HUDSON RIVER HABITAT RESTORATION

ECOSYSTEM RESTORATION
FINAL INTEGRATED FEASIBILITY REPORT AND ENVIRONMENTAL ASSESSMENT

Appendix C:
Plan Formulation

U.S. ARMY CORPS OF ENGINEERS
NEW YORK DISTRICT
August 2020

1. INTRODUCTION

This appendix supplements Chapter 3: Plan Formulation and Chapter 4: Recommended Plan in the Hudson River Habitat Restoration Feasibility Study Final Integrated Feasibility Report and Environmental Assessment. More detail is provided herein on the six sites for which alternatives were developed, the alternatives, and the preliminary screening process. This appendix contains site summaries for the six sites in the final array of sites (Binnen Kill, Schodack Island, Henry Hudson Park, Charles Rider Park, Rondout Creek, and Moodna Creek), mapped in Figure 1-1, and tables showing how 212 sites were screened to 13 (Attachment 1: Tables C-1 and C-2). The site summaries include concept plans for the alternatives that were developed.

Figure 1-1: Final Array of Six Sites.

2. SITE SUMMARIES

2.1. Binnen Kill

Site Setting

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, and encompasses approximately 1,000 acres of publicly- and privately-owned lands (Figure 2-1). The eastern edge of the site originally included islands that were separated from the historic shoreline by side channels in the 1800s but that are now contiguous with the site due to dredged material infilling. Binnen Kill is a tidal freshwater tributary that is 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).

Figure 2-1: Binnen Kill site overview.

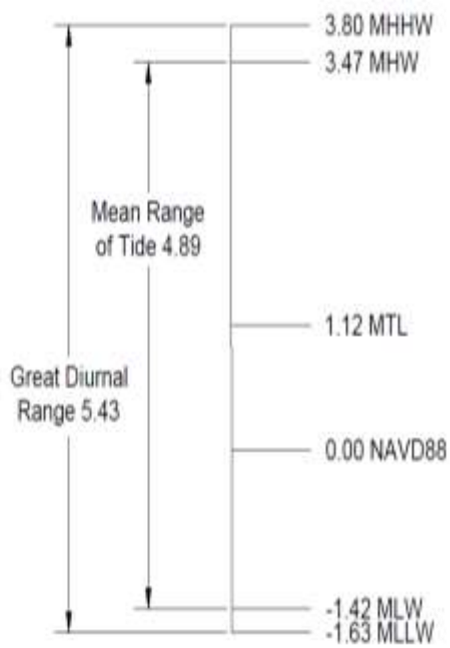


Figure 2-2: Tidal Stages Relative to NAVD88, feet.

The site includes a variety of vital ecological communities and habitats that have been significantly altered by a combination of human action, including dredged material placement and farming, and natural processes.

The Hudson River is tidal in this area; semidiurnal tides at the site range in elevation from 3.80 feet (North American Vertical Datum of 1988, NAVD88) at Mean Higher High Water (MHHW) to -1.63 feet (NAVD88) at Mean Lower Low Water (MLLW) (Figure 2-2) based on the Hudson River Environmental Conditions Observing System (HRECOS) monitoring station located at Schodack Island approximately 1,300 feet downstream of Binnen Kill's confluence with the Hudson River.

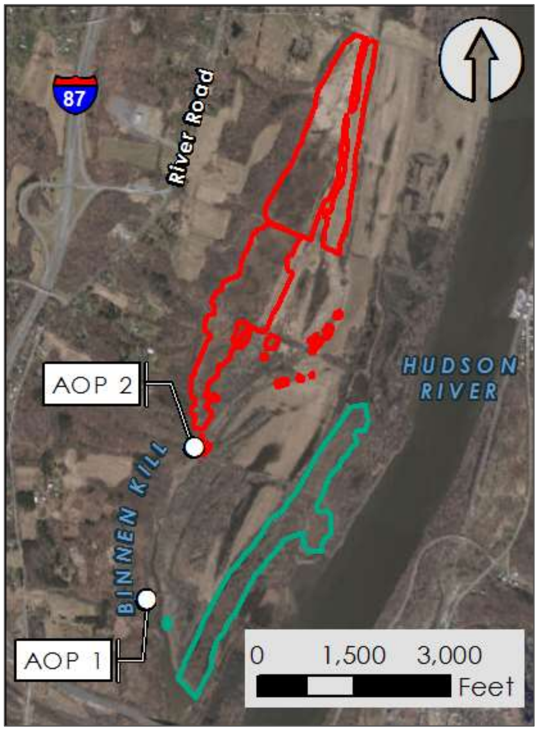


Figure 2-3: Binnen Kill site project components, north (red) and south (green), and AOP locations.

Binnen Kill proper has both tidal and non-tidal portions. The tidal portion begins at its confluence with the Hudson River below Castleton Bridge and extends upstream for approximately 7,500 feet. A bridge (AOP 1) and culvert crossing (AOP 2) span this segment of the stream (Photographs 1 and 2). Monitoring of water surface elevations immediately upstream of each crossing from June to November 2018 confirms that the tidal datum (e.g. MLLW and MHHW) elevations are not truncated by the infrastructure. The head of tide is upstream of AOP 2 and outside of the project area.

Supplemental site survey cross sections were collected at AOP 1 and AOP 2; refer to Appendix B - Engineering for additional information. AOP 1 is a steel girder supported bridge with a clear span approximately 45 feet in width (Photograph 1). Based on the cross sections and field observations, it is the professional opinion of the study team that AOP 1 does not affect the hydrology of Binnen Kill and does not function as a barrier to aquatic organism passage during normal flows. AOP1 was therefore removed from consideration. AOP 2 is a round metal pipe with an approximate diameter of 56 inches that conveys flow under a primitive earthen road (Photograph 2). During low to normal flows the crossing could be a barrier to aquatic organism passage.

For the purpose of this project, the Binnen Kill site was broken into two components, north and south (Figure 2-3). The north component includes AOP 2 and approximately 90 acres of various vegetation communities including *Phragmites australis* (common reed) and *Phalaris arundinacea* (reed canary grass). The land is privately held, however Scenic Hudson, an environmental group that preserves land and farms, owns the majority of land or holds conservation or access easements on some of the privately-owned land within the project footprint (Appendix I - Real Estate). Topographic data derived from LiDAR (Light Detection and Ranging) indicates that the average ground elevation in the north project footprint is 5.5 to 6 feet (NAVD88) with elevations up to 8 feet (NAVD88). The south component footprint is on New York State-owned lands and roughly overlaps the historic side channels that were infilled with dredged material. The footprint is comprised of emergent and forested non-tidal wetlands, tidal wetlands, and forested uplands with a dense understory of *Phragmites australis*. According to LiDAR data, the ground elevation ranges from 0.5 to 7 feet (NAVD88).

Refer to Appendix D - Benefits for a complete list of vegetation communities and see Appendix B - Engineering for details about LiDAR, ground elevations and field surveys (cross sections, shoreline profiles, and water levels) conducted in June/July 2018.

Supplemental site survey also included collection of cross sections along the shoreline on the State-owned southern extent of Shad Island. A portion of the shoreline there is protected by timber cribbing, with approximately 30 to 100 feet of beach landward, which transitions to forest.

Photograph 1 (Top). View of AOP 1 top of bridge. Photograph 2 (Below). View of AOP 2 metal pipe (left) and earthen road above the pipe (right).

The slope of the beach ranges from seven to ten percent. Little evidence of erosion was observed. Due to the vegetated condition of the forested shoreline and lack of erosion, this portion of the shoreline was removed from restoration consideration.

Site Background

The Binnen Kill site was significantly impacted by the placement of dredged material from the Hudson River navigation channel maintenance. Originally, Shad and Schermerhorn Islands were, in fact, islands and separated from the mainland by side channels. The side channels provided shallow water habitat, spawning and nursery habitat, and fish refugia during increased channel flow. This shallow water habitat was filled with dredged material making the islands continuous with the mainland; these lands are also referred to as Lands Now or Formerly under Water and are held in trust for the citizens of the State (Louis Berger US, Inc. & Hudsonia, Ltd., 2017). Dredged material was also placed throughout the site raising the ground elevation.

Previous Studies

The Binnen Kill site is a well-studied area and the focus of several project initiatives. The significant ecological habitats offered by the site including Shad and Schermerhorn islands were documented in the Significant Habitats and Habitat Complexes of the New York Bight Watershed (USFWS, 1997) and in Natural Areas and Wildlife in Your Community (NYSDEC, 2017). Additionally, the site is home to several tens of acres of wetlands that support a small population of a rare plant, northern estuarine beggar-ticks. The undeveloped nature of the site and its islands offers a unique opportunity to ensure tidal wetland migration without impediment.

In 2017, the *Natural Resource Inventory and Assessment of Conservation Priorities of the Binnen Kill and its Tidal Habitats* was published by the New York State Department of Environmental Conservation. The document inventories natural resources on the site including geology, soils, water resources, wildlife, and ecological habitats. The plan goes on to recommend six conservation priorities, management options, and action items to be implemented.

Most recently, the Binnen Kill floodplain was included in the Hudson River Comprehensive Restoration Plan, which catalogs “restoration progress to date in the Hudson, and set(s) long-term goals for its future.” The Binnen Kill floodplain was identified as having two physical habitat characterization impacts or ecological assessment threats, which may include items such as a hardened shoreline or high nutrient pollutant discharge. Two projects were identified, including restoring the floodplain to enhance hydrologic connectivity, facilitate tidal wetland migration, and improve habitat for target species; and to analyze farmland in divided spoils and restore the habitat to maximize biodiversity.

Constraints and Considerations

Constraints and considerations for this site range from property ownership to existing vegetation communities. To the extent practicable, privately-owned lands were avoided, particularly for the southern component. Additionally, a variety of rare plants were mapped as part of the Natural Resources Inventory effort (Louis Berger US, Inc. & Hudsonia, Ltd., 2017); project footprints were strategically placed to avoid rare plant populations. Maximizing ecological benefits was limited due to the significant forested areas present on site. Since forest is one of the highest-rated ecological functions in the Evaluation for Planned Wetlands assessment, replacing these areas with lower-rated functions would have been counterproductive. Given the well-established dense forest at Binnen Kill North, side channel restoration was not considered and the focus was placed on benefits maximized through the eradication of invasive plant species, the connection of tidal hydrology, and expansion of tidal wetlands.

EPW Considerations

As mentioned before, the Evaluation for Planned Wetlands results played a significant role in identifying opportunities for restoration. Several habitat communities are established on the site as reflected in the baseline Functional Capacity Unit; the north component is 222.94 for time years 0 and 50; and the south component for time years 0 and 50 are 78.80 and 86.73, respectively. Refer to Appendix D - Benefits for additional information.

Assumptions

Many assumptions were made in the development of the concept alternatives including:

- The proposed restoration would be continuous within a component, and that permission would be obtained from the appropriate property owners;
- The placement of the project footprints assumed that the presence of rare plants is limited to the mapped extent; a detailed botanical survey may be a requirement prior to design to ensure rare plants are absent from the project footprints;
- For the north component, it was assumed that wetland hydrology could be obtained to restore the freshwater non-tidal wetlands;
- For the south component, the placement of the side channel is based on historic shoreline and island spatial mapping. Excavation to restore the side channel should focus on existing areas of fill and avoid native soils;
- River velocities and flows are sufficient to maintain side channel flow and scour. By 2075 as sea levels change, it is assumed that the channel would convey flow at mean tide water levels and the riparian buffer would transition to tidal wetlands; and

- Existing timber cribbing structures and bulkhead features would remain in place.

Alternatives

Six alternatives were developed for this site; four alternatives for the north component and two alternatives for the south component. Concept plans for the Binnen Kill alternatives follow the narrative descriptions below.

Binnen Kill North - Alternatives 1 and 3

Wetland Restoration

Approximately 90 acres of existing habitat dominated by invasive species such as common reed or reed canary grass would be treated and replanted with native plant species.

AOP 2 Crossing Enlargement

The culvert at AOP 2 would be enhanced to ensure passage by aquatic organisms and was thought to improve hydrology within the Binnen Kill tributary. The metal pipe would be replaced with a box culvert with a stream substrate bottom. The road surface over the culvert would support farm equipment and all-terrain vehicles. Floodplain culverts would be installed on either side of the culvert to increase flow conveyance.

Alternative 1 incorporates both wetland restoration and crossing enlargement, while Alternative 3 only includes wetland restoration. Wetland restoration proposed on privately-owned property would be removed from Alternative 3.

Binnen Kill North - Alternatives 2 and 4

Wetland Restoration

Almost 44 acres of existing habitat dominated by invasive species such as common reed or reed canary grass would be treated and replanted with native plant species.

Forested Wetland Restoration

A portion of the existing hay field would be converted to forested wetland through the excavation of soil. Target ground elevations would need to be one foot above the groundwater table for two weeks during the growing season, to ensure wetland hydrology is achieved. After soil excavation, the area would be planted with native woody vegetation.

Emergent Wetland Restoration

This element would include the restoration of emergent wetland through the treatment of invasive plant species and excavation of soil. Target ground elevations would need to be within inches of the groundwater table, or contain ponded water, for two weeks during the growing season to ensure wetland hydrology is achieved. After soil excavation, the area would be planted with native vegetation.

Emergent Wetland Restoration and Channel Restoration

This element would include treatment of invasive plant species and the restoration of four connected pools along approximately 3,700 linear feet of new channel with varying widths. The channel would connect diffuse, shallow pools to form areas of ecological diversity. Soil excavation would need to ensure wetland hydrology is met and would be enhanced with hummock-hollow microtopography, which would support both emergent and forested wetland communities.

AOP 2 Crossing Removal

The culvert at AOP 2, earthen berm, and road crossing would be removed since the field investigation conducted in June 2018 indicated that modifications to AOP 2 would not significantly improve the hydrology of the tributary. The channel would be graded to allow aquatic organism passage and tidal wetlands would be established along the stream banks.

Alternative 2 incorporates each of the elements above, while Alternative 4 includes all of the elements except for AOP 2 crossing removal. Additionally, wetland restoration activities proposed on a small private parcel would be removed from Alternative 4.

As discussed in Chapters 3 and 4 of the main report, Alternative 4 was selected as the tentatively selected plan for Binnen Kill North.

Binnen Kill South - Alternative 1

Wetland Restoration

Almost 14 acres of existing forested habitat dominated by a common reed understory would be treated and replanted with native plant species.

Tidal Wetland Restoration East

This element includes treatment of invasive plant species and expansion of 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.

Tidal Wetland Restoration West

Approximately 0.28 acres of common reed would be treated and replanted with native vegetation. Careful attention to rare plants in the stream channel should be adhered to.

Side Channel and Riparian Corridor Restoration

A side channel would be excavated in areas of historic fill placement to hydrologically connect the Binnen Kill and the Hudson River with tidal waters. The channel would convey flow during large precipitation events and high tides and provide refuge to aquatic species during increased river velocities. Tidal wetlands would be established adjacent to the channel and transition to riparian buffer landward. By 2075 as sea levels change, it's anticipated that the channel would convey flow at mean tide water levels and the riparian buffer would transition to tidal wetlands. To accommodate local vehicular access to Shad Island, a privately-owned property, the channel would be spanned by rectangular reinforced box culverts and road surface.

Binnen Kill South - Alternative 2

Wetland Restoration

Almost 14 acres of existing forested habitat dominated by a common reed understory would be treated and replanted with native plant species.

Tidal Wetland Restoration East

This element includes treatment of invasive plant species and expansion of 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.

Tidal Wetland Restoration West

Approximately 0.28 acres of common reed would be treated and replanted with native vegetation. Careful attention to rare plants in the stream channel should be adhered to.

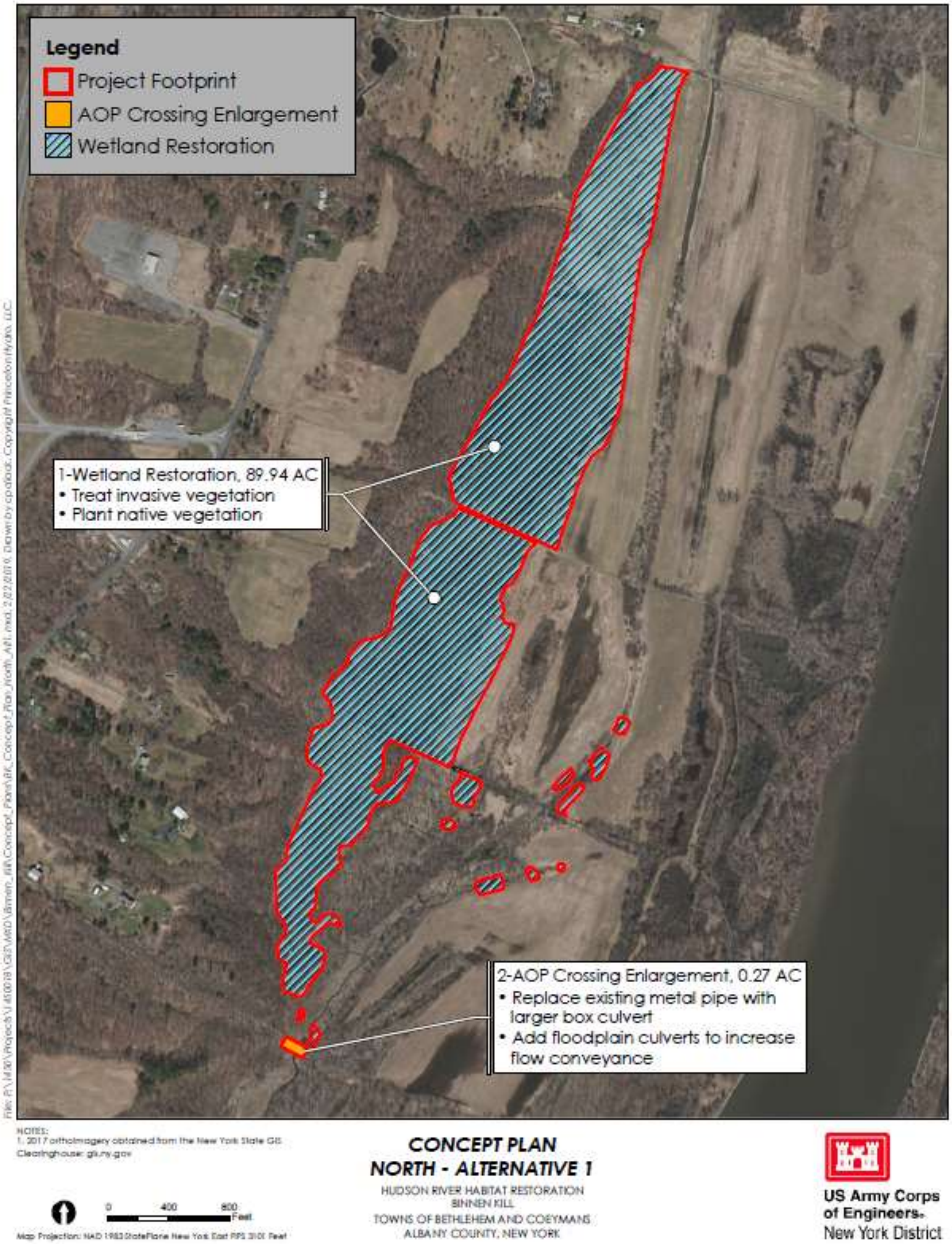
Side Channel and Tidal Wetland Corridor Restoration

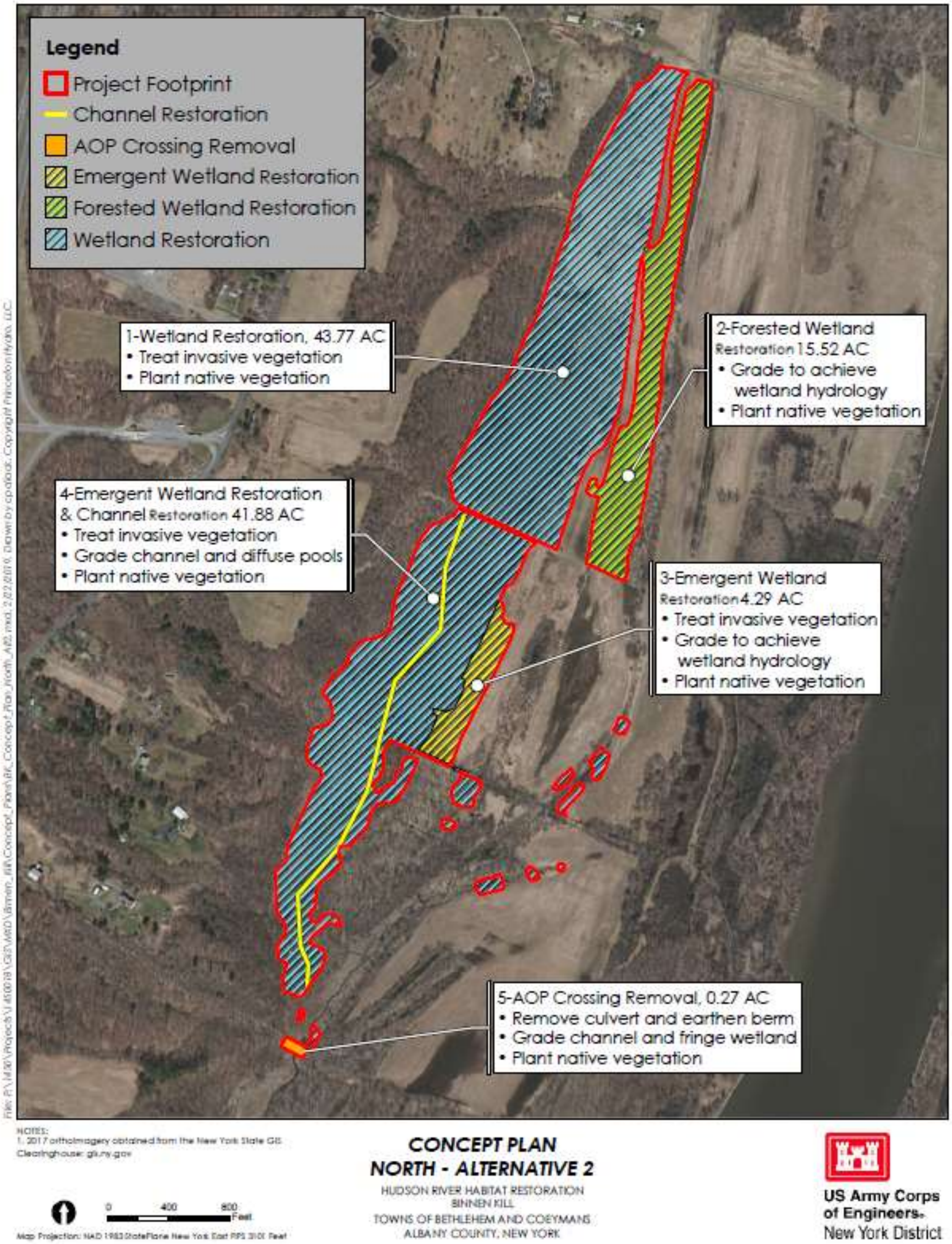
A side channel would be excavated in areas of historic fill placement to hydrologically connect the Binnen Kill and the Hudson River with tidal waters. The channel would convey flow during low tide and higher water levels providing refuge to aquatic species during increased river velocities. A 300-foot tidal wetland corridor would be established adjacent to the channel. To accommodate local vehicular access to Shad Island, a privately-owned property, the channel would be spanned by rectangular reinforced box culverts and road surface.

