HUDSON RIVER HABITAT RESTORATION

ECOSYSTEM RESTORATION
DRAFT INTEGRATED FEASIBILITY REPORT AND ENVIRONMENTAL ASSESSMENT

Appendix H: Monitoring and Adaptive Management Plan

U.S. ARMY CORPS OF ENGINEERS
NEW YORK DISTRICT

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1.0 Introduction

This Monitoring and Adaptive Management Plan was prepared for the Hudson River Habitat Restoration Draft Feasibility Report/Environmental Assessment (FR/EA). Section 2039 of Water Resource Development Act (WRDA) 2007 (as amended by Section 1161 of WRDA 2016) directs the Secretary of the Army to ensure, when conducting a feasibility study for a project (or component of a project) under the U.S. Army Corps of Engineers (USACE) ecosystem restoration mission, that the decision document include a monitoring plan to measures the success of the ecosystem restoration and to dictate the direction adaptive management should proceed, if needed. The Monitoring and Adaptive Management Plan includes a description of the monitoring activities, the criteria for success, and the estimated cost and duration of the monitoring, as well as specify that monitoring will continue until such time as the Secretary determines that the success criteria have been met.

Section 2039 of WRDA 2007 also directs USACE to develop an adaptive management plan for all ecosystem restoration projects. The adaptive management plan must be appropriately scoped to the scale of the project. The information generated by the monitoring plan will be used by the New York District (the District) in consultation with the federal and state resources agencies and the Vertical Team to guide decisions on operational or structural changes that may be needed to ensure that the ecosystem restoration project meets the success criteria.

An effective monitoring program is necessary to assess the status and trends of ecological health and biota richness and abundance on a per project basis, as well as to report on regional program success within the United States. Assessing status and trends includes both spatial and temporal variations. Gathered information under this monitoring plan will provide insights into the effectiveness of current restoration projects and adaptive management strategies, and indicate where goals have been met, if actions should continue, and/or whether more aggressive management is warranted.

Monitoring the changes at the project site is not a simple task. Restored wetlands can take decades to reach their dynamic equilibrium conditions, therefore the initial monitoring period of five years will be assessed as to whether the structural template has been established and if the site is on a trajectory toward ecological success. The task of tracking environmental changes can be difficult, and distinguishing the changes caused by human actions from natural variations can be even more difficult. This is why a focused monitoring protocol tied directly to the planning objectives needs to be followed.

This Monitoring and Adaptive Management Plan describes the existing habitats, monitoring methods, criteria for success and estimated cost and duration for monitoring for each restoration alternative that was evaluated in the draft FR/EA. This information was used to estimate costs for each alternative included in the Cost Appendix E. The specific monitoring and adaptive management for the Tentatively Selected Plan (TSP) is

highlighted within.

By reporting on environmental changes, the results from this monitoring effort will be able to evaluate whether measurable results have been achieved and whether the intent of the Hudson River Habitat Restoration projects has been met.

Guidance

The following documents provide distinct USACE policy and guidance that are pertinent to developing this Monitoring and Adaptive Management Plan:

1. Section 1161 of WRDA 2016. Completion of Ecosystem Restoration Projects.

2. USACE. 2009. Planning Memorandum. Implementation Guidance for Section 2039 of the Water

3. Resources Development Act of 2007 (WRDA 2007) - Monitoring Ecosystem Restoration

4. Section 2039 of WRDA 2007 Monitoring Ecosystem Restoration

5. USACE. 2000. ER 1105-2-100, Guidance for Conducting Civil Works Planning Studies.

6. USACE. 2003a. ER 1105-2-404. Planning Civil Work Projects Under the Environmental Operating Principles.

2.0 Project Area Description and Restoration Sites

The project area is bounded by the Governor Mario M. Cuomo (former Tappan Zee) Bridge (South) and the Troy Lock and Dam (North) and generally encompasses 125 miles of Hudson River as well as the immediate tributaries and land east and west of the Hudson River between these two boundaries. Within this project area, 5 restoration sites were included in the Tentatively Selected Plan (TSP):

- Binnen Kill
- Schodack Island
- Henry Hudson Park
- Charles Rider Park (No Action)
- Moodna Creek – 3 Aquatic Organism Passage (AOP) barriers including AOP 1 (Utility Crossing); AOP 2 (Firth Cliff Dam); and AOP 3 (Orr's Mill Dam)
- Rondout Creek – Eddyville Dam

The **Binnen Kill** site is located on the west shore of the Hudson River on the borders of the Towns of Bethlehem and Coeymans, New York and encompasses approximately 1,000 acres of publicly and privately-owned lands. The eastern edge of the site originally included islands that were separated from the historic shoreline by side channels in the 1800's but that are now contiguous with the site due to infilling. The Binnen Kill proper is a tidal freshwater tributary that is surrounded by a complex of tidal wetlands, upland forests, non-tidal swamps, and farmland. Proposed actions at the site consist of the restoration of wetlands and hydrological connections through the creation of side channels.

