US Army Corps of Engineers ®
Chicago District

BUBBLY CREEK, SOUTH BRANCH OF THE CHICAGO RIVER, ILLINOIS FEASIBILITY STUDY

APPENDIX H
MONITORING & ADAPTIVE MANAGEMENT PLAN

MARCH 2020

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BUBBLY CREEK, SOUTH BRANCH OF THE CHICAGO RIVER, ILLINOIS ECOSYSTEM RESTORATION FEASIBILITY STUDY

APPENDIX H – Monitoring & Adaptive Management Plan

March 2020

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1. Introduction

Section 2039 of Water Resources Development Act (WRDA) 2007, as amended by Section 1161 of WRDA 2016 (Section 1161 of WRDA), directs the Secretary of the Army to ensure, that 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 recommended project includes a monitoring plan to measure the success of the ecosystem restoration and to dictate the direction adaptive management should proceed, if needed. This monitoring and adaptive management plan shall include 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 would continue until such time as the Secretary determines that the success criteria have been met.

Section 1161 of WRDA also directs the 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 would be used by the USACE-Chicago District in consultation with the Federal and State resource agencies and the Major Subordinate Command (MSC) 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 would 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 a project site is not always a simple task. Ecosystems, by their very nature, are dynamic systems where populations of macroinvertebrates, fish, birds, and other organisms fluctuate with natural cycles. Water quality also varies, particularly as seasonal and annual weather patterns change. 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 and monitoring methods that could be utilized to assess projects. By reporting on environmental changes, the results from this monitoring effort would be able to evaluate whether measurable results have been achieved and whether the intent of the Bubbly Creek Ecosystem Restoration Project is being met.

Section 1161 of WRDA provides as follows:

(a) IN GENERAL-In conducting a feasibility study for a project (or a component of a project) for ecosystem restoration, the Secretary shall ensure that the recommended project includes, as an integral part of the project, a plan for monitoring the success of the ecosystem restoration.

(b) MONITORING PLAN.-The monitoring plan shall-

(1) include a description of the monitoring activities to be carried out, the criteria for

ecosystem restoration success, and the estimated cost and duration of the monitoring; and
(2) specify that the monitoring shall continue until such time as the Secretary determines that the criteria for ecosystem restoration success will be met.

(b) COST SHARE. For a period of 10 years from completion of construction of a project (or a component of a project) for ecosystem restoration, the Secretary shall consider the cost of carrying out the monitoring as a project cost. If the monitoring plan under subsection (b) requires monitoring beyond the 10-year period, the cost of monitoring shall be a non-federal responsibility.

(d) INCLUSIONS. A monitoring plan under subsection (b) shall include a description of
(1) the types and number of restoration activities to be conducted;
(2) the physical action to be undertaken to achieve the restoration objectives of the project;
(3) the functions and values that will result from the restoration plan; and
(4) a contingency plan for taking corrective actions in cases in which monitoring demonstrates that restoration measures are not achieving ecological success in accordance with criteria described in the monitoring plan.

(e) CONCLUSION OF OPERATION AND MAINTENANCE RESPONSIBILITY. The responsibility of a non-federal interest for operation and maintenance of the nonstructural and nonmechanical elements of a project, or a component of a project, for ecosystem restoration shall cease 10 years after the date on which the Secretary makes a determination of success under subsection (b)(2).

(f) FEDERAL OBLIGATIONS.-The Secretary is not responsible for the operation or maintenance of any components of a project with respect to which a non-federal interest is released from obligations under subsection (e).

1.1 Guidance

The following documents provide distinct USACE policy and guidance that are pertinent to the formulation of the project and developing this monitoring and adaptive management plan:

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

b. USACE. 2000. ER 1105-2-100, Guidance for Conducting Civil Works Planning Studies. Washington D.C.

c. USACE. 2003a. ER 1105-2-404. Planning Civil Work Projects under the Environmental Operating Principles. Washington, D.C.

1.2 Project Area Description

Detailed description of the study area (***Figure 1***) may be found in the Main Report – Chapter 2 – Study Area Inventory & Forecasting. Before the 1830's, Bubbly Creek was a prairie slough that drained five square miles of aquatic and terrestrial habitat mosaic. Over a period of several decades, this ecosystem was altered by human development. Currently, Bubbly Creek no longer provides a diversity of habitats, nor is the existing habitat does not have appropriate structure and is of a quality sufficient to support healthy plant and animal communities. Most of the plant and animal species present are tolerant to disturbance, poor water quality and habitat loss. No matter how transformed this system is; however, it still manages to occasionally attract interesting species; black-crown night-heron, king fisher, and white crappie.