As discussed in the Chapters 3 and 4 of the main report, Alternative 2 was selected as the tentatively selected plan for Binnen Kill South.

Design Elements Considered but Dismissed

Design elements considered but dismissed included restoration of AOP 1 and restoration of a portion of land south of the Route 912M bridge. Expansion or removal of AOP 1 was dismissed due to the high construction cost, site ownership complexities, and marginal ecological benefit potential. Restoration of the tidal wetland south of Route 912M bridge was dismissed due to potential property ownership complexities and marginal ecological benefits.


Legend
Project Footprint
AOP Crossing Enlargement
Wetland Restoration
1-Wetland Restoration, 89.94 AC
• Treat invasive vegetation
• Plant native vegetation
2-AOP Crossing Enlargement, 0.27 AC
• Replace existing metal pipe with larger box culvert
• Add floodplain culverts to increase flow conveyance
NOTES:
1. 2017 orthoimagery obtained from the New York State GIS Clearinghouse: gis.ny.gov
0 400 800 Feet
CONCEPT PLAN
NORTH - ALTERNATIVE 1
HUDSON RIVER HABITAT RESTORATION
BINNEN KILL
TOWNS OF BETHLEHEM AND COEYMANS
ALBANY COUNTY, NEW YORK
US Army Corps of Engineers
New York District



CONCEPT PLAN
NORTH - ALTERNATIVE 2
HUDSON RIVER HABITAT RESTORATION
BINNEN KILL
TOWNS OF BETHLEHEM AND COEYMANS
ALBANY COUNTY, NEW YORK

NOTES:
1. 2017 orthoimagery obtained from the New York State GIS Clearinghouse: gis.ny.gov

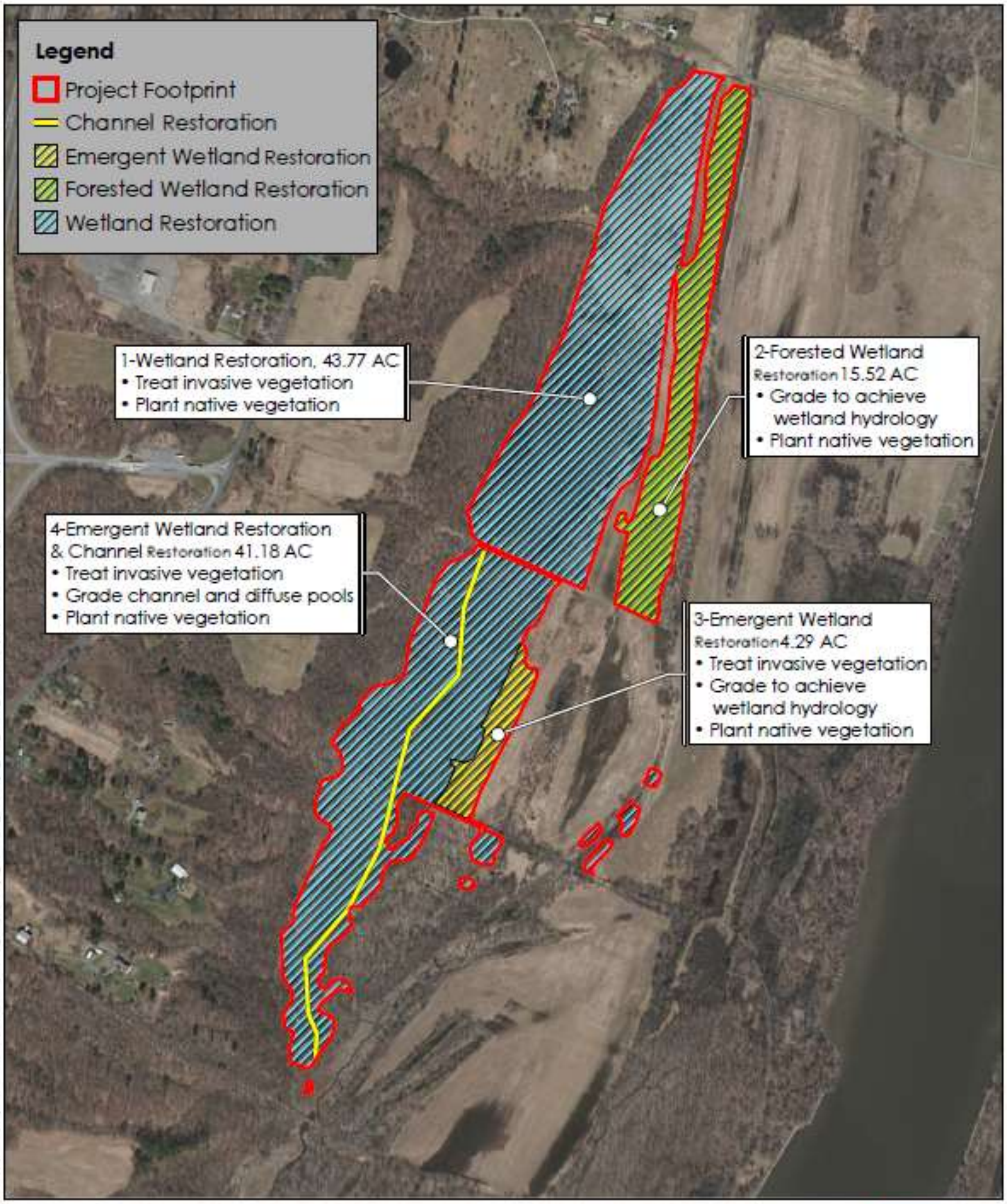
0 400 800 Feet

Map Projection: NAD 1983 StatePlane New York East FIPS 3101 Feet

CONCEPT PLAN
NORTH - ALTERNATIVE 3

HUDSON RIVER HABITAT RESTORATION
BINNEN KILL
TOWNS OF BETHLEHEM AND COEYMANS
ALBANY COUNTY, NEW YORK

US Army Corps of Engineers
New York District



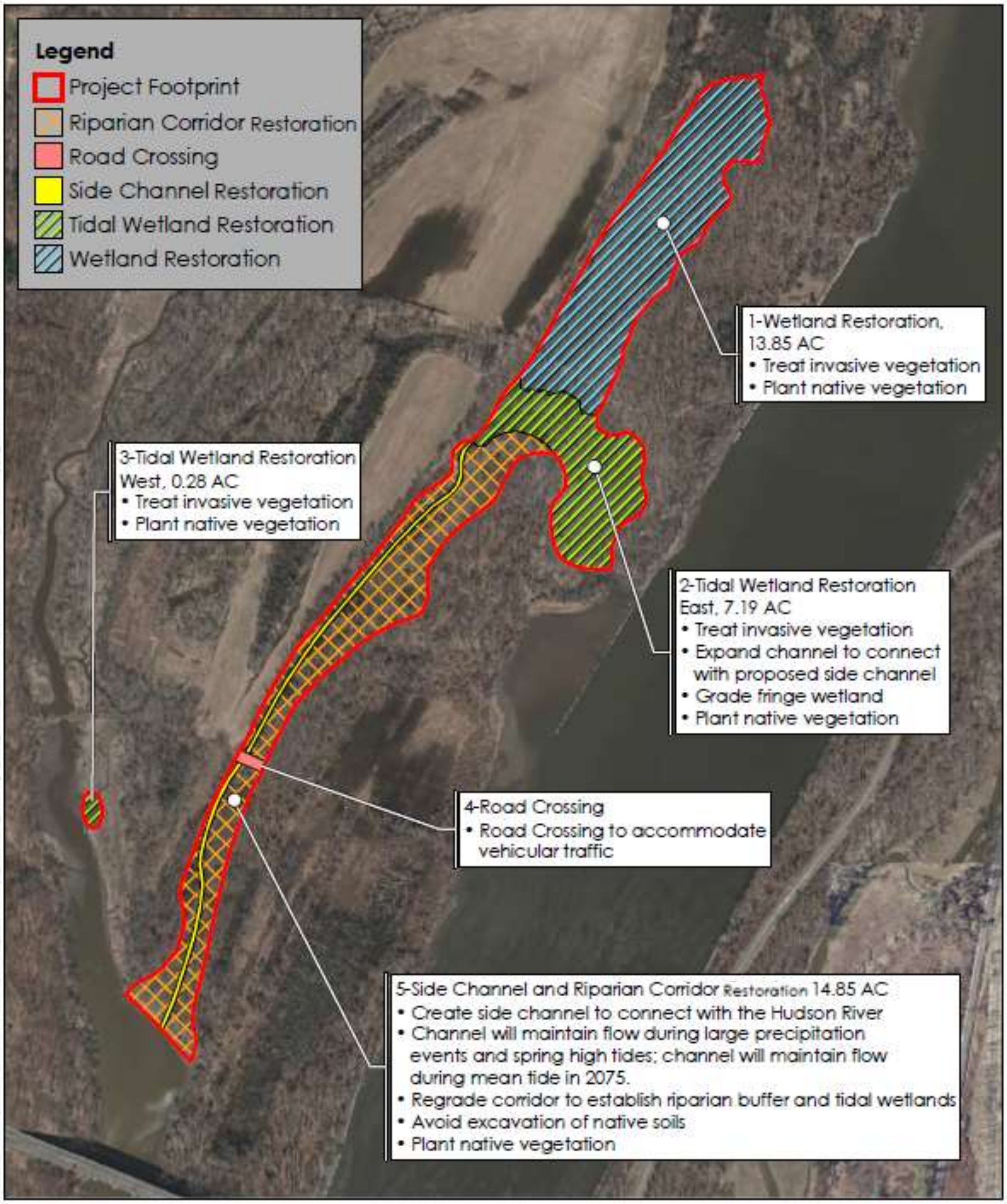
NOTES:
1. 2017 orthoimagery obtained from the New York State GIS Clearinghouse: gis.ny.gov

0 400 800 Feet

Map Projection: NAD 1983 StatePlane New York East FIPS 3101 Feet

CONCEPT PLAN
NORTH - ALTERNATIVE 4
HUDSON RIVER HABITAT RESTORATION
BINNEN KILL
TOWNS OF BETHLEHEM AND COEYMANS
ALBANY COUNTY, NEW YORK

US Army Corps of Engineers.
New York District



NOTES:
1. 2017 orthoimagery obtained from the New York State GIS Clearinghouse: gis.ny.gov

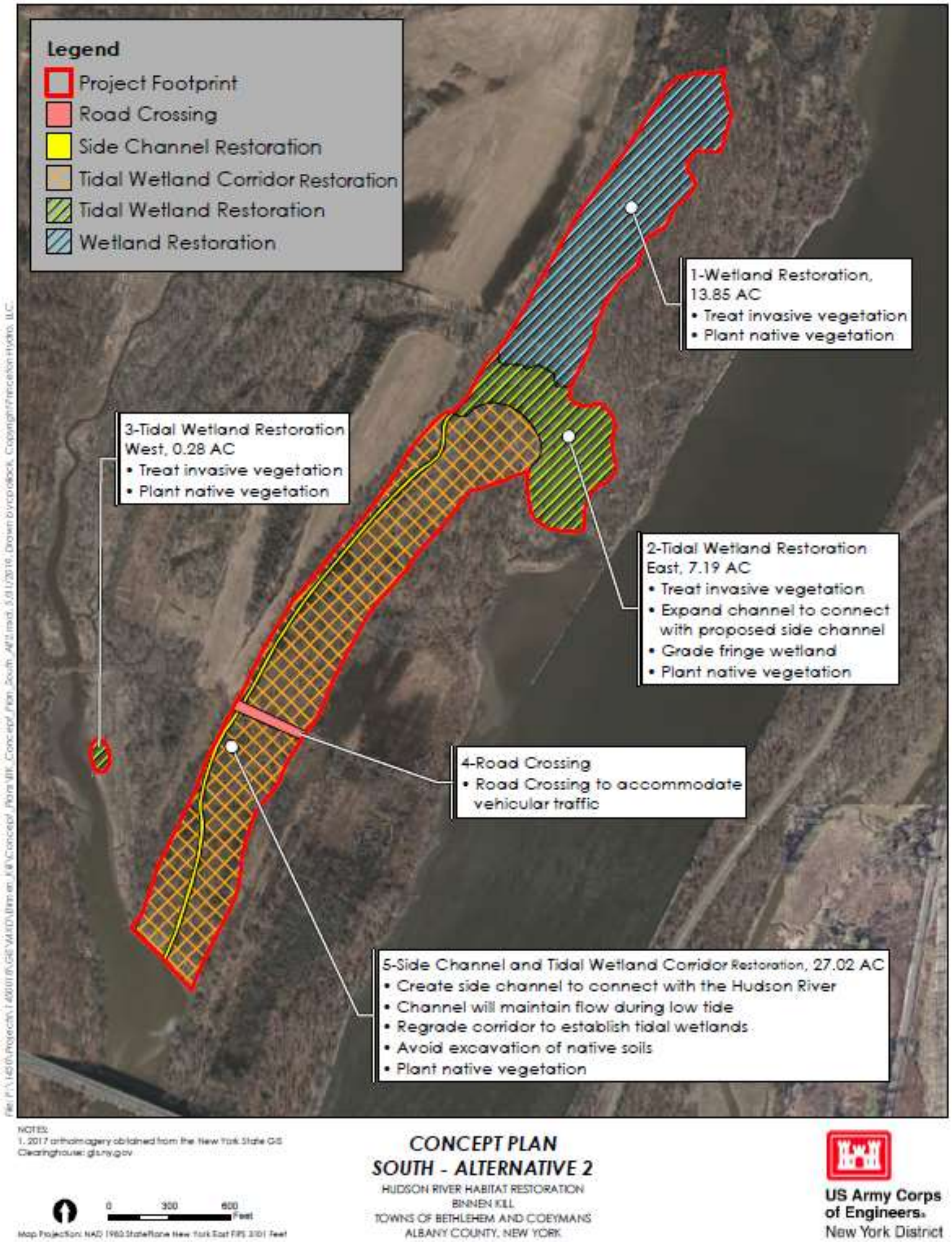
0 300 600 Feet

Map Projection: NAD 1983 StatePlane New York East FIPS 3101 Feet

CONCEPT PLAN
SOUTH - ALTERNATIVE 1

HUDSON RIVER HABITAT RESTORATION
BINNEN KILL
TOWNS OF BETHLEHEM AND COEYMANS
ALBANY COUNTY, NEW YORK

US Army Corps of Engineers
New York District


Legend
Project Footprint
Road Crossing
Side Channel Restoration
Tidal Wetland Corridor Restoration
Tidal Wetland Restoration
Wetland Restoration
1-Wetland Restoration, 13.85 AC
• Treat invasive vegetation
• Plant native vegetation
2-Tidal Wetland Restoration East, 7.19 AC
• Treat invasive vegetation
• Expand channel to connect with proposed side channel
• Grade fringe wetland
• Plant native vegetation
3-Tidal Wetland Restoration West, 0.28 AC
• Treat invasive vegetation
• Plant native vegetation
4-Road Crossing
• Road Crossing to accommodate vehicular traffic
5-Side Channel and Tidal Wetland Corridor Restoration, 27.02 AC
• Create side channel to connect with the Hudson River
• Channel will maintain flow during low tide
• Regrade corridor to establish tidal wetlands
• Avoid excavation of native soils
• Plant native vegetation
NOTES:
1. 2017 orthoimagery obtained from the New York State GIS Clearinghouse: gis.ny.gov
0 300 600 Feet
CONCEPT PLAN
SOUTH - ALTERNATIVE 2
HUDSON RIVER HABITAT RESTORATION
BINNEN KILL
TOWNS OF BETHLEHEM AND COEYMANS
ALBANY COUNTY, NEW YORK
US Army Corps of Engineers
New York District

2.2. Schodack Island

Site Setting

The Schodack Island project site is part of the Schodack Island State Park that 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 project site is limited to the southern portion of Schodack Island Park between the Hudson River and Schodack Creek (Figure 2-4). Schodack Island, which is in fact a peninsula, was historically comprised of 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.

Figure 2-4: Schodack Island site overview.

The original islands, Schodack Island (North and South) and Houghtailing Island, as well as Schodack Creek, are designated a Significant Coastal Fish and Wildlife Habitat, as well as a Bird Conservation Area, by New York State. 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, 2012; USFWS, 1997).

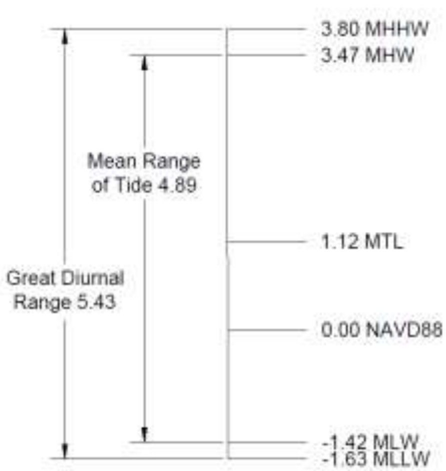


Figure 2-5: Tidal Stages Relative to NAVD88, feet.

The Hudson River is tidal in this area; semidiurnal tides at the site range in elevation from 3.80 feet (North American Vertical Datum of 1988, NAVD88) at Mean Higher High Water (MHHW) to -1.63 feet (NAVD88) at Mean Lower Low Water (MLLW) (Figure 2-5) based on the Hudson River Environmental Conditions observing System (HRECOS) monitoring station located on-site. Tidal influence likewise extends into Schodack Creek; monitoring of water surface elevations within Schodack Creek from June to November 2018 confirms that the tidal datum (e.g. MLLW and MHHW) elevations are not truncated in the monitored area which included stations at the southern extent of the north and south components each. In other words, the tidal elevations in Schodack Creek are comparable to those of the Hudson River.

Figure 2-6: Schodack Island project components, north (red), south (green), and pocket wetlands (yellow).

For the purpose of this project, the project site was broken into three components: north, south, and pocket wetlands (Figure 2-6). The north and south component footprints each overlap with historic side channels that were infilled with dredged material. Currently, the north footprint includes marginal tidal pocket wetlands along the Hudson River, tidal floodplain wetlands along a Schodack Creek tributary (Photograph 3), and upland separating the aforementioned wetland areas. The south footprint includes timber and rock bulkhead reinforced shoreline with marginal tidal wetlands along the Hudson River, tidal floodplain wetlands along a Schodack Creek tributary, and upland separating the aforementioned wetland areas. *Phragmites australis* (common reed) and *Typha angustifolia* (narrowleaf cattail) are the most prevalent vegetation communities in the north and south footprint wetlands. Refer to Appendix D - Benefits for a complete list of vegetation communities.

Photograph 3: Typical Schodack Creek tributary conditions. View from north component footprint.

The pocket wetlands footprint includes 4 sub-components, pocket wetlands A, B, C, and D, from north to south respectively. Pocket wetlands A and C are existing tidal

Photograph 4: Typical Hudson River shoreline with intact bulkhead.

pocket wetlands, hydrologically connected to the Hudson River, pocket wetland B is an existing non-tidal wetland and pocket wetland D is an existing wooded swamp located in a topographic depression and separated from the Hudson River by a thin strip of upland. *Phragmites australis* and wooded swamp are the most prevalent vegetation communities in the pocket wetlands.

Field investigations were conducted within the Park boundary which included collection of supplemental topographic cross sections along the Hudson River shoreline, a visual assessment of bulkhead condition, and an inventory of shoreline cover types. A timber and rock bulkhead is present along the majority of the Hudson River shoreline (Photograph 4). The bulkhead structure is mostly intact, however, there is an approximately 2,000-foot-long shoreline segment where incipient structural failure has occurred. In areas where the bulkhead is intact or failing, either a narrow band of wetland vegetation or upland forest is landward of the structure. For approximately 2,300-

Photograph 5: Typical Hudson River unprotected shoreline.

feet just south of the north component footprint, the shoreline is unprotected (Photograph 5) and consists of a sandy/silt beach of varying slope. Results of field investigations conducted in June 2018 are presented in Appendix B - Engineering.

Site Background

Schodack Island was significantly impacted by the placement of dredged material from the Hudson River navigation channel maintenance. Originally, North Schodack Island, South Schodack Island, Houghtailing Island, and various smaller islands were, in fact, islands and separated from the mainland by side channels. The side channels provided shallow water habitat, spawning and nursery habitat, and fish refugia during increased channel flow. Beginning in the late 19th to early 20th century, dikes were constructed along the western edge of the islands (Hutchinson, History of the Schodack Islands). Dredging of the Hudson River deepwater channel began in the 1920s and the dredged material was placed on top and between these islands. Shallow water habitats were filled with dredged material, converting the islands into a single peninsula, continuous with the mainland. Hydrological connections between Schodack Creek and the Hudson River are now limited to a single connection point at the southern tip of Schodack Island.

Previous Studies

The significant ecological habitats offered by the Park, including Schodack Islands (North and South) and Houghtailing Islands, are documented by three authorities; (1) the New York State Coastal Zone Management Program (USFWS, 1997), (2) the New York State Coastal Management Program which classifies the site as a Significant Coastal Fish and Wildlife Habitat (NYSDOS, 2012), and (3) the New York State Bird Conservation Area Program which classifies the site as a Bird Conservation Area (NYSDEC, 2002). The Park's extensive natural areas provide habitat for diverse ecological communities, including floodplain forests, freshwater tidal wetlands, tidal creeks, littoral zones, submerged aquatic vegetation beds, emergent marshes, and tidal swamps which support resident and migratory fish spawning, and provide nursery and foraging habitat for protected birds.

In 2015, New York State Office of Parks, Recreation and Historic Preservation contracted the engineering firm, Ecology and Environment Engineering, P.C. (EEEPC), to evaluate the feasibility of restoring hydrologic connections via the reintroduction of backwater channels through Schodack Island State Park, as well as the potential for additional alteration of the shoreline to allow Hudson River tidal waters access to the Park's floodplains (Ecology and Environment Engineering, P.C., 2015). EEEPC examined potential restoration at three sites. Site 1, towards the northern end of Schodack Island, was dismissed since it would require significant coordination with CSX Transportation, NYS Thruway Authority, and Amtrak. Sites 2 and 3 roughly align with the proposed north and south component footprints respectively. At both sites, EEEPC analyzed the flow rates and estimated costs of four channel construction scenarios, including a 4-foot, 10-foot, 15-foot, and 20-foot bottom width channel.

Schodack Island was also included in the Hudson River Comprehensive Restoration Plan which catalogs ‘restoration progress to date in the Hudson, and set(s) long-term goals for its future’ (Partners Restoring the Hudson, 2018). Most of the island was identified as having at least one, and up to three, physical habitat characterization impacts or ecological assessment threats which may include items such as a hardened shoreline or areas of fill. Ten potential projects were identified including both habitat and recreation/community infrastructure-oriented projects. Recreation/community infrastructure-oriented projects include restoring/preserving historic structures, improving overall site access, restoring the island’s boat launch, and establishing an estuary nature center in the Park to support public environmental education. Habitat-oriented projects include restoring and improving the habitat value of the Hudson River shoreline, and restoring the Houghtaling and Schodack Island side channels.

