 170 feet (NAVD88) at AOP 3. No habitable structures lie within the Moodna Creek floodplain in vicinity of any of the sites.

RESOURCE		MOODNA CREEK
	Conditions	**Description**
	FWOP	Under the No Action Alternative, the site would continue to be subject to flooding given its location within the Hudson River's one percent floodplain. New York State projects that the one percent storm may be 1.5 to 3.3 inches higher by 2100 (NYSDEC, 2018b), resulting in negligible adverse impacts to the sites.
	Recommended Plan	Under the Plan, the sites would remain within the Moodna Creek's one percent floodplain. Implementing the Plan would result in a beneficial impact to floodplains upstream of AOP2 and AOP3 by increasing flood storage along the Moodna Creek floodplain during precipitation and reducing flood elevations. Detailed hydrologic and hydraulic analysis would be required to affirm the extent and magnitude of this effect. Implementing the Plan would have no impact on floodplain in the vicinity of AOP1, as AOP1 does not form a significant impoundment on Moodna Creek.
Surface Waters	Existing Conditions	Located within the Hudson-Wappinger Watershed (HUC-8 02020008), Moodna Creek is the primary surface water body at the three sites. Moodna Creek is a tributary to the Hudson River, and has a total drainage area of approximately 180 square miles (USGS, Streamstats). AOP1 is located approximately 1.7 miles above the confluence with the Hudson River, and AOP2 and AOP3 are located 2.9 and 3.5 miles upstream of the confluence respectively. Several smaller tributaries join Moodna Creek throughout this reach. The Moodna Creek Watershed is the only major watershed located entirely within Orange County (other large watersheds, such as the Wallkill and Ramapo, extend into adjoining counties and states). The watershed includes parts of 22 towns and villages in Orange County (OCWA, 2010b).
	FWOP	The No Action Alternative would have no impact on surface waters at the sites.
	Recommended Plan	Implementing the Plan would result in moderate beneficial impacts to the site's surface waters through the removal of barriers along Moodna Creek. Surface water hydrology would be restored to a more natural condition and normal water surface elevation would drop the upstream vicinity of the AOP2 and AOP3.
Water Quality	Existing Conditions	Moodna Creek is classified as a Class C water body, which support fisheries and are suitable for non-contact recreation (6 CRR-NY X B Article 10- Lower Hudson River Drainage Basin Series). Moodna Creek is not listed as impaired on the 2016 USEPA 303(d) list (USEPA, 2016).
	FWOP	Under the No Action Alternative, Moodna Creek would continue to be impounded by AOP2 and AOP3. Impounded waters typically have elevated temperatures, decreased oxygen levels, and can trap sediments and nutrients (Gregory et al., 2002). Therefore, the No Action Alternative would result in minor adverse impacts to water quality.
	Recommended Plan	In the short-term, implementing the Plan would result in negligible adverse impacts on water quality due to increases in turbidity during the construction phase of the project. Erosion and sediment control practices would be implemented to minimize the deposition of sediment into surface waters. The risk of potential fuel spills and machinery leakage would be minimized by restricting maintenance, refueling, and storage of construction equipment to an upland staging area.

RESOURCE		MOODNA CREEK
	Conditions	**Description**
		In the long-term, implementing the Plan would result in moderate beneficial impacts to water quality in the vicinity of AOP2 and AOP3, decreasing water temperatures and increasing dissolved oxygen levels, through the removal of the impoundments. Implementing the Plan would have no impact on water quality in the vicinity of AOP1, as AOP1 does not form a significant impoundment on Moodna Creek. Hydrologic & hydraulic analysis at AOP1 (utility line) results indicate that its removal would mobilize a volume of impounded sediment that is equivalent to less than 1% of the annual watershed sediment yield volume. At AOPs 2 (Firth Cliff Dam) and 3 (Orrs Mill), results indicate that the removal would mobilize a volume of impounded sediment that is equivalent to 4-10% of the annual watershed sediment yield volume. Therefore, the removal of AOPs 2 and 3 may have short-term adverse impact (suspended sediment concentration and turbidity) on water quality due to the release of fine-grained impounded sediments. This risk should be further investigated during the PED phase of this project and will be considered as part of the monitoring and adaptive management and in related coordination with the resource agencies.
Regional Hydrogeology and Groundwater	Existing Conditions	This area of Moodna Creek is not associated with any major aquifer. Upper Moodna Creek and its tributary Woodbury Creek have extensive confined and unconfined aquifers. However, the reach associated with this project has small pockets of unconfined aquifers associated with glacial surface deposits in the vicinity, but are disconnected from the stream (OCWA, 2010a).
	FWOP	The No Action Alternative would have no impact on hydrogeology nor groundwater.
	Recommended Plan	Implementing the Plan may result in minor impacts on local shallow groundwater flows in the vicinity of AOP2 and AOP3 due to alterations to surface water elevations and surface water flow. Implementing the Plan would have no impact on groundwater flows in the vicinity of AOP1.
Tidal Influences	Existing Conditions	Moodna Creek is tidal only at the mouth of the creek. There are no tidal influences at the AOP sites.
	FWOP	The No Action Alternative would have no impact on tidal influences.
	Recommended Plan	The Recommended Plan would have no impact on tidal influences.
Land Use and Zoning	Existing Conditions	Each site lies primarily within the open waters of Moodna Creek. AOP1 lies within the Town of New Windsor, while AOP2 and AOP3 lie within the Town of Cornwall. Land uses near the sites primarily contain a mix of forested land and low to moderate density residential properties. Additionally, there is a vacant, ex-industrial site adjacent to AOP2. Historically, the Firth Cliff and Orr's Mill dams served to provide hydro mechanical power to adjacent industrial sites. It is not known when the dams were constructed, but historic USGS topographic mapping document both dam structures as far back as 1930.

RESOURCE		MOODNA CREEK
	Conditions	Description
		AOP1 is located within the Town of New Windsor's Suburban Residential (R-3) zoning district. This zone is regulated under Chapter 300 of the New Windsor municipal codes and generally zones for low to moderate density residential development. AOP2 is split between two zones within the Town of Cornwall, the planned commercial district (PCD) on river right, and suburban residence (SR-1) zoning district on river left. These zones are regulated under Chapter 158 of the Cornwall municipal codes. The planned commercial district zones for light agricultural, recreational, institutional, or commercial development. The suburban residence district zones for low-density residential or light agricultural development. AOP3 lies entirely within the Town of Cornwall suburban residence (SR-1) zoning district. The zoning transitions to the mountain and conservation residence (MCR) zoning district approximately 200 feet upstream of the site. The MCR district zone is for low-density residential, light agricultural, or timber production development. Habitat restoration and dam removals are not explicitly regulated under either town's municipal code.
	FWOP	The No Action Alternative would have no impact on the land use or zoning at the site.
	Recommended Plan	Implementing the Plan would have no impact on the land use or zoning at the site.
Economics	Existing Conditions	Although much of what was once farmland has since regrown into forest or been developed into urban or suburban uses, agriculture remains a vital component of the economic, scenic, and ecological fabric of the watershed. Today, farmland is largely clustered in the central, western, and northern reaches of the watershed where the topography is more inviting for grazing of livestock or cultivation of crops. The appealing farm views within the Towns of Goshen, Hamptonburgh, Blooming Grove, Chester, Cornwall, and New Windsor attract many tourists and residents and improve the quality of life. Five of the County's Special Scenic Areas are within the watershed and two of these are agricultural views: Oxford Depot (Blooming Grove) and Kings Highway (Chester) (OCWA, 2010b). Ecotourism is an important economic driver in this region, as the natural and scenic resources draw millions of visitors to New York's recreation areas (USFWS, 2006). Many people come from out of town to pursue wildlife-associated recreation, outdoor sporting, angling, hunting, and wildlife watching, bringing with them business for local restaurants, hotels, shops, etc. According to a report by the United States Fish and Wildlife Service (USFWS), 3.8 million people watch birds and other wildlife in New York State, generating approximately $1.6 billion in ecotourism revenue every year (USFWS, 2006).
	FWOP	The No Action Alternative would have no impact on local economic conditions.
	Recommended Plan	Implementing the Plan may have some incidental economic impacts on local economic conditions. Ecotourism, outdoor recreation, fishing, and boating may increase as a result of the improved conditions.

RESOURCE		MOODNA CREEK
	Conditions	**Description**
Socio-Economics	Existing Conditions	All three sites are located within the town boundaries of Cornwall and one site is partially located in the Town of New Windsor, New York in Orange County. According to the US Census Bureau (USCB) American Community Survey 5-year survey for 2013-2017 (USCB, 2013-2017), the population in the Town of Cornwall, NY is an estimated 12,646 people, and is predominantly white. The median age in the Town of Cornwall, NY is approximately 42.8 years of age and median household income is $89,520. An estimated 5,071 occupied housing units are present within the town, with a majority of structures being built in 1939 or earlier (1,664 structures). Approximately 94.3% of the population are high school graduates or higher while 47.6% of the population have a bachelor's degree or higher. The estimated number of companies in the Town of Cornwall is 805. The civilian employed population 16 and over is an estimated 6,250 people. Of this employed population, an estimated 2,987 people work in management, business, science, and arts occupations, 840 people in service occupations, 1,693 in sales and office occupations, 313 in natural resources, construction, and maintenance occupations, and 417 in production, transportation, and material moving occupations. The population in the Town of New Windsor, NY is an estimated 26,799 people and is predominantly white. The median age in the Town of New Windsor, NY is approximately 38.6 years of age and median household income is $77,210. An estimated 10,426 occupied housing units are present within the town, with a majority of structures being built in 1960 to 1969 (1,666 structures). Approximately 94.2% of the population are high school graduates or higher while 30.9% of the population have a bachelor's degree or higher. The estimated number of companies in the Town of New Windsor is 1,962. The civilian employed population 16 and over is an estimated 13,586 people. Of this employed population, an estimated 5,273 people work in management, business, science, and arts occupations, 2,423 people in service occupations, 3,438 in sales and office occupations, 887 in natural resources, construction, and maintenance occupations, and 1,565 in production, transportation, and material moving occupations.
	FWOP	The No Action Alternative would have no impact on local socio-economic conditions.
	Recommended Plan	Implementing the Plan may have some incidental positive socio-economic impacts. Ecotourism, outdoor recreation, fishing, educational opportunities, job creation from construction, and boating may increase because of the improved conditions.
Environmental Justice	Existing Conditions	According to the New York State Department of Environmental Conservation's Maps & Geospatial Information System (IGST) Tools for Environmental Justice data set, none of the sites are located within an Environmental Justice area (NYSDEC, 2018b).
	FWOP	There are no environmental justice populations in proximity to this site. Therefore, the No Action Alternative would have no impact on Environmental Justice populations.
	Recommended Plan	There are no environmental justice populations in proximity to this site. Therefore, implementing the Plan would have no impact on environmental justice populations.