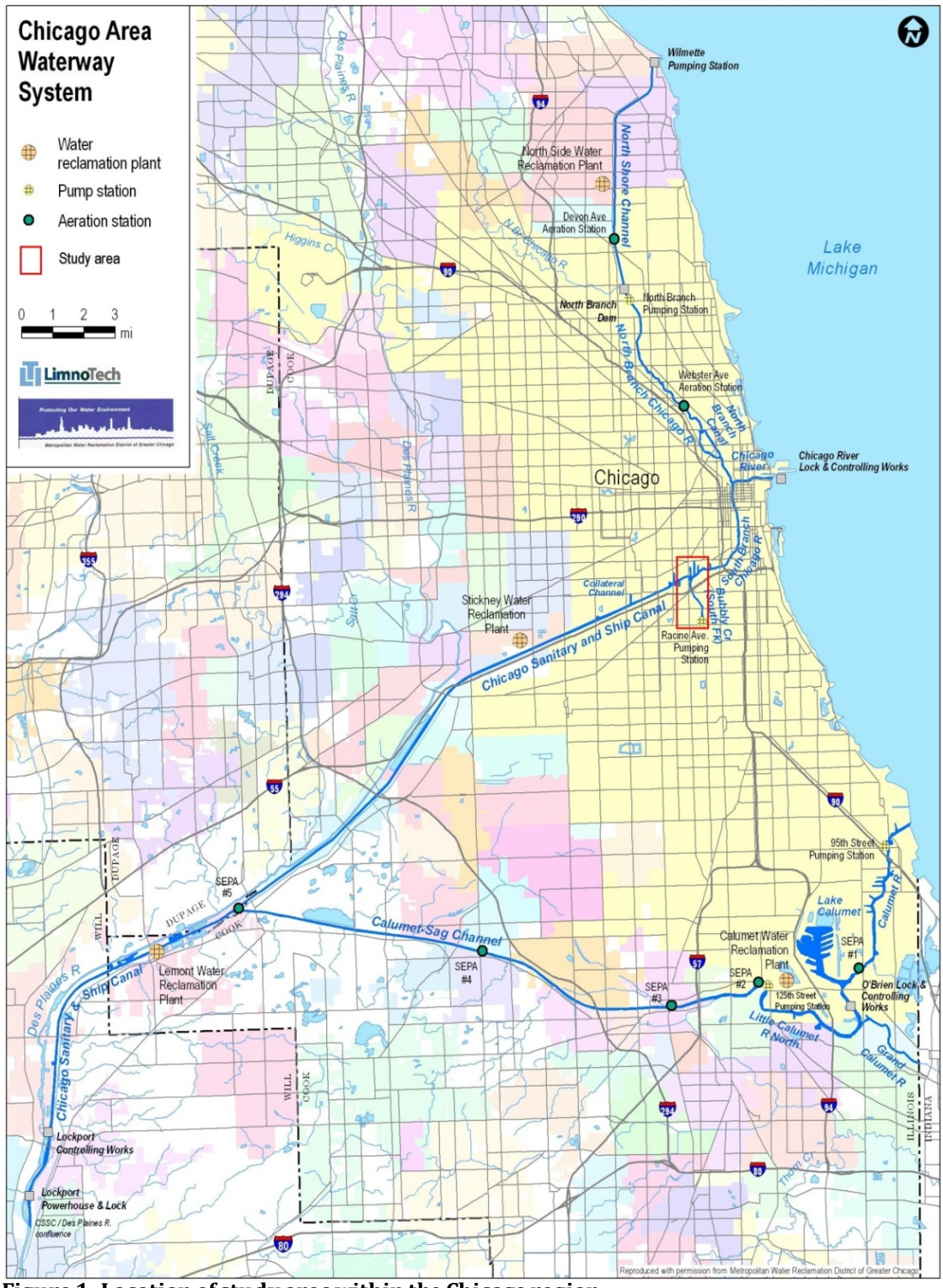

Figure 1: Location of study area within the Chicago region

1.3 Habitat Trends Triggering Restoration

This project aims to remedy adverse trends of degradation and homogenization of backwater and riparian plant community functions and habitat structure. Specific overarching trends include but are not limited to:

- Presence of impacted substrates that preclude plant and macroinvertebrate survival
- Absence of physical aquatic structure (habitat)
- Impaired riparian zone structure
- Impaired water column
- Lack of diverse native aquatic and riparian plant communities
- Lack of requisite composite habitats
- Does not contribute habitat to the Great Lakes portion of the Mississippi Flyway

1.4 Restoration Design Overview

Implementation of Alternative 3, the National Ecosystem Restoration (NER) Plan, which is the Recommended Plan, would greatly improve the ecosystem conditions of Bubbly Creek. See Table 1 and Figure 2 for details regarding the NER Plan.

Table 1: Summary of habitat suitability index (HSI) variables.

Measure /Scale	Type	Description
SR1 & SR2	Substrate Restoration	Broadcast a substrate restoration layer consisting of sand (6") and a layer (6") of rounded river stone or quarried stone to provide a stable basis for building a habitat as well as armoring in areas with high erosive forces to maintain the base, over 30.7 acres within the Bubbly Creek channel and turning basin. The substrate restoration layer would be monitored for effectiveness and repaired as needed through adaptive management. Annual OMRR&R costs include periodic monitoring and rehabilitation as needed. See Figure 15.
RP2	Riparian Plantings	Physically remove invasive plants and herbicide as needed along the banks of the channel, place an amended soil layer (6"), and plant native riparian species over 9.3 acres within the Bubbly Creek channel corridor. Monitor and adaptively manage to ensure proper establishment. Annual OMRR&R costs include periodic invasive species control.
EP	Emergent Plantings	Amend the substrate restoration layer with organic material and plant native emergent species over 1.0 acres within the Bubbly Creek channel. Monitor and adaptively manage to ensure proper establishment. Annual OMRR&R costs include periodic invasive species control.
SP1 & SP2	Submergent Plantings	Amend the substrate restoration layer with organic material and plant native submergent species over 3.3 acres within the Bubbly Creek channel and turning basin. Monitor and adaptively manage to ensure proper establishment. Annual OMRR&R costs include periodic invasive species control.
WD	Woody Debris	Anchor trees, rootwads, trunks and large branches in areas that experience high flow or erosion in approximately 10 locations within the Bubbly Creek channel. Monitor and adaptively manage to ensure stable placement and minimal impacts to the substrate restoration layer. Annual OMRR&R costs include periodic removal of foreign debris.

