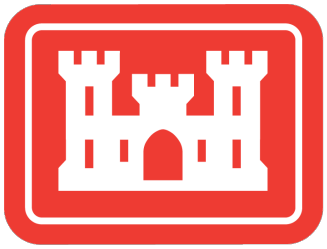
HUDSON RIVER HABITAT RESTORATION

ECOSYSTEM RESTORATION
FINAL INTEGRATED FEASIBILITY REPORT AND ENVIRONMENTAL ASSESSMENT

Appendix H: Monitoring and Adaptive Management Plan



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1.0 Introduction

This Monitoring and Adaptive Management Plan was prepared for the Hudson River Habitat Restoration Final 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 measure 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 specifies 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 USACE North Atlantic Division (NAD) 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 first five years are the most critical to monitor as the site is adjusting to changes in hydrologic conditions and plants are establishing. Additionally, regulatory requirements typically mandate a five-year monitoring period. Beyond the five-year period, generally plants are established and soil conditions are more stable, thus monitoring does not need to be aggressive; operation and maintenance site surveys are suitable to track the site's progression. In addition, the New York District's prior experience and track record in restoring wetlands in this region has resulted in the confidence that a five-year monitoring and adaptive management period is considered adequate.

The level of detail in this plan is based on currently available data and information developed during plan formulation as part of the feasibility study. Components of the monitoring and adaptive management plan, including costs, were also estimated using currently available information. Uncertainties will be addressed in the Preconstruction Engineering and Design (PED) phase, and a detailed monitoring and adaptive management plan, including a detailed cost breakdown, will be completed as a component of the design document. Changes inconsistent with this approved Monitoring and Adaptive Management Plan will be coordinated with USACE Headquarters in accordance with Section 2039 of WRDA 2007.

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 Final 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 Recommended Plan 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. USACE. 2009. Planning Memorandum. Implementation Guidance for Section 2039 of the Water Resources Development Act of 2007 (WRDA 2007) - Monitoring Ecosystem Restoration

3. Implementation Guidance for Section 2039 of the Water 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, three restoration sites were included in the Recommended Plan:

- Schodack Island
- Henry Hudson Park
- 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)

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 restoration 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.

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 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.

3.0 Monitoring and Adaptive Management Protocols

Each restoration alternative contains the following unique combination of one or more project elements (Table 1) each requiring specialized monitoring. Individual monitoring protocols, failure conditions and adaptive management protocols for the project elements are summarized in sections 3.1 through 3.8 below. Adaptive management protocols would be implemented when a failure condition is observed at any point in the five-year monitoring program.

Table 1: Project Elements by Alternative

Site	Barrier Removal	Boulder Cascade	Living Shoreline	Dam Breach	Side Channel	Stream Crossing	Tidal Wetland	Tributary Stabilization
Schodack Island					X	X	X	
Henry Hudson Park			X				X	
Moodna Creek – AOP1 (Utility Crossing)	X							
Moodna Creek – AOP2 (Firth Cliff Dam)	X							
Moodna Creek – AOP3 (Orr's Mill Dam)		X		X				X

3.1 Side Channel 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 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
Channel or Bank Erosion	Minor erosion will be mitigated via hand re-grading, matting, seeding, and/or coir log installation.. 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.

3.2 Tidal Wetlands 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 ends of the project area. 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.

3.3 Stream Crossing 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 fish 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 restoration 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.

3.4 Living Shoreline 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 (once annually during the wetland monitoring event for five years plus two 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.

3.5 Barrier Removal 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.
Debris blockage	Debris to be cleared manually or from bank edge with equipment, especially during target migration/movement periods.

3.6 Dam Breach 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 PED 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	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.
Debris blockage	Debris to be cleared manually or from bank edge with equipment, especially during target migration/movement periods.

3.7 Boulder Cascade 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.

3.8 Tributary Stabilization 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 and Adaptive Management at Each Site

A summary of the monitoring and adaptive management activities outlined in Section 3.0 for each project element/feature during the monitoring period is presented for each restoration site. The failure criteria outlined above would trigger adaptive management and the cost assumptions utilized for cost estimates presented in Section 5.0.

4.1 Henry Hudson Park

Monitoring and adaptive management procedures and cost assumptions for restoration activities at Henry Hudson Park are summarized in Tables 2 and 3, respectively.