RESOURCE		MOODNA CREEK
	Conditions	**Description**
Coastal Zone Management	Existing Conditions	Moodna Creek downstream of the Orr's Mill Dam is located within a designated Coastal Area, subject to regulation under the federal Coastal Zone Management Act,and managed under the New York Coastal Management Program. The New York State Department of State (NYSDOS) has designated Moodna Creek downstream of the Orr's Mill Dam as a Significant Coastal Fish and Wildlife Habitat. Based on an evaluation by the New York State Department of Environmental Conservation (NYSDEC), this area is considered significant because it consists of a major freshwater tributary to the Hudson River that is accessible to migratory fishes (NYSDOS, 2012).
	FWOP	The No Action Alternative would have no impact on any areas regulated under the New York Coastal Zone Management Program. State and/or municipal entities may initiate a project at any of the sites in the future. Any state agency action performed downstream of AOP1 (i.e. direct undertaking, financial assistance, or permitting) would require review by the Coastal Zone Management Program to ensure consistency with coastal policies established in Department of State regulations 19 NYCRR Part 600.
	Recommended Plan	Proposed actions under the Plan would occur in areas regulated under the New York Coastal Zone Management Program. The Plan would be consistent with the overall objectives of the Coastal Management Program. In particular, implementing the Plan would promote Coastal Policy 7, through the restoration of a Significant Coastal Fish and Wildlife Habitat by removing barriers to the upstream migration of aquatic organisms, resulting in major beneficial impacts on coastal resources.
Wetlands	Existing Conditions	The USFWS National Wetland Inventory (NWI) map does not indicate the presence of wetlands at the Moodna Creek sites. The area around AOP3 is mapped as a freshwater pond. AOP1 and AOP2 are mapped as riverine environments.
	FWOP	There are no wetlands present on any of the sites. Therefore, the No Action Alternative would have no impact on wetlands.
	Recommended Plan	In the long-term, implementing the Plan would result in a negligible beneficial impact on wetlands at AOP2 and AOP3 due to exposure previously impounded lands, which may naturally revert to wetlands. Since Moodna Creek is generally characterized by narrow floodplains confined by steep valley walls, it is likely that these areas would not be extensive. Implementing the Plan would have no impact on wetlands at AOP1.
Vegetation	Existing Conditions	The area around the Moodna Creek sites is mapped as a mixture of upland deciduous forest and upland evergreen forest (NYS GIS, 2018). Deciduous and evergreen forests commonly contain trees such as sugar maple (*Acer saccharum*), red maple (*Acer rubrum*), yellow birch (*Betula alleghaniensis*), black birch (*Betula lenta*), red oak (*Quercus rubra*), American beech (*Fagus grandifolia*), white ash (*Fraxinus americana*), chestnut oak (*Quercus montana*), white oak (*Quercus alba*), white pine (*Pinus strobus*), red pine (*Pinus resinosa*), and eastern hemlock (*Tsuga canadensis*; Edinger et al., 2014).

RESOURCE		MOODNA CREEK
	Conditions	**Description**
	FWOP	The No Action Alternative would have no impact on vegetation located at any of the sites.
	Recommended Plan	In the short-term, construction activities associated with implementing the Plan may result in negligible adverse impacts to vegetation along the banks of Moodna Creek in the immediate vicinity of the barriers. Tree protection and high visibility fencing would be installed during construction to reduce the risk of unnecessary damage to trees and other vegetation. In the long-term, implementing the Plan would result in a negligible beneficial impact on vegetation at AOP2 and AOP3, due to exposure previously impounded lands, which are expected to naturally revegetate. Since Moodna Creek is generally characterized by narrow floodplains confined by steep valley walls, it is likely that these areas would not be extensive. Implementing the Plan would have no impact on vegetation at AOP1.
Shellfish	Existing Conditions	No information regarding the presence, absence, or composition of shellfish communities on the site is readily available. Typically, there are fresh water clams, mussels, and invasive zebra mussels in this habitat.
	FWOP	AOP1, AOP2, and AOP3 each currently act as barriers to aquatic organism passage between the upper Moodna Creek and the lower Moodna Creek/Hudson River, resulting in moderate adverse impacts to shellfish. Under, the No Action Alternative, these barriers would remain and these impacts would continue into the foreseeable future.
	Recommended Plan	In the short-term, temporary reductions in water quality due to construction activities associated with implementing the Plan would result in negligible adverse impacts to shellfish, if present. In the long-term, the restoration of aquatic organism passage to Moodna Creek upstream of the barriers would result in moderate beneficial impacts to shellfish, as more areas become accessible to shellfish inhabitation.
Finfish	Existing Conditions	The NYSDEC Environmental Resource Mapper classifies the tidal portion of Moodna Creek as a 'Significant Anadromous Fish Concentration Area'. The tidal portion of Moodna Creek is also designated as a Significant Coastal Fish and Wildlife Habitat under the New York State Coastal Management Program. According to the Coastal Fish and Wildlife Rating Form (NYSDOS, 2012) associated with this designated habitat, Moodna Creek is an important spawning area for alewife (*Alosa pseudoharengus*), blueback herring (*Alosa aestivalis*), bay anchovy (*Anchoa mitchilli*), American eel (*Anguilla rostrata*), and striped bass (*Morone saxatilis*) between April and June, and for tomcod (*Microgadus tomcod*) between December and January. American shad (*Alosa sapidissima*) spawn in areas at the mouth of Moodna Creek. The barriers contained within the AOP sites likely impede or prevent the upstream migration of fish. A substantial warmwater fish community occurs in the lower portion of Moodna Creek throughout the year including bluegill (*Lepomis macrochirus*), brown bullhead (*Ameiurus nebulosus*), channel catfish (*Ictalurus punctatus*), common carp (*Cyprinus carpio*), golden shiner (*Notemigonus crysoleucas*), largemouth bass

RESOURCE	Conditions	MOODNA CREEK Description
		(*Micropterus salmoides*), pumpkinseed (*Lepomis gibbosus*), smallmouth bass (*Micropterus dolomieu*), white catfish (*Ameiurus catus*), yellow perch (*Perca flavescens*), and white perch (*Morone americana*). As the salt front moves up the Hudson during dry periods, bluefish (*Pomatomus saltatrix*), anchovy (*Anchoa mitchilli*), weakfish (*Cynoscion regalis*), silversides (*Menidia menidia*), hogchoker (*Trinectes maculatus*), and blue crab (*Callinectes sapidus*) may enter the area to feed.
	FWOP	AOP1, AOP2, and AOP3 each currently act as barriers to aquatic organism passage between the upper Moodna Creek and the lower Moodna Creek/Hudson River, resulting in major adverse impacts to finfish. Under, the No Action Alternative, these barriers would remain and these impacts would continue into the foreseeable future.
	Recommended Plan	In the short-term, temporary reductions in water quality due to construction activities associated with implementing the Plan would result in negligible adverse impacts to finfish, if present. In the long-term, the restoration of aquatic organism passage to Moodna Creek upstream of the barriers would result in major beneficial impacts to finfish and would collectively reconnect 7.8 miles of upstream tributary habitat to migratory fish in the Hudson River.
Benthic Resources	Existing Conditions	No information regarding the presence, absence, or composition of benthic resources in Moodna Creek is readily available.
	FWOP	The No Action Alternative would have no impact on benthic resources.
	Recommended Plan	Implementing the Plan would have no impact on benthic resources.
Reptiles and Amphibians	Existing Conditions	According to the Coastal Fish and Wildlife Rating Form associated with the designated Significant Coastal Fish and Wildlife Habitat (NYSDOS, 2012), the banks of Moodna Creek provide habitat for common snapping turtle (*Chelydra serpentina*), water snake (*Nerodia s. sipedon*), red-spotted newt (*Notophthalmus v. viridescens*), redback salamander (*Plethodon cinereus*), American toad (*Bufo americanas*), gray treefrog (*Hyla versicolo*r), spring peeper (*Pseudoacris crucifer*), bullfrog (*Rana catesbeiana*), green frog (*Rana clamitans*), and wood frog (*Rana sylvatica*).
	FWOP	The No Action Alternative would have no impact on reptiles, amphibians, or their respective habitats.
	Recommended Plan	In the short-term, temporary reductions in water quality due to construction activities associated with implementing the Plan would result in negligible adverse impacts to reptiles and amphibians, if present. In the long-term, removing the impoundment would de-water previously impounded areas upstream of AOP2 and AOP3, reducing surface water area and increasing flow speeds. This may result in negligible beneficial impacts, upstream of AOP2 and AOP3, to riverine reptile and amphibian species and negligible adverse impacts to reptile and amphibian species, which inhabit slow moving water bodies. Implementing the Recommended Plan would have no impact on reptile or amphibian species in the vicinity of AOP1, as AOP1 does not form a significant impoundment on Moodna Creek.