Constraints and Considerations

Constraints and considerations focused on impacts to existing infrastructure and Park access. The north and south footprints were placed to approximate the historic location of side channels. The north footprint was strategically positioned to avoid the active recreation area of the park (i.e. parking lot, playground, and boat launch) as well as the existing septic leach field. Additionally, an active dredged material disposal facility is located on the southern end of the island; road access to this location was considered essential. Proposed side channel locations and elevations were designed strategically to maximize hydrologic re-connection while limiting the required volume of excavation. Proposed actions in pocket wetlands A, B, and C, were limited to existing, low quality wetlands where maximizing ecological benefits could be achieved without topographic manipulation. Proposed actions in pocket wetland D were limited to an existing topographic depression which could be converted to a tidal system with minimal excavation.

EPW Considerations

As previously mentioned, the Evaluation for Planned Wetlands results played a significant role in identifying opportunities for restoration. Several habitat communities are established on the site as reflected in the baseline Functional Capacity Units summarized below. Refer to Appendix D - Benefits for additional information.

COMPONENT	TIME YEAR 0	TIME YEAR 50
North	54.42	64.30
South	10.96	12.71
Pocket Wetland A	10.10	2.64
Pocket Wetland B	2.64	1.11
Pocket Wetland C	5.42	6.14
Pocket Wetland D	3.32	3.27

Assumptions

Many assumptions were made in the development of the concept alternatives including:

- The placement of the project footprints assumed that the presence of rare plants is limited to the mapped extent; a detailed botanical survey may be requirement prior to design to ensure rare plants are absent from the project footprints;
- The placement of the side channel is based on historic shoreline and island spatial mapping. Excavation to restore the side channel should focus on existing areas of fill and avoid native soils;
- River velocities and flows are sufficient to maintain side channel flow and scour. By 2075 as sea levels change, it is assumed that the channel would convey flow at mean tide water levels and the riparian buffer would transition to tidal wetlands; and
- Construction of side channels would be paired with the construction of temporary road crossings to ensure continued access to the southern portion of Schodack Island.

Alternatives

Six alternatives were developed as part of this project; two alternatives for the north component, two alternatives for the south component, and one alternative for each pocket wetland component. Concept plans for the Schodack Island alternatives follow the narrative descriptions below.

Schodack Island North - Alternative 1

Tidal Wetland Restoration North

Approximately 1.8 acres of existing tidal habitat, dominated by invasive species such as common reed, would be treated and planted with native plant species.

Tidal Wetland Restoration & Conversion to Side Channel Connection

Approximately 2.31 acres of existing tidal habitat, dominated by invasive species such as common reed, would be treated and planted with native plant species. Additionally, minor grading would 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.

Tidal Wetland Restoration South

Approximately 15.69 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.

Side Channel and Riparian Corridor Restoration

A side channel would be excavated in areas of historic fill placement to hydrologically connect Schodack Creek and the Hudson River. The channel would convey flow during large precipitation events and high tides and provide refuge to aquatic species during increased river velocities. Tidal wetlands would be established adjacent to the channel and transition to riparian buffer landward, resulting in a 130-foot wide corridor. By 2075 as sea levels change, it’s anticipated that the channel would convey flow at mean tide water levels and the riparian buffer would transition to tidal wetlands. To accommodate local vehicular access to the southern portion of the island, the channel would be spanned by a road crossing with rectangular reinforced box culverts. The existing ski trail would also be redirected to this road crossing.

Schodack Island North - Alternative 2

Tidal Wetland Restoration North

Approximately 1.8 acres of existing tidal habitat, dominated by invasive species such as common reed, would be treated and planted with native plant species.

Tidal Wetland Restoration & Conversion to Side Channel Connection

Approximately 2.31 acres of existing tidal habitat, dominated by invasive species such as common reed, would be treated and planted with native plant species. Additionally, minor 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.

Tidal Wetland Restoration South

Approximately 15.69 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.

Side Channel and Tidal Wetland Corridor Restoration

A side channel would be excavated in areas of historic fill placement to hydrologically connect Schodack Creek and the Hudson River with tidal waters. 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 rectangular reinforced box culverts. The existing ski trail would also be redirected to this road crossing.

As discussed in Chapters 3 and 4 of the main report, Alternative 2 was selected as the tentatively selected plan for Schodack Island North.

Schodack Island South - Alternative 1

Tidal Wetland Restoration

Approximately 2.77 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.

Side Channel and Riparian Corridor Restoration

A side channel would be excavated in areas of historic fill placement to hydrologically connect Schodack Creek and the Hudson River. The channel would convey flow during large precipitation events and high tides and provide refuge to aquatic species during increased river velocities. Tidal wetlands would be established adjacent to the channel and transition to riparian buffer landward, resulting in a 60-foot wide corridor. By 2075 as sea levels change, it is anticipated that the channel would convey flow at mean tide water levels and the riparian buffer would transition to tidal wetlands. To accommodate local vehicular access to the southern portion of the island, the channel would be spanned by a road crossing with rectangular reinforced box culverts.

Schodack Island South - Alternative 2

Tidal Wetland Restoration

Approximately 2.77 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.

Side Channel and Tidal Wetland Corridor Restoration

A side channel would be excavated in areas of historic fill placement to hydrologically connect Schodack Creek and the Hudson River with tidal waters. The channel would convey flow during low tide and higher water levels providing refuge to aquatic species during increased river velocities. A 160-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 rectangular reinforced box culverts.

As discussed in Chapter 3 of the main report, the Future Without Project was selected as the tentatively selected plan for Schodack Island south.

Schodack Island Pocket Wetland - Alternative 1

Tidal Wetland Restoration A and C

Approximately 5.62 acres of existing tidal habitat, dominated by invasive species such as common reed, would be treated and planted with native plant species.

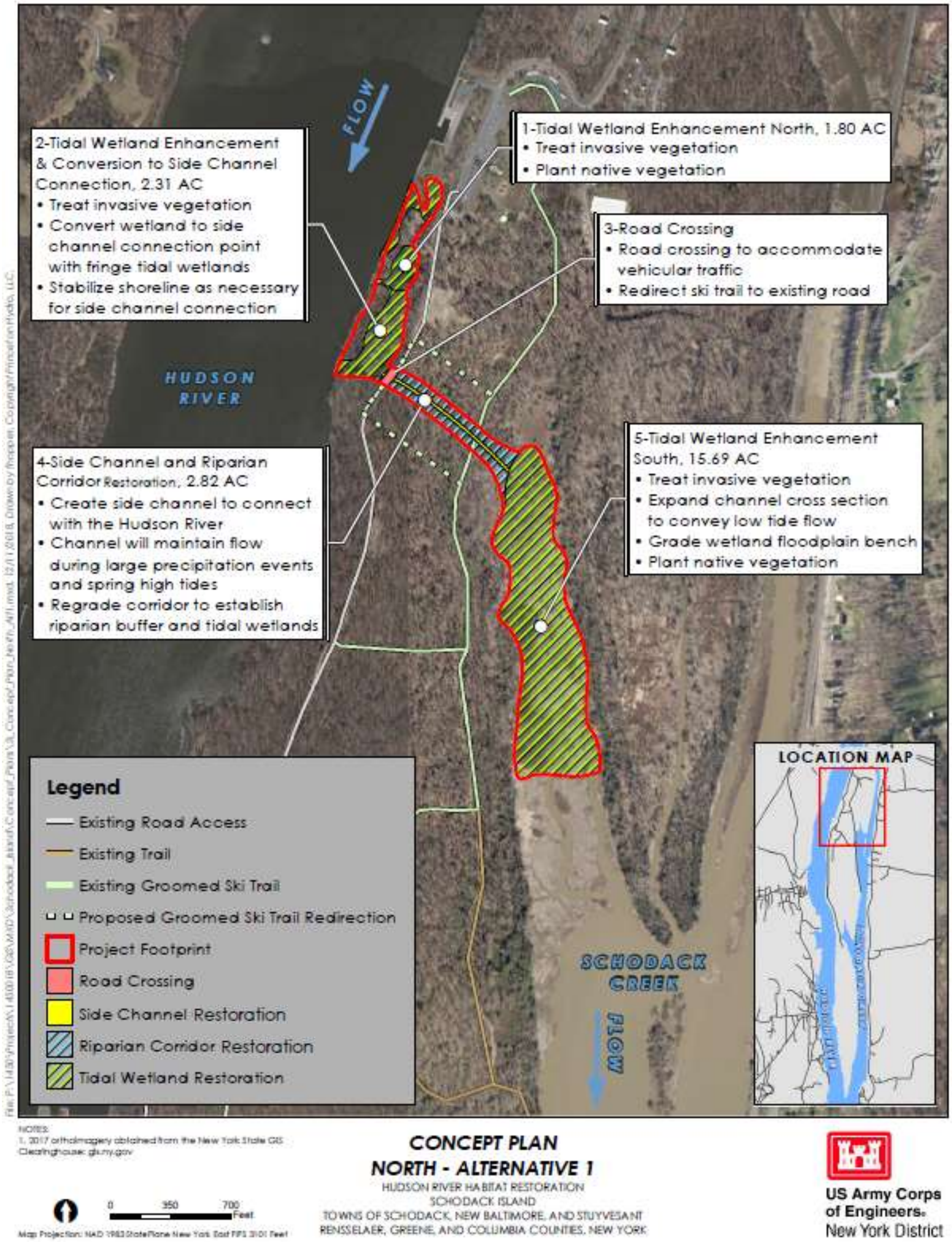
Non-Tidal Wetland Restoration B

Approximately 1.48 acres of existing non-tidal wetland habitat, dominated by invasive species such as common reed, would be treated and planted with native plant species.

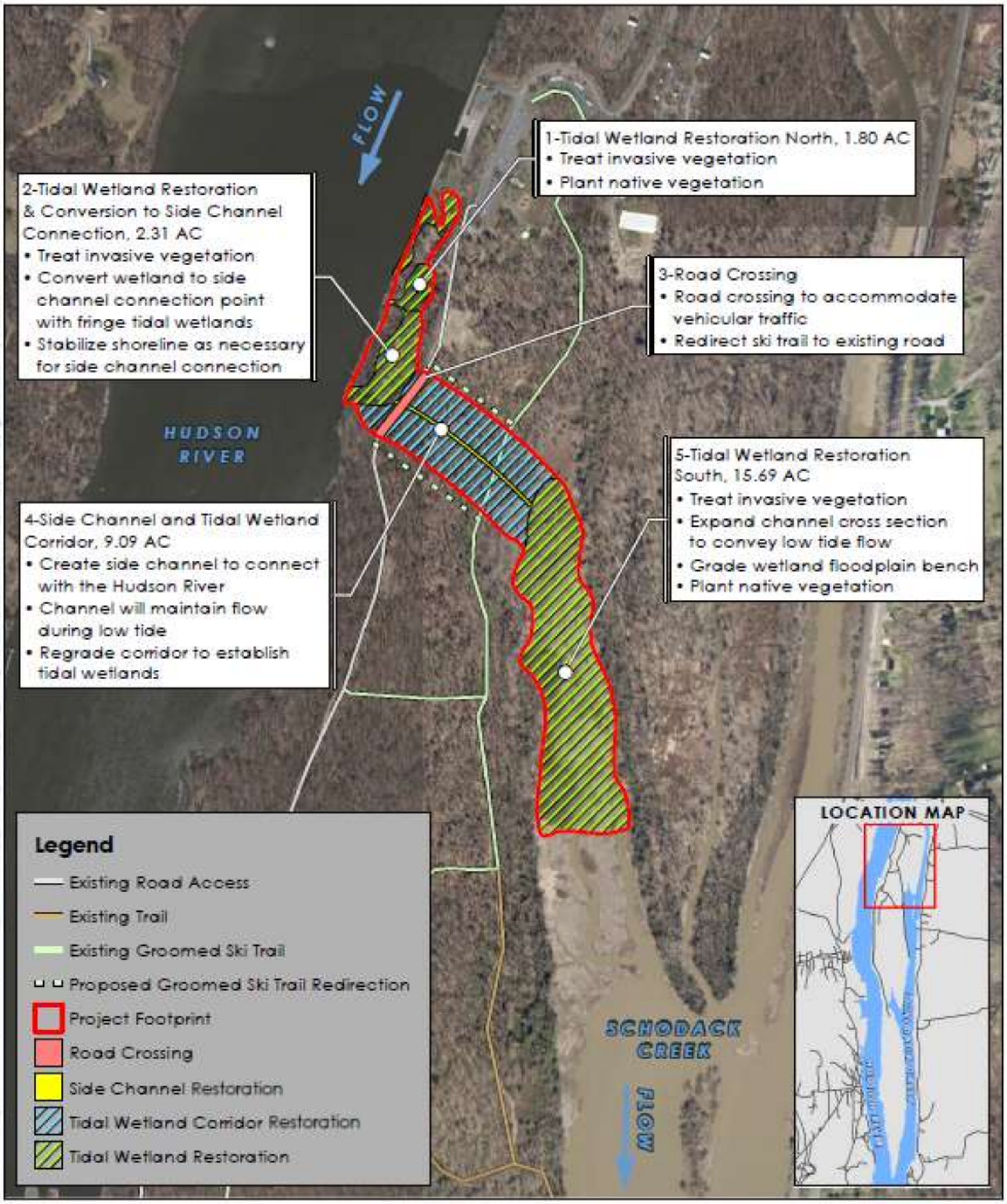
Tidal Wetland Restoration D

Approximately 3.85 acres of existing upland and non-tidal wetland habitat would be graded to allow tidal flushing and planted with native plant species.

As discussed in Chapter 3 of the main report, the Future Without Project was selected as the tentatively selected plan for Schodack Island pocket wetlands.



1-Tidal Wetland Enhancement North, 1.80 AC
• Treat invasive vegetation
• Plant native vegetation
2-Tidal Wetland Enhancement & Conversion to Side Channel Connection, 2.31 AC
• Treat invasive vegetation
• Convert wetland to side channel connection point with fringe tidal wetlands
• Stabilize shoreline as necessary for side channel connection
3-Road Crossing
• Road crossing to accommodate vehicular traffic
• Redirect ski trail to existing road
4-Side Channel and Riparian Corridor Restoration, 2.82 AC
• Create side channel to connect with the Hudson River
• Channel will maintain flow during large precipitation events and spring high tides
• Regrade corridor to establish riparian buffer and tidal wetlands
5-Tidal Wetland Enhancement South, 15.69 AC
• Treat invasive vegetation
• Expand channel cross section to convey low tide flow
• Grade wetland floodplain bench
• Plant native vegetation
FLOW
HUDSON RIVER
SCHODACK CREEK
FLOW
LOCATION MAP
Legend
Existing Road Access
Existing Trail
Existing Groomed Ski Trail
Proposed Groomed Ski Trail Redirection
Project Footprint
Road Crossing
Side Channel Restoration
Riparian Corridor Restoration
Tidal Wetland Restoration
NOTES:
1. 2017 orthoimagery obtained from the New York State GIS Clearinghouse: gis.ny.gov
0 350 700 Feet
CONCEPT PLAN
NORTH - ALTERNATIVE 1
HUDSON RIVER HABITAT RESTORATION
SCHODACK ISLAND
TOWNS OF SCHODACK, NEW BALTIMORE, AND STUYVESANT
RENSSELAER, GREENE, AND COLUMBIA COUNTIES, NEW YORK
US Army Corps of Engineers
New York District



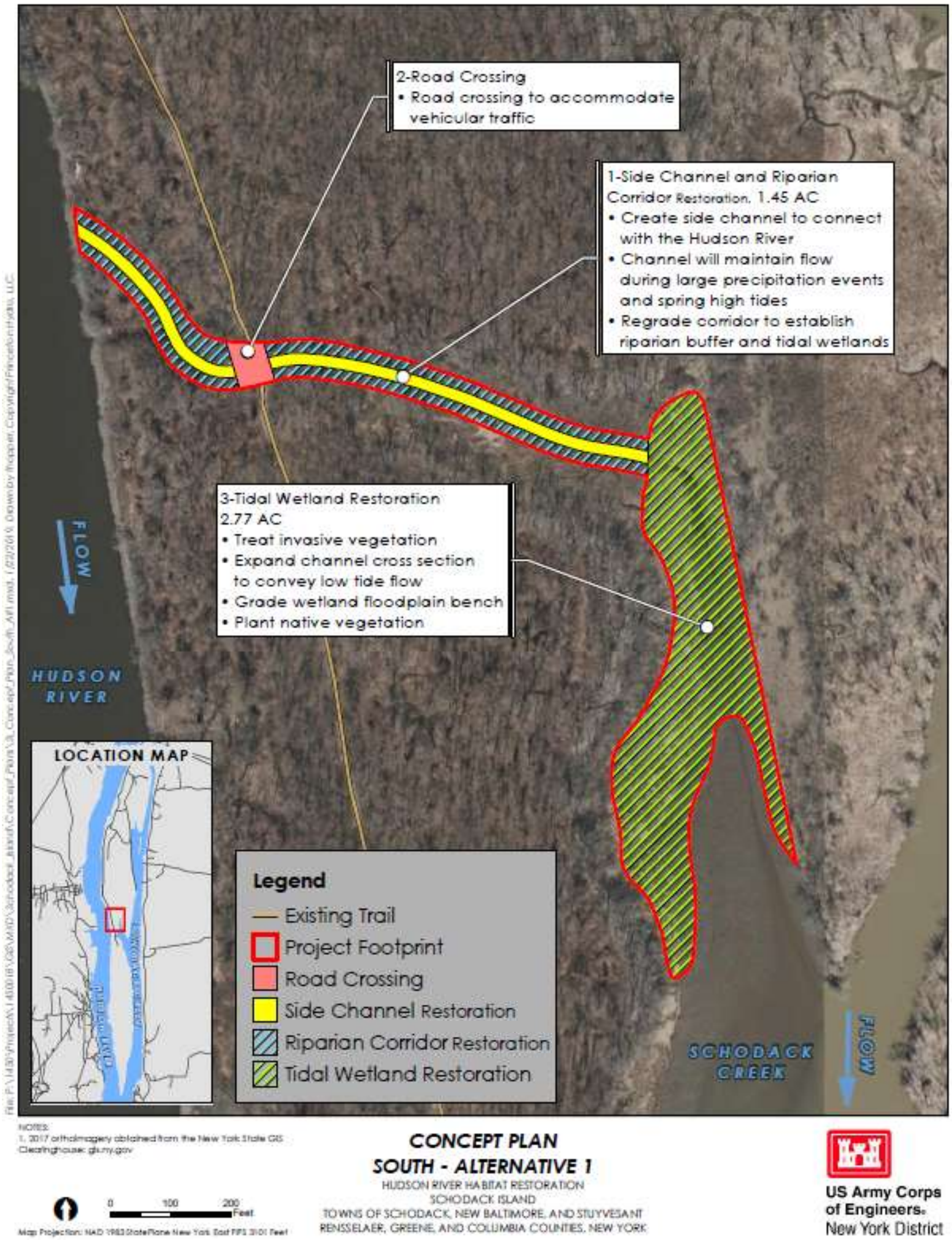
NOTES:
1. 2017 orthoimagery obtained from the New York State GIS Clearinghouse: gis.ny.gov