Table 2: Summary of Monitoring Procedures and Cost Assumptions for Restoration at Henry Hudson Park

Monitoring Item	General Monitoring Procedure	Cost Assumption
Shoreline Monitoring	- Visual inspections will occur once annually and after major flooding events to assess the stability of the placed boulders.	- Once per year for 5 years; 5 events, will occur on the same day as wetland monitoring - Once per major flood for 5 years; assume 2 floods per year; 10 events
Tidal Wetland Monitoring	- Wetland inspections will occur twice annually, in the spring and fall. - Spring inspections will consist solely of visual assessments. - Fall inspections will include visual assessment, hydrophytic vegetation assessment, and wetland soil assessment. During each assessment, quadrats will be established at a rate of one quadrat per five acres, or a minimum of five quadrats per vegetation community type, whichever is greater	- Twice per year for 5 years. Assuming a labor capacity of 20 quadrats per day and visual assessments take 1 day. - Spring: 1 day per year - Fall: 5 quadrats per year; 1 day per year - Total: 10 days

Table 3: Summary of Adaptive Management Procedures and Cost Assumptions for Restoration at Henry Hudson Park

Management Item	General Adaptive Management Procedure	Cost Assumption
Deer Fence	- Replace compromised sections of deer fence.	- 5% of total fence length replaced per year
Goose Fence	- Replace compromised sections of goose fence.	- Year 3-5: 5% of total fence area replaced per year
Planting	- Additional native vegetation will be planted in areas with significant mortality. 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.	- Year 3-5: Cumulative total of 6% replanting - Replanting to include 2" plugs, 24" – 36" containers, and live stakes; seeding excluded
Invasive Species Management	- Removal of invasive species via manual pulling or herbicide application as needed. Subsequent replanting as necessary.	- Percent of planting area treated: o Year 3: 5% o Year 4: 2.5% o Year 5: 2% - Following invasive species treatment, all treated areas will be replanted with 2" plugs and/or 24" – 36" containers as needed.
Wetland Hydrology	- 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.	- Lump sum of 2 hydrologists (senior and junior) to evaluate and perform manual manipulations in field; 16 hours at a senior rate and 24 hours at a junior rate

4.2 Schodack Island State Park

Monitoring and adaptive management procedures and cost assumptions for restoration activities at Schodack Island State Park are summarized in Tables 4 and 5, respectively.

Table 4: Summary of Monitoring Procedures and Cost Assumptions for Restoration at Schodack Island State Park

Monitoring Item	General Monitoring Procedure	Cost Assumption
Tidal Wetland Monitoring	- Wetland inspections will occur twice annually, in the spring and fall. - Spring inspections will consist solely of visual assessments. - Fall inspections will include visual assessment, hydrophytic vegetation assessment, and wetland soil assessment. During each assessment, quadrats will be established at a rate of one quadrat per five acres, or a minimum of five quadrats per vegetation community type, whichever is greater	- Twice per year for 5 years. Assuming a labor capacity of 20 quadrats per day and visual assessments take 1 day. - Spring: 1 day per year - Fall: 5 quadrats per year; 1 day per year - Total: 10 days
Side Channel Monitoring	- Visual inspections will occur once annually along the channel banks and the channel connection points to assess vegetation, erosion, sedimentation, and/or debris. - Channel geometry will be measured annually. Geometry measured at cross sections spaced at an interval of 5 sections per 1,000 feet of channel	- Visual assessments once per year for 5 years. Will occur on the same day as culvert monitoring - Channel geometry measurements assumed to occur at a rate of 1 day per 1,600 feet of channel (8 sections per day); 3 days per year for 5 years
Stream Crossing Culvert Monitoring	- Inspections will occur once during a low flow event shortly after construction and continue once annually during target movement/migratory periods (March through June). - 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.	- Year 1: 2 days - Year 2-5: 4 days - Total: 6 days

Table 5: Summary of Adaptive Management Procedures and Cost Assumptions for Restoration at Schodack Island State Park