Schodack Island project site is part of the Schodack Island State Park that sits off the eastern shore of the Hudson River just south of Albany. Approximately seven miles of Hudson River and Schodack Creek shoreline bound the 1,052-acre park. The park has been designated a State Estuary, and a portion of the park shelters a Bird Conservation Area that is home to bald eagles, cerulean warblers, and blue herons. Eight miles of multi-use trails wind through a variety of ecological communities. In addition, the park has 66 campsites for use, an improved bike trail, volleyball nets, horseshoe pit, and a kayak/canoe launch. Interpretive signage highlights the park's historic and environmental significance. Proposed actions at the site consist of the restoration of wetlands and hydrological connections through the creation of side channels.

Henry Hudson Park is located on the west shore of the Hudson River and is bisected by the Vloman Kill. The park encompasses approximately 64.2 acres of public open space owned by the Town of Bethlehem. The Hudson River shoreline consists of a dilapidated timber cribbing structure, which has either partially or completely failed along the majority of the structure. Proposed actions at the site focus on shoreline restoration and consist of shoreline stabilization using living shoreline techniques including the establishment of tidal wetlands.

Charles Rider Park is located on the west shore of the Hudson River and encompasses approximately 29.6 acres of public open space owned by the Town of Ulster. The shoreline consists of failed timber cribbing and rock riprap and is largely void of vegetation. Proposed actions at the site focused on shoreline restoration and consisted of shoreline stabilization using living shoreline techniques including the establishment of tidal wetlands. No Action was recommended for Charles Rider Park and was not included in the TSP.

Moodna Creek:

AOP 1 (Utility Crossing) is located along Moodna Creek upstream of the Forge Hill Road (Route 74) crossing. A concrete encased decommissioned sewer line crosses Moodna Creek forming a weir that creates a vertical drop of water approximately 2 feet in height during low flows. This sewer line is a potential barrier to AOP, including both migratory and inland resident fish. Proposed actions at the site seek to restore aquatic organism passage by removing the structure.

AOP 2 (Firth Cliff Dam) is located along Moodna Creek adjacent to the former textile manufacturing factory historically known as Firth Carpet Company. The factory was previously demolished but the nine-foot high dam remains, acting as a barrier to AOP. Proposed actions at the site seek to restore aquatic organism passage by removing the structure.

AOP 3 (Orr's Mill Dam) is located along Moodna Creek upstream of the Route 32 crossing. The 10-foot high dam is in poor condition and a barrier to AOP. Normal river flow passes under the spillway suggesting the structure is substantially undermined. Proposed actions at the site seek to restore aquatic organism passage by breaching the structure.

The **Eddyville Dam** is located on Rondout Creek, on the boundary between the Towns of Esopus and Ulster. The 12-foot high dam sits on a bedrock ledge and is the current head of tide. Proposed actions at the site will seek to restore aquatic organism passage by removing the structure.

3.0 Monitoring Protocols

Each restoration alternative contains the following unique combination of one or more project elements (Table 1) each requiring specialized monitoring. Individual monitoring protocols for the project elements are summarized in sections 3.1 through 3.13 below. Note information presented in sections 3.7, 3.10, 3.11 include monitoring protocols

associated with measures that are not included in the TSP and are included only for the purpose of cost estimating purposes for all alternatives.

Table 1: Project Elements by Alternative

Site	Alternative	Barrier Removal	Boulder Cascade	Boulder Stabilization*	Concrete Cribbing	Dam Breach	Non-tidal Wetland	Riparian	Rock Ramp	Side Channel	Stream Crossing	Technical Fishway	Tidal Wetland	Tributary Stabilization
Charles Rider Park	1			X								X		
Henry Hudson Park	1			X								X		
Henry Hudson Park	2			X	X							X		
Schodack Island – North	1			X				X		X	X		X	
Schodack Island – North	2			X						X	X		X	
Schodack Island – South	1			X				X		X	X		X	
Schodack Island – South	2			X						X	X		X	
Schodack Island – Pocket Wetlands	1			X			X						X	
Binnen Kill – North	1						X				X			
Binnen Kill – North	2	X					X			X				
Binnen Kill – North	3						X							
Binnen Kill – North	4						X			X				
Binnen Kill – South	1						X	X		X	X		X	
Binnen Kill – South	2						X			X	X		X	
Rondout Creek - Eddyville Dam	1											X		
Rondout Creek - Eddyville Dam	2	X												
Rondout Creek - Eddyville Dam	3					X								
Moodna Creek – AOP1 (Utility Crossing)	1	X												
Moodna Creek – AOP1 (Utility Crossing)	2								X					
Moodna Creek – AOP2 (Firth Cliff Dam)	1	X												
Moodna Creek – AOP2 (Firth Cliff Dam)	2											X		
Moodna Creek – AOP3 (Orr's Mill Dam)	1	X	X											X
Moodna Creek – AOP3 (Orr's Mill Dam)	2		X			X								X

*Boulder Stabilization applies to both the rock revetment and bank stabilization in the pocket wetlands alternative

3.1 Side Channel Monitoring Protocol

Purpose

The purpose of this monitoring protocol is to assess the success or failure of the restoration of a side channel. The monitoring protocol will assess the structure and function of the side channel based on morphology and the ability to convey water.