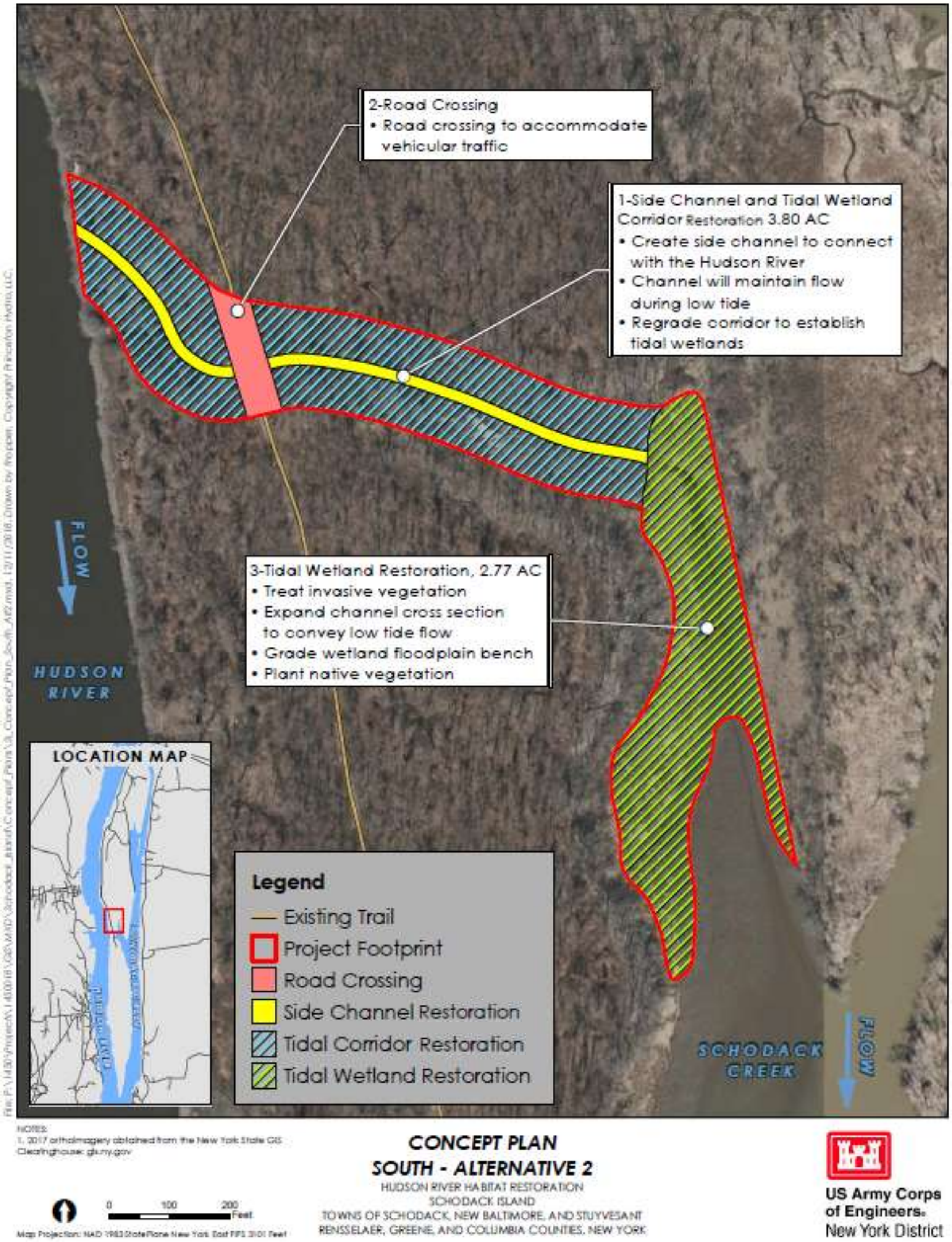
0 350 700 Feet

Map Projection: NAD 1983 StatePlane New York East FIPS 3101 Feet

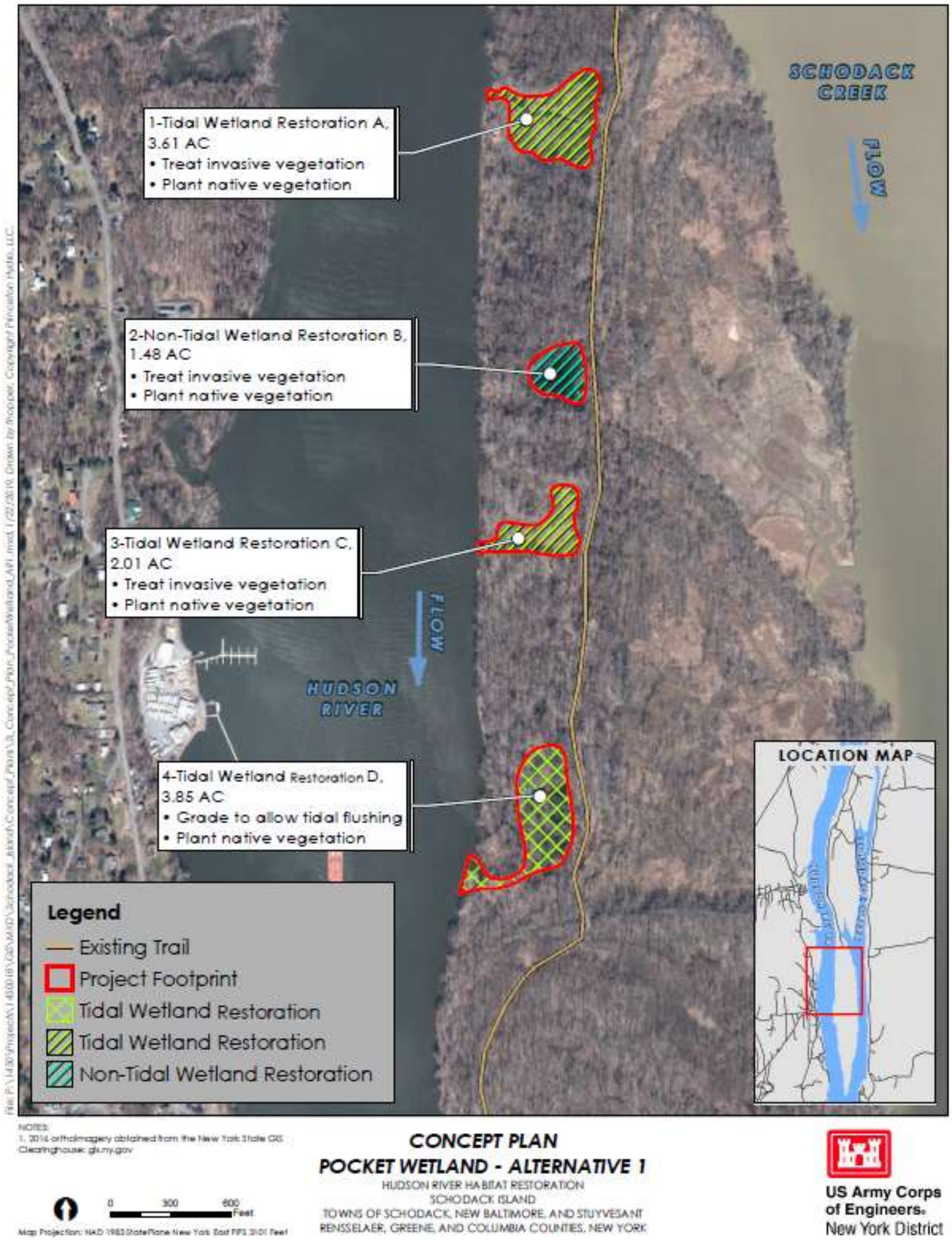
CONCEPT PLAN
NORTH - ALTERNATIVE 2
HUDSON RIVER HABITAT RESTORATION
SCHODACK ISLAND
TOWNS OF SCHODACK, NEW BALTIMORE, AND STUYVESANT
RENSSELAER, GREENE, AND COLUMBIA COUNTIES, NEW YORK

US Army Corps of Engineers
New York District


2-Road Crossing
• Road crossing to accommodate vehicular traffic
1-Side Channel and Riparian Corridor Restoration. 1.45 AC
• Create side channel to connect with the Hudson River
• Channel will maintain flow during large precipitation events and spring high tides
• Regrade corridor to establish riparian buffer and tidal wetlands
3-Tidal Wetland Restoration
2.77 AC
• Treat invasive vegetation
• Expand channel cross section to convey low tide flow
• Grade wetland floodplain bench
• Plant native vegetation
FLOW
HUDSON RIVER
LOCATION MAP
Legend
Existing Trail
Project Footprint
Road Crossing
Side Channel Restoration
Riparian Corridor Restoration
Tidal Wetland Restoration
SCHODACK CREEK
FLOW
NOTES:
1. 2017 orthoimagery obtained from the New York State GIS Clearinghouse: gis.ny.gov
0 100 200 Feet
Map Projection: NAD 1983 StatePlane New York East FIPS 3101 Feet
CONCEPT PLAN
SOUTH - ALTERNATIVE 1
HUDSON RIVER HABITAT RESTORATION
SCHODACK ISLAND
TOWNS OF SCHODACK, NEW BALTIMORE, AND STUYVESANT
RENSSELAER, GREENE, AND COLUMBIA COUNTIES, NEW YORK
US Army Corps of Engineers
New York District



CONCEPT PLAN
SOUTH - ALTERNATIVE 2
HUDSON RIVER HABITAT RESTORATION
SCHODACK ISLAND
TOWNS OF SCHODACK, NEW BALTIMORE, AND STUYVESANT
RENSSELAER, GREENE, AND COLUMBIA COUNTIES, NEW YORK



SCHODACK CREEK
FLOW
1-Tidal Wetland Restoration A, 3.61 AC
• Treat invasive vegetation
• Plant native vegetation
2-Non-Tidal Wetland Restoration B, 1.48 AC
• Treat invasive vegetation
• Plant native vegetation
3-Tidal Wetland Restoration C, 2.01 AC
• Treat invasive vegetation
• Plant native vegetation
FLOW
HUDSON RIVER
4-Tidal Wetland Restoration D, 3.85 AC
• Grade to allow tidal flushing
• Plant native vegetation
LOCATION MAP
Legend
Existing Trail
Project Footprint
Tidal Wetland Restoration
Tidal Wetland Restoration
Non-Tidal Wetland Restoration
NOTES:
1. 2016 orthoimagery obtained from the New York State GIS Clearinghouse: gis.ny.gov
0 300 600 Feet
Map Projection: NAD 1983 StatePlane New York East FIPS 3101 Feet
CONCEPT PLAN
POCKET WETLAND - ALTERNATIVE 1
HUDSON RIVER HABITAT RESTORATION
SCHODACK ISLAND
TOWNS OF SCHODACK, NEW BALTIMORE, AND STUYVESANT
RENSSELAER, GREENE, AND COLUMBIA COUNTIES, NEW YORK
US Army Corps of Engineers
New York District

2.3. Henry Hudson Park

Site Setting

Figure 2-7: Henry Hudson Park Property Boundary.

Henry Hudson Park is public open space owned by the Town of Bethlehem and is located on the western shore of the Hudson River (Figure 2-7). The park's amenities include 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 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 Vloman Kill traverses through the southern portion of the park and drains to the Hudson River; the area of the park to the south of the Vloman Kill is inaccessible by foot from the main area of the park.

Approximately 15 acres of the park is managed as recreational open space (e.g. grass, picnic areas, playgrounds, etc.) while the remaining area is primarily undisturbed, including upland forest and vegetated areas adjacent to the Vloman Kill. The recreational area of the park is located immediately west of 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 (North American Vertical Datum of 1988, NAVD88), and is primarily grass with large shade trees interspersed.

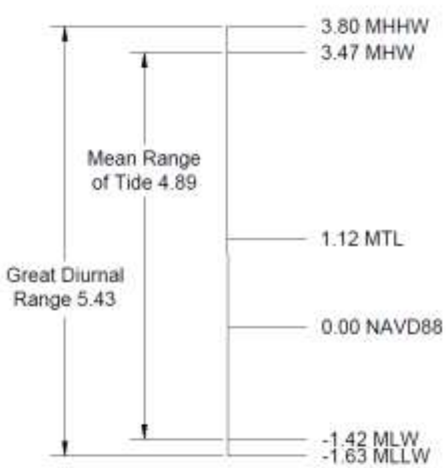


Figure 2-8: Tidal Stages Relative to NAVD88, feet.

The Hudson River is tidal in this area; semidiurnal tides at the park range in elevation from 3.80 feet (NAVD88) at Mean Higher High Water (MHHW) to -1.63 feet (NAVD88) at Mean Lower Low Water (MLLW) (Figure 2-8) based on the Hudson River Environmental Conditions Observing System (HRECOS), Schodack Island Station.

The park's shoreline varies in condition (Figure 2-9). The northern section of the Hudson River shoreline is lined with riprap and established vegetation

Figure 2-9: Shoreline Condition.

(Photograph 6). The riprap in this section is in good condition and no significant signs of erosion are present. Based on a supplemental site survey, the riprap portion of the shoreline has a slope of approximately 30 percent before transitioning to the river channel. Refer to the Engineering Appendix for detailed cross sections of the site. This portion of the shoreline 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, filled with riprap between two timber crib walls, and capped with convex concrete segments (Photograph 7). 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 (Photograph 8). Supplemental site survey indicates that the grass area adjacent to the shoreline ranges in elevation from 5 to 9 feet (NAVD88) with an average slope of four percent. At the waterward edge of the grass, the topography undulates with the concrete capping and riprap decreasing 7 feet in elevation over approximately 15 to 20 feet. There is another steep drop off from the edge of the timber cribbing structure to the river channel.

Photograph 6: View looking north at the riprap portion of the shoreline.

Two floating structures are present along the southern section of shoreline. A floating fishing platform is present approximately 250 feet south of the boat ramp and was constructed between 2011 and 2013 (Ocean and Coastal Consultants, 2011). A Bethlehem Fire Department dock is also present approximately 375 feet north of the Vloman Kill. The

Photograph 7: View looking south at the timber cribbing with riprap and concrete capping.

cribbing structure extends south of the docks and terminates along the confluence with the Vloman Kill, sheltering a small cove.

The cove on the Vloman Kill contains an unvegetated, tidal mudflat area showing signs of erosion (Photograph 9). A floating dock with a kayak and canoe ramp is also anchored to the land.

Site Background

According to a Shoreline Stabilization Study prepared for the Town of Bethleham (Ocean and Coastal Consultants, 2011), the site was constructed from dredged material placement in the 1860s by the USACE. The riprap filled timber cribbing was also constructed at this time to contain the dredged material and to increase water conveyance in the Hudson River. The concrete capping was added to the cribbing structure in the early 1900s.

Photograph 8: View of upland areas of erosion.

Photograph 9: View of cove area on the Vloman Kill.

Previous Studies

Previous studies include the aforementioned Henry Hudson Shoreline Stabilization Study (Ocean and Coastal Consultants, 2011), Hudson River Shoreline Restoration Alternatives Analysis (ASA & Alden, 2006), and Hudson River Comprehensive Restoration Plan (Partners Restoring the Hudson, 2018).

According to the Henry Hudson Shoreline Stabilization Study, the park's soils consist of sandy outwashed soils and fine grain dredged material, which are susceptible to erosion and frost action. The study examined hydraulic forces impacting the shoreline including wave action from the wakes of passing ships and frost action. Wave heights of up to six feet could occur during the passing of a typical cargo vessel (623 ft length) traversing the Hudson River at typical speeds (20 knots). This section of the Hudson River is also subject to high ice coverage and thickness. The park's shoreline has a high potential for ice damage; the study recommended that any riprap used should be designed with a median stone diameter of two to three times the maximum ice thickness to avoid damage. The study's final recommendation was the full replacement of the existing shoreline structure with a combination riprap revetment and vegetated riprap. The study stated that for either method the shoreline should be graded back approximately three feet landward to achieve a more shallow bank slope.

The Hudson River Shoreline Restoration Alternatives Analysis similarly concluded that ship wakes and ice sheet scour were a concern in this portion of the Hudson River and recommended the complete removal of concrete caps, the addition of timber piles to the existing bulkhead where necessary, the regrading of the existing riprap to a minimum slope of 1V:2H (vertical:horizontal) with a minimum depth of 12 inches, and the installation of live stakes in the riprap material.

Henry Hudson (Town) Park was also included in the Hudson River Comprehensive Restoration Plan which catalogs "restoration progress to date in the Hudson, and set(s) long-term goals for its future." Henry Hudson Park was identified as having four physical habitat characterization impacts or ecological assessment threats which may include items such as a hardened shoreline or high nutrient pollutant discharge. Several Project types were identified for the Park including naturalized shoreline stabilization, public access improvements, and trail connections to the Scenic Hudson preserved land on the Binnen Kill. The 2011 Shoreline Stabilization Study was also referenced.

Constraints and Considerations

Several major considerations guided the development of alternatives. The lack of tidal wetland and other shoreline vegetation prompted the need to incorporate such features into any alternative. The continued accessibility to the floating fishing platform and fire department dock was considered mandatory. It was also considered important that any replacement to the existing timber cribbing be permeable and maximize aquatic organism passage and water conveyance.

One of the main considerations in the development of alternatives was preserving existing recreational open space to the extent practicable. The restoration of tidal wetlands or other shoreline structures would inherently reduce existing recreational areas. Thus, the geographic extent of the alternatives was limited to avoid significantly reducing open space.

EPW Considerations

The Evaluation for Planned Wetlands results played a significant role in identifying opportunities for restoration. Currently, no wetlands are present along the length of the site's shoreline and consequently, the baseline Functional Capacity Unit is 0.72 and 0.90 for time year 0 and time year 50, respectively. Refer to Appendix D - Benefits for additional information.

Assumptions

For design purposes, it was assumed that the site's shoreline has a high risk of significant wave action and ice sheet scour. It was also assumed that the steep drop-off (10 plus feet) from the grass area to river channel would need to be stabilized and reinforced to prevent historic dredged material from eroding away. Additionally, Alternative 1, described below, assumes that, with reinforcement, the existing timber cribbing could stay in place and function properly to stabilize the shoreline.

Alternatives

Two alternatives were developed and advanced for Henry Hudson Park. Each alternative proposes modifications to the entire length of the existing shoreline structure. Alternative 1 is a *hard engineering* approach and would impact a smaller footprint than Alternative 2, whereas, Alternative 2 incorporates more ecological elements to stabilize the shoreline and increase ecological communities. Concept plans for the Henry Hudson alternatives follow the narrative descriptions below.

Alternative 1

Western Tidal Wetland Restoration

Approximately 3.6 acres of existing upland will be converted to tidal wetland. Soils would be excavated to an average depth of five feet below existing grade to achieve tidal wetland hydrology. The soils would be amended as necessary and planted with native vegetation. The shoreline would also be stabilized with rock to dissipate erosive forces.

Vegetated Riprap

Along the Hudson River shoreline, the existing timber cribbing would remain. The concrete cap would be removed and replaced with riprap and graded to achieve a 1V:3H slope. The void spaces of the riprap would be filled with soil and subsequently planted with native vegetation. These modifications to the structure would not significantly encroach upon the park's upland areas.

Cove Tidal Wetland Restoration

Along the northern bank on the Vloman Kill, coir log toe protection would be installed at the toe of the slope around the existing mudflat and riprap would be installed at the top of slope to stabilize existing scour. Native wetland vegetation would be planted within the intertidal area.

As discussed in Chapters 3 and 4 of the main report, Alternative 1 was selected as the tentatively selected plan.

Alternative 2

Northern Tidal Wetland Restoration

Along the northern section of the Hudson River shoreline for a length of approximately 900 linear feet, the timber cribbing and concrete caps would be removed and replaced with a concrete cribbing structure which would have gaps, so as to be permeable to water and aquatic organisms. The top of bank along this section would be graded landward approximately 10 feet, avoiding the removal of large trees, and the banks would be graded to have a shallow slope. Tidal wetlands would be established behind the concrete cribbing through the addition of suitable substrate, matting, and native vegetation planting. The top of bank, landward of proposed tidal wetlands, would be stabilized with boulders.

Pocket Wetland Restoration

A pocket wetland would be constructed landward of the northern tidal wetland creation area, connected to the Hudson River approximately midway along the proposed concrete cribbing structure. The pocket wetland would be established through grading, which would allow tidal flushing, the addition of suitable substrate and native vegetation planting. The top of bank would be stabilized with boulders.

Western Tidal Wetland Restoration

Approximately 3.6 acres of existing upland will be converted to tidal wetland. Soils would be excavated to an average depth of five feet below existing grade to achieve tidal wetland hydrology. The soils would be amended as necessary and planted with native vegetation. The shoreline would also be stabilized with rock to dissipate erosive forces.

Southern Tidal Wetland Restoration

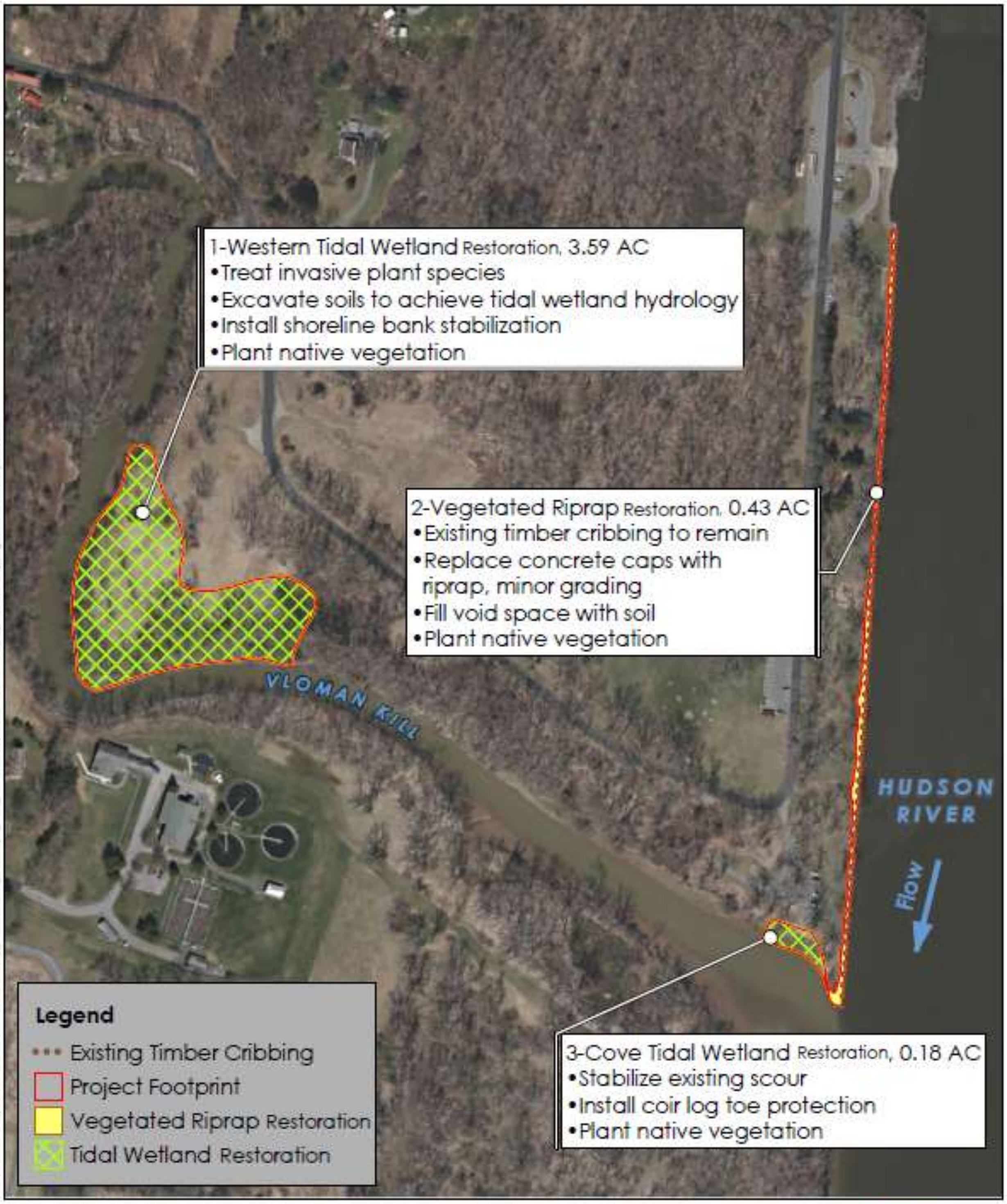
Along the southern section of the shoreline for a length of approximately 700 linear feet, the timber cribbing and concrete caps would be removed. The banks would be graded landward ranging from 50 to 90 feet and the bottom of the slope would be stabilized with riprap. Tidal wetlands would be established landward of the riprap through the addition of suitable substrate and native vegetation planting. The top of slope would be stabilized with boulders.

Cove Tidal Wetland Restoration

Similar to alternative 1, the existing mudflat along the northern bank at the Vloman Kill would receive coir log toe protection, riprap scour stabilization, and native vegetation plantings within the intertidal area.

Rock Revetment Reinforcement

The point at the mouth of Vloman Kill, which shelters the cove, would be reinforced with rock. Existing vegetation would be preserved to the maximum extent practicable.