RESOURCE		MOODNA CREEK
	Conditions	**Description**
Birds	Existing Conditions	The NYSDEC Environmental Resource Mapper (NYSDEC, Environmental Resource Mapper, Accessed December 2018) classifies the tidal portion of Moodna Creek as a 'Significant Waterfowl Winter Concentration Area'. According to the Coastal Fish and Wildlife Rating Form associated with the designated Significant Coastal Fish and Wildlife Habitat (NYSDOS, 2012), Moodna Creek provides valuable habitats for many species of shorebirds, wading birds, waterfowl, and songbirds, and is reported to be a major crossing point for raptors migrating through the Hudson Valley. Probable or confirmed breeding bird species in the area include Green Heron (*Butorides virescens*), American bittern (*Botaurus lentiginosus*), Canada goose (*Branta canadensis*), mallard (*Anas platyrhynchos*), American black duck (*Anas rubripes*), wood duck (*Aix sponsa*), Virginia rail (*Rallus limicola*), spotted sandpiper (*Actitis macularia*), belted kingfisher (*Ceryle alcyon*), fish crow (*Corvus ossifragu*s), marsh wren (*Cistothorus palustris*), common yellowthroat (*Geothlypis tricha*s), hooded warbler (*Wilsonia citrina*), red-winged blackbird (*Agelaius phoeniceus*), downy woodpecker (*Picoides pubescens*), northern flicker (*Colaptes auratus*), eastern kingbird (*Tyrannus tyrannus*), and swamp sparrow (*Melospiza georgiana*). The wetlands located at the mouth of Moodna Creek are productive feeding areas for significant concentrations of herons, waterfowl, and shorebirds during spring and fall migrations such as osprey (*Pandion haliaetus*).
	FWOP	The No Action Alternative would have no impact on birds or their habitat.
	Recommended Plan	In the short-term, temporary reductions in water quality due to construction activities associated with implementing the Plan would result in negligible adverse impacts to birds, if present. In the long-term, removing the impoundment would de-water previously impounded areas upstream of AOP2 and AOP3, reducing surface water area and increasing flow speeds. This may result in negligible beneficial impacts, upstream of AOP2 and AOP3, to riverine bird species and negligible adverse impacts to bird species, which inhabit slow moving water bodies. Implementing the Plan would have no impact on bird species in the vicinity of AOP1, as AOP1 does not form a significant impoundment on Moodna Creek.
Mammals	Existing Conditions	No information regarding the presence, absence, or composition of mammals on the site is readily available. It is likely that the floodplains, wetlands, and forested land in vicinity of the site provide habitat for numerous mammalian species.
	FWOP	The No Action Alternative would have no impact on state species of concern at the site.
	Recommended Plan	In the short-term, temporary reductions in water quality due to construction activities associated with implementing the Plan would result in negligible adverse impacts to mammals, if present. In the long-term, removing the impoundment would de-water previously impounded areas upstream of AOP2 and AOP3, reducing surface water area and increasing flow speeds. This may result in negligible beneficial impacts, upstream of AOP2 and AOP3, to riverine mammalian species and negligible adverse impacts to mammalian species, which inhabit slow moving water bodies. Implementing the Plan would have

RESOURCE		MOODNA CREEK
	Conditions	**Description**
		no impact on mammalian species in the vicinity of AOP1, as AOP1 does not form a significant impoundment on Moodna Creek.
Federal Species of Concern	Existing Conditions	The USFWS iPac system identified the threatened northern long-eared bat (*Myotis septentrionalis*), the endangered Indiana bat (*Myotis sodalis*), and the threatened small whorled pogonia (*Isotria medeoloides*) and bog turtle *(Clemmys muhlenbergli)* as potentially occurring at the site. The bog turtle is the smallest emydid turtle, and one of the smallest turtles in the world. Adult carapace length is 7.9 to 11.4 cm (3.1 to 4.5 inches). The species historical range included Connecticut, Delaware, Georgia, Maryland, Massachusetts, New Jersey, New York, North Carolina, Pennsylvania, South Carolina, Tennessee, and Virginia. Bog turtles usually occur in small, discrete populations, generally occupying open-canopy, herbaceous sedge meadows and fens bordered by wooded areas. These wetlands are a mosaic of micro-habitats that include dry pockets, saturated areas, and areas that are periodically flooded. The species has been identified in Orange County (www.fws.org). The small-whorled pogonia is a member of the orchid family. It usually has a single grayish-green stem that grows about 10 inches tall when in flower and about 14 inches when bearing fruit. The small-whorled pogonia favors open, dry, deciduous forests with low nutrient, acidic soils that are very stony, fine sandy loams and contain a thick layer of dead leaves. They require filtered sunlight and sparse shrub and herbaceous layers. They often grow on slopes near small streams. This species has been located only seven times in New York State, with only two recent records in 1976 in Onondaga County and again in Schunnemunk Mountain State Park in Orange County in 2010 (NYSDEC 2019). For Indiana bat and northern long-eared bat descriptions please see Schodack Island site assessment. There are no reports of the northern long-eared bat, Indiana bat, or small whorled pogonia at the site. The GARFO did not identify any threatened or endangered species.
	FWOP	The No Action Alternative would have no impact on federal species of concern at the site.
	Recommended Plan	The Plan is the removal of two dams and one utility line within the Moodna Creek. There is no habitat for the Indiana and northern long-eared bats, or bog turtles at or near the site. Therefore, the Plan will have no effect on the Indiana and northern long-eared bats or the bog turtle. As well, there is no habitat for the small whorled pogonia at the site and therefore no effect.
State Species of Concern	Existing Conditions	The NYSDEC identified the endangered Indiana bat (*Myotis sodalis*) as potentially occurring at the site.
	FWOP	The No Action Alternative would have no impact on state species of concern at the site.
	Recommended Plan	As identified above in Federal Species of Concern, the Plan will not affect the Indiana bat.

RESOURCE	**Conditions**	**MOODNA CREEK** **Description**
Designated Critical Habitat	Existing Conditions	The USFWS and NOAA Fisheries have not designated any critical habitat in the site.
	FWOP	The No Action Alternative would have no impact on federal species of concern at the site.
	Recommended Plan	There is no designated critical habitat at the site. The Plan will not have impacts on critical habitat.
Essential Fish Habitat	Existing Conditions	Utilizing NMFS's essential fish habitat (EFH) designation and the EFH Mapper, the site is potential essential fish habitat for various life stages of winter flounder (*Pseudopleuronectes americanus*), little skate (*Leucoraja erinacea*), Atlantic herring (*Clupea harengus*), red hake (Urophycis chuss), windowpane flounder (*Scophthalmus aquosus*), winter skate (*Leucoraja ocellata*), and clearnose skate (*Raja eglanteria*). There are no reports of the above EFH species at the site.
	FWOP	Under the No Action Alternative, the site's existing ratio of intertidal and upland area would change slightly with projected sea level rise. The net increase in the extent of intertidal areas with projected sea level rise would result in negligible beneficial impacts to EFH, as more areas become accessible to finfish inhabitation.
	Recommended Plan	In the short-term, temporary reductions in water quality due to construction activities associated with implementing the Plan would result in negligible adverse impacts to EFH species, if present. In the long-term, the restoration of aquatic organism passage to Moodna Creek upstream of the barriers would result in major beneficial impacts to EFH by increasing available habitat. In consultation with NOAA Fisheries, they provided conservation measures that the District will follow during construction (Appendix G1).
Cultural Resources	Existing Conditions	There are no archaeological sites or historic properties recorded within the AOP 1 site, however, the boundaries of the Knox's Headquarters/John Ellison House grounds (90NR02311) are adjacent to the site. There are no archaeological sites or historic properties documented within the AOP2 site, however the Firthcliff Dam is a historic structure that was associated with the Firth Carpet Company complex (07149.000103) which has been demolished in recent years. The dam has not yet been evaluated for its National Register eligibility. The historical record indicates that the Firth Cliff Dam may have been preceded by earlier dam structures associated with predecessor mills and therefore there is potential for archaeological remains of the dams and factory structures to lie below the surface. AOP 3 is known as Orr's Mill Dam and the dam and the mill pond should be evaluated for eligibility for listing in the NRHP and as contributing elements to the NRHP-eligible Orr's Mill Historic District that lies at the intersection of Orr's Mill Road and NYS Route 32 and includes several historic structures. Archaeological remains of the mill features such as the raceway and retaining walls are likely to be located within the immediate vicinity of the dam.
	FWOP	Under the No Action Alternative no historic properties would be affected/No effect or Impact.

RESOURCE	Conditions	MOODNA CREEK Description
	Recommended Plan	There are no previously documented historic properties within the Area of Potential Effect (APE) for AOP 1. The proposed undertaking is likely to adversely effect cultural resources. AOPs 2 and 3 are historic dams that are currently of undetermined eligibility. Additionally, there is potential for prehistoric and historic archaeological remains to exist within the AOP 2 and 3 sites on Moodna Creek. As the plan is further developed and the Area of Potential Effect (APE) is better defined cultural resources surveys will be required to evaluate the National Register eligibility of the Firth Cliff Dam and the Orr's Mill Dam and to determine the effect of the plan on cultural resources. A Programmatic Agreement signed July 6, 2020 outlines the steps that the Corps will take to carry out the remaining Section 106 responsibilities including conducting additional surveys, consulting with interested parties, determining adverse effects, and if necessary, mitigation for adverse effects (See Appendix G-5).
Air Quality	Existing Conditions	The USEPA Green Book provides detailed information about area National Ambient Air Quality Standards (NAAQS) designations, classifications, and nonattainment statuses (USEPA, 2018). All three sites are located in a region classified as "in attainment" for all pollutants tracked under the NAAQS including ozone (O_3), particulate matter (PM10 & PM2.5), sulfur dioxide (SO_2), lead (Pb), carbon monoxide (CO), and nitrogen dioxide (NO_2). There are no major sources of air pollutants (Title V facilities) on or in proximity to the sites.
	FWOP	There are no significant sources of air pollution present on the site. Therefore, the No Action Alternative would have no impact on air quality.
	Recommended Plan	In the short-term, negligible adverse impacts on local air quality from construction vehicles would occur temporarily during the construction period, which would have a projected duration of approximately three months at AOP1 and six months at AOP2 and AOP3. Temporary impacts associated with construction emissions would be mitigated through the implementation of air quality best management practices. Ultra-low sulfur diesel fuel would be used for all construction-related vehicles and non-road construction equipment, limiting SOx emissions. Fugitive dust control measures such as speed limit reductions, water or other dust suppressant application, and regular vehicle rinsing would be managed according to proper standards and procedures. In the long-term, implementing the Plan would have no impact on air quality.
Noise	Existing Conditions	The Moodna Creek site currently consists of a series of barriers along Moodna Creek. Land in vicinity of the sites mostly consists of low to medium density residential development. Additionally, the State Route 32 crossing over Moodna Creek is located immediately downstream of AOP3. Local noise is likely limited to the flow of water over the dam structure and ambient sounds from the surrounding residential community. AOP3 is also likely subject to traffic noise from the Route 32 crossing.
	FWOP	There are no significant sources of noise pollution present on the site. Therefore, the No Action Alternative would have no impact on noise levels.