Management Item	General Adaptive Management Procedure	Cost Assumption
Deer Fence	- Replace compromised sections of deer fence.	- 5% of total fence length replaced per year
Goose Fence	- Replace compromised sections of Goose fence.	- Year 3-5: 5% of total fence area replaced per year
Planting	- Additional native vegetation will be planted in areas with significant mortality. 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.	- Year 3-5: Cumulative total of 6% replanting - Replanting to include 2" plugs, 24" – 36" containers, and live stakes; seeding excluded
Invasive Species Management	- Removal of invasive species via manual pulling or herbicide application as needed. Subsequent replanting as necessary.	- Percent of planting area treated: o Year 3: 5% o Year 4: 2.5% o Year 5: 2% - Following invasive species treatment, all treated areas will be replanted with 2" plugs and/or 24" – 36" containers as needed.
Wetland Hydrology	- 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.	- Lump sum of 2 hydrologists (senior and junior) to evaluate and perform manual manipulations in field; 48 hours at a senior rate and 72 hours at a junior rate.
Channel Erosion	- Erosion and/or gully formation will be mitigated via hand re-grading, matting, seeding, and/or coir log installation. If erosion is severe or persistent an engineer or ecologist will evaluate potential stabilization measures.	- Assuming 1% of area will require hand re-grading, matting, and seeding; Assuming 100LF of coir log for each 1000 SY of stabilization. - 421 SY of hand re-grading, matting, and seeding; 42 feet of coir log placement.
Culvert Erosion/ Overtopping	- Erosion and/or gully formation will be mitigated via hand re-grading, matting, and seeding. If erosion is severe or persistent an engineer or ecologist will evaluate potential stabilization measures.	- Assuming a 10 ft by 500 ft area (555 SY) will require hand re-grading, matting, and seeding.

Management Item	General Adaptive Management Procedure	Cost Assumption
Culvert/Channel Blockage	- Blockages caused by debris or vegetation will be cleared.	- Mobilize/Demobilize: $5000 - Assuming 10 CY of debris excavation

4.3 Moodna Creek

Monitoring and adaptive management procedures and cost assumptions for restoration activities at the three Aquatic Fish Passage sites along Moodna Creek are summarized in Tables 6, 8, 10 (monitoring) and 7, 9 and 11 (adaptive management).

AOP1 – Utility Crossing Barrier Removal

Table 6: Summary of Monitoring Procedures and Cost Assumptions for Utility Crossing Barrier Removal along Moodna Creek

Monitoring Item	General Monitoring Procedure	Cost Assumption
Barrier Removal	- Visual inspections of the stream bed and banks will be conducted once annually during the target migratory/movement period (March through June)	- Once per year for 5 years; Assumed 1 day per event, 10 hours per day - Total: 50 hours

Table 7: Summary of Adaptive Management Procedures and Cost Assumptions for Utility Crossing Barrier Removal along Moodna Creek

Management Item	General Adaptive Management Procedure	Cost Assumption
Debris Blockage	- Major debris blockages will be excavated as needed. Excavated material disposed on-site.	- Mobilize/Demobilize: $5000 - Assuming 10 CY of excavation
Channel Bed Erosion	- Areas with significant channel bed erosion will be stabilized via rock placement. Rock sourced from off-site.	- Mobilize/Demobilize: $5000 - Assuming 20 Tons of rock placement
Bank Erosion	- Areas with significant bank erosion will be stabilized via plantings and/ or rock placement. Rock sourced from off-site.	- Mobilize/Demobilize: $5000 - Assuming 225 SY area will require matting, planting, and seeding at a rate of 1 plug per SY - Assuming 20 Tons of rock placement

AOP 2- Firth Cliff Dam Removal

Table 8: Summary of Monitoring Procedures and Cost Assumptions for the Removal of Firth Cliff Dam along Moodna Creek

Monitoring Item	General Monitoring Procedure	Cost Assumption
Barrier Removal	- Visual inspections of the stream bed and banks will be conducted once annually during the target migratory/movement period (March through June)	- Once per year for 5 years; Assumed 1 day per event, 10 hours per day - Total: 50 hours

Table 9: Summary of Adaptive Management Procedures and Cost Assumptions for Removal of Firth Cliff Dam along Moodna Creek

Management Item	General Adaptive Management Procedure	Cost Assumption
Debris Blockage	- Major debris blockages will be excavated as needed. Excavated material disposed on-site.	- Mobilize/Demobilize: $5000 - Assuming 10 CY of excavation
Channel Bed Erosion	- Areas with significant channel bed erosion will be stabilized via rock placement. Rock sourced from off-site.	- Mobilize/Demobilize: $5000 - Assuming 20 Tons of rock placement
Bank Erosion	- Areas with significant bank erosion will be stabilized via matting and planting, and/or rock placement. Rock sourced from off-site.	- Mobilize/Demobilize: $5000 - Assuming 225 SY area will require matting, planting, and seeding at a rate of 1 plug per SY - Assuming 20 Tons of rock placement