NOTES:
1. 2017 orthoimagery obtained from the New York State GIS Clearinghouse: gis.ny.gov

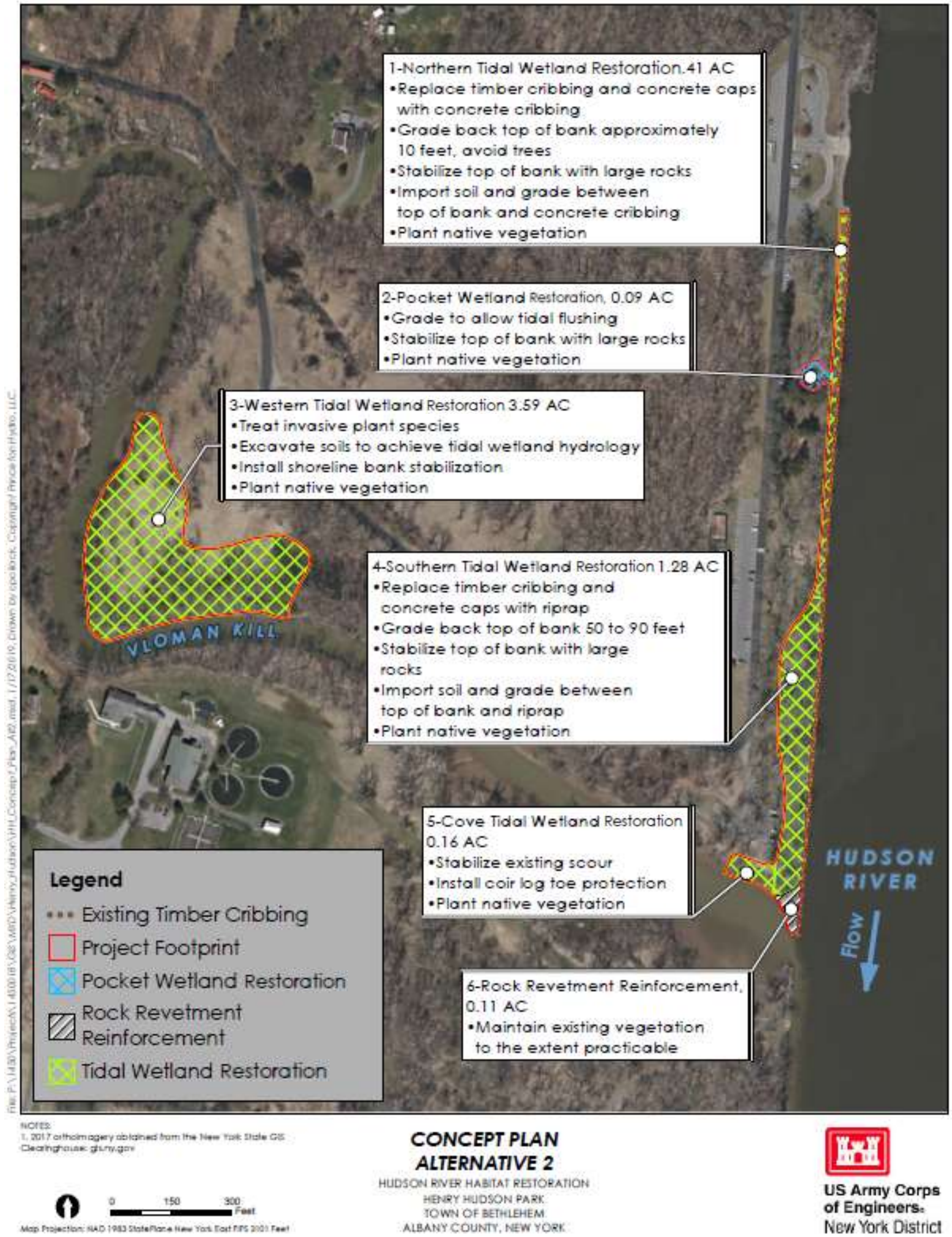
0 150 300 Feet

Map Projection: NAD 1983 StatePlane New York East FIPS 3101 Feet

CONCEPT PLAN
ALTERNATIVE 1

HUDSON RIVER HABITAT RESTORATION
HENRY HUDSON PARK
TOWN OF BETHLEHEM
ALBANY COUNTY, NEW YORK

US Army Corps of Engineers
New York District


1-Northern Tidal Wetland Restoration.41 AC
•Replace timber cribbing and concrete caps with concrete cribbing
•Grade back top of bank approximately 10 feet, avoid trees
•Stabilize top of bank with large rocks
•Import soil and grade between top of bank and concrete cribbing
•Plant native vegetation
2-Pocket Wetland Restoration, 0.09 AC
•Grade to allow tidal flushing
•Stabilize top of bank with large rocks
•Plant native vegetation
3-Western Tidal Wetland Restoration 3.59 AC
•Treat invasive plant species
•Excavate soils to achieve tidal wetland hydrology
•Install shoreline bank stabilization
•Plant native vegetation
4-Southern Tidal Wetland Restoration 1.28 AC
•Replace timber cribbing and concrete caps with riprap
•Grade back top of bank 50 to 90 feet
•Stabilize top of bank with large rocks
•Import soil and grade between top of bank and riprap
•Plant native vegetation
5-Cove Tidal Wetland Restoration 0.16 AC
•Stabilize existing scour
•Install coir log toe protection
•Plant native vegetation
6-Rock Revetment Reinforcement, 0.11 AC
•Maintain existing vegetation to the extent practicable
VLOMAN KILL
HUDSON RIVER
Flow
Legend
Existing Timber Cribbing
Project Footprint
Pocket Wetland Restoration
Rock Revetment Reinforcement
Tidal Wetland Restoration
NOTES:
1. 2017 orthoimagery obtained from the New York State GIS Clearinghouse: gis.ny.gov
0 150 300 Feet
CONCEPT PLAN
ALTERNATIVE 2
HUDSON RIVER HABITAT RESTORATION
HENRY HUDSON PARK
TOWN OF BETHLEHEM
ALBANY COUNTY, NEW YORK
US Army Corps of Engineers
New York District

2.4. Charles Rider Park

Site Setting

Charles Rider Park is a 29.6-acre public open space, located on the west shore of the Hudson River, owned by the Town of Ulster. The park's amenities include a paved access road and parking areas, a picnic area, and a boat ramp/docking structure. The only access road to the park is Charles Rider Park Road which runs east from Ulster Landing Road (Figure 2-10). Approximately 5.5 acres of the park is actively managed while the remaining area is primarily forested. The actively managed area of the park is located immediately adjacent to the Hudson River and is relatively flat, ranging in elevation from approximately 5 to 7 feet (North American Vertical Datum of 1988, NAVD88). The actively managed area is bounded to the west by forested steep slopes, quickly reaching elevations of 30 to 65 feet (NAVD88). Parking areas and internal roadways run close to the shoreline, separated from the shoreline edge by 15 to 50 feet of maintained grass.

Figure 2-10: Charles Rider Park Property Boundary.

The Hudson River is tidal in this area; semidiurnal tides at the park range in elevation from 2.47 feet (NAVD88) at Mean Higher High Water (MHHW) to -1.39 feet (NAVD88) at Mean Lower Low Water (MLLW) (Figure 2-11) based on USGS gage 01372043 near Poughkeepsie, NY. Shoreline width ranges from approximately 5 to 25 feet at mean high tide and approximately 20 to 50 feet at mean low tide.

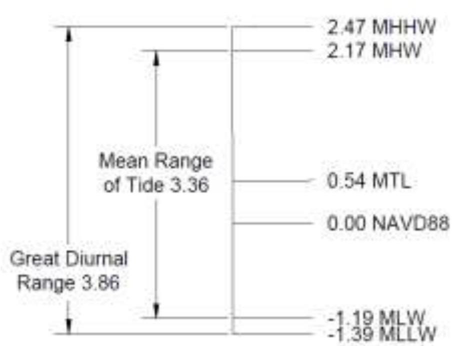


Figure 2-11: Tidal Stages Relative to NAVD88, feet.

The park's shoreline varies in condition (Figure 2-12). The northern most portion of the shoreline is part of a small cove, partially protected by large rock material at the cove's mouth (Photograph 10). Based on a supplemental site survey, the beach portion of the cove has a slope of approximately 17 percent and a sandy gravel substrate. Refer to Appendix B - Engineering for detailed cross sections of the site. The eastern shoreline, north of the boat ramp, consists of a stone filled timber cribbing which is dilapidated and has predominantly failed (Photograph

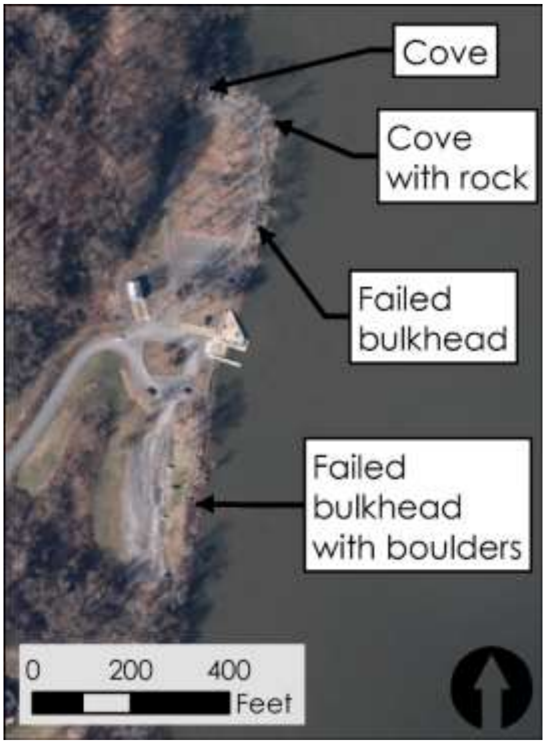


Figure 2-12: Shoreline Condition.

11). A steep drop-off ranging from 7 to 10 feet is present at the riverward face of the cribbing; riverbed elevations at the base of the cribbing reach -6.7 to -9.7 feet (NAVD88).

The eastern shoreline, south of the boat ramp, also consists of a stone filled timber cribbing which is dilapidated. However, large boulders were placed along the shoreline, adjacent to existing erosional scour (Photograph 12). These boulders appear to have been placed recently, presumably to stabilize the shoreline. Unlike the area north of the boat ramp, there is a gradual transition from shoreline to riverbed with a slope of approximately 10 percent. 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. A remnant boat ramp structure is also present approximately 100 feet south of the active boat ramp.

Site Background

Historically, the site was used as a disposal location for dredged material from maintaining the Hudson River navigation channel. The existing topography is a remnant of the fill material, which has been subject to erosive forces by the Hudson River since placement. Subsequent to the placement of dredged material, a brick factory with a number of structures including a bulkhead, docks, and multiple buildings were located on site. The structures are documented on USGS topographic maps published from 1934 to 1970. Based on historic aerial imagery and topographic maps, the site transitioned to a park sometime between 1970 and

Photograph 10: View looking northwest at the cove.

1995. The park is dedicated in honor of Charles Rider, Town Supervisor from 1978 to 1987.

Photograph 11: View looking north at the eastern shoreline north of the boat ramp.

Previous Studies

Previous studies focusing on Charles Rider Park were not readily found. However, the park was one of many sites evaluated in the regionally focused, multi-site *Hudson River Wake Study*, prepared by Stevens Institute of Technology in 2015 as part of the Hudson River Sustainable Shorelines Project. The study sought to determine wake heights between the Tappan-Zee Bridge (now the Governor Mario M. Cuomo Bridge) and the Albany dam. Researchers recorded wake height, boat type, vessel speed, and size at 32 sites, including Charles Rider Park. The scope of this study was limited, recording data for only a four-hour period on a single day (8:00 am – 1:00 pm, 6/29/13) for Charles Rider Park, and lacking in robust quantitative or statistical analysis. The average wake height at Charles Rider Park, nine inches, was larger than most of the sites studied. Charles Rider Park also had the largest maximum wave height (42 inches) observed of any site in the study.

Photograph 12: View looking south at the eastern shoreline south of the boat ramp.

Constraints and Considerations

Several considerations guided the development of alternatives. The lack of tidal wetlands and other shoreline vegetation prompted the need to incorporate such features into any developed alternatives. Additionally, the main constraint in the development of alternatives was the limited workable area between the paved roads/parking lots and the shoreline.

EPW Considerations

The Evaluation for Planned Wetlands results played a significant role in identifying opportunities for restoration. Currently, no wetlands are present along the length of the site's shoreline and consequently, the baseline Functional Capacity Unit is 0.53 and 0.65 for time year 0 and time year 50, respectively. Refer to Appendix D - Benefits for additional information.

Assumptions

A number of assumptions were made during the development of alternative concepts. Firstly, it was assumed that the site is subject to high wave energy due to the prevalence of boat traffic on the Hudson River, including large shipping vessels and a large fetch length, with the river spanning over 4,000 feet wide in this area. Secondly, it was assumed that the boulders along the eastern shoreline are of suitable size and diameter to stabilize the shoreline given the existing erosional forces. Lastly, given the steep drop off along the shoreline north of the boat ramp, it was assumed a structure was warranted to contain the fill from eroding into the river. The slope of the remaining portions of the shoreline were shallow enough to stabilize the area with vegetation and riprap.

Alternatives
Alternative 1

One alternative was developed and advanced for Charles Rider Park. The concept plan follows this narrative description. Under this alternative, shoreline modifications would allow for the establishment of tidal wetlands, which are not currently present on the site.

Interstitial Rock Plantings Enhancement

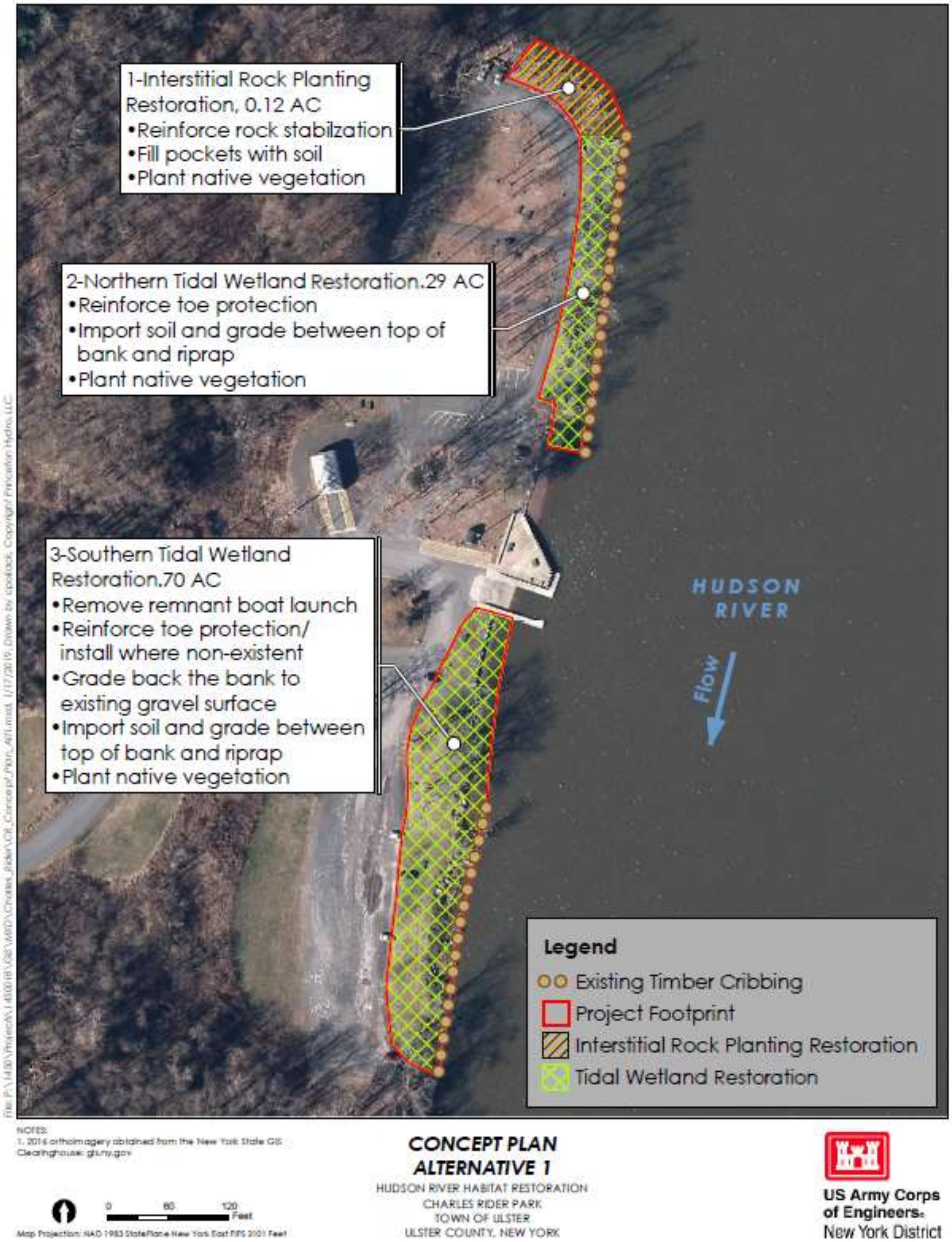
Along the cove area, the existing rock stabilization would be reinforced with appropriately sized rock, and rock interstices would be filled with soil and planted with native vegetation.

Northern and Southern Tidal Wetland Restoration

Along the eastern shoreline, the remnant boat launch would be removed. The existing timber cribbing would be reinforced, particularly along the northern portion, and a riprap toe would be installed where necessary. The top of bank would be graded back to the edge of the existing gravel or paved surface and large boulders would be placed to stabilize the shoreline. Suitable substrate would be backfilled between the top of bank and reinforced timber cribbing. The substrate would be graded to allow for intertidal flow and tidal wetland restoration. Native wetland vegetation would be planted within the intertidal area.

Alternatives Considered but Dismissed

One alternative was considered but dismissed. This alternative would consist of the same modifications as Alternative 1, apart from preserving the maintained grass area adjacent to the southern parking lot rather than converting it to tidal wetland. This alternative was not further pursed because it would have limited benefits to aquatic habitat relative to the high potential cost of implementation.


1-Interstitial Rock Planting Restoration, 0.12 AC
•Reinforce rock stabilzation
•Fill pockets with soil
•Plant native vegetation
2-Northern Tidal Wetland Restoration.29 AC
•Reinforce toe protection
•Import soil and grade between top of bank and riprap
•Plant native vegetation
3-Southern Tidal Wetland Restoration.70 AC
•Remove remnant boat launch
•Reinforce toe protection/ install where non-existent
•Grade back the bank to existing gravel surface
•Import soil and grade between top of bank and riprap
•Plant native vegetation
HUDSON RIVER
Flow
Legend
Existing Timber Cribbing
Project Footprint
Interstitial Rock Planting Restoration
Tidal Wetland Restoration
NOTES:
1. 2016 orthoimagery obtained from the New York State GIS Clearinghouse: gis.ny.gov
0 60 120 Feet
Map Projection: NAD 1983 StatePlane New York East FIPS 3101 Feet
CONCEPT PLAN
ALTERNATIVE 1
HUDSON RIVER HABITAT RESTORATION
CHARLES RIDER PARK
TOWN OF ULSTER
ULSTER COUNTY, NEW YORK
US Army Corps of Engineers
New York District

2.5. Rondout Creek – Eddyville Dam

Site Setting

Eddyville Dam (Figure 2-13) is the first aquatic organism passage (AOP) barrier on Rondout Creek, located approximately 3.6 miles upstream of its confluence with the Hudson River. The dam lies on the boundary between the Towns of Esopus and Ulster in Ulster County and has the following characteristics:

Eddyville Dam – Rondout Creek	
State ID	193-0812
Federal ID	NY01136
Dam Height	12 ft
Dam Length	220 ft
Storage Capacity	90 ac-ft
Surface Area	15 ac
Town	Esopus / Ulster
County	Ulster

Figure 2-13: Eddyville Dam project area on Rondout Creek.

Eddyville Dam is classified as a Class A - Low Hazard dam, and is currently a barrier to tidal flow and serves as the 'head of tide' on Rondout Creek. Eddyville Dam is privately owned along with three adjacent parcels. While permission from the owner to access the dam was never granted, the Federal Emergency Management Agency (FEMA) water surface profile was reviewed and the channel upstream and downstream of the dam was examined during field investigations. The primary findings include an irregular riverbed with very deep pools (30 to 50 feet), which are likely artifacts from instream mining, a natural bedrock ledge underlies the dam, impounded water extends to a glacial erratic approximately two miles upstream during normal flows, little impounded sediment exists upstream of the dam, and river substrate consists primarily of bedrock and cobbles.

Based on historical data from the State, the dam appears to be a stone masonry dam capped with concrete, although an older timber crib structure might also exist along the upstream side of the visible stone masonry but could not be confirmed.

For further discussion of Eddyville Dam, refer to Appendix B - Engineering.

Figure 2-14: The alignment of Rondout Creek was likely altered to accommodate the canal system, source: Dan Miller, NYSDEC.

Site Background

The extraordinary manipulation of the river bed upstream and downstream of the dam, coupled with the presence of large backwater areas visible in aerial photography, suggest that Rondout Creek may have been heavily altered from its original planform alignment potentially to accommodate the course of a canal system. Specifically, it appears that the river channel may have flowed north toward Creek Locks Road (Route 25) and then east toward Route 213 and connected with the existing main channel of Rondout Creek at the existing marina (Figure 2-14).

Previous Studies

The Eddyville Dam on Rondout Creek has been the subject of numerous studies due to the potential to reconnect fish habitat and restore significant portions of historic migratory fish runs with its removal. For the purpose of this technical memorandum, issues related to Fish Passage and Water and Sediment Quality are summarized below.

Fish Passage

The removal of the Eddyville Dam on the Rondout Creek is an important barrier for fish passage. Waldman (2006) estimates that removal of the Eddyville Dam would “open up 7 miles of the Rondout Creek, potentially large enough to support American shad reproduction.” Alderson and Rosman (2012) of NOAA assessed fish passage on 65 tributaries (224 miles) of the Lower Hudson River (including Rondout Creek) and 165 dams, and identified the potential removal of the Eddyville Dam as the single dam removal yielding among the greatest benefit to migratory fish.

Water Quality

Water quality classifications differ upstream and downstream of the dam. Specifically, from the dam to its mouth at the Hudson River, Rondout Creek is designated a Class C waterway. Upstream of the Eddyville Dam to its confluence with the Wallkill River, Rondout Creek is designated a Class B waterway. While the removal of the dam serves as the boundary between water quality classifications, current and ongoing water quality monitoring should be used to consider the need for modifying existing water quality designations.

Similarly, New York State Department of Health provides different fish consumption advisories for fishes in the Hudson River at the mouth of Rondout Creek and for the Catskill Region, which includes Rondout Creek upstream of the dam. It is possible that, if the Eddyville Dam were removed, the fish consumption advisories for the Hudson River would be expanded to a new upstream extent on Rondout Creek.

Sediment Quality

Sediment sampling was conducted by NYSDEC Division of Water in September 2003 as part of an assessment for dam modification or removal, and out of concern regarding high concentrations of contaminants previously detected upstream in the Walkill River (NYSDEC, 2003). Sampling and analysis were limited primarily to two samples, R1 and R3, upstream of the Eddyville Dam due to funding constraints. Laboratory results were compared to consensus-based sediment quality guidelines for freshwater sediment for metals, polycyclic aromatic hydrocarbons (PAHs), dichlorodiphenyltrichloroethane (DDT) compounds, and polychlorinated biphenyls (PCBs) (Macdonald et al., 2000).

Metals were detected at very low concentrations, mostly below the conservative Threshold Effect Concentration (TEC) and none in excess of the Probable Effect Concentration (PEC). PCBs (Aroclors) were not detected in any sample; however, detection limits for some samples exceeded the TEC but were well below the PEC. Only one compound each of DDT and its metabolites - DDD, and DDE - were analyzed and were either estimated or not detected in any sample. However, since total DDT, DDD, and DDE were not analyzed, direct comparison with the sediment guideline was not possible. Despite this limitation, the report draws from past sampling results to infer that DDT/DDD/DDE concentrations are likely above TEC but below PEC. PAHs and other organics were largely not detected; however, detection limits frequently exceeded the TEC and, in some cases, exceeded the PEC.

These two samples provide limited information about sediment quality upstream of Eddyville Dam, and suggest that common contaminants are not a concern; however, limitations in sampling and analysis preclude any definitive conclusions.

The report also reviews and compares results to previous sampling in 2001 and 1998 in the region. Collectively, these results suggest that the Walkill River may be a source of DDTs, the majority of which have been deposited in Sturgeon Pond, and that the primary sources of PCBs in the Hudson River are located upstream of Rondout Creek.

Constraints and Considerations

A primary consideration for this project remains with the landowner. The landowner has shown interest in the construction of the dam and the history of the site, and has not been supportive of dam removal in the past However, NYSDEC is currently conducting outreach with the dam owner and their support will be required in order to proceed with any restoration action at the site.

Assumptions

Eddyville Dam is situated in a narrow valley with steep bedrock walls, which limits access for construction. It is assumed that adequate shallow bedrock or consolidated river bottom exists immediately upstream and/or downstream of the dam to allow for a rock-lined construction accessway to convey an excavator to the dam and across the spillway. The only feasible location to access the river channel is from the private property of the current dam owner immediately adjacent to the dam. The bedrock ledge, upon which the dam is founded, could simplify construction or demolition by providing a solid base for new construction, or a clear limit for spillway removal.