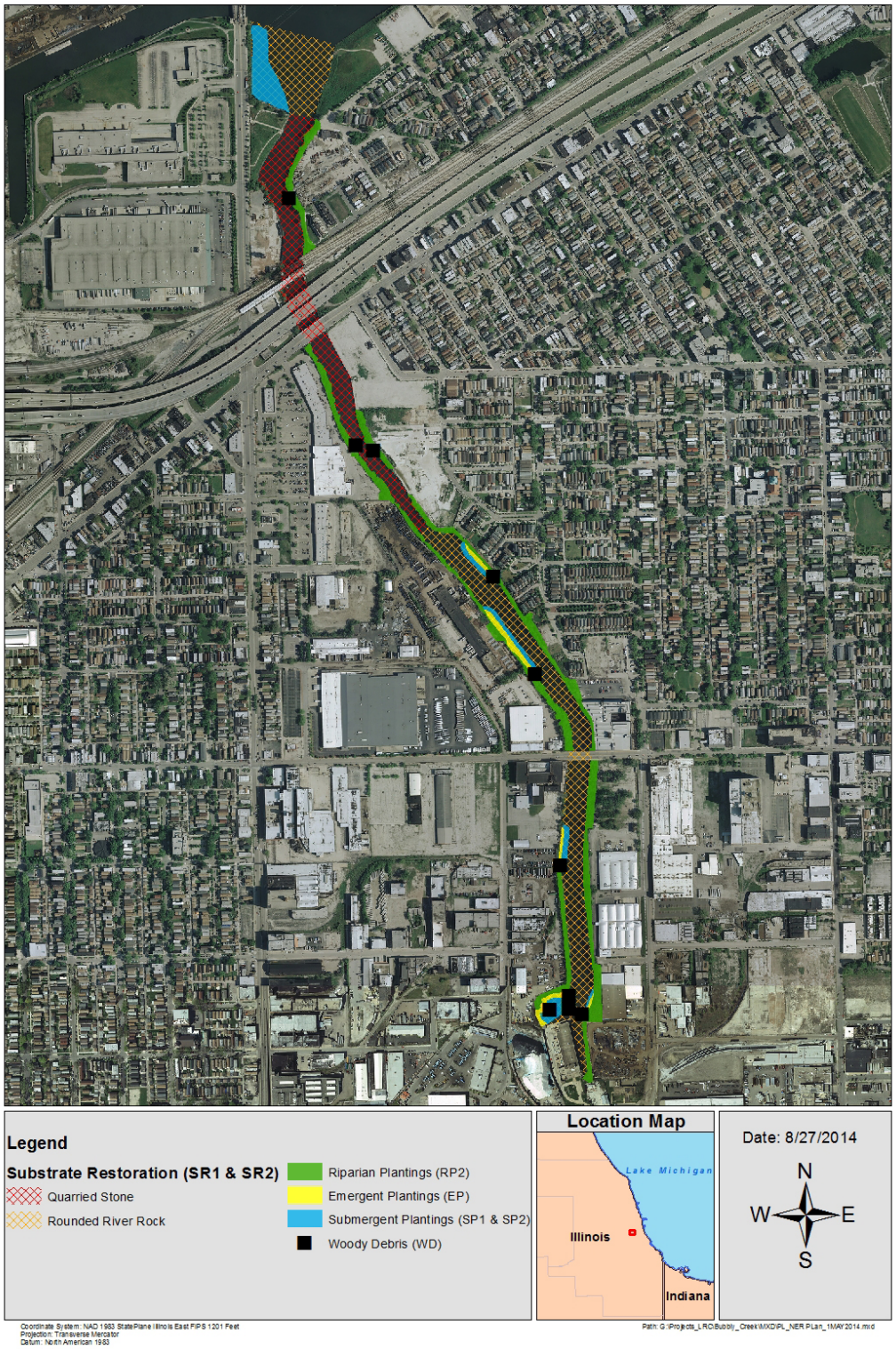

Figure 2: NER (Recommended) Plan Overview Map

The addition of several native habitat types and close to 50^{+} native plant species would increase species richness and abundance of the surrounding environment. The plan selected in the Main Report is the most environmentally and economically justifiable and would address the adverse trends of Bubbly Creek. Key habitat features include 1) substrate layer composed of sand and rounded river rock or quarried stone, 2) large woody debris structures, and 3) plant community reestablishment. Large woody debris can be broken down into 3 structural components: a) fish & turtle habitat (trunk & limbs), b) heron & bird habitat (trunk & limbs), c) wetland structural habitat (rootwads). Plant communities are specified by a) submergent, b) emergent, and c) riparian.

1.5 General Monitoring Objectives

As presented in "Guidance on Monitoring Ecosystem Restoration Project" on 12 January 2010, the following are general project monitoring objectives:

- To determine and prioritize needs for ecosystem restoration
- To support adaptive management of implemented projects
- To assess and justify adaptive management expenditures
- To minimize costs and maximize benefits of future restoration projects
- To determine "ecological success", document, and communicate it
- To advance the state of ecosystem restoration practice

These objectives provide direction for monitoring plans and help establish project specific objectives. Specific project objectives can be found below in the section labeled Planning Goals and Objectives.

2. Monitoring Components

All monitoring components would continue to be refined and designed as construction progresses. This version of the monitoring plan is based on feasibility level information.

2.1 Planning Goal & Objectives

The principal goal of the potential project is to restore a functional backwater habitat and riparian buffer zone for resident and migratory birds and spawning fishes in Bubbly Creek. The monitoring plan's goal is to determine if the planning goal is being met. For this project, the monitoring plan's goal also ensures a planning constraint is met. An assessment of whether planning goals are being met is determined through the assessment of whether the study objectives are being met. Planning objectives for this study are as follows:

Objective 1 – Provide Diverse Habitat Structure within Bubbly Creek – This objective seeks to increase the quantity and improve quality of backwater habitat to the Chicago River South Branch, inclusive of critical physical habitat and biological components.

Objective 2 – Provide a Viable Foundation for Plant Growth and Aquatic Habitats – This objective seeks to increase the quantity and improve quality of Bubbly Creek's substrates and banks. The substrate and banks serve as the foundation of a backwater habitat to the Chicago River South Branch.

These two objectives would be assessed the same way as the FWOP and FWP project benefits were modeled as described in the Main Report, Section 2.5 – Habitat Quality Forecasting. The floristic portion of the modeling would be completed as described in Section 2.5.1 – Plant Communities Assessment and Monitoring Component 2, Biological Response, Plant Communities. The habitat portion of the modeling would be completed as described in Section 2.5.2 – Aquatic Habitat Assessment. The following (***Table 2***) shows what data would be collected:

Table 2: Summary of habitat suitability index (HSI) variables.