RESOURCE		MOODNA CREEK
	Conditions	**Description**
	Recommended Plan	In the short-term, minor adverse impacts on local noise levels from construction activities would occur temporarily during the construction period, which would have a projected duration of approximately three months at AOP1 and six months at AOP2 and AOP3. Construction activities would be limited to times of the day specified by local noise and construction ordinances. In the long-term, implementing the Plan would have no impact on local noise levels.
Recreation	Existing Conditions	Moodna Creek and its watershed offer a plethora of recreation opportunities for visitors. There are miles of hiking trails, as well as paved trails for walking and biking. In the vicinity, municipal parks are equipped with ballparks and other related amenities. There are six known public access points to lakes or streams within the watershed, all of which are located within the town boundaries of Cornwall and New Windsor (OCWA, 2010). There are abundant recreational opportunities located in the Moodna Watershed. About 1.75 miles of the renowned Appalachian Trail crosses through the southwest portion of the Watershed, where it connects to the Highlands Trail. The Highlands Trail crosses through the greater portion of the Watershed, north over Schunnemunk Mountain, through Black Rock Forest, and to the top of Storm King Mountain. The Long Path travels up from New Jersey and crosses northwest, through the central portion of the Watershed. Black Rock Forest is located in the eastern part of the Watershed, in the Town of Cornwall. The Museum of the Hudson Highlands, also located in Cornwall, offers many activities, including the Outdoor Discovery Center. The more urbanized, paved Heritage Trail passes through the southwest portion of the Watershed and provides access to developed areas of the County in a vegetated, natural setting (OCWA, 2010). There are many parks and nature preserves for recreational activities, bird watching, horseback riding, and some hunting. Moodna Creek Park, in the Town of New Windsor and in the shadow of Storm King Mountain, is available for several activities including creek access to the Hudson River. Hamptonburgh Preserve in the Town of Hamptonburgh is a 130-acre property and is prime nesting habitat for many species of birds. Seventy-four of these acres are wildflower meadow, farmland, and riverine forest along the Wallkill River. Stewart State Forest in New Windsor, located at the northeastern tip of the Watershed, is a wildlife management area with semi-paved lanes for biking and walking. Schunnemunk Preserve in Cornwall, located at the northwest edge of Schunnemunk Ridge, contains several trails with rocky summits for Hudson River views. Adjacent is Schunnenunk Mountain in Mountainville, with six marked trails and excellent views that include those from the highest point in the Lower Hudson Valley. Goosepond Mountain, in the Town of Chester, is largely wooded and undeveloped, but contains hiking areas and horseback riding by permit. Finally, the Kowawese Unique Area at Plum Point in New Windsor is a 102-acre park directly on the Hudson River with vistas of the Hudson Valley gorge and 2,000 feet of sandy beach (OCWA, 2010).

RESOURCE		MOODNA CREEK
	Conditions	Description
		The Moodna Creek and its tributaries have long suffered from a low public profile as a recreational resource. A few public access points within the watershed today include: ● Kowawese Unique Area at Plum Point, New Windsor – This County Park is open to the public and permits many activities including swimming, fishing, boating (car-top boats only), picnicking and grilling, and also has a visitor center and a beach. ● Earl Reservoir, Town of Woodbury – This town-owned park (available to residents of Woodbury only) allows swimming and diving, fishing and has paddleboats. ● NYS Route 32, Town of Cornwall – Along this stretch of road, there are three well known access points for fishing and hiking on the Moodna Creek. This area has been classified by the State of New York as a Class A Trout Stream, which is stocked with fish annually. ● Town of New Windsor Water Treatment Facility, New Windsor – There is a small boat launch open to the public at the Town of New Windsor Water Treatment Facility off Route 9W just upstream from the Mouth of the Moodna. Additionally, the Otter Kill and Moodna and Woodbury Creeks (and possibly others) provide great kayaking opportunities when water levels allow. There are limited designated and legal access points to these waterways (Orange County Water Authority, 2010).
	FWOP	There are no designated recreational areas present on any of the sites. Therefore, the No Action Alternative would have no impact on recreation.
	Recommended Plan	In the short-term, the No Action Alternative would have minor impacts on recreational resources. Boaters, recreational fishers, and other recreational activities will be restricted from the construction sites. However, after the construction they will be able to return. In the long-term, implementing the Plan would result in minor impacts to the site's potential recreational uses. Upstream of AOP2 and AOP3, the removal of the impoundment would inhibit activities involving watercraft designed for slow-moving waters but enhance recreational activities associated with riverine environments. The restoration of aquatic organism passage and riverine flow upstream of all the barriers at each site would likely alter the species availability to fishers and birders.

RESOURCE		MOODNA CREEK
	Conditions	**Description**
Aesthetics and Scenic Resources	Existing Conditions	The site is not designated as a Scenic Areas of Statewide Significance (SASS) under the New York Coastal Management Program. However, Policy 25 of the Coastal Management Program requires that state agencies must ensure proposed actions in the coastal zone “Protect, restore or enhance natural and man-made resources which are not identified as being of statewide significance, but which contribute to the overall scenic quality of the coastal area.” (NYSDOS, 2017). Activities, which could impair or degrade scenic quality, include the modification of natural landforms, removal of vegetation, removal of existing structures, and the addition of structures that diminish scenic quality. Stewardship groups locally recognize the aesthetic and scenic resources provided by the Moodna Creek. During the 1960’s, Consolidated Edison (Con-Ed) proposed a pumped storage hydroelectric plant at the base of Storm King Mountain, which would significantly impact aesthetic and scenic resources. The stewardship group Scenic Hudson opposed and ultimately defeated the development in court (OCWA, 2010).
	FWOP	The No Action Alternative would have no impact on aesthetics and scenic resources.
	Recommended Plan	In the short-term, minor adverse impacts to aesthetic and scenic resources would occur during the construction phase of the project due to the presence of heavy equipment, material piles, staging areas, traffic control signs, disturbed land, and high visibility fencing. In the long-term, implementing the Plan would result in minor beneficial impacts to the site’s aesthetic and scenic resources through the restoration of historic riverine conditions.
Hazardous, Toxic, and Radioactive Waste	Existing Conditions	A review of the databases yields two state Superfund sites. The New York State Superfund Site Number: 336028 is just below AOP 2 for metals, chlorocarbons, and hydrocarbons. Remediation at the site is complete and has removed contamination from the site. The site was delisted in September 2016. The New York State Superfund Site Number: 336008 is located upstream of AOP 3 about 3 miles near Woodbury Creek which flows into Moodna Creek. The site was the subject of numerous environmental investigations and remedial activities, between 1985 and 1997, including a Phase I Investigation of a former landfill and RCRA Facility Assessments and Investigations of several other on-site and off-site release areas. The site was never remediated. Contaminants of concern are lead, chlorinated VOCs, and petroleum hydrocarbons. According to the State, the concern is with groundwater and well water contamination. There is a decommissioned sewer utility line at AOP 1. This utility line was used by the former textile manufacturing factory site adjacent to AOP 2 on the south side of the Moodna Creek. It has not been used in many years. The town has no concerns with removing the pipe.
	FWOP	The No Action Alternative would have no impact on aesthetics and scenic resources.

RESOURCE		MOODNA CREEK
	Conditions	**Description**
	Recommended Plan	The New York State Superfund Site Number: 336028 has been remediated and has been delisted and will not impact the Plan. The New York State Superfund Site Number: 336008 is more than three miles from AOP 3 and not in the Moodna Creek, the site does not present a HTRW concern with the implementation of the Plan. The utility line at AOP 1 presents no concerns of contaminants, as it has not been used in many years.
Transportation and Other Infrastructure	Existing Conditions	An important node in the Moodna Watershed is Vails Gate, which consists of the five-point intersection of NYS Routes 32, 300 and 94, and the surrounding area. Along with being a dense commercial and residential area, there are many historic and recreational attractions within a very short distance of the intersection, including trail access to the Moodna itself at Knox's Headquarters State Historic Site. Other attractions include the historic Edmonston House, the Last Encampment of the Continental Army, the National Purple Heart Hall of Honor, and the New Windsor Cantonment State Historic Site. Also, nearby is Schunnemunk Shadow Stables, off Route 94, and the regionally renowned Storm King Art Center in Mountainville (Orange County Water Authority, 2010). It is also important to mention that two commuter rail stations are located within the Watershed. There is one in Salisbury Mills between Vails Gate and Washingtonville and one in the aforementioned Hamlet of Campbell Hall. Also noteworthy is Hudson Valley Biking, based in Monroe, which gives guided, customized bicycle tours through rural roads to local attractions (Orange County Water Authority, 2010).
	FWOP	The No Action Alternative would have no impact on transportation or infrastructure.
	Recommended Plan	In the short-term, minor adverse impacts to local traffic conditions would occur during the construction phase of the project due to the transport of material and heavy equipment. In the long-term, implementing the Plan would have no impact on transportation or infrastructure.

Chapter 6: Cumulative Impacts*

The Council on Environmental Quality's regulations for implementing NEPA define a cumulative effect as "the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time" (40 CFR §1508.7).