Alternatives

Through the review of existing information and site assessment, three viable conceptual design alternatives were identified which include (1) Fishway, (2) Dam Removal, and (3) Dam Notching. Concept plans for the Rondout Creek alternatives follow the narrative descriptions below.

Alternative 1 - Fishway

This alternative entails the construction of a technical fishway at the dam. A nature-like fish bypass would not be feasible at this location due to the confining valley walls and deep river depths upstream and downstream of the dam. A technical fishway would be most feasible if situated on the river left side of the spillway making use of the existing lower spillway crest and less steep river rapids extending downstream. At this location, the fishway would be more accessible for construction as well as long-term maintenance and repairs. While an effort would be made to design the fishway around the existing free-standing masonry training wall, its preservation would depend on further site investigation and structural considerations. The type of technical fishway (e.g. Denil pool-weir, Alaskan Steep-pass) would be determined following further consideration of the target species (and swimming abilities), and hydrologic and hydraulic analysis. Fishways typically are not capable of restoring fish passage to the full range of diadromous or resident fish, or all size classes (e.g. age classes), and are therefore considered to be partial restoration of passage at a dam. This structure would require routine inspections, maintenance, and repairs over the long-term in order to ensure optimal fish passage conditions. This alternative assumes the dam owner would grant access to the site, across his residential property, to construct, inspect, maintain, and repair the fishway.

With a technical fishway, the dam spillway would remain, and therefore normal water surface elevation in the impoundment would change minimally from existing conditions. With minimal change to the dam and the impoundment, there would be little or no change in actual water quality conditions nor any cause for a change in designated water quality classifications. Furthermore, there would be little or no change to upstream river habitat conditions (other than through the introduction of previously excluded native species), riverfront properties, or river navigability.

One substantial limitation is the need for a designated long-term owner/operator of the fishway, in the form of a nonprofit organization or state agency.

Alternative 2 - Dam Removal

Alternative 2 entails removal of the entire concrete spillway down to the elevation of the underlying bedrock. The free-standing masonry training wall may remain, pending more detailed site investigation and survey. Normal water surface elevation would drop approximately 10 feet in the upstream vicinity of the dam and tidal fluctuation would extend upstream into the impoundment. Despite full removal of the spillway, a bedrock ledge feature would likely remain onsite in some form, separating the deeper portions of the river bed upstream and downstream. This bedrock ledge may still be visible at the surface at some point during the daily tidal fluctuation and variation in river flows;

although, more detailed site survey and hydrologic and hydraulic analysis are needed to affirm this with greater specificity.

Dam removal would rely on construction access from the dam owner's property; however, after removal, there would be no need for inspections, maintenance, or repairs. The dam owner would not need to provide ongoing access through his property, and no nonprofit or state agency would need to serve as long-term owner and operator of the site. As stated above, it is assumed that adequate shallow bedrock or consolidated river bottom exists immediately upstream and/or downstream of the dam to allow for a rock-lined construction accessway to convey an excavator to the dam and across the spillway.

The bedrock ledge, upon which the dam is founded, and the bedrock valley walls limit the potential for channel instability and geomorphic adjustment at the dam if the dam were to be removed. The deeply mined sections of the river bed upstream of the dam that created pools up to 50 feet deep would still remain if the dam were removed and normal water surface elevation dropped by approximately 10 feet at the dam. Upstream of those deep pools, the river would revert to free-flowing conditions, but with daily tidal fluctuation.

None of the concerns raised by the dam owner are anticipated to be adverse so as to preclude or prohibit dam removal. While tidal fluctuation would extend into the upstream reaches, it is unlikely that water quality conditions would change such that a change in water quality classification would be warranted; although, that decision lies with NYSDEC and the results of ongoing water quality monitoring. With a drop in normal water surface elevation, some narrowing of the normal wetted width would also be expected, both of which would diminish in the upstream direction and would be partially offset or muted by the daily tidal fluctuation. Since the river would remain adjacent to existing riverfront properties, land values related to river views and access to the river are not anticipated to be adversely affected. River navigability upstream of the dam would vary with river flows and tidal fluctuation. The bedrock ledge, which is anticipated to remain in some form, would likely remain as a barrier or deterrent to boat navigation from downstream of the dam to the upstream reaches.

One potential positive impact is in the reduction of flood elevations upstream of the dam. It is understood that the upstream riverfront landowners experienced severe river flooding and flood damage during recent flood events. Removal of the dam, and reduction in normal water surface elevation, could result in reduced flooding for neighboring properties. Detailed hydrologic and hydraulic analysis would be required to affirm the extent and magnitude of this effect. Meanwhile, as a run-of-river dam not designed for flood control, the removal of the dam is not anticipated to adversely affect flooding in the downstream reaches.

The multiple papers about the Hudson River and Rondout Creek make a strong case for the potentially profound impacts this dam removal could have on the fishery. With such a diverse fish community immediately downstream in the Hudson River and the lower reaches of Rondout Creek, many fish are poised to benefit from the removal of the dam and reconnection to approximately seven miles of river upstream. They include migratory fish, including catadromous American eel, and anadromous species including American shad, Hickory shad, Blueback herring, alewife, Striped bass, and Rainbow smelt, as well as potamodromous fish including White sucker, Smallmouth bass, White and Yellow perch, Spottail and Golden shiner, carp, Northern pike, walleye, Shorthead redhorse, and Gizzard shad. As the first barrier on Rondout Creek, Eddyville Dam is the most important barrier to be considered for removal in the river system.

Alternative 3 - Dam Notching

This alternative involves removing a portion of the spillway, likely in the center, to provide for fish passage and leaving the remainder of the spillway intact at its existing elevation. This extent of the notch (width and depth) of the spillway would be determined through detailed site survey and hydrologic and hydraulic analysis to create optimal hydraulic conditions for upstream fish passage for as many target species as possible.

Notching, as opposed to full removal, allows a portion of the spillway to remain as an enduring feature on the site and physical marker of the historic dam. 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 notching of the dam would also result in a reduction in normal water surface elevation albeit less than the full removal, in addition to an upstream tidal influence likely less than the full removal would create.

Dam notching would also rely on construction access from the dam owner's property; however, like full removal, there would be no need for inspections, maintenance, or repairs. The dam owner should not need to provide ongoing access through his property, and no nonprofit or state agency should need to serve as long-term owner and operator of the site. As stated above, it is assumed that adequate shallow bedrock or consolidated river bottom exists immediately upstream and/or downstream of the dam to allow for a rock-lined construction accessway to convey an excavator to the portion of the spillway to be notched.

Like with full dam removal, none of the concerns raised by the dam owner are anticipated to be adverse so as to preclude or prohibit dam notching. While tidal fluctuation would extend into the upstream reaches, it is unlikely that water quality conditions would change such that a change in water quality classification would be warranted; although that decision lies with NYSDEC and the results of ongoing water quality monitoring. With a slight drop in normal water surface elevation, some narrowing of the normal wetted width would also be expected, both of which would diminish in the upstream direction and would be muted by the daily tidal fluctuation. Since the river would remain adjacent to existing riverfront properties, land values related to river views and access to the river are not anticipated to be adversely affected. River navigability upstream of the dam would vary with river flows and tidal fluctuation. The dam and shallow bedrock at the notch would remain as a barrier to boat navigation from downstream of the dam to the upstream reaches.

Notching the dam would result in diminished potential benefits to flooding upstream of the dam as compared to full dam removal. While notching the dam would reduce normal water surface elevation, and could result in reduced flooding for neighboring properties, this effect is anticipated to be less than with full dam removal. A detailed hydrologic and hydraulic analysis would be required to affirm the extent and magnitude of this effect.

Similar to dam removal, notching could have potentially profound impacts on the fishery if the notch is wide enough such that optimal hydraulic conditions are created and the full gamut of potential fish able to benefit could pass upstream. With such a diverse fish community immediately downstream in the Hudson River and the lower reaches of Rondout Creek, nearly 20 fish species are poised to benefit from the removal of the dam and reconnection to approximately seven miles of river upstream. The beneficial impact of this alternative hinges on the proper application of a detailed hydrologic and hydraulic analysis to ensure the creation of optimal fish passage conditions.

As discussed in Chapters 3 and 4 of the main report, Alternative 2 - Dam Removal - was selected as the tentatively selected plan for Rondout Creek.

NOTES:
1. 2016 orthoimagery obtained from the New York State GIS Clearinghouse: gis.ny.gov

0 50 100 Feet

Map Projection: NAD 1983 StatePlane New York East FIPS 3101 Feet

CONCEPT PLAN
ALTERNATIVE 1
HUDSON RIVER HABITAT RESTORATION
RONDOUT CREEK
TOWNS OF ULSTER AND ESOPUS
ULSTER COUNTY, NEW YORK

US Army Corps of Engineers
New York District

CONCEPT PLAN
ALTERNATIVE 2
HUDSON RIVER HABITAT RESTORATION
RONDOUT CREEK
TOWNS OF ULSTER AND ESOPUS
ULSTER COUNTY, NEW YORK


Existing masonry abutment to remain
Dam Notching
•Remove central portion of the spillway
Normal water surface elevation to drop slightly as determined by hydraulic modeling
Flow
RONDOUT CREEK
Legend
Project Footprint
Dam Notching
NOTES:
1. 2016 orthoimagery obtained from the New York State GIS Clearinghouse: gis.ny.gov
0 50 100 Feet
Map Projection: NAD 1983 StatePlane New York East FIPS 3101 Feet
CONCEPT PLAN
ALTERNATIVE 3
HUDSON RIVER HABITAT RESTORATION
RONDOUT CREEK
TOWNS OF ULSTER AND ESOPUS
ULSTER COUNTY, NEW YORK
US Army Corps of Engineers
New York District

2.6. Moodna Creek – AOP #1, AOP #2, and AOP #3

Three Aquatic Organism Passage (AOP) barriers on Moodna Creek in Orange County were investigated to improve passage, AOP #1: Utility Crossing; AOP #2: Firth Cliff Dam; and AOP #3: Orr's Mill Dam (Figure 2-15).

The following document synthesizes findings from the literature review, field observations and site survey and concept development. For more information refer to Appendix B - Engineering.

Figure 2-15: Location of three aquatic organism passage barriers on Moodna Creek.

2.6.1. AOP #1: Utility Crossing

Site Setting

Approximately 1,000 feet upstream of the Forge Hill Road (Route 74) crossing in the Town of New Windsor and 1.8 miles upstream of the Hudson River confluence, a sewer utility line crosses Moodna Creek, forming a weir that creates a vertical drop of water approximately two feet in height at normal flows (Figure 2-16).

The utility crossing is encased in concrete, and approximately five feet wide (Photograph 13). The encasement has a vertical downstream face with a 6 to 12-inch lip just below water surface elevation. However, the lip is not continuous across the structure and scour is undercutting the concrete encasement. The deepest point in a scour hole downstream of the encasement was observed to be four to five feet below water surface elevation at the time of the investigation. Additionally, water was observed flowing into cavities in the streambed upstream of the structure, suggesting the utility crossing was starting to be undermined. Sediment in the channel was coarse-grained and compact (i.e. bedload), and not manually penetrable with rebar; fine sediment depths are negligible. At the utility crossing, the river left bank is two feet above water surface elevation, while the river right bank is stabilized with large angular rip rap on a slope rising 15-20 feet above water surface elevation.

Two valley wall failures are present both upstream and downstream of the utility crossing. At a riffle upstream of the utility crossing at the location of the upstream landslide, the main river flow goes through boulder steps which consist of two steep

Figure 2-16: Location of AOP #1 Utility Crossing. Note the upstream riffle and landslide.

drops, one of which is about five feet, the other about four feet. Likely, these drops are not passable for fish passage and rock configuration may need to be adjusted during construction to ensure fish passability. The secondary flow paths have smaller vertical drops but have lower water depths, and thus remain a fish passage concern, at least during low flows.

Additionally, the downstream valley wall failure extends from the utility crossing to approximately 800 linear feet downstream, rising up to 100 feet in height in places; the entire valley wall slope has been exposed and destabilized (Princeton Hydro, 2018). The destabilized valley wall would need to be considered during engineering design as it could present long-term channel stability issues.

Site Background

The utility crossing is a sewer line that was used by the former textile manufacturing factory site adjacent to the Firth Cliff Dam on the south side of the Moodna Creek (this factory was formerly known as Firth Carpet, and now Majestic Weaving). According to Town representatives, the 16-inch, ductile pipe is abandoned and has not been in use for many years. The sewer line is located within an existing sewer easement.

Constraints and Considerations

This sewer line is likely a barrier to fish passage, both migratory and inland resident fish. However, the large, apparently natural, boulder steps approximately 250 feet upstream may also be impediments to fish passage. Through communications with the NYSDEC, and the Division of Marine Fisheries – Hudson and Delaware Diadromous Fisheries Unit, it was learned that there are no official fish records in Moodna Creek, but at least one local fishermen (George Greene, Town of New Windsor Supervisor) reports having caught River herring in the lower reaches downstream of the Forge Hill Road bridge and Striped bass immediately downstream of the sewer line, and reports observations of Smallmouth bass, sunfish, catfish, grass pickerel in this area as well. It is likely that American eel can pass the boulder steps, but other species may not.

Photograph 13. View of concrete encased utility line from river left (top) and from downstream looking upstream (bottom).

Another consideration is that the sewer line descends steeply down from the former rail bed that then runs parallel to Moodna Creek, on the south bank (river right bank) approximately 30 vertical feet above the valley bottom. This steep valley wall limits how and where the sewer line could be accessed and decommissioned.

As mentioned above, upstream and downstream of the sewer line crossing, recent valley wall failures occurred during a large storm and flood event. These failures contributed a large volume of fine- and coarse-grained glacial till (e.g. clay, silt, sand, gravel, cobble, and boulder) to the channel in a single event, which altered the main flow, alignment, and slope of the channel, and created coarse-grained bars in the channel. These valley wall failures are not stable and have the potential to continue to generate sediment in abrupt, catastrophic events that could adversely affect the fish passage conditions at a constructed rock ramp.

Lastly, as stated above, during the site investigation, river water was observed flowing into the stream bed, which then flowed beneath the sewer line, indicating the sewer line was undermined from the deep scour hole on the downstream side. This condition threatens the long-term stability of the sanitary sewer line.

Assumptions

According to the Town, the sanitary sewer line is contained within a privately held lease that spans the Creek and the adjacent properties. The utility owner's authorization is necessary prior to its removal or modification, and therefore remains the primary constraint.

The upstream boulder steps may also require modification to enhance fish passage. The boulder step feature upstream of the utility line is likely passable by American eel but other species that have been observed in these reaches may be limited. For this reason, both alternatives include modification of this feature in the central flow path of the river with imported boulders to create smaller grade changes in-between the two existing steps.

The existing upstream valley wall failure presents the potential for additional erosion in abrupt, catastrophic events that could alter the fish passage conditions, positively or negatively, at the existing boulder step feature. Likewise, the existing downstream valley wall failure presents the potential for additional erosion in abrupt, catastrophic events that could adversely affect the fish passage conditions. For the purpose of this study, it is assumed that, despite these potential events, the river would remain passable.

Alternatives

Through the review of existing information and site assessment, two alternatives were identified, which include (1) Utility Removal and (2) Rock Ramp. Concept plans for the Moodna Creek AOP #1 - Utility Crossing alternatives follow the narrative descriptions below.

AOP #1 Alternative 1 - Utility Removal

This alternative entails decommissioning the utility line and removal of the section that crosses Moodna Creek. The sanitary sewer line is a 16-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 north (i.e. river left side), 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 install a manhole in connection with upgradient line, but with no outlet toward the Creek. The installation of the manhole on river right creates a stable and secure closure to the existing sewer line, and prevents any inadvertent leakage or discharge of fluid into the Creek, in the event of any unknown inflow or infiltration into the sewer line. 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. The proposed manhole could potentially be used to re-install the line in the future, if necessary.

AOP #1 Alternative 2 - Rock Ramp

Alternative 2 entails maintaining the utility line but constructing a stabilized boulder rock ramp on the downstream side that is fish passable. The rock ramp would be approximately 20:1 slope as per fish passage guidelines for nature-like fishways, and would be comprised of several boulder rock weirs and intervening pools that provide deeper, slower water to facilitate upstream fish passage. The appropriate boulder size and the configuration of the rock ramp would be determined following a detailed topographic survey, hydrologic and hydraulic analysis, and consideration of fish passage guidelines. In addition, the existing utility crossing would likely require sheet-piling, or similar subsurface barrier, installed upstream of the concrete encasement to eliminate the existing subsurface flow that is undermining the utility crossing as that could undermine the constructed rock ramp. This structure would require routine inspections, maintenance, and repairs over the long-term in order to ensure optimal fish passage conditions.

As discussed in Chapters 3 and 4 of the main report, Alternative 1 – Utility Removal – was selected as the tentatively selected plan for Moodna Creek AOP #1.

NOTES:
1. 2016 orthoimagery obtained from the New York State GIS Clearinghouse: gis.ny.gov

0 50 100 Feet

Map Projection: NAD 1983 StatePlane New York East FIPS 3101 Feet

CONCEPT PLAN
ALTERNATIVE 1
HUDSON RIVER HABITAT RESTORATION
MOODNA CREEK - AOP 1: UTILITY CROSSING
TOWN OF NEW WINDSOR
ORANGE COUNTY, NEW YORK

US Army Corps of Engineers
New York District

NOTES:
1. 2016 orthoimagery obtained from the New York State GIS Clearinghouse: gis.ny.gov

0 50 100 Feet

Map Projection: NAD 1983 StatePlane New York East FIPS 3101 Feet

CONCEPT PLAN
ALTERNATIVE 2

HUDSON RIVER HABITAT RESTORATION
MOODNA CREEK - AOP 1: UTILITY CROSSING
TOWN OF NEW WINDSOR
ORANGE COUNTY, NEW YORK

US Army Corps of Engineers.
New York District

2.6.2. AOP #2: Firth Cliff Dam

Site Setting

Firth Cliff Dam is located on Moodna Creek adjacent to a former textile manufacturing site (Figure 2-17) and is approximately three miles upstream of the Hudson River confluence.

Firth Cliff Dam – Moodna Creek – AOP #2	
State ID	195-0501
Federal ID	NY14793
Dam Height	9 ft
Dam Length	162 ft
Storage Capacity	13 - 18 ac-ft
Surface Area	3 Acres

The Firth Cliff Dam is classified as a Class A – Low Hazard Dam and has the following characteristics:

Figure 2-17: Location of AOP #2 Firth Cliff Dam.

The dam is privately owned. Based on field investigations, the dam crest is two feet wide and the downstream spillway slopes down with an estimated nine feet of elevation change and an additional one-foot estimated lip on the edge of the spillway (Photograph 14). A large abutment straddles each side of the dam. On the river left, the abutment is about 60 feet long and two feet wide. The river left valley wall near the dam is steeply sloped, nearly vertical in places. On the river right immediately beyond the impoundment, is the factory parking lot; the river right abutment also shows evidence of a gate structure which likely included a diversion for a mill race. The gate is on the upstream end of the abutment and was approximately six feet wide and with gate guides that are an estimated three feet high. During the field investigation in June 2018, no evidence of leakage could be seen, suggesting that the dam is intact and in good condition.

Sediment texture was characterized throughout the impoundment. Immediately upstream of the dam, the sediment was very coarse sand and small gravel. The sediment was compact and could only be probed manually with rebar between two and five inches with the exception of a downstream log debris area where fine sediment

Photograph 14: View of Firth Cliff Dam from river left (top) and from downstream looking upstream (bottom).

deposited was approximately two feet deep. Sediment material was coarser moving upstream, transitioning from gravel, cobble, and boulders.

Upstream, there were bedrock/glacial erratics on the banks that would maintain bank stability in the event of dam removal. Downstream, the main channel is along the river right bank. Immediately downstream of the dam, the Creek returns to a pool-riffle stream.

Site Background

It is unclear when the Firth Cliff Dam was constructed but it was presumably in use when the historic Firth Carpet Company Mill was in operation. Legacy contamination of this former manufacturing site was previously addressed by others. In 2016, NYSDEC determined that the site, immediately adjacent to the dam, no longer "presents a threat to public health or the environment and is proposing to delist the site from the [State Superfund Program]" because "Remedial actions included the removal of contaminated soil and drums containing hazardous waste. Sampling indicates groundwater is not contaminated, soil meets the soil cleanup objectives for residential use and soil vapor intrusion is not an exposure concern" (NYSDEC, 2016).

Constraints and Considerations

Obtaining landowner permission and support is required to move forward with restoration activities at this site. Minimizing disturbance to the adjacent facility would likely aide in that process. Further, despite state records that indicate the site has been adequately remediated, any proposed activities in the facility immediately adjacent to the dam have the potential to expose contaminated soils that are currently contained and capped.

Assumptions

Regardless of the history of the adjacent manufacturing site, impounded sediment upstream of the dam should be sampled and analyzed during the pre-construction engineering and design phase. However, for the purpose of this project, it is assumed that upstream impounded sediments do not contain concentrations of contaminants that would prohibit dam removal. If contamination is identified during the pre-construction engineering and design phase, the non-federal sponsor will conduct any necessary remediation of the sediment prior to dam removal. Refer to Appendix G2 – Hazardous, Toxic, and Radioactive Waste for more information.

Alternatives

Through the review of existing information and site assessment, two alternatives were identified, which include (1) Dam Removal and (2) Fish Ladder. Concept plans for the Moodna Creek AOP #2 - Firth Cliff Dam alternatives follow the narrative descriptions below.

AOP #2 Alternative 1 - Dam Removal

This alternative entails demolition and removal of the concrete spillway to the full vertical extent and passive release of the impounded sediment. 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.

Due to the narrow riverine impoundment and steep confining valley walls, this dam impounds mainly bedload sediment (sand, gravel, cobble, boulder); most finer grain sizes (silt and clay), pass through to downstream reaches. Sediment would need to be sampled and analyzed in a NY-certified laboratory for a broad range of potential pollutants (metals, PAHs, PCBs, dioxins, pesticides/herbicides) and, analytical results would have to show few or no exceedances for human health and ecological criteria, and show comparable concentrations of contaminants to upstream or downstream reaches. Coarse-grained sediment has less propensity for binding pollutants; therefore, due to the dominance of coarse-grained sediment in the impoundment, results are anticipated to indicate a lack of contamination and allow for passive sediment management.

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 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.

This alternative is anticipated to re-create 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.

AOP #2 Alternative 2 – Fish Ladder

Alternative 2 entails maintaining the dam spillway but installing a technical fishway that passes through or around the spillway. The entrance (i.e. downstream end) would likely be placed as close to the spillway as possible to ensure that fish that arrive at the dam, could still locate the fishway entrance. The specific type of technical fishway (e.g. Denil Step-pool or Alaskan Steep-pass) and its design would be determined following detailed topographic survey, hydrologic and hydraulic analysis, identification of target species, and consideration of fish passage guidelines. A nature-like bypass fishway is not considered to be a feasible alternative because it would likely require extensive disturbance to the site including the concrete foundations of the former buildings and potential disturbance and re-exposure of contaminated soils. A technical fishway could provide passage for some species, typically the stronger swimming species and size classes. This structure would require routine inspections, maintenance, and repairs over the long-term in order to ensure optimal fish passage conditions.