Model	Model Acronym	Metrics	Range of Values	
(1) Floristic Quality Assessment	FQA		0	10
		Mean C (coefficient of conservatism)	0	10
(2) CAWS Habitat Assessment Index	CAWSHAI		0	100
		Max channel depth (ft)	6	26
		Off-channel bays	0	9
		Vertical wall banks (%)	0	100
		Riprap banks (%)	0	100
		Manmade structures	1.0	4.0
		Macrophyte cover (%)	0	13
		Overhanging vegetation (%)	0	33
		Bank pocket areas	0	20
		Large substrate, shallow (%)	0	85
		Large substrate, deep (%)	0	31
		Organic sludge (%)	0	48

The planning constraint assessed through monitoring of the project after implementation is:

To Avoid and Minimize Hazardous Wildlife Attractants - Within five miles of Chicago Midway International Airport. The Department of the Army is a party to the 2003 *Memorandum of Agreement Between the Federal Aviation Administration, the U.S. Air Force, the U.S. Army, the U.S. Environmental Protection Agency, the U.S. Fish and Wildlife Service, and the U.S. Department of Agriculture to address Aircraft-Wildlife Strikes*. Land uses and changes in land uses within five miles of an airport's air operations area are of interest when assessing whether a land use is a potentially hazardous wildlife attractant.

2.2 Component 1 – Structural Sustainability

This component covers the structural sustainability of the implemented features. It is a qualitative assessment of whether each feature is retaining its physical character and project purpose. The most important information derived from this component would be to determine if adaptive management measures are needed or not. To ensure the substrate does not undergo excessive scour or movement, monitoring of the substrate for scour would be completed after a combined sewage pumping event by the

Racine Avenue Pumping Station (RAPS) and monitoring the new substrate for movement during settlement would occur one or two additional times per year following placement of the new substrate. The monitoring would be completed using hydrosurveys during the construction contract term and monitoring and adaptive management phases. Additionally, monitoring for other structural sustainability factors would also be completed following large RAPS overflow events. The monitoring costs are estimated to be $100,000. Monitoring would be broken down into the following structural features:

1) Substrate layer and culverts
2) Large woody debris structures
    a) Fish & turtle habitat (trunk & limbs)
    b) Heron & bird habitat (trunk & limbs)
    c) Wetland structural habitat (rootwads)
3) Plant community reestablishment
    a) Aquatic bed (eel grass & pondweeds)
    b) Emergent (buttonbush, sedges & rushes)
    c) Transitional bank (wet - mesic shrub prairie)
    d) Riparian (mesic - dry shrub savanna)

The following is a list (living list) of parameters that would be visually assessed during site visits to determine if structural integrity and sustainability exist within the project:

1. Substrate layer and culvert erosion protection
    a. Substrate - scour yes/no
    b. Pebble/cobble beds - presence/absence
    c. Culvert erosion protection - presence/absence
2. Woody Debris
    a. Presence/absence
    b. Stability and durability
3. Plant Community Zones
    a. Spatial coverage
    b. Invasive species % coverage
    c. Herbivory damages
    d. Hydraulic induced damages
4. Human Interference & Damages
    a. Physical damage
    b. Removal
    c. Rubbish and foreign debris

Success criteria will be set to measure the success of the restored channel substrates. Criteria are set after a baseline study of channel substrates is completed after the substrate has been placed. The following standards would be considered as measures of success with regard to channel substrates and in-channel habitat structure.

Success Criteria:

1. Minor scouring of substrates (≤ 5% of the channel bottom) and presence of culvert erosion protection.
2. Maintained presence of installed large woody debris.
3. Minor herbivory and hydraulic induced damages observed (≤ 10%). For success criteria related to spatial coverage and invasive species % coverage refer to the success criteria defined for 'Plant Communities' under Component 2 – Biological Resources.
4. Minimal human interference and induced damages (≤ 10%).

2.3 Component 2 – Biological Response

This component covers the biological response to the implemented restoration features. It is a quantitative assessment of whether the ecosystem restoration project is successful in restoring targeted plant and animal communities. This monitoring would take place once the plants are established and would traditionally take place when during the summer. Monitoring would be broken down into the following biological communities and is included in the planning, engineering and design labor associated with the riparian and emergency plantings:

Plant Communities

Evaluation of plant community zones would be accomplished using the FQA and native plant richness. The FQA is a measure of overall environmental quality based the presence or absence of certain plant species. Plant species assigned a coefficient of conservatism (C) of 5 to 10 are considered to be indicative of less human mediated disturbance and a higher level of functionality. As the area stabilizes after restoration measures are complete, the number of higher conservative plant species that become established should increase. Communities that have an average mean C between 3 and 5 are considered to be fair quality. This is a good estimate of the future quality of the area based on the current plant community restorations and ongoing monitoring. Three different criteria would be used to determine the effectiveness of plant community establishment: 1) maintain less than 5% invasive species cover, 2) maintain a minimum mean C of 3.0, and 3) maintain 30 or more native species. Failure to meet these criteria would result in the implementation of adaptive management processes. Please see the Adaptive Management section for examples.

Success will be determined by comparing FQA results with those predicted from the Future With Project Conditions. Adaptive management measures (refer to Section 4 – Adaptive Management) will be taken if there is a decreasing trend of floristic quality over a period of three consecutive years.

Success criteria will be set to measure the success of the restored plant communities. Criteria are set after a baseline study of existing vegetation is completed, usually the last year of construction. The following standards will be considered as measures of success, in addition to FQA.

Success Criteria:

1. Maintain a minimum mean C of 3.0.
2. By the end of the third growing season, at least 75% of the vegetative cover (as measure by aerial coverage) will consist of seeded/planted species. The planted areas shall exhibit at least the

following at the end of each growing season: Year 1 ≥ 25% vegetative cover, Year 2 ≥ 50% vegetative cover, and Year 3 ≥ 75% vegetative cover.