Consistent with CEQ guidance, this cumulative impact analysis focuses on potential cumulative impacts of past and present actions associated with the resources analyzed in Chapters 2 and 5, plus those actions that are in the planning phase—limited to future actions that are reasonably foreseeable (CEQ, 1997). Only actions that have the potential to interact with or be impacted by the Recommended Plan are addressed in this cumulative impact analysis. The analysis evaluates only actions with potential impacts on the environment that are fundamentally similar to the anticipated impacts of the Recommended Plan, in terms of the nature of the impacts, the geographical area affected, and the timing of the impacts. In addition, this analysis will also examine instances where two or more individual impacts of the Recommended Plan, which, when considered together, are considerable or which compound or increase other environmental impacts.

This analysis covers actions in the study area from the recent past through the 50-year period of analysis described in Section 3.1.3.

6.1 Recent Past, Present, and Foreseeable Future Actions

A number of actions occurring historically and up to the present time, or reasonably expected to occur in the future, have the potential to influence the resources affected by implementation of the Recommended Plan, as identified in Chapter 5. Multiple restoration and conservation programs and development projects were identified. A brief description of these relevant past, present, and reasonably foreseeable future actions follows, with an emphasis on components of the activity that are relevant to the impacts previously identified. When determining whether a particular activity may contribute cumulatively and significantly to the impacts identified in Chapter 5, the following attributes are considered: geographical distribution, intensity, duration, and the historical impacts of similar activities.

6.1.1 Hudson River Estuary Program

Timeframe: Recent past, present, and foreseeable future
Implementing Entity: New York State Department of Environmental Conservation

The Hudson River Estuary Program (HREP) was established in 1987 through the Hudson River Estuary Management Act and focuses on the tidal Hudson River and adjacent watershed from the federal dam at Troy to the Verrazano Narrows in New York City. The program has developed a Hudson River Estuary Habitat Restoration Plan and the NYSDEC Hudson River Estuary Action Agenda that supports conservation and restoration through grant funding, research, education, training, community planning assistance, land acquisition and restoration projects. These activities are likely to improve water quality and habitat in the future, and encourage future environmental restoration projects similar to those proposed under the Recommended Plan.

6.1.2 State Pollutant Discharge Elimination System Program

Timeframe: Recent past, present, and foreseeable future
Implementing Entity: New York State Department of Environmental Conservation

Article 17 (Water Pollution Control) of the Environmental Conservation Law (ECL) authorized creation of the State Pollutant Discharge Elimination System (SPDES) program to maintain New York's waters with reasonable standards of purity. New York's SPDES program has been approved by the EPA for the control of surface wastewater and stormwater discharges in accordance with the Clean Water Act. The SPDES program regulates water discharges from numerous sources including direct discharges from industrial facilities, combined sewer overflows (CSOs), power plants, and ship ballasts, as well as indirect stormwater discharges from certain industrial activities, in urbanized areas, and from construction sites. Improvements to water quality have occurred and are expected to continue under the SPDES program. Due to the extensive size of the Hudson River's drainage area at the study area, as well as the concentration of industrial sites, shipping ports, urban areas, and CSOs along the Hudson River, the long-term impacts to water quality will be very positive.

6.1.3 Governor's Office of Storm Recovery

Timeframe: Recent past, present, and foreseeable future
Implementing Entity: New York State Governor's Office of Storm Recovery

In 2013, New York State established the Governor's Office of Storm Recovery (GOSR) following the occurrence of Hurricane Irene, Tropical Storm Lee, and Superstorm Sandy to centralize recovery and rebuilding efforts in impacted areas of New York State. GOSR is allocating federal funds to support the planning and implementation of community-developed recovery and resiliency projects via the New York Rising Community Reconstruction (NYRCR) Program. The NYRCR Program is currently implementing over 3,000 projects throughout the state, including critical facility/infrastructure hardening, drainage improvements and green infrastructure, economic development, emergency preparedness and recovery operations, housing resiliency, shoreline protection, and transportation infrastructure.

Planned projects under the NYRCR program are located throughout the state, including sites along the Hudson River, Rondout Creek, Moodna Creek, and their respective tributaries. While the program will primarily result in short-term construction impacts from rebuilding on existing developed property, some long-term negative impacts could result from reconstruction or infrastructure projects that have a larger impervious footprint or that alter existing hydrology and habitat. Numerous projects proposed under the NYRCR program could also result in long-term positive impacts; improvements to waste water treatment infrastructure throughout the state could improve water quality and reduce the risk of accidental water contamination during storm events. Shoreline protection projects, such as the proposed stream bank restoration sites along Rondout Creek and the Hudson River, could reduce erosion and introduce living shorelines, improving water quality and providing intertidal and/or aquatic habitat.

6.1.4 Climate Smart Communities Program

Timeframe: Recent past, present, and foreseeable future
Implementing Entity: New York State Department of Environmental Conservation

Climate Smart Communities (CSC) is a New York State program that assists local governments (i.e. counties and towns/cities) take action to reduce greenhouse gas emissions and adapt to a changing climate by providing a legal framework to guide their climate action efforts, free technical assistance, grant access, and recognition of achievements via a certification program. Numerous project sites lie within or in the vicinity of CSC designated areas. Under the program, these communities have implemented climate programs and policies, including commitments to reduce vulnerability to natural hazards, conserve natural habitats, and support green infrastructure. This may encourage future environmental restoration projects similar to those proposed under the Recommended Plan.

6.1.5 Coastal Zone Management Program

Timeframe: Recent past, present, and foreseeable future
Implementing Entity: New York State Department of State (NYS DOS)

In 1981, the New York State Legislature enacted Article 42 of the Executive Law, the Waterfront Revitalization of Coastal Areas and Inland Waterways Act. In 1982, the New York State Coastal Management Program (NYSCMP) was created, with federal authorization and oversight. It was created to establish the boundaries of the Coastal Area within which the NYSCMP and its policies apply, to describe the organizational structure required to implement the NYSCMP, and to provide a set of statewide policies enforceable on all state and federal agencies that manage resources and coordinate actions within the State's federally approved Coastal Area Boundary coastline. Each of the Recommended Plans project sites are within the New York State Coastal Area.

6.1.6 Scenic Hudson Conservation and Advocacy

Timeframe: Recent past, present, and foreseeable future
Implementing Entity: Scenic Hudson, Inc.

Scenic Hudson is the largest environmental nonprofit group focused on the Hudson River Valley. Scenic Hudson supports direct conservation via land acquisition, conservation easements, and farming preservation, as well as advocating for environmentally beneficial public policy and opposing environmentally harmful projects. These activities are likely to have a beneficial impact on water quality and habitat in the future.

6.1.7 Hudson River Comprehensive Restoration Plan

Timeframe: Recent past, present, and foreseeable future
Implementing Entity: Partners Restoring the Hudson

In August 2018, a collective group of more than 30 nonprofit organizations, public agencies, and academic institution organizations called “Partners Restoring the Hudson,” released the “Hudson River Comprehensive Restoration Plan: Recommendations for the New York-New Jersey Harbor & Estuary Program Action Agenda and the New York State Hudson River Estuary Action Agenda.” The plan details the current conditions of the Hudson River Estuary, identifies potential restoration sites and recognizes the needs that must be addressed in the coming decades to restore the river and prepare for future conditions, including rising sea levels and increasingly frequent and severe storms (Partners Restoring the Hudson, 2019a).

Four sites (Binnen Kill Watershed, Rondout Creek, Henry Hudson Town Park, and Schodack Island) are included in the Hudson River Comprehensive Restoration Plan, which catalogs ‘restoration progress to date in the Hudson, and sets long-term goals for its future’ (Partners Restoring the Hudson, 2018). The three Recommended Plan sites are included as “Candidate Project Opportunities” in the Hudson River Comprehensive Restoration Plan, and are displayed on The Hudson We Share’s “Hudson River Mapper”, an interactive web application that identifies Candidate Project Opportunities, which were established through a participatory community planning process. The three Recommended Plan sites currently have physical habitat characterization impacts or ecological assessment threats, which may include items such as a hardened shoreline, aquatic organism barriers, high nutrient pollutant discharge, and/or areas of fill.

Implementing the Recommended Plans on the three aforementioned sites would support the goals outlined in the Hudson River Comprehensive Restoration Plan.

While not within the site boundary of the Moodna Creek Recommended Plan, the report identifies “Moodna Creek Marsh Protection & Enhancement” as a Candidate Project Opportunity. This area lies at the confluence of Moodna Creek, and therefore implementing the Recommended Plan upstream will have a beneficial cumulative impact on the Candidate Project Opportunity identified in the report.

6.1.8 Federal Navigation Project Maintenance Dredging

Timeframe: Recent past, present, and foreseeable future
Implementing Entity: United States Army Corps of Engineers

The Rivers and Harbors Acts of 1910 to 1930 authorized the Hudson River federal navigation project, and it was modified in 1934, 1935, 1938, and 1954. The United States Army Corps of Engineers perform regular maintenance dredging approximately every three to four years on the Hudson River between New York City and Waterford, New York. The existing navigation project authorizes a channel with depths ranging from 34 (in rock) to 14 ft feet deep at the Federal Lock and Dam at Troy. Currently, dredged material from the Operation and Maintenance project is placed at a federally owned upland dredged material placement site on Houghtaling Island, New Baltimore, New York.
Channel maintenance activities and the historic subsequent placement of dredged materials as fill have significantly altered the Hudson River and its shoreline in the past, present, and foreseeable future.

6.1.9 Trees for Tribs Program

Timeframe: Recent past, present, and foreseeable future
Implementing Entity: New York State Department of Environmental Conservation

The Trees for Tribs Program was established in 2007 in an effort to reforest New York's tributaries. The goal of the program is to plant young trees and shrubs along stream corridors in order to prevent erosion, increase floodwater retention, improve wildlife and stream habitat, as well as protect water quality. Trees for Tribs has engaged more than 8,751 volunteers in planting more than 101,416 trees and shrubs at 614 sites across New York State. The program also awards grant funding for organizations or municipalities interested in conducting large-scale streamside planting projects in New York State. These activities are likely to have a beneficial impact on water quality and riparian habitats in the future.