The fishway would result in minimal change in normal water surface elevation and no downstream transport of impounded sediment. Impounded sediments would not need to be sampled and analyzed in a laboratory. This alternative does not re-create a free-flowing reach of river or improve water quality conditions. Full fish passage conditions could not be guaranteed by a technical fishway; passage would be limited to stronger swimming fish and size classes, such as trout. In addition, technical fishways do not restore the natural transport of bedload sediment, improve downstream benthic habitat conditions or offset any past vertical channel degradation.

As discussed in Chapters 3 and 4 of the main report, Alternative 1 – Dam Removal was selected as the tentatively selected plan for Moodna Creek AOP #2.


Dam Removal
•Remove full vertical and horizontal extent of spillway
•Stabilize abutment
•Grade streambed as necessary
•Stabilize banks as necessary
Minimal volume of fine sediment in impoundment. In the absence of sediment contamination, river bed shall be allowed to adjust naturally after dam removal
Flow
MOODNA CREEK
Channel and wetted width under normal flows to narrow post dam removal
Legend
Project Footprint
Dam Removal
NOTES:
1. 2016 orthoimagery obtained from the New York State GIS Clearinghouse: gis.ny.gov
0 50 100 Feet
Map Projection: NAD 1983 StatePlane New York East FIPS 3101 Feet
CONCEPT PLAN
ALTERNATIVE 1
HUDSON RIVER HABITAT RESTORATION
MOODNA CREEK - AOP 2: FIRTH CLIFF DAM
TOWN OF CORNWALL
ORANGE COUNTY, NEW YORK
US Army Corps of Engineers
New York District

NOTES:
1. 2016 orthoimagery obtained from the New York State GIS Clearinghouse: gis.ny.gov

0 50 100 Feet

Map Projection: NAD 1983 StatePlane New York East FIPS 3101 Feet

CONCEPT PLAN
ALTERNATIVE 2

HUDSON RIVER HABITAT RESTORATION
MOODNA CREEK - AOP 2: FIRTH CLIFF DAM
TOWN OF CORNWALL
ORANGE COUNTY, NEW YORK

US Army Corps of Engineers
New York District

2.6.3. AOP #3: Orr's Mill Dam

Site Setting

Orr's Mill Dam is located on Moodna Creek 75 feet upstream of the Route 32 bridge crossing (Figure 2-18) and is approximately 3.7 miles upstream of the Hudson River confluence.

Orr's Mill Dam is classified as a Class A - Low Hazard Dam and has the following characteristics:

Orr's Mill Dam – Moodna Creek – AOP #3	
State ID	195-0494
Federal ID	NY13204
Dam Height	10 ft
Dam Length	180 ft (165 ft Dike Length)
Storage Capacity	16 ac-ft (Normal) / 17 (Maximum)
Surface Area	2 ac
Dam Owner	Anthony Incanno

Figure 2-18: Location of AOP #3 Orr's Mill Dam.

The dam is privately owned. The structure is unique in that the spillway is made of cobbles/boulders with steel I-beams and timbers running longitudinally along the spillway, and capped with a layer of concrete (Photograph 15). Based on a visual assessment, the concrete does not appear to have reinforcement bar and the steel I-beams do not appear to be structurally connected. Historical photographs from circa 1900 confirm that the dam at that time was a stone dam and the reinforcement and concrete were added at a later date. Presently, there are multiple holes in the concrete cap where timber and stone underneath can be observed. The downstream edge of the spillway is elevated two feet above the downstream river bed. During field investigations, water could be seen flowing out of this downstream edge of the spillway clearly indicating that the dam is undermined and leaking.

Sediment upstream of the dam was compact, primarily bedload, and was not penetrable with a manual probe; as such, there is no substantial fine sediment accumulation impounded by this dam. On river right upstream of the dam, there is a point bar mostly consisting of sand, gravel, and cobble with some boulders. Additionally, there may be a natural boulder cascade or bedrock falls in the vicinity of the current dam location. In addition to large boulders, the lower impoundment is made up of large cobble with limited bedrock outcrop and/or glacial erratics.

Photograph 15: View of Orr's Mill Dam from river right

Approximately 350 feet downstream of the dam is a major valley wall failure (Princeton Hydro, 2018). The valley wall failure extends for approximately 450 linear feet, rising up to 100 feet in height; the entire valley wall has been exposed and destabilized.

Site Background

Anecdotally, the dam dates back to the American Revolution; however, that has not been confirmed. There are two legacy millraces that historically bypassed flow to mill buildings that are now residential. Historically, the river right millraces extended from downstream of the dam, underneath the porch of the existing house, and connected with Moodna Creek upstream. However, currently, the millrace extends from downstream of the dam to the brick wall on the side of the house. The elevation of the current millrace is higher than the downstream river channel by approximately five feet.

The legacy millrace on the river left connects upstream of the dam near the dam abutment, and continues into a 15-foot culvert underneath the abutment and then through a 50-foot-long, 5x5 foot box culvert underneath the road. The culvert and dam spillway empty into a holding pond approximately four feet deep. The grade continues to drop in elevation, approximately eight feet, until it connects with the river at least 50 feet downstream.

NYSDEC provided records of dam inspections from 1980, 1987, and 1990. During each inspection, the dam was observed to be in a state of disrepair, including a void in the river left of the spillway.

Constraints and Considerations

Site investigation revealed that Orr's Mill Dam is in very poor condition; although the spillway has been repaired since the 1990 inspection, normal river flow passes under the entire breadth of the spillway, indicating it is substantially undermined. Since the dam is officially classified as low hazard, its failure is not anticipated to present a risk to lives or property; however, it is the PDT's professional opinion that a single catastrophic failure could severely reduce the hydraulic capacity of the Route 32 bridge or exacerbate the valley wall failure immediately downstream. Cracks and holes in the spillway indicate that the thin concrete cap is not reinforced and will continue to rapidly deteriorate. This poor condition renders a fish passage alternative infeasible, as it would require extensive repair or potentially an entire rebuild to ensure long-term water control and hydraulic function of a fishway or fish-ladder, thus making that alternative cost-prohibitive.

In addition, the two legacy millraces that historically bypassed flow could not be re-purposed as fishways. Historically, the river right millrace passed underneath a former building which is now the porch of the existing house; however, currently, the millrace extends from downstream of the dam and terminates at a brick wall on the side of the house. There is no current millrace from the house to tie into the upstream edge of the river. Re-purposing this millrace into a fishway would require extensive repair, alteration of the residential buildings, and new construction, thus limiting its feasibility.

The legacy millrace on the river left was comprised of several culverts that are now disconnected and ultimately discharges to Moodna Creek approximately 350 feet downstream of the dam. Due to its state of disrepair and the distance between the outlet and the spillway, this millrace could not be feasibly re-purposed into a fishway.

Despite the poor condition, dam ownership remains a major consideration for the feasibility of any alternative at this dam.

Assumptions

It was assumed that if the dam is breached, the faces of the spillway could be stabilized with boulders at the base, and that higher portions above normal water surface elevation would not be structurally reinforced. As the remaining spillway sections are not structurally required for this alternative, it is also assumed that they would be allowed to continue to degrade in place, albeit at a slower rate than in current conditions due to its full exposure to flow.

Alternatives

Through the review of existing information and site assessment, two viable conceptual design alternatives were identified, which include (1) Dam Removal and (2) Dam Breach. Concept plans for the Moodna Creek AOP #3 - Orr's Mill Dam alternatives follow the narrative descriptions below.

AOP #3 Alternative 1 - Dam Removal

This alternative entails demolition and removal of the concrete-capped, cobble/boulder-filled timber crib spillway to the full vertical extent and passive release of the impounded sediment. The abutment on river left associated with a former bridge may be lowered or removed entirely. The abutment on river right should remain as it is part of a retaining wall that protects the adjacent property.

Due to the narrow riverine impoundment and narrow valley, this dam impounds mainly bedload sediment (sand, gravel, cobble, boulder); most finer grain sizes (silt and clay), pass through to downstream reaches. Sediment would need to be sampled and analyzed in a NY-certified laboratory for a broad range of potential pollutants (metals, PAHs, PCBs, dioxins, pesticides/herbicides) and, analytical results would have to show few or no exceedances for human health and ecological criteria, and show comparable concentrations of contaminants to upstream or downstream reaches. Coarse-grained sediment has less propensity for binding pollutants; therefore, due to the dominance of coarse-grained sediment in the impoundment, results are anticipated to indicate a lack of contamination and allow for passive sediment management.

Approximately 900 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 adjustment in the main channel in the event of dam removal. Multiple extremely large boulders (i.e. five to ten feet in diameter) are situated immediately upstream of the spillway and likely form boulder-dominated steps or a cascade. At least one of the boulders may be a bedrock outcrop. Following dam removal, finer sediment would transport downstream, while the larger cobble and boulder may shift position. Due to the steep slope that is anticipated to re-form, full fish passage conditions for the full range of target fish could not be guaranteed to form passively and thus, some active re-grading and re-positioning of boulders may be necessary to establish a stable grade control and to facilitate fish passability. If *in situ* boulders are insufficient to maintain a stable grade change and/or fish passage conditions, this alternative also includes supplementing this reach with large boulders to establish grade control.

Approximately 250 feet upstream of the dam, a smaller, cobble-dominated tributary, which flows under a residence, joins the main stem, forming a steep, cobble delta at the confluence. This tributary and confluence requires additional investigation and would likely necessitate a stone grade control structure to prevent undermining of the over-lying residence.

This alternative is anticipated to remove the stagnant backwater conditions that occur during low flows and base flows, and re-create a free-flowing reach of river with increased dissolved oxygen content and moderated water temperatures. While full fish passage conditions could not be guaranteed due to the likely steep channel post dam removal, removal of the dam would reconnect to 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 offset any vertical channel degradation that has occurred in the decades and centuries since dam construction.

AOP #3 Alternative 2 - Dam Breach

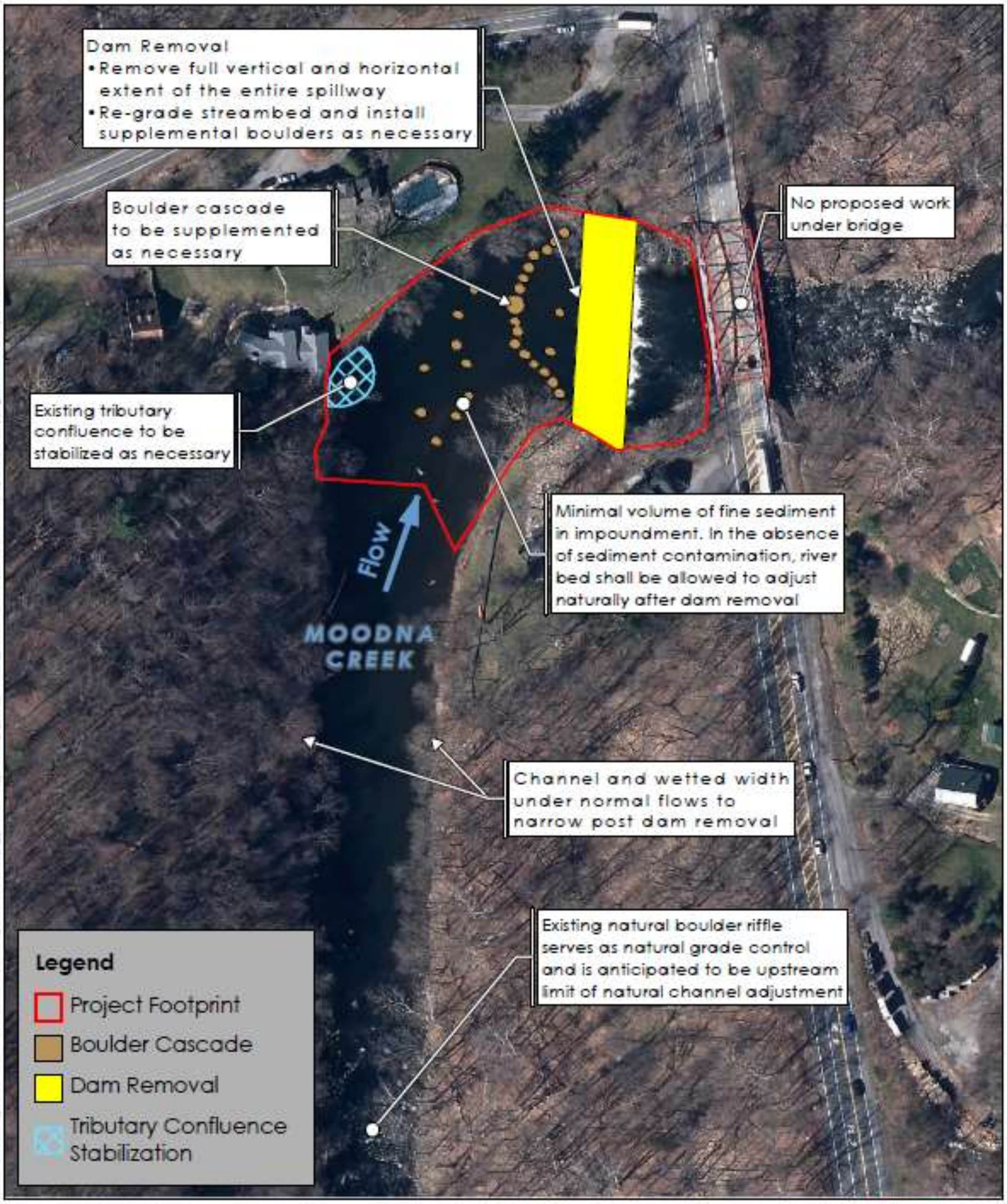
Alternative 2 entails breaking through the spillway concrete crest, and underlying cobble/boulder-filled timber crib structure, removing the vertical extent of a central portion of the spillway, and leaving the side portions in place. The ends of the spillway could be stabilized at their base with placed boulders, while the upper portions could be left open for visibility of the spillway's interior construction.

With the full vertical extent of the central portion of the spillway removed, a similar channel response is likely to be triggered as with full removal but with more retention of sediment on the channel margins proximal to the dam. The pronounced boulder riffle approximately 900 feet upstream of the dam would serve as a natural grade control that would limit the upstream extent of any vertical channel adjustment in the main channel if the dam is notched. The multiple extremely large boulders (i.e. five to ten feet in diameter) that are situated immediately upstream of the spillway are anticipated to form boulder-dominated steps or a cascade. Following dam notching, finer sediment would transport downstream, while the larger cobble and boulder may shift position. Due to the steep slope that is anticipated to re-form, full fish passage conditions for the full range of target fish could not be guaranteed to form passively and thus, some active re-grading and re-positioning of boulders may be necessary to facilitate the formation of a stable grade control and fish passability. If *in situ* boulders are insufficient to maintain a stable grade change and/or fish passage conditions, this alternative also includes supplementing this reach with large boulders to establish grade control.

As in the full dam removal alternative, the cobble-dominated tributary confluence requires additional investigation and would likely necessitate a stone grade control structure to prevent undermining of the over-lying residence.

This alternative, much like the full dam removal alternative, is anticipated to remove the stagnant backwater conditions that occur during low flows and base flows, and re-create a free-flowing reach of river with increased dissolved oxygen content and moderated water temperatures. Full fish passage conditions could not be guaranteed, and are likely to be less passable than the full dam removal option due to the likely steep channel post dam removal; however, removal of the dam would reconnect to 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 offset any vertical channel degradation that has occurred in the decades and centuries since dam construction.

As discussed in Chapters 3 and 4 of the main report, Alternative 2 – Dam Breach – was selected as the tentatively selected plan for Moodna Creek AOP #3.



NOTES:
1. 2016 orthoimagery obtained from the New York State GIS Clearinghouse: gis.ny.gov

0 60 120 Feet

Map Projection: NAD 1983 StatePlane New York East FIPS 3101 Feet

CONCEPT PLAN
ALTERNATIVE 1

HUDSON RIVER HABITAT RESTORATION
MOODNA CREEK - AOP 3: ORR'S MILL DAM
TOWN OF CORNWALL
ORANGE COUNTY, NEW YORK

US Army Corps of Engineers
New York District

Dam Breach
• Remove full vertical and horizontal extent of the central portion of the spillway
• Re-grade streambed and install supplemental boulders as necessary
Boulder cascade to be supplemented as necessary
No proposed work under bridge
Existing tributary confluence to be stabilized as necessary
Minimal volume of fine sediment in impoundment. In the absence of sediment contamination, river bed shall be allowed to adjust naturally after dam removal
Flow
MOODNA CREEK
Channel and wetted width under normal flows to narrow post dam removal
Existing natural boulder riffle serves as natural grade control and is anticipated to be upstream limit of natural channel adjustment
Legend
Project Footprint
Boulder Cascade
Dam Breach
Tributary Confluence Stabilization
NOTES:
1. 2016 orthoimagery obtained from the New York State GIS Clearinghouse: gis.ny.gov
0 60 120 Feet
Map Projection: NAD 1983 StatePlane New York East FIPS 3101 Feet
CONCEPT PLAN
ALTERNATIVE 2
HUDSON RIVER HABITAT RESTORATION
MOODNA CREEK - AOP 3: ORR'S MILL DAM
TOWN OF CORNWALL
ORANGE COUNTY, NEW YORK
US Army Corps of Engineers
New York District

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Attachment 1

Preliminary Screening of 212 Sites

- Table C-1: Mosaic Habitat and Shoreline Restoration Sites
- Table C-2: Tributary Connection Sites

Table C-1: Site Screening of Mosaic Habitat and Shoreline Restoration Sites with Five Screening Criteria and Nexus to USACE Actions.

Project Title	County	Known Contamin-ation (Y/N)	Unwilling Landowner (Y/N)	Low Benefits Relative to Existing Info (Y/N)	Not Complex or Large (Y/N)	Current Funding by Others	Retained? (Y/N)	Nexus to USACE Actions	Retained? (Y/N)
Annsville-Invasive removal and Recreational Access	Westchester	?	?	?	?	?	Y	N	N
Athens Boat Launch and Takeout	Greene	?	?	?	Y	?	N	N	N
Bear Island Side Channel	Albany	?	Y	?	?	?	N	Y	N
Bear Mountain State Park	Rockland	N	?	?	?	?	Y	?	Y
Binnen Kill Habitat Restoration	Albany	N	?	N	N	N	Y	Y	Y
Bronck Island Side Channel	Greene	?	Y	?	?	?	N	Y	N
Brownfield Cleanup-Access and Remediate	Ulster	Y	?	?	?	?	N	?	N
Bulkhead Repairs/ Habitat Restoration	Albany	N	?	?	?	?	Y	?	Y
Campbell Island Side Channel	Rensselaer	?	Y	?	?	?	N	Y	N
Catskill Habitat Restoration	Greene	?	?	Y	?	?	N	N	N
Center Island Shoreline Stabilization	Albany	Y	?	?	?	?	N	N	N
Channel/ Island Restoration	Rensselaer	N	?	?	?	?	Y	?	Y
Charles Rider Park	Ulster	N	N	N	N	N	Y	?	Y

Project Title	County	Known Contamin-ation (Y/N)	Unwilling Landowner (Y/N)	Low Benefits Relative to Existing Info (Y/N)	Not Complex or Large (Y/N)	Current Funding by Others	Retained? (Y/N)	Nexus to USACE Actions	Retained? (Y/N)
City of Poughkeepsie Waterfront Redevelopment	Dutchess	?	?	?	?	?	Y	N	N
Coeymans Creek Shoreline Restoration	Albany	N	?	?	Y	?	N	?	N
Cohotate Preserve	Greene	?	?	Y	?	?	N	N	N
Colonie Rec. Conn.	Albany	?	?	Y	?	?	N	N	N
Consolidated Iron	Orange	Y	?	?	?	?	N	?	N
Control of Invasive Species	Rensselaer	?	?	?	?	?	Y	N	N
Corning Preserve Master Plan	Albany	?	?	?	?	?	Y	N	N
Corning Preserve Master Plan	Albany	?	?	?	?	?	Y	N	N
Cow Island Dike	Rensselaer	N	?	?	N	?	Y	Y	Y
Coxsackie Boat Launch and Takeout	Greene	?	?	?	Y	?	N	N	N
Croton Marsh and Estuary Restoration	Westchester	Y	?	?	?	?	N	?	N
Croton Marsh and Estuary Restoration	Westchester	Y	?	?	?	?	N	?	N
Croton Point Park Landfill Meadow Restoration	Westchester	?	?	?	?	?	Y	N	N
Croton Point Park Marsh	Westchester	?	?	?	?	?	Y	N	N
Croton Point Park Wetland Restoration	Westchester	Y	?	?	?	?	N	?	N

Project Title	County	Known Contamin-ation (Y/N)	Unwilling Landowner (Y/N)	Low Benefits Relative to Existing Info (Y/N)	Not Complex or Large (Y/N)	Current Funding by Others	Retained? (Y/N)	Nexus to USACE Actions	Retained? (Y/N)
Devries Village Park	Westchester	?	?	?	?	?	Y	N	N
Dockside Shoreline	Putnam	?	?	?	?	Y	N	?	N
Dutchman's Landy Swamp	Greene	?	?	?	?	?	Y	N	N
Esopus Meadows Preserve Shoreline Restoration	Ulster	?	?	?	?	?	Y	N	N
Falling Waters Preserve Stream Restoration (1)	Ulster	N	?	Y	?	?	N	?	N
Falling Waters Preserve Stream Restoration (2)	Ulster	?	?	?	?	?	Y	N	N
Greenport Conserv. Area & North Bay of Hudson, NY	Columbia	N	?	?	?	?	Y	?	Y
Habershaw Park	Westchester	Y	?	?	?	?	N	?	N
Hannacroix Creek/ HR Interpret Trail Conserv. Area	Greene	?	?	?	?	?	Y	N	N
Haverstraw Bay County Park Shoreline Restoration Plan	Rockland	?	?	Y	Y	?	N	?	N
Henry Hudson Park Shoreline	Albany	N	N	N	N	N	Y	Y	Y
Houghtaling Island Side Channel	Columbia	N	N	N	N	N	Y	Y	Y
Hudson Shores Park Shoreline Stabilization	Albany	N	?	?	?	?	Y	N	N
Improving Recreational Access	Rensselaer	?	?	?	Y	?	N	?	N