Monitoring Procedures

Post-construction monitoring will begin four to five weeks after side channel construction is completed and continue once a year for five years post-construction. The performance targets will include:

- Bank erosion extending no more than 10% of the channel length
- No significant head cutting or instability at channel's connection points with the Hudson River and Binnen Kill / Schodack Creek.
- No significant vegetation overgrowth, sedimentation, or other debris hindering the conveyance of flow and fish passage
- Channel width and depth adequate to convey flows and accommodate fish passage

To that end, during each monitoring event the following shall occur:

- A visual inspection of erosion along the channel banks and the channel connection points.
- A visual inspection of the levels of vegetation, sedimentation, and debris
- Cross section measurements of channel geometry taken at a rate of five cross sections for every 1,000 feet along the entire channel length. The end points of each cross section should be physically monumented (e.g. stakes in ground) to ensure the exact location can be measured each year.

Adaptive Management Procedures

In the event that the side channel fails to retain its designed structure or achieve its designed function, the following adaptive management procedures will be implemented.

Failure condition	Adaptive management procedure
Erosion along the channel banks and/or channel connection points	Minor erosion will be mitigated with planting. If erosion is severe an engineer or ecologist will evaluate potential stabilization measures.
Blockage of channel flow and/or fish passage due to sedimentation, vegetation, or debris	Debris and vegetation will be cleared by hand to the maximum extent practicable.
Erosion and/or gully formation	Hand re-grading and stabilization methods such as the installation of matting with seed or coir logs

3.2 Non-Tidal Wetland Monitoring Protocol

Purpose

The purpose of this monitoring protocol is to assess the progress towards, and the success or failure of, the restoration of a non-tidal wetland habitat and the achievement of acceptable standards of wetland structure and function. The monitoring protocol will assess the structure and function of the restored wetland via three key ecological parameters of a functioning wetland as per the *USACE Wetlands Delineation Manual* (Environmental Laboratory, 1987) and the *Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Northcentral and Northeast Region* (USACE, 2012), which include:

- Hydrophytic Vegetation
- Wetland Soils
- Wetland Hydrology

General Monitoring Procedures

Monitoring will seek to assess the success of the restored habitat using a modified version of the protocols proposed in 2000 by New York State Department of State and New York State Department of Environmental Conservation (Niedowski, 2000).

Pre-restoration monitoring protocols will seek to obtain baseline data in order to establish the existing ecological conditions of the project site. This monitoring will take place within a one-year period prior to the start of project implementation. Alternatively, a reference site, such as a wetland benchmark identified during the Evaluation of Planned Wetlands field effort, could be established as a control.

Post-restoration monitoring will begin four to five weeks after wetland restoration is completed and continue twice a year, including a fall monitoring event (August-October) and spring monitoring event (March-May), for five years post-restoration.

Transects will be placed randomly across the restoration site. Transect locations will be permanently marked, and easily located, at each end. The end markers of each transect will also be used as permanent photo stations for annual photographic monitoring, taken from the one end marker to the other and vice versa. During monitoring events, a tape measure will run between each end marker, with distance measurements originating from the northern most marker for north-south oriented transects or the western most marker for east-west oriented transects.

A minimum of three one square meter quadrats will be placed randomly along the transects at least three meters apart. Quadrats will occur at a rate of one quadrat per five acres, or a minimum of five quadrats per vegetation community type, whichever is greater. Quadrats will be placed on a randomly chosen side of the transect within two meters. The corners closest to the transect line will be permanently marked.

Visual Assessment Procedures

A visual assessment to broadly track the site's development will occur. During the Spring monitoring event, the following parameters will be monitored via visual assessment:

- General site hydrology (see wetland hydrology monitoring procedures below)
- Indication of soil erosion or instability
- Presence or absence of invasive species
- Structural integrity of deer fence and/or goose fence

Hydrophytic Vegetation Monitoring Procedures

Investigations to track the establishment of hydrophytic vegetation will occur annually. The performance target is for plantings to have a minimum of 80% survival at the end of five years and 75% coverage after five years. To ensure a successful vegetation effort, all plants shall be monitored and maintained as necessary for five years. During the fall monitoring event, the following parameters will be monitored:

- Percent vegetative cover in each transect
- Plant species occurring in each quadrat
- Signs of disease, predation, or other disturbance in each quadrat
- Stem density in randomly selected sub-quadrat (0.25 m^2) within each quadrat
- Plant height in randomly selected sub-quadrat (0.25 m^2) within each quadrat

During the spring monitoring event, a visual assessment will be conducted to identify the presence or absence of invasive species (see visual assessment procedures).