6.1.10 Green Innovation Grant Program

Timeframe: Recent past, present, and foreseeable future
Implementing Entity: New York State Environmental Facilities Corporation

The Green Innovation Grant Program (GIGP) supports projects across New York State that utilize stormwater infrastructure design. Eligible projects include floodplain, stream, and wetland restoration, stream daylighting, permeable pavement, bioretention, green roofs, stormwater harvesting and reuse, urban forestry, and downspout disconnection. These activities are likely to have a beneficial impact on water quality and riparian habitats in the future.

6.1.11 Tappan Zee Bridge Environmental Mitigation

Timeframe: Present, and foreseeable future
Implementing Entity: New York State Thruway Authority

As part of the replacement of the Tappan Zee Bridge with the Governor Mario M. Cuomo Bridge, restoration projects will occur to mitigate environmental damages. Restoration projects will include oyster restoration in the Hudson River in proximity to the bridge, wetland restoration and management, and Green Infrastructure and stormwater treatment construction projects.

6.1.12 Smaller Restoration Projects

Timeframe: Recent past, present, and foreseeable future

Many other, smaller restoration projects have been, are, or will be conducted within the study area. Such projects include dam removals, shoreline restoration projects, stormwater management and green infrastructure projects, wetland and flood restoration projects, and other similar projects, which seek to restore or enhance natural resources. These projects, although too numerous to enumerate and too early in their planning to ensure their ultimate implementation, could lead to positive cumulative impacts.

6.2 Summary of Cumulative Effects Relative to the Recommended Plan

Environmental impacts associated with the Recommended Plan were analyzed in Chapter 5. The proposed alternative at each restoration site will increase the amount of high-quality habitat through restoration measures including:

- Side Channel/Wetland Complex: 8.5 acres
- Tidal Wetlands: 22.8 acres

- Living Shoreline/Tidal Wetlands: 0.6 acres and 1,760 linear feet
- Full or Partial Removal of 3 Barriers collectively reconnecting 7.8 miles of upstream tributary habitat to the Hudson River

All of the alternatives, except the no action alternative, are presumed to improve the habitat and ecological integrity with varying degrees of effectiveness. The alternatives will also mitigate past human actions that harmed habitat and ecological integrity, including the removal of past fill and barriers to aquatic organism passage.

Construction activities associated with the Recommended Plan could cause temporary adverse impacts. These impacts listed below were determined individually to be negligible to moderate, or to have no impact. Implementation of the Recommended Plan may have cumulative impacts when combined with other similar actions occurring in the region of influence, on the resources discussed below.

The overall cumulative effects of the Recommended Plan would be synergistic benefits to all wetland and aquatic species through habitat restoration in the lower Hudson River. The benefits of increasing the number and size of side channels, reconnecting aquatic habitats in the adjacent floodplain, and greatly increasing the acreage of riparian zones and wetlands along the river and its tributaries will provide significant benefits to fish and wildlife species that utilize the habitat, especially for anadromous and catadromous species.

6.2.1 Cumulative Impacts on Wetlands

Short-term, negative impacts to wetlands may occur as a result of construction activities at restoration sites. These impacts are unlikely to be cumulative as a result of implementation, but may become cumulative if larger construction projects that are unrelated to the Recommended Plan occur in the vicinity. As previously discussed, impacts related to construction would be short-term and would be minimized using applicable BMPs, such as soil erosion control measures, to protect water quality.

Long-lasting, beneficial cumulative impacts to wetlands may occur as a result of implementing the Recommended Plan alongside other ongoing and future wetland restoration projects, wetland conservation via land acquisition, and water pollution control measures. Implementing the Recommended Plan would also mitigate past cumulative negative impacts to wetlands by restoring wetlands that were historically filled.

6.2.2 Cumulative Impacts on Water Quality

Short-term, negative impacts to water quality may occur as a result of construction activities at restoration sites. These impacts are unlikely to be cumulative as a result of implementation, but may become cumulative if larger construction projects that are unrelated to the Recommended Plan occur in the vicinity. As previously discussed, impacts related to construction would be short-term and would be minimized using applicable BMPs such as soil erosion control measures to protect water quality.

Long-term positive impacts to water quality, as a result of implementing the Recommended Plan, would primarily be driven by proposed wetland restoration. Long-lasting, beneficial cumulative impacts to water quality may occur as a result of implementing the Recommended Plan alongside other ongoing and future wetland restoration projects, shoreline stabilization projects, land conservation, and water pollution control measures. Implementing the Recommended Plan would also mitigate past cumulative negative impacts to water quality by restoring wetlands that were historically filled.

6.2.3 Cumulative Impacts on Biological Resources

Short-term, negative impacts to species diversity and abundance may occur as a result of construction activities at restoration sites. These impacts are unlikely to be cumulative as a result of implementing the Recommended Plan alone, but may become cumulative if larger construction projects that are unrelated to the Recommended Plan occur in the vicinity. As previously discussed, impacts related to construction would be short-term and would be minimized using applicable BMPs such as soil erosion control measures, to protect water quality, and fencing/tree protection to minimize unnecessary disturbances to vegetation. Ongoing consultation with the USFWS, National Marine Fisheries Service (NMFS), and NYSDEC, will take place over the duration of the project to prevent adverse impacts to federal- or state-listed threatened and endangered species from implementation of the Recommended Plan.

Long-term positive impacts to biological resources as a result of implementing the Recommended Plan would primarily be driven by proposed wetland restoration, side channel restoration, and aquatic organism passage restoration. Long-lasting, beneficial cumulative impacts to biological resources may occur as a result of implementing the Recommended Plan alongside other ongoing and future habitat conservation and restoration projects, hydrological connection restoration, and water pollution control measures. Implementing the Recommended Plan would also mitigate past cumulative negative impacts to biological resources by restoring historically disturbed habitats and removing man-made barriers to aquatic organism passage.

6.2.4 Cumulative Impacts on Climate Resilience

Long-term positive impacts to climate resiliency, as a result of implementing the Recommended Plan, would primarily be driven by proposed increases in flood storage and stabilization of shorelines. Long-lasting, beneficial cumulative impacts to climate resiliency may occur as a result of implementing the Recommended Plan alongside other ongoing and future side channel restoration, shoreline stabilization, and climate-related planning and policies by local, state, and federal entities.

6.2.5 Cumulative Impacts on Coastal Resources

Long-term positive impacts to coastal resources as a result of implementing the Recommended Plan would primarily be driven by proposed habitat restoration, aquatic organism passage restoration, and stabilization of shorelines. Proposed actions at each of the Recommended Plan sites are consistent with one or more of the objectives of the Coastal Management Program. In particular, implementing the Recommended Plan would promote Coastal Policy 7, through the restoration of a Significant Coastal Fish and Wildlife Habitat, and Coastal Policy 44, through the restoration of wetland habitat.

Long-lasting, beneficial cumulative impacts to coastal resources may occur as a result of implementing the Recommended Plan alongside other ongoing and future habitat restoration, aquatic organism passage restoration, and shoreline stabilization.

6.2.6 Irreversible or Irretrievable Commitments of Resources Involved in the Implementation of the Recommended Plan

The environmental analysis includes identification of any irreversible and irretrievable commitments of resources, which would be involved in the implementation of the Recommended Plan." This clause in NEPA refers to the use of nonrenewable resources and the effects that the use of these resources may have on future generations. Irreversible effects primarily result from use or destruction of a specific resource (e.g., energy and minerals) that cannot be replaced within a reasonable period. Irretrievable resource commitments involve the loss in value of an affected resource that cannot be restored because of the action (e.g., extinction of a species or the disturbance of a cultural site). As an ecosystem restoration project, the proposed federal action is designed to have little or no irreversible and irretrievable commitment of resources. The Recommended Plan would result in a minor irreversible loss of upland areas associated with wetland restoration activities. All construction effects are assumed to be short-term reductions in aquatic and plant resources, which would recover their abundances in a relatively short period.

Chapter 7: Environmental Compliance*

The status of the Recommended Plans compliance with applicable federal environmental requirements is summarized below. Prior to initiation of construction, the work would be in compliance with all applicable federal laws and Executive Orders.

7.1 National Environmental Policy Act of 1969

The National Environmental Policy Act (NEPA) (40 CFR §1502.16) commits federal agencies to considering, documenting, and publicly disclosing the environmental impacts of their actions. This Final Integrated Feasibility Report and Environmental Assessment (FR/EA) is intended to achieve NEPA compliance for the Recommended Plan. Consistent with USACE NEPA regulations and guidance, the draft FR/EA was published for a 30-day public comment period on June 25, 2019. Based on local sponsor and stakeholder requests, the comment period was extended an additional 30 days to August 26, 2019. This final FR/EA, which takes into account all comments received (Appendix G7), as well as additional feasibility-level analyses (e.g., more detailed designs and accurate cost estimates), will be published prior to project implementation.

7.1.1 Public Involvement

There has been significant support and involvement from federal, state, local, and non-governmental organizations (NGOs) to advance the restoration of the Hudson River Estuary. Since the original initiation of the HRHR Feasibility Study in 1997, USACE has participated in the NYSDEC's Hudson River Estuary Program with partners to coordinate in the development and advancement of the NYS Hudson River Estuary Action Agenda and the NYSDEC Habitat Restoration Plan. The Hudson River Estuary Program has frequently hosted meetings to enhance coordination and public involvement for this study.

In 2013, USACE worked more closely with NYSDEC, local stakeholders and the 'Partners Restoring the Hudson' (composed of approximately 30 organizations) to successfully resume the HRHR Feasibility Study. USACE coordinated with the partners and NYSDEC during the development of the Hudson River Comprehensive Restoration Plan (HR CRP) (Partners Restoring the Hudson, 2018) to supplement the NYS Hudson River Estuary Action Agenda. The HR CRP provided valuable information to the feasibility study on existing current conditions, regional goals and targets and potential restoration opportunities.