3. By the end of the fifth growing season, at least 95% of the planted areas must contain native, non-invasive perennial species as measured by aerial coverage. The planted areas shall exhibit at least the following at the end of each growing season: Year 1 through 3 ≥ 25%, Year 3 through 6 ≥ 60%, and Year 6 through 10 ≥ 95%. Note that Growing Season Years 1 through 5 would be monitored as a requirement under the construction contract. Growing Season Years 6 through 10 would be monitored as part of the Recommended Plan's monitoring and adaptive management period.
4. 100% of the planted trees and shrubs shall be alive, in healthy condition, and representative of the individual species at the end of each growing season.
5. If these criteria are not met within the 5-year monitoring period, monitoring may extend up to a total of 10 total years as a cost-shared cost.

Floristic Data Gathering Protocol:

Data collection will follow the Standard Vegetation Monitoring Protocols for Grasslands and Prairie for herbaceous vegetation. Formal line transect surveys will be conducted yearly. In general, surveys will be conducted in summer/early fall during the course of the monitoring period. Transects will be laid out to include all habitats and restoration measures. Vegetation community composition (identification of plant species and estimated coverage of each) within quadrats will be made along each transect in 10 meter intervals. The first and last 10 meters within each transect will be skipped. Because transect data may not provide information needed to evaluate overall herbicide efficacies (or plant establishment efforts), meander surveys will be conducted at the same time as line transect surveys to supplement transect data, with focuses on plant response to herbicide applications, volunteer plant species occurrences, and survival, growth, and spread of planted species. The estimated monitoring costs for the fish, plant and macroinvertebrate communities is $55,000.

Fish Community

The Illinois Department of Natural Resources Illinois Fish Index of Biotic Integrity (IBI) would be used to score species richness and abundance within Bubbly Creek. An IBI score represents how much the biotic integrity (in terms of fish metrics) differs at a site from a benchmark set of biological conditions (in terms of the same fish metrics) that reflect a known level of biotic integrity. For Illinois fish IBIs, these benchmark conditions – often called "reference conditions" – are defined as the biological conditions expected in Illinois streams least disturbed by human impacts. Therefore, the degree to which an IBI score deviates from the score that best represents the typical reference conditions reflects the relative amount of human impact (i.e., loss of integrity) additional to that already represented by the reference conditions. The Illinois IBI ranges from 0 to 65 with the ranges representing the following:

- **0-15**: Biotic integrity is much lower than that expected in Illinois streams that reflect the typical reference (i.e., least disturbed) conditions. The number of native species is reduced further due to pronounced, indiscriminate loss of species across major families (minnows, suckers, sunfish) with a concurrent increase in the proportion of tolerant species. Intolerant species are absent; benthic-invertivore species are nearly absent. Pronounced reductions in abundances of specialist benthic

invertivores and mineral-substrate spawners indicate extreme imbalance in trophic and reproductive functional structure.

- **16-30**: Biotic integrity is much lower than that expected in Illinois streams that reflect the typical reference conditions. The number of native species is reduced further from reference conditions due to near-complete loss of intolerant species and further pronounced loss of sucker species and benthic-invertivore species. Imbalance of fish-community structure is evidenced as indiscriminate loss of species across major families (minnows, suckers, sunfish). Further reductions in abundances of specialist benthic invertivores and mineral-substrate spawners indicate moderate to extreme imbalance in trophic and reproductive functional structure.

- **31-45**: Biotic integrity is lower than that expected in Illinois streams that reflect the typical reference conditions. The number of native fish species is reduced from reference conditions primarily due to further loss of intolerant species, but also due to loss of sucker species and benthic-invertivore species. Reduced abundances of specialist benthic invertivores and increased abundances of generalist feeders indicate slight to moderate imbalance in trophic functional structure. Further reduction in abundances of mineral-substrate spawners indicates moderate imbalance in reproductive functional structure.

- **46-55**: Biotic integrity is similar to that expected in Illinois streams that reflect the typical reference conditions. The number of native fish species is reduced primarily due to loss of some intolerant species. Reduced abundances of mineral-substrate spawners indicate slight imbalance in reproductive functional structure. Trophic functional structure appears balanced.

- **55-60**: Biotic integrity is higher than that expected in Illinois streams that reflect the typical reference conditions. The number of native fish species is greater than that in streams reflecting the current, typical reference conditions primarily due to presence of intolerant species. Reproductive and trophic functional structure appears balanced.

The current condition average IBI for Bubbly Creek is 13, which was based upon fish data collected from Bubbly Creek by the Metropolitan Water District of Greater Chicago from 2001 to 2005. It is expected that structural features of the project would increase the CAWSHAI and would lead to an improvement in the fish metrics that were used to create the CAWSHAI. These fish metrics are related to species health, abundance, and richness. A projected IBI of 30 was developed based on data collected by Metropolitan Water Reclamation District of Greater Chicago (MWRDGC), Fishes of the Chicago Region Database, observational data by USACE ichthyologist, the proximity and possibility of fish migration, habitat affinity, and water quality. This projected IBI would likely be attained at the end of the monitoring period. If the projected IBI is not met at the end of the 5-year monitoring period, the reasons why would be evaluated and monitoring would continue as a cost-shared cost up to 10 years. If the IBI is less than or similar to the current condition IBI of 13, the reasons would be assessed and adaptive management measures may be implemented (see Adaptive Management Section). If the IBI is similar to the projected IBI of 30, no adaptive management processes would be implemented (refer to Section 4 – Adaptive Management).

Success criteria would be set to measure the anticipated improvement of the fish community as a result of channel substrate restoration and plant community restoration. Criteria would be set after a baseline study

of the existing fish community, which would be conducted prior to project construction. Based on available data, the following standards would be considered as measures of success.

Success Criteria:

1. Increases in fish richness and abundance for years 1 and 2 of monitoring, Richness and abundance may stay the same or continue to increase years 3-5 of monitoring.
2. Achieve the projected fish IBI, 30, at the end of the 5-year monitoring period.
3. If success has not been achieved within the 5-year monitoring period, the monitoring period may extend up to a total of 10 years.