Wetland Soil Monitoring Procedures

Investigations to track the progression of hydric soil formation will occur annually. The performance target is for at least 80% of the area of disturbed soils to develop the wetland characteristics of hydric soils after five years. During the fall monitoring event, the following parameters will be monitored in each quadrat:

- Soil characteristics including texture, color, structure, and hydric indicators such as redoximorphic features

Wetland Hydrology Monitoring Procedures

Monitoring of wetland hydrology will occur twice a year during the spring and fall monitoring events.

- Visual hydrologic surveys to characterize water inundation or depth to groundwater and erosion/sedimentation processes across the site

Adaptive Management Procedures

In the event that the wetland habitat fails to retain its designed structure or achieve its designed function, the following adaptive management procedures will be implemented.

Failure condition	**Adaptive management procedure**
Less than 80% survival or 75% coverage of target vegetation	Additional native vegetation will be planted. If issues of vegetation establishment persist past two years beyond construction, an ecologist will investigate the cause of failure and recommend modifications to the plant species as appropriate.
Invasion of non-native species into the restored habitat	Removal of invasive species via manual pulling or herbicide application. Subsequent replanting as necessary.
Failure to achieve wetland hydrological regimes and/or failure to achieve wetland soil characteristics	A hydrologist will investigate the cause of failure and recommend minor topographic modifications. Potential strategies include but are not limited to the addition of drainage swales to increase water conveyance or altering wetland elevations.

3.3 Tidal Wetlands Monitoring Protocol

Purpose

The purpose of this monitoring protocol is to assess the progress towards, and the success or failure of, the restoration of a tidal wetland habitat and the achievement of acceptable standards of wetland structure and function. The monitoring protocol will assess the structure and function of the restored tidal wetland via three key ecological parameters of a functioning tidal wetland as per the *USACE Wetlands Delineation Manual* (Environmental Laboratory, 1987) and the *Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Northcentral and Northeast Region* (USACE, 2012), which include:

- Hydrophytic Vegetation
- Wetland Soils
- Wetland Hydrology

General Monitoring Procedures

Monitoring will assess the success of the restored habitat using a modified version of the protocols proposed in 2000 by New York State Department of State and New York State Department of Environmental Conservation in their *New York State Salt Marsh Restoration and Monitoring Guidelines Report* (Niedowski, 2000).

Pre-restoration monitoring protocols will obtain baseline data in order to establish the existing ecological conditions of the project site. This monitoring will take place within a one-year period prior to the start of project implementation. Alternatively, a reference site, such as a wetland benchmark identified during the Evaluation of Planned Wetlands field effort, could be established as a control.

Post-restoration monitoring will begin four to five weeks after tidal wetland restoration is completed and continue twice a year, including a fall monitoring event (August-October) and spring monitoring event (March-May), for five years post-restoration.

Transects will be evenly spaced across the site. Transects will run perpendicular to the main channel and/or parallel with the elevation gradient, from the seaward edge of the low marsh zone to the landward extent of the restoration site. Transect locations will be permanently marked, and easily located, at the landward and seaward. The landward and seaward markers of each transect will also be used as permanent photo stations for annual photographic monitoring, taken from the landward marker facing the seaward marker and vice versa. During monitoring events, a tape measure will run from the

landward to seaward markers, with distance measurements originating from the landward marker.

One square meter quadrat will be placed along a transect at a minimum of three different elevations and will include, as applicable, all vegetation zones. Quadrats will occur at a rate of one quadrat per five acres, or a minimum of five quadrats per vegetation community type, whichever is greater. Quadrats will be placed on a randomly chosen side of the transect within two meters. The landward and seaward corners closest to the transect line will be permanently marked.

Visual Assessment Procedures

A visual assessment to broadly track the site's development will occur during the Spring monitoring event; the following parameters will be monitored via visual assessment:

- General site hydrology (see wetland hydrology monitoring procedures below)
- Indication of soil erosion or instability
- Presence or absence of invasive species
- Structural integrity of deer fence and/or goose fence

Hydrophytic Vegetation Monitoring Procedures

Investigations to track the establishment of hydrophytic vegetation will occur annually in both spring and fall. The performance target is for plantings to have a minimum of 80% survival at the end of five years and 75% coverage after five years. To ensure a successful vegetation effort, all plants shall be monitored and maintained as necessary for five years. During the fall monitoring event, the following parameters will be monitored:

- Percent vegetative cover in each transect
- Plant species occurring in each quadrat
- Signs of disease, predation, or other disturbance in each quadrat
- Stem density in randomly selected sub-quadrat (0.25 m^2) within each quadrat
- Plant height in randomly selected sub-quadrat (0.25 m^2) within each quadrat
- Vegetation zone transition distances along each transect

During the spring monitoring event, a visual assessment will be conducted to identify the presence or absence of invasive species (see visual assessment procedures).