Project Title	County	Known Contamin-ation (Y/N)	Unwilling Landowner (Y/N)	Low Benefits Relative to Existing Info (Y/N)	Not Complex or Large (Y/N)	Current Funding by Others	Retained? (Y/N)	Nexus to USACE Actions	Retained? (Y/N)
Ingalls Ave. Boat Launch	Rensselaer	Y	?	?	?	?	N	?	N
Island Dock-Riparian Buffer	Ulster	?	?	?	?	?	Y	N	N
Kaal Rock Park	Dutchess	Y	?	?	?	?	N	?	N
Kenny's Cove	Westchester	?	?	Y	?	?	N	?	N
Least Bittern Nest Preservation	Columbia	?	?	?	?	?	Y	N	Y
Lower Wappinger Creek Superfund Site	Dutchess	Y	?	?	?	?	N	?	N
Madam Brett Park Shoreline Restoration	Dutchess	?	?	?	?	?	Y	N	N
Madam Brett Park Tidal Wetland Migration Monitoring	Dutchess	?	?	?	?	?	Y	N	N
Manitou Station Road Improvements	Putnam	?	?	Y	?	?	N	N	N
Mohawk Hudson Hike Bike Trail	Albany	N	N	?	?	?	Y	Y	Y
Moodna Creek Marsh Protection & Enhancement	Orange	?	?	?	?	?	Y	N	N
North Bay Recreation and Natural Area	Columbia	?	?	?	?	?	Y	N	N
Nyack Beach State Park	Rockland	N	?	?	Y	?	N	?	N
Oscawana Island Habitat Restoration	Westchester	?	?	?	?	?	Y	N	N

Project Title	County	Known Contamin-ation (Y/N)	Unwilling Landowner (Y/N)	Low Benefits Relative to Existing Info (Y/N)	Not Complex or Large (Y/N)	Current Funding by Others	Retained? (Y/N)	Nexus to USACE Actions	Retained? (Y/N)
Oscawana Park Marsh	Westchester	?	?	?	?	?	Y	N	N
Pixtaway Island Side Channel	Rensselaer	?	Y	?	?	?	N	Y	N
Pocantico River	Westchester	Y	?	?	?	?	N	?	N
Poet's Walk Park Stream Restoration	Dutchess	?	?	?	?	?	Y	N	N
Poplar Island Side Channel	Greene	?	Y	?	?	?	N	Y	N
Proposed Pipeline Crossing	Westchester	?	?	Y	?	?	N	N	N
Ramshorn- Livingston Marsh and Sanctuary	Greene	?	?	?	?	?	Y	N	N
Ramshorn-Livingston Sanctuary Expansion	Greene	?	?	?	?	?	Y	N	N
Rattlesnake Island Dike Side Channel	Greene	N	N	N	N	N	Y	Y	Y
Research Project to Investigate Brownfield Cleanup	Columbia	Y	?	?	?	?	N	?	N
Restore Biodiversity in Land in Dredged Spoils	Albany	N	?	Y	?	?	N	N	N
Revitalizing Old Pier	Columbia	Y	?	Y	?	?	N	?	N
Riverfront State & Private Land Restoration	Rockland	?	?	?	?	?	Y	N	N
Riverwalk-Kingsland Point Park	Westchester	?	?	?	Y	?	N	?	N

Project Title	County	Known Contamin-ation (Y/N)	Unwilling Landowner (Y/N)	Low Benefits Relative to Existing Info (Y/N)	Not Complex or Large (Y/N)	Current Funding by Others	Retained? (Y/N)	Nexus to USACE Actions	Retained? (Y/N)
Rotary Park	Ulster	N	?	?	?	?	Y	?	Y
Saw Kill Watershed Community Stewardship	Dutchess	?	?	?	?	?	Y	N	N
Schermerhorn Island Side Channel	Greene	N	?	N	N	N	Y	Y	Y
Schodack Island State Park Shoreline	Rensselaer	N	N	N	N	N	Y	Y	Y
Sediment Management	Westchester	?	?	?	?	?	Y	N	N
Shad Island Side Channel	Greene	N	?	N	N	N	Y	Y	Y
Shallow Wetland Restoration Potential	Greene	N	?	Y	?	?	N	?	N
Shoreline Stabilization	Orange	?	?	?	?	?	Y	N	N
Shoreline Stabilization and Restoration	Westchester	Y	?	?	?	?	N	?	N
Sleepy Hollow 1	Westchester	?	?	Y	?	?	N	?	N
Sleepy Hollow 2	Westchester	?	?	Y	?	?	N	?	N
South Bay Restoration Project	Columbia	Y	?	?	?	?	N	?	N
Sparkill Creek Riparian Buffer Project	Rockland	?	?	?	Y	?	N	N	N
Upper Schodack Island Side Channel	Columbia	N	N	N	N	N	Y	Y	Y
Waryas Park	Dutchess	N	?	?	?	?	Y	?	Y

Project Title	County	Known Contamin-ation (Y/N)	Unwilling Landowner (Y/N)	Low Benefits Relative to Existing Info (Y/N)	Not Complex or Large (Y/N)	Current Funding by Others	Retained? (Y/N)	Nexus to USACE Actions	Retained? (Y/N)
Water Chestnut	Columbia	?	?	?	?	?	Y	N	N
Waterfront Protection	Orange	?	?	?	?	?	Y	N	N
Willows @ Brandow Point	Greene	?	?	Y	?	?	N	N	N
Wynankskill Canal Future Stabilization	Rensselaer	?	?	?	?	?	Y	?	N

Legend - N: NO, Y: Yes, ?: Unknown

Table C-2: Site Screening of Tributary Connection Sites with Screening Criteria.

Tributary		Site Component Title (Provided by NYSDEC)	Cumulative Mileage of Habitat Opened (Miles)*	# Barriers	Natural Barrier Prior to First Dam (Y/N)	Multiple Species Benefit (Y/N)**	Screening Rationale	Retained? (Y/N)
1	Saw Mill River	Saw Mill #4 Dam	7.32	1	?	?	Tributary removed since it is outside of study area.	N
2	Sparkill	Sparkill Dam #1-Piermont Paper Company Dam	0.41	2	N	Y	Tributary removed since it is outside of study area and provides limited ecological benefits	N
		Sparkill Dam #2 - Boss Pond Dam	**2.12 (total)**					
3	Pocantico River	Pocantico-mouth of river, Kingsland Point Park	-	2	N	Y	Schmidt 1996 states there is a natural falls barrier approximately 0.56 miles upstream of the Sleepy Hollow Dam.	N
		Pocantico River Dam #1 -Sleepy Hollow Dam	**0.56 (Schmidt 1996)**					
		Phillipsburgh Manor Dam	-					
		Pocantico River #5 Pocantico Lake Dam	-					
4	Sing Brook	Sing Brook #2 Dam (QA)	0.17	3	Y	N	Tributary removed due to natural barrier and does not benefit multiple species.	N
		Sing Brook #3 Dam (QA)	0.32					
		Sing Brook #4 Dual Box Culvert (QA)	**3.5 (total)**					

Tributary		Site Component Title (Provided by NYSDEC)	Cumulative Mileage of Habitat Opened (Miles)*	# Barriers	Natural Barrier Prior to First Dam (Y/N)	Multiple Species Benefit (Y/N)**	Screening Rationale	Retained? (Y/N)
5	Croton River	Croton River Silver Lake Dam #2	0.39	3	N	Y	Tributary removed due to limited ecological benefits (1.66 miles) due to the presence of an upstream New Croton Reservoir Dam.	N
		Croton River Dam #4 Ottaviano's Dam Black Rock Park	0.82					
		Croton River #6 - Croton Water Supply a and b Breached Dam (Old Water Supply Dam)	**1.66 (total)**					
6	Minisce-ongo Creek	Minisceongo Creek Culverts #2 - Rte 202 Dual Square Culverts	0.65	6	N	Y	Assume too many impediments (6) would require removal to achieve benefits (maximum of 7.18 miles)	N
		Minisceongo Creek Dam #5b - Rockland Print Company Dam	0.95					
		Minisceongo Creek Dam #6 - Church St Dam	1.06					
		Minisceongo Creek Dam #7 - Rockland Print Company Dam #2	1.28					
		Minisceongo Creek Dam #8 - Garnerville Dam	2.5					

Tributary		Site Component Title (Provided by NYSDEC)	Cumulative Mileage of Habitat Opened (Miles)*	# Barriers	Natural Barrier Prior to First Dam (Y/N)	Multiple Species Benefit (Y/N)**	Screening Rationale	Retained? (Y/N)
		Minisceongo Creek Dam #9 - Langshur Dam	**7.18 (total)**					
7	Furnace Brook	Furnace Brook Dam #1 - Oscawana Park Dam/Ledge at Crugers Mill	0.19	4	N	Y	Tributary removed due to limited ecological benefits (only 1.29 miles)	N
		Furnace Brook Dam #4 - Maiden Lane Upper Dam (#2)	0.19					
		Furnace Brook Dam #2 Ledge/Rapids/Dam (#3)	0.36					
		Furnace Brook Ledge/Dam #3 (#4)	0.88					
		Furnace Brook Dam #6 -Chimney Corners Dam at Watergate Motor Hotel	**1.29 (total)**					
		Furnace Brook Removal Project	-					
8	Cedar Pond Brook	Cedar Pond Brook #2 Stony Point Dam	5.55	1	Y	N	Tributary removed due to natural barrier and does not benefit multiple species.	N
9	Dickey Brook	Dickey Brook #3 - Dam	0.02	4	N	N	Tributary removed due to limited ecological benefits (2.71 miles)	N

Tributary		Site Component Title (Provided by NYSDEC)	Cumulative Mileage of Habitat Opened (Miles)*	# Barriers	Natural Barrier Prior to First Dam (Y/N)	Multiple Species Benefit (Y/N)**	Screening Rationale	Retained? (Y/N)
		Dickey Brook #4 - Dam	0.35				and does not benefit multiple species	
		Dickey Brook #6- Lounsbury Pond Dam	0.58					
		Dickey Brook #7 - Dam	**2.71 (total)**					
10	Peekskill Hollow Brook	Peekskill Hollow Brook Dam #1	2.33	10	N	Y	Second highest amount of barriers per tributary (10) of all 41 tributaries and would incur high costs to achieve benefits.	N
		Peekskill Hollow Brook Dam #2 - Old Oregon Rd Dam	3.63/4.37					
		Peekskill Hollow Brook Dam #4	4.65					
		Peekskill Hollow Brook Breached Dam #5 - White Road	5.31					
		Peekskill Hollow Brook Dam #6 - Quincy Rd (BEHIND #14 or #18)	6.88					
		Peekskill Hollow Brook - Miller/Tyler Road Dam #7A	6.99					
		Peekskill Hollow Brook - Miller/Tyler Road Dam #7B	8.53					

Tributary		Site Component Title (Provided by NYSDEC)	Cumulative Mileage of Habitat Opened (Miles)*	# Barriers	Natural Barrier Prior to First Dam (Y/N)	Multiple Species Benefit (Y/N)**	Screening Rationale	Retained? (Y/N)
		Peekskill Hollow Brook - Bryant Pond Road Dam #9	8.69					
		Peekskill Hollow Brook Dam on ledge #10	8.79					
		Peekskill Hollow Brook Dam #11	**12.53 (total)**					
11	Sprout Brook	Sprout Brook Dam #1 - Cortland Town Park Dam	1.09	9	N	Y	Assume too many impediments (7) would require removal to achieve benefits (5.9 miles) and 9 to achieve 11.85. Third highest amount of barriers per tributary of all 41 tributaries.	N
		Sprout Brook Dam #2 - Highland Dr Dam use private or residential	1.18					
		Sprout Brook Dam #3 - Cortland Lake Dam	1.86					
		Sprout Brook/Canopus Creek Dam #4 Steuben Lane	1.96					
		Sprout Brook/Canopus Creek Dam #5	2.11					

Tributary		Site Component Title (Provided by NYSDEC)	Cumulative Mileage of Habitat Opened (Miles)*	# Barriers	Natural Barrier Prior to First Dam (Y/N)	Multiple Species Benefit (Y/N)**	Screening Rationale	Retained? (Y/N)
		Sprout Brook/Canopus Creek Ledges/Former Dam #6	4.96					
		Sprout Brook/Canopus Creek Dam #11	5.91					
		Sprout Brook/Canopus Creek Pond Dam #12 a and b	7.07					
		Sprout Brook/Canopus Creek Dam #13	**11.85 (total)**					
12	Annsville Creek	Annsville Creek Dam #2- Wallace Pond (Westchester Lake Dam)	**4.27 (total)**	1	Y	N	Removed due to natural barrier and does not benefit multiple species.	N
13	Popolopen Brook	Popolopen Brook #2 Roe Dam	**1.26 (total)**	1	Y	N	Removed due to limited ecological benefits (1.6 miles), presence of natural barrier and would not benefit multiple species.	N
14	Arden Brook	Arden Brook #1 - Triple Culverts	0.23	2	N	N	Removed due to limited ecological benefits and would not benefit multiple species.	N
		Arden Brook #5 - Sloan Dam	**2.11 (total)**					

	Tributary	Site Component Title (Provided by NYSDEC)	Cumulative Mileage of Habitat Opened (Miles)*	# Barriers	Natural Barrier Prior to First Dam (Y/N)	Multiple Species Benefit (Y/N)**	Screening Rationale	Retained? (Y/N)
15	Crows Nest Brook	Crows Nest Brook #1 - Culvert	1.3	1	N	N	Removed due to limited ecological benefits	N
16	Moodna Creek	Moodna Creek - Interstate Container Dam #1	1.68	3	N	Y	Maintained due to gain of significant habitat (8.19 miles) for multiple species (including river herring)	Y
		Moodna Creek Dam #3 – Firth Cliff Dam	2.43					
		Moodna Creek Dam #5 – Orr's Mill Dam	**8.19 (total)**					
		Tributary Connectivity	-					
17	Gordons Brook	Gordons Brook #1 - Dual Culverts	1	1	N	Y	Tributary removed due to limited ecological benefits and a manmade barrier approximately 1 mile upstream.	N
18	Fishkill Creek	Fishkill Creek Dam #1 -Tioronda Falls/NY Rubber Co Dam	0.16	5	Y	N	Tributary removed due to limited ecological benefits (maximum of 2.8 miles), presence of natural barrier at first dam and would not benefit multiple species.	N
		Fishkill Creek Dam #3 - Tuck Dam-Simmons Lane	1.2					
		Fishkill Creek Dam #6 - Verplanck Ave, Braendly Fishkill Dam	1.6					

Tributary	Site Component Title (Provided by NYSDEC)	Cumulative Mileage of Habitat Opened (Miles)*	# Barriers	Natural Barrier Prior to First Dam (Y/N)	Multiple Species Benefit (Y/N)**	Screening Rationale	Retained? (Y/N)
	Fishkill Creek Dam #7 - Delavan Ave Dam	2.4					
	Fishkill Creek Dam #8 - Beacon Foundry Dual Dam (Glenham Dam)	**2.8 (total)**					
19 Quassaic Creek	Quassaick Creek	0.15	17	N	Y	Tributary screened out due to minimal ecological benefits without removal of 13 barriers. This tributary has the highest number of barriers (17) of all 41 being considered.	N
	Quassaic Creek Breached Dam #2 - Strooks Felt Mill Dam	0.21					
	Quassaic Creek #3 -Stone Double Arched Bridge	0.35					
	Quassaic Creek Dam #5 S Robinson Ave/Rte 9W Dam	0.49					
Quassaic Creek (continued)	Quassaic Creek Holden Dam #6	0.71					
	Quassaic Creek Dam #7 Downstream Walsh Rd	0.77					

Tributary	Site Component Title (Provided by NYSDEC)	Cumulative Mileage of Habitat Opened (Miles)*	# Barriers	Natural Barrier Prior to First Dam (Y/N)	Multiple Species Benefit (Y/N)**	Screening Rationale	Retained? (Y/N)
	Quassaic Creek Little Falls Park Dam #8 (Walsh Rd Dam)	1.03					
	Quassaic Creek Dam #9 - Muchattoes Lake Dam	1.33					
	Quassaic Creek Upper Muchattoes Twin Culverts # 10	2.05					
	Quassaic Creek Dam #11 - McDole Mill Pond Dam	2.15					
	Quassaic Creek Dam #12 - Harrison Dam	2.9					
	Quassaic Creek Brookside Pond Dam #13	3.89					
	Quassaic Creek Dam #14a -Winona Lake Dam	5.22					
	Quassaic Dam #16 - Gardenertown Rd. DeCarlo Dam	6.3					
	Quassaic Creek #17a Little Brook Lane Dual Culverts	6.34					

Tributary	Site Component Title (Provided by NYSDEC)	Cumulative Mileage of Habitat Opened (Miles)*	# Barriers	Natural Barrier Prior to First Dam (Y/N)	Multiple Species Benefit (Y/N)**	Screening Rationale	Retained? (Y/N)
	Quassaic Creek Dam #17b Little Brook Lane	6.37					
	Quassaic Creek Dam #18 Little Brook Lane	**7.29 (total)**					
20 Little Falls	Quassaic Creek Tributary -Little Falls Park Dam #2	0.87	2	N	Y	Tributary removed due to limited ecological benefits (Note: this tributary is upstream of 7 dams on the Quisssaic tributary)	N
	Quassaic Creek Tributary -Little Falls Park Dam #3	1.08					
21 Roseton Brook	Roseton Brook #2 - Culverts	0.07	3	N	N	Tributary removed due to limited ecological benefits. Schmidt 1996 stated the water quality in this tributary is also a concern due to upstream sewage treatment discharge as well as "cold" water temperatures in comparison to other tributaries studied.	N
	Roseton Brook #3 - Culverts	0.25					
	Roseton Brook #4 - Single Culvert	**1.73 (total)**					
22 South Lattinto-wn Creek	South Lattintown Creek #2 Dam	0.8	2	Y	N	Tributary removed due to natural barrier and does not benefit multiple species.	N
	South Lattintown Creek #5 Mill House Dam	**5.11 (total)**					

Tributary		Site Component Title (Provided by NYSDEC)	Cumulative Mileage of Habitat Opened (Miles)*	# Barriers	Natural Barrier Prior to First Dam (Y/N)	Multiple Species Benefit (Y/N)**	Screening Rationale	Retained? (Y/N)
23	Black Creek	Black Creek Dam#1	**>5 (total)**	1	N	N	USFWS 1998, the dam is broken and does not prevent fish movement. Water levels in the river are low during the low water period and are not suitable to be considered a nursery habitat.	N
24	Indian Kill	Indian Kill Culvert #2	**0.83 (total)**	1	Y	N	Tributary removed due to limited ecological benefits (0.83 miles), presence of natural barrier and would not benefit multiple species.	N
25	Twaalfskill Creek	Twaalfskill Creek Restore Riparian Buffer	**0.78 (total)**	1	Y	N	Tributary removed due to limited ecological benefits (0.78 miles), presence of natural barrier and would not benefit multiple species.	N
26	Rondout Creek	Rondout Creek Dam #1 - Eddyville Dam	**9.99 (total)**	1	N	Y	Maintained due to gain of significant habitat (9.99 miles) for multiple species (including river herring)	Y
		Tributary Connectivity	-					
27	Walkill	Walkill Dam #1 - Sturgeon Pool Dam	**10.86 (total)**	1	N	N	Tributary removed since project will not benefit multiple species. Additionally, the Eddyville dam would need to be removed to achieve any benefits.	N
28	Saw Kill	Saw Kill Dam #2 change use to abandoned	0.47	4	Y	N	Tributary removed due to natural barrier.	N

Tributary	Site Component Title (Provided by NYSDEC)	Cumulative Mileage of Habitat Opened (Miles)*	# Barriers	Natural Barrier Prior to First Dam (Y/N)	Multiple Species Benefit (Y/N)**	Screening Rationale	Retained? (Y/N)
	Saw Kill Dam (?) #4	0.7					
	Saw Kill Dam #6 Annandale Dam	4.18					
	Saw Kill Dam #8 - Red Hook Mills Dam	**11.88**					
29 Stony Creek	Stony Creek Tivoli Dam #6	5.64	2	Y	N	Removed due to natural barrier and does not benefit multiple species.	N
	Stony Creek Madalin Mill Dam #8 concrete spillway?	**8.43 (total)**					
30 Esopus Creek	Esopus Creek Dam Ledges/Dam #1 - Diamonds Mill Paper Co Dam	**4.22 (total)**	1	N	Y	The dam is built on top of natural falls (3 meters) (USFWS 1998) and there are another set of natural falls recorded 4.22 miles upstream (Schmidt 1996).	N
31 Cheviot Creek	Cheviot Creek Culvert #1	0.34	2	N	Y	Removed due to limited ecological benefits.	N
	Cheviot Creek Culvert #3	**4.74 (total)**					
32 Roeliff Jansen Kill	Tributary Connectivity	**>5 (total)**	1	?	?	Site was eliminated during site visit on 11Sept17 due to natural barrier downstream and benefits only to eel.	Y

Tributary	Site Component Title (Provided by NYSDEC)	Cumulative Mileage of Habitat Opened (Miles)*	# Barriers	Natural Barrier Prior to First Dam (Y/N)	Multiple Species Benefit (Y/N)**	Screening Rationale	Retained? (Y/N)
33 Catskill Creek	Catskilll Creek Mill Pond Hydroelectric Dam #8 on Ledges	10.1	2	Y	N	Removed due to natural barrier and does not benefit multiple species.	N
	Catskilll Creek Klatz Dam #11 on ledges	**>10.1 (total)**					
34 South Bay Creek	South Bay Creek Culvert #1		2	N	Y	Removed since this is low cost effort (single culvert) to be handled by others.	N
	South Bay Creek Culvert #2	**6.36 (total)**					
35 Claverack Creek	Claverack Creek Van Der Carrs Dam #1 (Minsky Dam)	3.86	5	N	N	Removed during site visit (11Sept17) since diadromous fish would not benefit due to natural barriers downstream.	Y
	Claverack Creek Dam #3 -Begos Rd	2.42					
	Claverack Creek Stottsville Mill Dam #4 –	2.54					
	Claverack Creek Dam/Falls #5 - Atlantic Ave Dam at Stottsville	12.55					
	Claverack Creek Dam #7 - Red Mills	**26.83 (total)**					
	Tributary Connectivity	-					

	Tributary	Site Component Title (Provided by NYSDEC)	Cumulative Mileage of Habitat Opened (Miles)*	# Barriers	Natural Barrier Prior to First Dam (Y/N)	Multiple Species Benefit (Y/N)**	Screening Rationale	Retained? (Y/N)
36	Mill Creek (C)	Mill Creek Columbia Co. Series Culverts #2	**7.23 (total)**	1	Y	N	Removed due to natural barrier and does not benefit multiple species.	N
37	Hannacrois Creek	Hannacrois Creek #7 Deans Mill Dam	**7.06 (total)**	1	Y	N	Removed due to the presence of natural barrier and would not benefit multiple species.	N
38	Vloman Kill	Vloman Kill Dam/Falls #1	**>5 (total)**	1	Y	N	Removed due to the presence of natural barrier and would not benefit multiple species.	N
39	Mill Creek (R)	Mill Creek Rennselaer Co. #1 Dam (Kenwood Mill Dam)	**1.96 (total)**	1	N	N	Removed since project will not benefit multiple species.	N
40	Little River Inlet	Little River Inlet/ Culvert Replacement	**0.68 (total)**	1	?	?	Removed due to limited ecological benefits (0.68 miles)	N
41	Wynants Kill	Wynants Kill #1 - Stop Log Barrier	0.5	3	N	Y	The Burden's Pond Dam (#5) is built on top of an existing ledge considered a natural barrier (USFWS 1998). Limited benefits achieved (0.76 miles) with removal of two dams.	N
		Wynants Kill #3- Rail Joint Mill Dam	0.76					
		Wynants Kill Dam #5 - Burden Pond Dam	**8.41 (total)**					
		Fish Barrier Removal on Wynantskill at the Hudson	-					