Macroinvertebrate Community

Macroinvertebrate data for Bubbly Creek was collected by MWRDGC in July 2010. Two methods, Hester-Dendy and Petite Ponar, were used to sample a single station within Bubbly Creek. A total of 13 taxa and 2 ephemeroptera-plecoptera-tricoptera (EPT) taxa were recorded (***Table 3***). Total richness was similar using both sampling methods, with total richness being 7 for the Hester-Dendy samples and 8 for the Ponar samples. Oligochaeta were the dominant taxon comprising 95% of the total density. The MWRDGC labeled the macroinvertebrate community as highly stressed.

In order to determine what richness and abundance could potentially be after implementation of the project, macroinvertebrate data collected by MWRDGC in 2010 from the South Branch Chicago River (SBCR), Chicago Sanitary and Ship Canal (CSSC), and North Shore Channel (NSC) (***Figure 1***) were reviewed. Two stations were sampled in the SBCR yielding 30 total taxa and 1 EPT taxa, six stations were sampled in the CSSC yielding 39 taxa and 3 EPT taxa, and one station was sampled in the NSC yielding 22 taxa and 1 EPT taxa.

Although recolonisation of restored river reaches by macroinvertebrates is being studied, often the studies are still in a state of infancy and can be flawed due to uncertainties about what species existed prior to restoration. Regardless, it is expected that within a few years of project implementation macroinvertebrates would recolonize Bubbly Creek; however, the community would likely be comprised mostly of habitat generalists/specialists having a winged adult stage and high dispersal capabilities[1]. A greater length of time is expected to pass before the macroinvertebrate community becomes mature and includes wingless taxa without the ability for aerial dispersal and habitat specialists/generalists with a winged adult stage but with low dispersal capabilities[2]. Therefore, the goal of the project would be to maintain and improve upon the current total taxa count within Bubbly Creek of 13 by the end of the 5-year monitoring period. It is anticipated that macroinvertebrate richness and abundance would increase to values similar to those in nearby source reaches such as the SBCR and CSSC. This is primarily due to substrates within Bubbly Creek being more desirable after project implementation than the silty sediments which would still be present in the SBCR and CSSC.

[1] Winking, C., A.W. Lorenz, B. Sures, and D. Hering. 2014. Recolonisation patterns of benthic invertebrates: a field investigation of restored former sewage channels. Freshwater Biology 59:1932-1944.
[2] Winking, C., A.W. Lorenz, B. Sures, and D. Hering. 2014. Recolonisation patterns of benthic invertebrates: a field investigation of restored former sewage channels. Freshwater Biology 59:1932-1944.

Table 3: Densities at sampling station within Bubbly Creek, July 2010[3]

	Hester-Dendy		Petite Ponar	
Taxa	**#/m2**	**%**	**#/m2**	**%**
Oligochaeta	439.5	96.84	64,223.7	99.72
Baetis intercalaris	1.8	0.40		
Cheumatopsyche	1.8	0.40		
Ceratopogonidae	5.4	1.19		
Hyalella azteca			7.2	0.01
Procladius			14.4	0.02
Cricotopus sylvestris grp.			14.4	0.02
Mesosmittia			7.2	0.01
Chironomus	1.8	0.40	107.6	0.17
Dicrotendipes lucifer	1.8	0.40		
Parachironomus	1.8	0.40		
Tipula			7.2	0.01
Physa			21.5	0.03
Total Benthos	453.9	100.0	64,403.1	100.0
Total Taxa Richness	7		8	
EPT Taxa Richness	2		0	

Success criteria will be set to measure the anticipated improvement of the macroinvertebrate community as a result of channel substrate restoration and plant community restoration. Criteria are set after a baseline study of the existing macroinvertebrate community, which would be prior to placement of the new substrate. The following standards would be considered as measures of success.

Success Criteria:

1. Maintenance or improvement of macroinvertebrate species richness and abundance. Total taxa count should be $\geq$ 13 at the end of the five-year monitoring period.
2. If these criteria are not met within the 5-year monitoring period, monitoring may extend up to a total of 10 total years as a cost-shared cost.

Hazardous Wildlife for Airports (Chicago Midway International Airport)

The Department of the Army is a party to the 2003 *Memorandum of Agreement Between the Federal Aviation Administration, the U.S. Air Force, the U.S. Army, the U.S. Environmental Protection Agency, the U.S. Fish and Wildlife Service, and the U.S. Department of Agriculture to address Aircraft-Wildlife Strikes.* Land uses and changes in land uses within five miles of an airport's air operations area are of interest when assessing whether a land use is a potentially hazardous wildlife attractant. Bubbly Creek is located within five miles of Chicago Midway International Airport.

[3] EA Engineering, Science, and Technology, Inc. 2012. A Study of the Benthic Macroinvertebrate Community in Selected Chicago Metropolitan Area Waterways during 2010. Metropolitan Water Reclamation District of Greater Chicago, Monitoring and Research Department, Chicago, IL.

This monitoring would assess and address the potential that a restored Bubbly Creek would attract avian species most likely to cause a hazard at an airport. To mitigate the potential attractant a restored Bubbly Creek may pose to hazardous avian species, the project area would be monitored for hazardous avian species over five years by a qualified airport wildlife biologist as defined in Federal Aviation Administration Advisory Circular 150/5200-36A, *Qualifications for Wildlife Biologist Conducting Wildlife Hazard Assessments and Training Curriculums for Airport Personnel Involved in Controlling Wildlife Hazards on Airports*. The cost of these surveys are estimated to be $12,000.

Other Communities

Ancillary data would be collected on other assemblages too. During fish and macroinvertebrate collections, effort would be spent observing and counting (if necessary) wildlife utilizing the habitats, including terrestrial insects, amphibians, reptiles, birds and mammals. This ancillary data can sometimes provide very beneficial data that may lead to additional monitoring. For instance, if a state threatened organism is observed during other monitoring efforts, it may be necessary and beneficial to conduct additional monitoring for that specific organism. This ancillary data can also lead to adaptive management practices if necessary. If nuisance species are observed within the site, adaptive measures can be adjusted or added to prevent the establishment of the nuisance species and also ensure long-term sustainability of the project. Other communities would be monitored via a presence/absence during routine monitoring of other species. Failure to meet these criteria would result in the implementation of adaptive management processes. Please see the Adaptive Management section for examples.