The feasibility study has benefited from the dozens of technical and public outreach meetings held to develop the regional targets and goals and identify restoration opportunities throughout the study area. Specifically, USACE and NYSDEC have met with stakeholders, Scenic Hudson, Schodack Island State Park officials, local landowners from the Binnen Kill area (September 2018), and the Town of Bethlehem at Henry Hudson Park (October 2018). NYSDEC and USACE also met with landowners of the AOP barriers, in March, April, and June 2019.

The draft FR/EA underwent public review from 25 June 2019 to 26 August 2019. Nineteen comments were received and New York District's responses to each are included in Appendix G7. The comments resulted in two sites, Rondout Creek (Eddyville Dam) and Binnen Kill, being removed from the plan prior to feasibility-level design.

The study has generated strong letters of endorsement from members of the New York delegation to the House of Representatives. Other federal agencies have supported the study by sharing information and providing expertise.

The recommendations outlined in this Final Integrated FR/EA will advance the NYSDEC Hudson River Estuary Action Agenda 2015-2020, NYSDEC Hudson River Estuary Habitat Restoration Plan, and the partnership's regional Target Ecosystem Characteristics targets and goals that are outlined in the Hudson River Comprehensive Restoration Plan (The Partners Restoring the Hudson, 2018).

7.1.2 Compliance with Fish and Wildlife Coordination Act Recommendations

a. The District will utilize best management practices for invasive species treatment. On sites where rare and or state listed species were identified to potentially occur, surveys will be conducted to identify and avoid the species prior to and spraying or construction activities.
b. The design of the Schodack side channel will incorporate sea level change in order to maximize life of the vegetation. The designs will incorporate nature-based features to all extents practicable.
c. Soils will be tested for hazardous substances before removal from the site. The District will follow NYSDEC guidance for *In-Water and Riparian Management of Sediment and Dredged Material* and utilize best management practices for sediment and erosion control during construction.
d. The District will utilize an adaptive management strategy (see Appendix H) in the treatment of invasive plants. Strategies will include but not limited to mechanical removal, pesticides, and replanting.
e. Adverse impacts to migratory birds will be minimized by removing trees during the winter or conducting surveys prior to removal if during the breeding season.
f. Tree cutting will not occur within 150 feet of a known occupied maternity roost tree during the pup season (June 1 through July 31) or within a 0.25 miles of a

hibernation site, year round. The District will consult with the NYFO for northern long-eared bats during the Pre-Engineering and Design (PED) phase of the project.

g. The District will maintain the tree line on the western tidal measure along the Vloman Kill for the Henry Hudson Park site. The District will conduct hydrological modeling to determine flow and any necessary channels into the site.

h. For the Moodna sites, the District will re-grade the substrate upstream of AOP 1 to tie into the downstream riverbed elevation. For AOP 2, during the PED phase the District will investigate the best way to minimize excessive sediment bedload on the creek system with the removal of the dam. For AOP 3, during PED, the District will investigate a phased approach to the removal of the dam. Grade structures are planned to be installed after the removal.

7.1.3 Compliance with Executive Order 11988

Executive Order 11988 requires that Agencies avoid, to the extent possible, adverse impacts associated with the occupancy and modification of flood plains and to avoid support of floodplain development wherever there is a practicable alternative. In accomplishing this objective, "each agency shall provide leadership and shall take action to reduce the risk of flood loss, to minimize the impact of floods on human safety, health, and welfare, and to restore and preserve the natural and beneficial values served by flood plains in carrying out its responsibilities."

The Water Resources Council Floodplain Management Guidelines for implementation of E.O. 11988, as referenced in ER 1165-2-26, requires an eight-step process that agencies should carry out as part of their decision-making on projects that have potential impacts to, or are within the floodplain. The eight steps and project-specific responses to them are summarized below in Table 7-1.

Table 7-1: Project Response to E.O. 11988.

EXECUTIVE ORDER 11988 STEP	PROJECT-SPECIFIC RESPONSE
Determine if a proposed action is in the base floodplain (that area which has a one percent or greater chance of flooding in any given year).	The proposed action is within the base floodplain.
If the action is in the base floodplain, identify and evaluate practicable alternatives to the action or to location of the action in the base flood plain.	As the primary objective of the project is aquatic ecosystem restoration, no practicable alternatives are completely outside of the base floodplain for the sites that would achieve this objective.
If the action must be in the floodplain, advise the general public in the affected area and obtain their views and comments.	The integrated FR/EA has been released to public review, and coordination with agency officials and the public have been held throughout the study.
Identify beneficial and adverse impacts due to the action and any expected losses of natural and beneficial flood plain values. Where actions proposed to be located outside the base floodplain will affect the base flood plain, impacts resulting from these actions should also be identified.	Potential impacts and benefits were evaluated in Chapter 5. The anticipated impacts associated with the Recommended Plan are summarized. While construction of project features would result in mostly minor and temporary adverse impacts to the natural environment, the proposed restoration would result in a substantial and long-term increase in habitat values including an increase in the quantity and quality of riparian and aquatic habitat. For each resource analyzed in Chapter 5, wherever there is a potential for adverse impacts, appropriate best management practices or other environmental considerations were identified.
If the action is likely to induce development in the base floodplain, determine if a practicable non-floodplain alternative for the development exists.	The project will not encourage development in the floodplain.

EXECUTIVE ORDER 11988 STEP	PROJECT-SPECIFIC RESPONSE
As part of the planning process under the Principles and Guidelines, determine viable methods to minimize any adverse impacts of the action including any likely induced development for which there is no practicable alternative and methods to restore and preserve the natural and beneficial flood plain values. This should include reevaluation of the "no action" alternative.	The project would not induce development in the flood plain. Chapter 3 of this report summarizes the alternative identification, screening and selection process. The "no action" alternative was included in the plan formulation phase.
If the final determination is made that no practicable alternative exists to locating the action in the floodplain, advise the general public in the affected area of the findings.	The Final Integrated FR/EA documents the final determination.
Recommend the plan most responsive to the planning objectives established by the study and consistent with the requirements of the Executive Order.	The Recommended Plan is the most responsive to all of the study objectives and the most consistent with the executive order.

7.1.4 Compliance with Federal Law and Regulations

Compliance of the Recommended Plan with applicable federal statutes and executive orders is outlined in Table 7-2.

Table 7-2: Summary of Primary Federal Laws and Regulations Applicable to the Recommended Plan.

LEGISLATIVE TITLE	U.S. CODE/OTHER	COMPLIANCE
Bald and Golden Eagle Act of 1940	16 U.S.C. §668-668c	Compliant. Construction activities with the proposed actions have potential to disturb bald and golden eagles due to the presence of heavy machinery and elevated noise levels. Review of USFWS database showed there are no recorded eagle nesting sites within two miles of the project areas.
Clean Air Act	42 U.S.C. §§ 7401 7671g	Compliant. The Project is in an attainment area; therefore a RONA is not required. Construction activities associated with the Recommended Plan will create air emissions and would have no lasting effect on the study area.

LEGISLATIVE TITLE	U.S. CODE/OTHER	COMPLIANCE
Clean Water Act	33 U.S.C. §§ 1251 et seq.	Compliant. USACE produced an evaluation complying with the Clean Water Act in Appendix G2.
Coastal Zone Management Act	16 U.S.C. §§ 1451-1464 N.J.	Compliant. A CZM Determination was prepared and is in Appendix G4. Consistency review was completed on 15 July 2020 with NYSDOS concurring with the consistency determination.
Endangered Species Act of 1973	16 U.S.C. §§ 1531 et seq.	Compliant. T&E coordination is complete. See Appendix G1 and G6.
Environmental Justice in Minority and Low-Income Populations	Executive Order 12898	Compliant. USACE performed an analysis and has determined that a disproportionate negative impact on minority or low-income groups in the community is not anticipated; a full evaluation of Environmental Justice issues is not required.
Executive Order 11988, Protection of Floodplains	May 24, 1977	Compliant. Recommended Plan will not cause significant changes in future with-project flood conditions compared to future without-project conditions.
Executive Order 11990, Protection of Wetlands	May 24, 1977	Compliant. Recommended Plan has overall effect of enhancing wetlands and increasing their total area. Circulation of this report for public and agency review fulfills the requirements of this order.
Executive Order 13045, Protection of Children from Environmental Health Risks and Safety Risks	April 21, 1997	Implementation of this project will reduce environmental health risks. Circulation of this report for public and agency review fulfills the requirements of this order.
Executive Order 13751, Safeguarding the Nation from the Impacts of Invasive Species	Dec 5, 2016	Compliant. Directs actions to continue coordinated federal prevention and control efforts related to invasive species. The Recommended Plan includes removal of invasive species and establishment of native habitat and complies with this EO.

LEGISLATIVE TITLE	U.S. CODE/OTHER	COMPLIANCE
Fish and Wildlife Coordination Act	16 U.S.C. § 661 et seq.	Compliant. See Appendix G6.
Magnuson-Stevens Act Fishery Conservation and Management Act	Section 305(b)(2) 1996 Amendments	Compliant. The District submitted an EFH assessment in a letter dated 8 September 2020, NOAA Fisheries responded 6 October 2020. NOAA Fisheries provided conservation measures that the District will follow See Appendix G1.
Migratory Bird Treaty Act of 1918	16 U.S.C. §703-712	Compliant. Recommended Plan will not have any negative effects on migratory bird habitat. Neo-tropical migratory birds that use the riparian zone in the river and tributary corridors will benefit from increase in available habitat. Removal of trees will occur during non-breeding season or surveys will be conducted.
National Environmental Policy Act of 1969	42 U.S.C. §§ 4321-4347	Compliant. Recommended Plan would have the overall effect of enhancing wetlands and increasing their total area in the lower Hudson River. The circulation of the Draft EA with the Draft FONSI fulfilled requirements of this act. See Appendix G7.
National Historic Preservation Act of 1966	54 U.S.C. §§ 300101	Compliant. The District prepared a Historical and Archaeological Assessment to identify cultural resources and the potential for adverse effects to cultural resources and coordinated its findings with the New York State Historic Preservation Office, the Advisory Council on Historic Preservation, and federally recognized tribes. The public was afforded an opportunity to review and comment upon the District's findings and the draft Programmatic Agreement (PA) through the public review period (June 24 - August 26, 2019) for the draft FR/EA. The PA was signed on July 6, 2020 and is included in Appendix G5. Execution and implementation of the provisions outlined in the PA fulfill the requirements of the NHPA.
Prime and Unique Farmlands	CEQ Memorandum of August 1, 1980: Analysis of Impacts on Prime or Unique Agricultural Lands in	Compliant. Not present in project area.