Wetland Soil Monitoring Procedures

Investigations to track the progression of hydric soil formation will occur annually. The performance target is for at least 80% of the area of disturbed soils to develop the wetland

characteristics of hydric soils. During the fall monitoring event, the following parameters will be monitored in each quadrat:

- Soil characteristics including texture, color, structure, and hydric indicators such as redoximorphic features

Wetland Hydrology Monitoring Procedures

Monitoring of wetland hydrology will occur twice a year during the spring and fall monitoring events.

- Visual hydrologic surveys to characterize tidal inundation regimes, depth and duration of tidal inundation, and erosion/sedimentation processes across the site

Adaptive Management Procedures

In the event that the tidal wetland habitat fails to retain its designed structure or achieve its designed function, the following adaptive management procedures will be implemented.

Failure condition	**Adaptive management procedure**
Less than 80% survival or 75% coverage of target vegetation	Additional native vegetation will be planted. If issues of vegetation establishment persist beyond two years post construction, an ecologist will investigate the cause of failure and recommend modifications to the plant species as appropriate.
Invasion of non-native species into the restored habitat	Removal of invasive species via manual pulling or herbicide application. Subsequent replanting as necessary.
Failure to achieve wetland hydrological regimes and/or failure to achieve wetland soil characteristics	A hydrologist will investigate the cause of failure and recommend minor topographic modifications. Potential strategies include but are not limited to the addition of runnels to increase water conveyance or altering wetland elevations.

3.4 Riparian Monitoring Protocol

Purpose

The purpose of this monitoring protocol is to assess the success or failure of the restoration of riparian habitat including woody vegetation. The monitoring protocol will assess the function of the riparian habitat based on vegetation establishment and composition.

Monitoring Procedures

Post-restoration monitoring will begin four to five weeks after riparian restoration is completed and continue twice a year, including a fall monitoring event (August-October) and spring monitoring event (March-May), for five years post-restoration. During the spring monitoring event a visual assessment will evaluate site hydrology, soil erosion or gully formation, and the presence or absence of invasive species. During the fall monitoring event, quadrat surveys will track the establishment of vegetation quantitatively. The performance target is for plantings to have a minimum of 80% survival at the end of five years and 75% coverage after five years.

Quadrats will be placed randomly at a rate of one quadrat per five acres, or a minimum of five quadrats per vegetation community type, whichever is greater. The corners of each quadrat will be permanently marked, and easily located. During the fall monitoring event the following parameters will be monitored for each transect:

- Percent vegetative cover
- Plant species occurring
- Signs of disease, predation, or other disturbance
- Stem density
- Plant height

Adaptive Management Procedures

In the event that the riparian habitat fails to achieve its designed function, the following adaptive management procedures will be implemented.

Failure condition	Adaptive management procedure
Less than 80% survival or 75% coverage of target vegetation	Additional native vegetation will be planted. If issues of vegetation establishment persist beyond two years post construction, an ecologist will investigate the cause of

Failure condition	Adaptive management procedure
	failure and recommend modifications to the plant species as appropriate.
Invasion of non-native species into the restored habitat	Removal of invasive species via manual pulling or herbicide application. Subsequent replanting as necessary.
Erosion and/or gully formation	Hand re-grading and stabilization methods such as the installation of matting with seed or coir logs

3.5 Stream Crossing Monitoring Protocol

Purpose

The purpose of this monitoring protocol is to assess the success or failure of a culvert installation on a side channel. The monitoring protocol will assess the culvert passability based on hydraulic conditions.

Monitoring Procedures

Post-construction monitoring will begin four to five weeks after the culvert is constructed. Monitoring will occur once during low flow conditions (one event) and continue once annually during target movement/migratory periods (March through June – one event, annually) for five years post-construction. The performance target is for hydraulic conditions (e.g. depth and flow velocity) to meet the fish passage criteria of target fish species. Target fish species will be determined during the engineering design phase of the project; target species passage will be evaluated based on criteria specified in the "Federal Interagency Nature-like Fishway Passage Design Guidelines for Atlantic Coast Diadromous Fishes" technical memorandum. To that end, during each monitoring event the flow rate and depth at the culvert will be measured, a visual assessment will also be conducted to ensure the culvert is not blocked by debris.