Supporting Data

During community assessments, air, water and soils parameters would be measured if appropriate to the given community. These include but are not limited to: temperature, pH, conductivity, dissolved oxygen, turbidity, nitrogen, and phosphorus.

3. Monitoring Responsibilities and Schedule

The USACE would currently be responsible for implementing the Monitoring Components described above. Coordination with partner agencies to discuss future monitoring responsibilities is planned. The monitoring schedule is found in Table 4. The construction contract would end five years after planting and substrate and woody debris placement. The monitoring phase for the plantings is projected to be five-years based on other similar projects. At the end of the monitoring phase, USACE will assess whether ecological success has been met in accordance with the monitoring plan. If success has not been met, the monitoring phase would extend up to 10 years as a cost-shared cost. Additional monitoring beyond 10 years would be a non-federal sponsor's responsibility.

Table 4. Monitoring Schedule – Construction phase ends after year 5

Tasks	Construction Phase					Monitoring Phase[3]				
	FY23	FY24	FY25	FY26	FY27	FY28 yr 1	FY29 yr 2	FY30 yr 3	FY31 yr 4	FY32 yr 5
Structural Sustainability – Plants	Construction contract for planting includes monitoring by contractor to ensure plant establishment.					X	X	X	X	X
Structural Sustainability – Substrate, Woody Debris, etc.[1]	Construction contract for monitoring and adaptive management of substrate and woody debris placement included.					X	X	X	X	X
Biological Response						X	X	X	X	X
Avian Fauna[2]	X	X	X	X	X					

[1]Assume monitoring after RAPS events would be less frequent after the substrate construction phase ends. Monitoring of the substrate in years 1-5 account for weather variability which ensures monitoring is conducted after large RAPS events occurring during those years.
[2]Project-funded monitoring conducted by the U.S. Department of Agriculture, Animal and Plant Health Inspection Service (USDA-APHIS).
[3] If project success has not been met after the 5-year monitoring period, the monitoring phase would be extended for up to 10 years as a cost-shared cost. After 10 years, monitoring costs become a non-federal sponsor's cost.

3.1 Reporting Results

A monitoring summary report would be drafted by the USACE that briefly summarizes the data and other information collected and determines if adaptive management is needed. A final monitoring report would be drafted that details the outcomes of the restoration project.

4. Adaptive Management

Adaptive management measures are response actions to changed conditions that would adversely affect how the system was predicted to respond. Implementation of adaptive management features extends through the monitoring phase of the project, which can last up to 10 years post construction. Implemented adaptive management features are cost-shared with the non-federal sponsor. In being adaptive, no absolute measures can be defined prior to an issue arising. General concerns and examples of adaptive management processes can be identified at this stage.

The primary concern for this project is the integrity of the habitat after CSO events. Below are brief descriptions of potential adaptive management measures that could be implemented to address issues that may arise during the establishment period of this project. Additional detail would be developed during the design phase since the adaptive management measures would need to be based upon contracting bid items, final feature designs and predicted adverse responses. Due to low risk of establishing the desired project outputs, potential adaptive management measures are estimated to have relatively low costs as compared to implementation costs of the project.

Substrate Layer Repair & Modification – If the monitoring program identifies localized areas of scour or erosion additional substrate would be added with the size adjusted to account for flow velocities or other stressors. The assumption is additional substrate would be added to approximately 5% of the surface area of the channel. The stone is assumed to be larger than the original armor stone, approximately 2 to 3 inches

in diameter, and placed in a 4 inch lift. Stone has been sized conservatively to avoid scour, however risks associated with scour repairs have been identified and included in the project contingency. The scope of the substrate restoration includes adaptive management costs to increase stone size and quantity during the monitoring after RAPS events. The addition of larger stone would repair the areas that experience scour or erosion so future maintenance would not be needed in these areas. This effort is estimated to be $200,000.

Temporary Dissolved Oxygen Sags – The potential for dips in dissolved oxygen following CSO events are possible, but not expected to significantly impact the restored ecosystem. Extreme dips in dissolved oxygen are well known occurrences in natural systems, mostly occurring in lentic systems (i.e. lakes, ponds, marshes, bogs, swamps, backwaters, sloughs.) The native plants selected for restoration have adapted to living in these conditions.

Plant Communities – The risk of large scale plant failure is low, mostly due to the species selection of those adapted to backwater quality conditions. Five years after the plants were planted would be the construction phase and would be covered by the planting contract. In years 6 through 10, if for some reason extensive patches of native plant community begin to fail, the cause would need to be determined in order to design and implement repair measures. Accidental or intentional human induced instances have damaged or removed native plantings in the past as well. Additionally, herbivory by common carp (*Cyprinus carpio*) could potentially damage emergent and submergent plants during the establishment period. No matter what the solution would be for the cause of the problem, it would certainly be coupled with reestablishing native plant patches by replanting. It may be that other thriving areas would be able to have live plants and seed transferred to the damaged patch. Or it may be that plants and seed would need to be repurchased. If herbivory is the main problem, exclusion cages could be added around emergent and submergent vegetation to reduce herbivory during the establishment period. An amount of approximately $140,000 has been added to the cost of the submergent, riparian, and emergent plantings for the adaptive management of native plantings. Stage 2 McCook Reservoir will be on line in 2029 prior to the end of the monitoring and adaptive management phase. The monitoring and adaptive management phase overlaps the anticipated improved change in conditions in Bubbly Creek after Stage 2 McCook comes on line.