AOP 3- Orr's Mill Partial Dam Removal

Table 10: Summary of Monitoring Procedures and Cost Assumptions for Orr's Mill Dam Partial Barrier Removal (Breach) along Moodna Creek

Monitoring Item	General Monitoring Procedure	Cost Assumption
Dam Breach	- Visual inspections of hydraulic conditions (e.g. depth and flow velocity) will be conducted once annually during the target migratory/movement period (March through June).	- Once per year for 5 years; Assumed 1 day per event, 10 hours per day - Total: 50 hours - Year 1: Once per week, March to June (16 events) - Year 2-5: Once per year - Assumed 1 day per event, 10 hours per day - Total: 200 Hours
Boulder Cascade	- Visual inspections of the boulder cascade will be conducted once annually to assess the stability of the placed boulders and flow conditions.	- Once per year for 5 years; Assumed 0.33 days per event, 10 hours per day - Total: 16.5 Hours
Tributary Stabilization	- Visual inspections will occur once annually and after major flooding events to assess the stability of the placed rock and identify the presence of down-cutting or head cutting.	- Once per year for 5 years; Assumed 0.33 days per event, 10 hours per day - Once per major flood for 5 years; assume 2 floods per year (10 events); Assumed 0.66 days per event, 10 hours per day - Total: 82.5 Hours

Table 11: Summary of Adaptive Management Procedures and Cost Assumptions for the Partial Removal of Orr's Mill Dam along Moodna Creek

Management Item	General Adaptive Management Procedure	Cost Assumption
Debris Blockage	- Major debris blockages will be excavated as needed. Excavated material disposed on-site.	- Mobilize/Demobilize: $5000 - Assuming 10 CY of excavation
Channel Bed Erosion	- Areas with significant channel bed erosion will be stabilized via rock placement. Rock sourced from off-site.	- Mobilize/Demobilize: $5000 - Assuming 20 Tons of rock placement
Boulder Cascade	- If structural instability is observed, supplemental boulders will be placed to provide additional stability - If vertical drops greater than 8 inches or plunging flows are observed, existing boulders will be adjusted and supplemental boulders will be placed to improve flow conditions	- Mobilize/Demobilize: $5000 - Assuming 112 tons of supplemental boulder placement (10% of design specified boulder placement) - Assuming 34 CY of excavation to embed supplemental boulders half way into the channel bed
Tributary Stabilization	- If down-cutting or head cutting is present, supplemental boulders will be placed to provide additional stability	- Mobilize/Demobilize: $5000 - Assuming 112 tons of supplemental boulder placement (10% of design specified boulder placement) - Assuming 34 CY of excavation to embed supplemental boulders half way into the channel bed

5.0 Monitoring Costs

Required effort and work-hours were determined, costs developed and updated for Fiscal Year 2021 (Table 2) for the monitoring of each alternative for the five-year monitoring period utilizing the cost assumptions presented in Tables 2, 4, 6, 8 and 10. The monitoring costs (First Costs including contingency) for Fiscal Year 2020 (Attachment C) and updated Fiscal Year 2021 (Attachment D) are also presented in the Cost Engineering Appendix E.

Table 12: Monitoring Costs for the Recommended Plan (FY21 Costs)

Site Name and Alternative	Cost
Schodack Island North Alternative 2	$319,000
Henry Hudson Park Alternative 1	$146,000
Moodna Creek AOP1 Alternative 1 – Barrier Removal	$42,000
Moodna Creek AOP2 Alternative 1 – Dam Removal	$42,000
Moodna Creek AOP3 Alternative 2 – Dam Breach	$251,000

6.0 Adaptive Management Costs

Adaptive management costs for each alternative were calculated and updated for Fiscal Year 2021 (Table 13) based on the efforts and criteria described in Section 3.0 and cost assumptions presented in Section 4.0 outlined in Tables 3, 5, 7, 9 and 11. These first costs (including contingency) are also presented in the Cost Appendix E for Fiscal Year 2020 (Attachment C) and updated for Fiscal Year 2021 (Attachment D).

Table 13: Adaptive Management Costs for the Recommended Plan (FY21 Costs)

Site Name and Alternative	Cost
Schodack Island North Alternative 2	$720,000
Henry Hudson Park Alternative 1	$177,000
Moodna Creek AOP 1 Alternative 1 – Barrier Removal	$34,000
Moodna Creek AOP 2 Alternative 1 – Dam Removal	$34,000
Moodna Creek AOP 3 Alternative 2 – Dam Breach	$60,000

7.0 References

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