Adaptive Management Procedures

In the event that the culvert fails to achieve its designed function, the following adaptive management procedures will be implemented.

Failure condition	Adaptive management procedure
Structural failure such as cracking, leaking, or slumping	The cause of the structural failure will be identified for further evaluation.
Overtopping during large flood event and subsequent creation of a new channel	The newly carved channel will be filled and planted and the channel would be redirected to design conditions.
Debris blockage	Debris to be cleared manually or from bank edge with equipment, especially during target migration/movement periods.

3.6 Boulder Stabilization Monitoring Protocol

Purpose

The purpose of this monitoring protocol is to assess the success or failure of the installation of shoreline boulder stabilization.

Monitoring Procedures

Post-construction monitoring will begin four to five weeks after the boulder stabilization is installed, once annually and after major flooding events (three events per year, assuming two major flooding events a year) for five years post-construction. The performance target is for the boulders to be stable, without significant migration or boulder loss. To that end, during each monitoring event visual inspections will occur to assess the stability of the placed boulders

Adaptive Management Procedures

In the event that the boulder stabilization fails to retain its designed structure or achieve its designed function, the project design would need to be revisited as an independent project.

3.7 Concrete Cribbing Monitoring Protocol

Purpose

The purpose of this monitoring protocol is to assess the success or failure of the installation of a concrete cribbing as a form of bank stabilization. The monitoring protocol will assess the concrete cribbing based on structural integrity.

Monitoring Procedures

Post-construction monitoring will begin four to five weeks after the cribbing is installed and continue annually for five years post-construction. The performance target is for the structure to be physically intact and stable. To that end, during each monitoring event a visual inspection will occur to confirm the structure is intact, and free of cracking, spalling, leaning, or slumping.

Adaptive Management Procedures

In the event that the concrete cribbing fails to retain its designed structure, the following adaptive management procedures will be implemented.

Failure condition	Adaptive management procedure
Structural failure such as cracking, spalling, leaning, or slumping.	Identify the cause of structural failure and determine the appropriate path forward to be taken as an independent project.

3.8 Barrier Removal Monitoring Protocol

Purpose

The purpose of this monitoring protocol is to assess the success or failure of a barrier removal such as a dam or utility crossing. The monitoring protocol will assess the removal based on the presence of blockages and the stability of the streambed and bank.

Monitoring Procedures

Post-construction monitoring will begin four to five weeks after the barrier is removed and occur once annually during the target migratory/movement period (March through June), for five years post-construction. The performance target is for the streambed and bank in the area of removal to be free flowing and stable, free of blockages, or erosion. To that end, during each monitoring event a visual assessment of the stream bed and banks will be conducted. Fish surveys will be conducted when appropriate and compared to baseline conditions as determined during the pre-construction engineering and design phase.

Adaptive Management Procedures

In the event that the barrier removal fails to achieve its designed function, the following adaptive management procedures will be implemented.

Failure condition	Adaptive management procedure
Erosion along channel banks	Minor erosion will be mitigated with planting. If erosion is severe or chronic, structural stabilization will be added, such as the placement of riprap.
Erosion in channel bed	Provide stabilization measures as necessary, such as the addition of riprap or large woody debris.
Debris blockage	Debris to be cleared manually or from bank edge with equipment, especially during target migration/movement periods.

3.9 Dam Breach Monitoring Protocol

Purpose

The purpose of this monitoring protocol is to assess the success or failure of a dam breach. The monitoring protocol will assess the dam breach based on hydraulic conditions.

Monitoring Procedures

Post-construction monitoring will begin four to five weeks after the dam is breached and continue weekly during the target migratory/movement period (March through June – 16 events) of the first year, and annually during target migration/movement periods of subsequent years, for five years post-construction. Monitoring events will capture multiple flow conditions including high tide, low tide, and low flow conditions. The performance target is for hydraulic conditions (e.g. depth and flow velocity) to meet the fish passage criteria of target fish species. Target fish species will be determined during the engineering design phase of the project; target species passage will be evaluated based on criteria specified in the “Federal Interagency Nature-like Fishway Passage Design Guidelines for Atlantic Coast Diadromous Fishes” technical memorandum. To that end, during each monitoring event the flow rate and depth at the dam breach will be measured. Fish surveys will be conducted when appropriate and compared to baseline conditions as determined during the pre-construction engineering and design phase.

Adaptive Management Procedures

In the event that the dam breach fails to achieve its designed function, the following adaptive management procedures will be implemented.

Failure condition	Adaptive management procedure
Flow velocities are too strong to allow fish passage	Widen the breach to the maximum extent practicable while maintaining adequate flow depth, or an engineer will evaluate the feasibility of the addition of roughness boulders.
Erosion in channel bed	Provide stabilization measures as necessary, such as the addition of riprap or large woody debris.
Debris blockage	Debris to be cleared manually or from bank edge with equipment, especially during target migration/movement periods.