Fish Community– The triggers for adaptive management associated with fish are linked to the Illinois fish index of biotic integrity (IBI). The target IBI for fish at the end of the monitoring phase is 30. If the target IBI is not met at the end of the monitoring phase the reasons why will be evaluated and adaptive management may be implemented to increase the richness and abundance of native fish. Possible measures could include the addition of habitat to increase local habitat diversity. This costs is included in the estimated adaptive management cost for substrate layer repair & modification and plant communities.

Other Communities– Adaptive management triggers from other communities will be based on observational data. For instance, if a state threatened species of reptile is spotted after restoration, it may be important to see how that species is utilizing the habitat and whether the species was positively or negatively impacted.

Supporting Data– Supporting data will mostly be used to guide adaptive management implementation for other biological communities. An example would be a change in the plant community that is caused by a higher than expected pH. This information can then be used to appropriately seed for the correct species at the rates previously described.

5. Operation & Maintenance

The NER Plan includes costs associated with OMRR&R of plan components (***Table 18***). The non-Federal sponsor is responsible for 100 percent of OMRR&R costs. A detailed OMRR&R Manual containing all the requirements to ensure long-term project success would be provided to the non-Federal sponsor after construction. The projected OMRR&R requirements are estimated to be minimal due to initial project design efforts targeted for sustainability and a robust monitoring and adaptive management phase. Most, if not all, of the projected OMRR&R activities are no different than the specific activities that would take place during construction.

OMRR&R is the responsibility of the non-Federal Sponsor to ensure project success. OMRR&R activities listed below would continue throughout project life except for invasive plant species control and native plant community maintenance. Per Section 1161 of WRDA 2016, the non-federal sponsor would be responsible for the control of invasive plant species and maintenance of native plant communities for ten years after achieving ecological success which is estimated to be five years after the construction has ended (Table 4). See Table 5 for the estimated cost for the first 10 years of OMRR&R which includes invasive plant species control and native plant community maintenance. After the 10-year period has ended, see Table 6 for the estimated OMRR&R of structural features which continues through project life.

Rip Rap and Pebble/Cobble Bed Replenishment – The OMRR&R costs for replenishment of riprap around outfalls and of pebble/cobble substrates within the existing wood cribs are included in the cost of the adaptive management for the substrate layer and would vary depending on the amount of repairs required. It is anticipated that minor repairs to the riprap at the culvert outfalls would be needed. Repair work would need to be done from the water with a sectional barge/boat.

Woody Debris – Occasional replacement of snags would be necessary because minimal natural sources for large woody debris are along the channel. This activity would be very infrequent and could be supplied from tree removals completed by Chicago Park District and City of Chicago. The only cost would be cutting and transporting the trees to the site. It would be more costly to replace vertical heron snags, if needed, because they would need to be driven down into the subsurface material. Addition of sand and stone around these may be necessary to fill voids that would occur. The cost of this activity is captured in the "Sand, Gravel and Stone Replenishment" cost estimate.

Invasive Plant Species Control – Staying ahead of weed growth goes a long way in avoiding large scale herbicide or physical eradication and replanting efforts. The most problematic areas would be the bank transition and emergent marsh zones. Species such as white and yellow sweet clover, cut-leaved teasel, reed canary grass, common reed, buckthorn, honeysuckle, tree of heaven, Japanese knotweed, phragmites, cattails and curly dock are all Chicago River bank invaders that will need to be kept at bay.

For control of the invasive plant species the estimated costs would be approximately $13,000/year. This would provide for spot herbiciding of the entire site as well as replanting roughly 5% of the original total of planted plugs. This work would occur after the establishment period is over.

Native Plant Community Maintenance – It will be required to maintain the species richness, abundance and structure of the restored plant communities within and along Bubbly Creek. Invasive plant species are not the only threat to plant community degradation. Aside from minor re-plantings, it will be important to

continue to protect plant communities from external stressors, whether single incidents or chronic stressors. These can cause plant communities to experience significant species richness declines even to the point of becoming monotypic stands. The best operational measure to quickly identify and rectify external stressors is vigilance. Routine inspections by the non-Federal sponsor's qualified stewards are imperative to notice adverse change quickly. The cost of this activity is captured in the Invasive Plant Species Control activity.

Trash Removal – After CSO discharges and occasionally throughout the year, the channel would need to be monitored for trash and litter carried by CSO discharges and wind. MWRDGC would continue to implement their floatable collection program as described in Section 2.2 of the Main Report. Trash removal is for the trash found along the planted shores and within the plants that would grow within the creek due to project implementation. Trash removal from the channel and turning basin was estimated to cost approximately $30,000/year; however, this cost depends on the number of CSO events occurring in a year.

Duration – OMRR&R activities listed above would continue throughout project life except for invasive plant species control and native plant community maintenance. Per Section 1161 of WRDA 2016, the non-federal sponsor would be responsible for the control of invasive plant species and maintenance of native plant communities for ten years after achieving ecological success which is estimated to be five years after the construction has ended (Table 4). See Table 5 for the estimated cost for the first 10 years of OMRR&R which includes invasive plant species control and native plant community maintenance. After the 10-year period has ended, see Table 6 for the estimated OMRR&R of structural features which continues through project life.

Table 5 OMRR&R costs incurred for 10 years after the monitoring phase identified in Table 17[1] (Estimated FY2032-FY41)

OMRR&R Activity	Estimated Annual Cost ($/year)
Rip Rap and Pebble/Cobble Bed Replenishment	$20,000
Woody Debris	
Invasive Plant Species Control	$13,000
Native Plant Community Maintenance	
Trash Removal	$30,000
OMRR&R Total	$63,000

[1]Section 1161 of WRDA 2016 provides that OMRR&R costs of native and invasive plants will occur for 10 years after completion of the monitoring phase identified in Table 4.

Table 6: OMRR&R Costs incurred after 10 years of OMRR&R of native plant community maintenance and invasive species removal is completed. (Estimated FY2042 through project life)

OMRR&R Activity	Estimated Annual Cost ($/year)
Rip Rap and Pebble/Cobble Bed Replenishment	$20,000
Woody Debris	
Trash Removal	$30,000
OMRR&R Total	$50,000