LEGISLATIVE TITLE	U.S. CODE/OTHER	COMPLIANCE
	Implementing NEPA.	
Wild and Scenic Rivers	Wild and Scenic Rivers Act, as amended (16 USC 1271 et seq.)	Compliant. Not present in project area.
Federal Aviation Administration (FAA)	FAA Advisory Circular 150/5200-33B and the MOA with FAA to address aircraft- wildlife strikes	Compliant. Two of the restoration project sites (Charles Rider Park and Rondout Creek) that were near to an airport are no longer part of the Recommended Plan does not require consultation since sites exceed the 5,000 ft criteria from nearest air operations area (AOA).

Chapter 8: Conclusions and Recommendations

I recommend that the Recommended National Ecosystem Restoration (NER) Plan for the Hudson River Habitat Restoration (HRHR), Ecosystem Restoration Feasibility Study, as fully detailed in this Final Integrated Feasibility Report and Environmental Assessment, be authorized for construction as a federal project, subject to such modifications as may be prescribed by the Chief of Engineers.

I have given full consideration to all significant aspects of this recommendation in the overall public interest, including environmental, social, and economic effects, engineering feasibility and compatibility of the project with the policies, desires and capabilities of the State of New York and other non-federal interests. The Recommended NER Plan consists of restoration activities at three sites in the Hudson River watershed:

RESTORATION CATEGORY	SITE	ELEMENT DESCRIPTION OF RECOMMENDED ALTERNATIVES
Shoreline Restoration	Henry Hudson Park	▪ Tidal wetland restoration (3.7 acres) ▪ Hardened bulkhead replaced with a living shoreline (1,760 linear feet of shoreline restoration with 0.6 acres of tidal wetlands)
Large River Mosaic	Schodack Island	▪ Side channel and wetland complex restoration (8.5 acres) ▪ Tidal wetland restoration (19.1 acres)
Tributary Connectivity	Moodna Creek	▪ Removal of a utility crossing (barrier 1) ▪ Removal of Firth Cliff Dam (barrier 2) ▪ Partial removal of Orr's Mill Dam (barrier 3) ▪ Collectively, reconnection of 7.8 miles of habitat
Total		**• 22.8 acres of tidal wetlands in the Hudson River corridor** **• 8.5 acres of side channel and tidal wetland complex** **• 1,760 linear feet of living shoreline with 0.6 acres of tidal wetlands** **• 7.8 miles of tributary habitat reconnected**

The Recommended NER Plan provides positive ecosystem and social benefits that support the USACE's restoration mission. The plan cost-effectively meets the study planning objectives for ecosystem restoration of nationally and regionally significant resources. The recommended alternatives were incrementally-justified for each site and the plan recommended for each site is considered a best-buy plan.

As documented in this report, no significant adverse environmental impacts would occur as a result of implementation of the Recommended Plan. Pending completion of public and State and Agency Review, a Finding of No Significant Impact (FONSI) will be prepared as part of the final recommendation. The plan includes monitoring and adaptive management until ecological success criteria are met, for no more than 10 years, and adaptive management as described in this document. A final Operations, Maintenance, Repair, Replacement, and Rehabilitation plan will be established upon completion of each project.

The Recommended NER Plan would restore a total of approximately 22.8 acres of tidal wetlands, 8.5 acres side channel and wetland complex, 1,760 linear feet of living shoreline with 0.6 acres of tidal wetands, and would reconnect 7.8 miles of tributary habitat to the Hudson River. The plan would provide a total of 59.2 average annual functional capacity or habitat units. The plan would lessen some of the impacts constructing a federal navigation channel in the Hudson River had on aquatic ecosystems, including the loss and degradation of subtidal, shallow water and side channels, intertidal, and shoreline habitats, as well as the fragmentation of aquatic habitats that occurred as small dams were placed on tributaries to the Hudson River for industrial purposes.

The Recommended NER Plan has an estimated first cost of $43,143,000 which includes monitoring costs of $764,000 and adaptive management costs of $980,000. The estimated total fully funded cost of the project is $62,784,000. The fully funded costs will be the basis for Design and Project Partnership agreements.

The Recommended NER Plan supports HRHR study objectives and restoration goals set by the region. It complements past, ongoing, and planned restoration work by other parties as described in the Hudson River Comprehensive Restoration Plan. In order to fully address the restoration needs of the Hudson River study area, I also recommend that the USACE participate in additional future restoration feasibility studies identified in the Hudson River Comprehensive Restoration Plan via the study authorization.

My recommendation is made with the provisions outlined that the non-federal sponsors will provide the following items of cooperation prior to implementation:

a. Provide, during the periods of design and construction, funds necessary to make its total contribution for ecosystem restoration equal to 25 percent of the total project cost;

b. Provide all lands, easements, and rights-of-way, including those required for relocations, the borrowing of material, and the disposal of dredged or excavated material; perform or ensure the performance of all relocations; and construct all improvements required on lands, easements, and rights-of-way to enable the disposal of dredged or excavated material as determined by the Federal government to be required or to be necessary for the construction, operation, and maintenance of the project;

c. Prevent obstructions or encroachments on the project (including prescribing and enforcing regulations to prevent such obstructions or encroachments) such as any new developments on project lands, easements, and rights-of-way or the addition of facilities which might reduce the outputs produced by the project, hinder operation and maintenance of the project, or interfere with the project's proper function;

d. Operate, maintain, repair, rehabilitate, and replace the project at no cost to the Federal government, in a manner compatible with the project's authorized purposes and in accordance with applicable Federal and State laws and regulations and any specific directions prescribed by the Federal government;

e. Give the Federal government a right to enter, at reasonable times and in a reasonable manner, upon property that the non-Federal sponsor owns or controls for access to the project for the purpose of completing, inspecting, operating, maintaining, repairing, rehabilitating, or replacing the project;

f. Hold and save the United States free from all damages arising from the construction, operation, maintenance, repair, rehabilitation, and replacement of the project and any betterments, except for damages due to the fault or negligence of the United States or its contractors;

g. Keep, and maintain books, records, documents, and other evidence pertaining to costs and expenses incurred pursuant to the project, for a minimum of 3 years after completion of the accounting for which such books, records, documents, and other evidence are required, to the extent and in such detail as will properly reflect total cost of the project, and in accordance with the standards for financial management systems set forth in the Uniform Administrative Requirements for Grants and Cooperative Agreements to State and local governments at 32 CFR, Section 33.20;

h. Perform, or ensure performance of, any investigations for hazardous substances that are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 USC 9601-9675, that may exist in, on, or under lands, easements, or rights-of-way that the Federal government determines to be necessary for the construction or operation and maintenance of the project;

i. Assume, as between the Federal government and the non-Federal sponsor, complete financial responsibility for all necessary cleanup and response costs of any hazardous substances regulated under CERCLA that are located in, on, or under lands, easements, or rights-of-way that the Federal government determines to be necessary for the construction, operation, maintenance, repair, rehabilitation, or replacement of the project;

j. Agree, as between the Federal government and the non-Federal sponsor, that the non-Federal sponsor shall be considered the operator of the project for the purpose of CERCLA liability, and to the maximum extent practicable, operate, maintain, repair, rehabilitate, and replace the project in a manner that will not cause liability to arise under CERCLA;

k. Comply with Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended, (42 U.S.C. 1962d-5b) and Section 101(e) of the WRDA 86, Public Law 99-662, as amended, (33 U.S.C. 2211(e)) which provide that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof, until the non-Federal sponsor has entered into a written agreement to furnish its required cooperation for the project or separable element;

l. Comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, as amended, (42 U.S.C. 4601-4655) and the Uniform Regulations contained in 49 CFR Part 24, in acquiring lands, easements, and rights-of-way necessary for construction, operation, and maintenance of the project including those necessary for relocations, the borrowing of material, or the disposal of dredged or excavated material; and inform all affected persons of applicable benefits, policies, and procedures in connection with said act;

m. Comply with all applicable Federal and state laws and regulations, including, but not limited to: Section 601 of the Civil Rights Act of 1964, Public Law 88-352 (42 U.S.C. 2000d), and Department of Defense Directive 5500.11 issued pursuant thereto; Army Regulation 600-7, entitled “Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army”; and all applicable Federal labor standards requirements including, but not limited to, 40 U.S.C. 3141-3148 and 40 U.S.C. 3701-3708 (revising, codifying and enacting without substantive change the provisions of the Davis-Bacon Act (formerly 40 U.S.C. 276a et seq.), the Contract Work Hours and Safety Standards Act (formerly 40 U.S.C. 327 et seq.), and the Copeland Anti-Kickback Act (formerly 40 U.S.C. 276c));

n. Not use the project or lands, easements, and rights-of-way required for the project as a wetlands bank or mitigation credit for any other project;

o. Not use funds from other Federal programs, including any non-federal contribution required as a matching share therefore, to meet any of the non-Federal sponsor's obligations for the project unless the Federal agency providing the funds verifies in writing that such funds are authorized to be used to carry out the project.

The recommendations contained herein reflect the information available at this time and current Department of the Army policies governing formulation of individual projects. They do not reflect program and budgeting priorities inherent in the formulation of a national Civil Works construction program nor the perspective of highest review levels within the Executive Branch. Consequently, the recommendations may be modified (by the Chief of Engineers) before they are transmitted to the Congress as proposals for authorization and implementing funding. However, prior to transmittal to Congress, the partner, the State, interested Federal Agencies, and other parties will be advised of any modifications and will be afforded an opportunity to comment further.

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