3.10 Rock Ramp Fishway Monitoring Protocol

Purpose

The purpose of this monitoring protocol is to assess the success or failure of the installation of an instream rock ramp fishway. The monitoring protocol will assess the rock ramp based on stability and hydraulic conditions.

Monitoring Procedures

Pre-restoration monitoring during pre-construction engineering and design will obtain baseline data through fish surveys. This monitoring will take place within a one-year period prior to the start of project implementation.

Post-construction monitoring will begin four to five weeks after the rock ramp is installed. Monitoring will occur once during low flow conditions (one event) and continue once annually during target movement/migratory periods (March through June – one event, annually) for five years post-construction. Target fish species will be determined during the pre-construction engineering and design phase of the project; target species passage will be evaluated based on criteria specified in the “Federal Interagency Nature-like Fishway Passage Design Guidelines for Atlantic Coast Diadromous Fishes” technical memorandum. The performance targets include the following items:

- Permanent boulders are stable
- Stream banks are free of erosion
- Hydraulic conditions (e.g. depth and flow velocity) meet the fish passage criteria of target fish species

To that end, during each monitoring event the following shall occur:

- A visual inspection to confirm boulders are stable and banks are not eroding
- Measurements of the flow rate and depth

Additionally, fish surveys will be conducted when appropriate and compared to baseline conditions as determined during the pre-construction engineering and design phase.

Adaptive Management Procedures

In the event that the rock ramp fishway fails to retain its designed structure or achieve its designed function, the following adaptive management procedures will be implemented.

Failure condition	Adaptive management procedure
Structural instability or erosion	Provide stabilization measures as necessary
Hydraulic conditions do not meet fish passage criteria	Adjust rock ramp to improve fish passage conditions by • Adding roughness boulders • Extending length of ramp to reduce slope • Adjusting weirs to reduce vertical drops • Deepening pools.

3.11 Technical Fishway Monitoring Protocol

Purpose

The purpose of this monitoring protocol is to assess the success or failure of the installation of a technical fishway. The monitoring protocol will assess the function of the fishway based on structural integrity and the achievement of fish passage.

Monitoring Procedures

Post-construction monitoring will begin four to five weeks after the fishway is installed and continue weekly during target migration/movement periods (March through June – 16 events, annually) for five years post-construction. Target fish species will be determined during the pre-construction engineering and design phase of the project; target species passage will be evaluated based on criteria specified in the USFWS “Fish Passage Engineering Design Criteria” manual. The performance targets will include:

- The structure is physically intact and stable
- No buildup of debris in the fishway
- Hydraulic conditions (e.g. depth and flow velocity) meet the fish passage criteria of target fish species

- Evidence of successful fish passage

To that end, during each monitoring event the following shall occur:

- A visual inspection to confirm the structure is free of cracking and/or leaking, baffles are intact, and foundations are stable
- A visual inspection to confirm the fishway is free of debris
- Measurements of flow depth and velocity
- An assessment of successful fish passage or lack thereof. Evidence may include, but not limited to the following assessments:
    - Wildlife monitoring camera footage
    - Fishery surveys upstream of dam for species diversity, presence/absence of target species, and abundance to the extent practicable
    - Public reports of fish sightings
    - eDNA sampling
    - Velocity and depth measurements

Additionally, fish surveys will be conducted when appropriate and compared to baseline conditions as determined during the pre-construction engineering and design phase.

Adaptive Management Procedures

In the event that the fishway fails to retain its designed structure or achieve its designed function, the following adaptive management procedures will be implemented.

Failure condition	Adaptive management procedure
Structural failure such as cracking, leaking, or slumping	The cause of the structural failure will be identified for further evaluation.
Debris blockage	Debris to be cleared manually during monitoring event especially during target migration/movement periods.

3.12 Boulder Cascade Monitoring Protocol

Purpose

The purpose of this monitoring protocol is to assess the success or failure of the installation of an instream boulder cascade as a form of grade control. The monitoring protocol will assess the boulder cascade based on stability and hydraulic conditions.

Monitoring Procedures

Post-construction monitoring will begin four to five weeks after the boulder cascade is installed, monitoring will occur once annually for five years. The performance targets will include:

- Permanent boulders are stable
- Vertical drops are less than 8 inches and no plunging flows are present

To that end, during each monitoring event visual inspections will occur to assess the stability and flow conditions of the cascade.

Adaptive Management Procedures

In the event that the boulder cascade fails to retain its designed structure or achieve its designed function, the following adaptive management procedures will be implemented.

Failure condition	Adaptive management procedure
Structural instability	Provide stabilization measures as necessary
Vertical drops greater than 8 inches or plunging flows are present	Adjust boulders to improve flow conditions by • Adding roughness boulders • Deepening pools.

3.13 Tributary Stabilization Monitoring Protocol

Purpose

The purpose of this monitoring protocol is to assess the success or failure of the stabilization of a tributary confluence. The monitoring protocol will assess the tributary stabilization based on successful erosion mitigation.

Monitoring Procedures

Post-construction monitoring will begin four to five weeks after the tributary stabilization is installed, monitoring will occur once annually and after major flooding events (three events per year, assuming two major flooding events a year) for five years post-construction. The performance target is for the stabilization to successfully prevent down-cutting or head cutting in the confluence. To that end, during each monitoring event a visual assessment will be conducted to determine the presence of down-cutting or head cutting.

Adaptive Management Procedures

In the event that the tributary stabilization fails to retain its designed structure or achieve its designed function, the following adaptive management procedures will be implemented.

Failure condition	Adaptive management procedure
Down-cutting or head cutting	The stabilization will be repaired and grade control measures will be installed in upstream channel as necessary

4.0 Monitoring Costs

Required effort and man-hours were determined and costs developed (Table 2) for the monitoring of each alternative for the five-year monitoring period. More information regarding the development of costs is available in the Cost Engineering Appendix E. It should be noted that if the monitoring cost for an alternative was less than one percent of the construction and implementation cost, the default one percent cost was used.

Table 2: Monitoring Costs (TSP Highlighted in green)

Site Name and Alternative	Cost
Binnen Kill North Alternative 1	$236,421*
Binnen Kill North Alternative 2	$296,099*
Binnen Kill North Alternative 3	$222,652*
Binnen Kill North Alternative 4	$291,792*
Binnen Kill South Alternative 1	$195,538
Binnen Kill South Alternative 2	$217,704
Schodack Island North Alternative 1	$188,428
Schodack Island North Alternative 2	$168,278
Schodack Island South Alternative 1	$195,538
Schodack Island South Alternative 2	$168,278

Site Name and Alternative	Cost
Schodack Island Pocket Wetlands	$61,455*
Charles Rider Park Alternative 1	$123,072
Henry Hudson Park Alternative 1	$125,619
Henry Hudson Park Alternative 2	$161,168
Moodna Creek AOP1 Alternative 1 – Barrier Removal	$35,550
Moodna Creek AOP1 Alternative 2 – Rock Ramp	$42,659
Moodna Creek AOP2 Alternative 1 – Dam Removal	$35,550
Moodna Creek AOP2 Alternative 2 – Fishway	$568,793
Moodna Creek AOP3 Alternative 1 – Dam Removal	$106,649
Moodna Creek AOP3 Alternative 2 – Dam Breach	$213,297
Rondout Creek Alternative 1 – Fishway	$568,793
Rondout Creek Alternative 2 – Dam Removal	$35,550
Rondout Creek Alternative 3 – Dam Notching	$142,198

*The default one percent of construction and implementation cost was used

5.0 Adaptive Management Costs

Adaptive management costs for each alternative were calculated (Table 3) based on the efforts and criterial described in Section 3.0. It should be noted that if the adaptive management cost for an alternative was less than three percent of the construction and implementation cost, the default three percent cost was used.

Table 3: Adaptive Management Costs (TSP Highlighted in green)

Site Name and Alternative	Cost
Binnen Kill North Alternative 1	$981,139
Binnen Kill North Alternative 2	$1,241,257
Binnen Kill North Alternative 3	$957,154
Binnen Kill North Alternative 4	$1,212,587
Binnen Kill South Alternative 1	$546,787
Binnen Kill South Alternative 2	$514,741
Schodack Island North Alternative 1	$292,895
Schodack Island North Alternative 2	$441,826*
Schodack Island South Alternative 1	$145,501
Schodack Island South Alternative 2	$181,670*
Schodack Island Pocket Wetlands	$184,365*
Charles Rider Park Alternative 1	$58,981*
Henry Hudson Park Alternative 1	$178,696*
Henry Hudson Park Alternative 2	$355,037*
Moodna Creek AOP 1 Alternative 1 – Barrier Removal	$50,296
Moodna Creek AOP 1 Alternative 2 – Rock Ramp	$49,704
Moodna Creek AOP 2 Alternative 1 – Dam Removal	$75,296
Moodna Creek AOP 2 Alternative 2 – Fishway	$46,995*

Site Name and Alternative	Cost
Moodna Creek AOP 3 Alternative 1 – Dam Removal	$66,081
Moodna Creek AOP 3 Alternative 2 – Dam Breach	$190,678
Rondout Creek Alternative 1 – Fishway	$51,939*
Rondout Creek Alternative 2 – Dam Removal	$75,296
Rondout Creek Alternative 3 – Dam Notching	$100,069

*The default three percent of construction and implementation cost was used.

6.0 References

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