US Army Corps of Engineers ®
Chicago District

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

APPENDIX H
MONITORING & ADAPTIVE MANAGEMENT PLAN

DRAFT REPORT - NOT FOR DISTRIBUTION

APRIL 2015

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

APPENDIX H – Monitoring & Adaptive Management Plan

April 2015

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1. Introduction

Section 2039 of WRDA 2007 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 will continue until such time as the Secretary determines that the success criteria have been met.

Section 2039 of Water Resources Development Act (WRDA) 2007 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 will 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 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 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 will be able to evaluate whether measurable results have been achieved and whether the intent of the Bubbly Creek Ecosystem Restoration Project is being met.

WRDA 2007

Section 2039 of WRDA 2007 Monitoring Ecosystem Restoration

> (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.

(c) 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.

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 a pristine aquatic and terrestrial habitat mosaic. Over a period of several decades approximately, this ecosystem was severely altered by human development. Currently, Bubbly Creek no longer provides a diversity of habitats, nor is the existing habitat quality sufficient to maintain structure and 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 attract an interesting species from time to time; black-crown night-heron, king fisher, and white crappie.

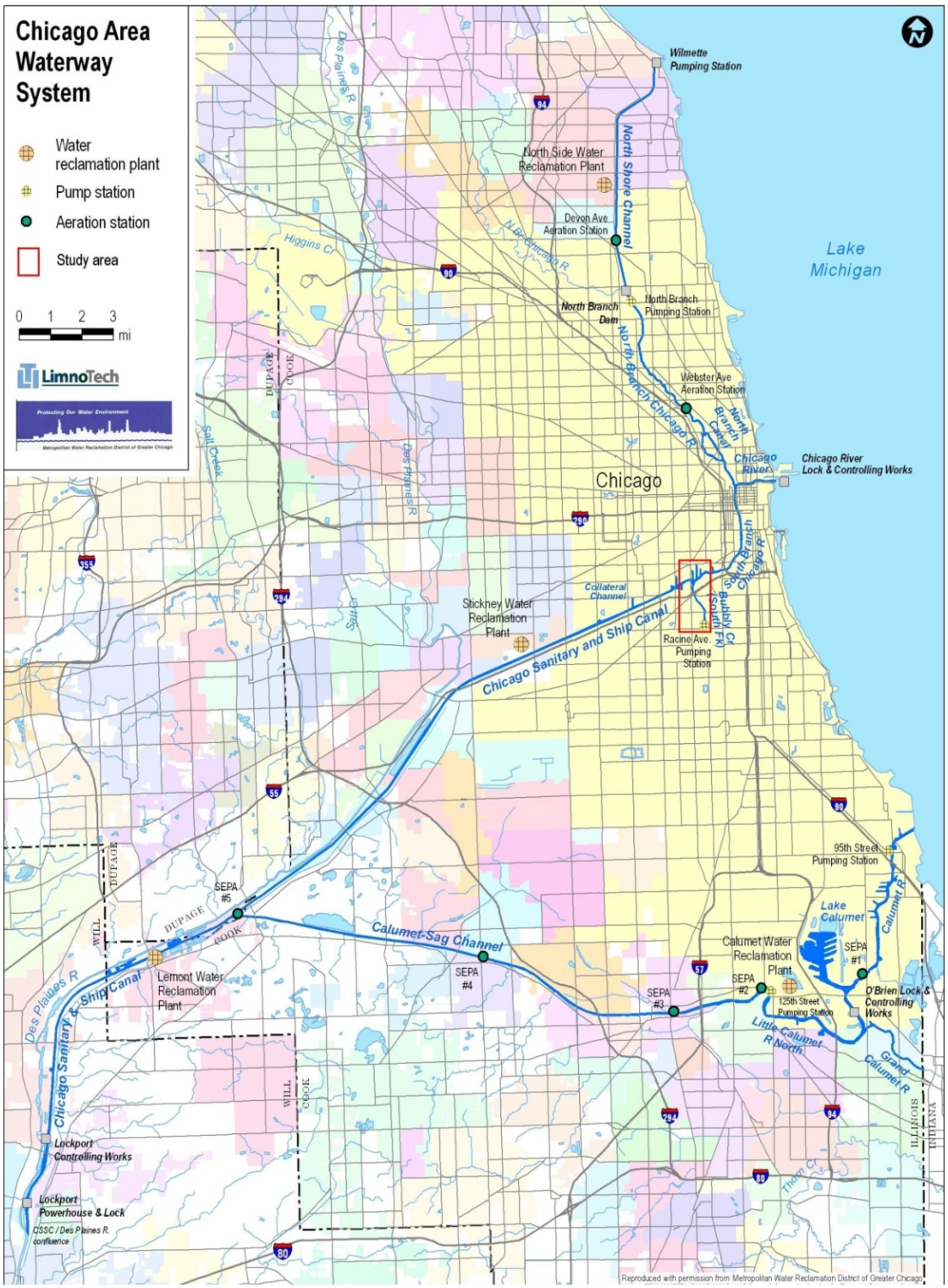

Figure 1: Location of study area within the Chicago region

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 NER Plan, would greatly improve the ecosystem conditions of Bubbly Creek. 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 will 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 as stated is being met. This would be 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 as it would be the foundation for any given means to provide 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 1***) shows what data would be collected:

Table 1: 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

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 doesn't undergo excessive scour or movement, monitoring of the substrate will be completed after a Racine Avenue Pumping Station (RAPS) event and typically one or two times per year. The monitoring will be completed using hydrosurveys and is estimated to be $100,000 ($20,000/year) for the five-year monitoring period. Monitoring for other structural sustainability factors will also typically follow a large RAPS overflow event and is estimated to be $8,000 per year. Monitoring will 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

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 every other year for ten years, typically during the summer months. Monitoring would be broken down into the following biological communities and would cost $10,000 per year monitoring occurs:

Plant Communities

Evaluation of plant community zones would be accomplished using the FQA and native plant richness, as described in the 2.5.1 Plant Communities Assessment. In short, the FQA is a measure of overall environmental quality based the presence or absence of certain plant species. Plant species that are 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 will 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 will result in the implementation of adaptive management processes. Please see the Adaptive Management section for examples.

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 10-year monitoring period the reasons why will be evaluated in the final monitoring report. If the IBI is similar to the projected IBI of 30 no adaptive management processes will be implemented. If the IBI is similar to the current condition IBI of 13 the reasons why will be assessed and adaptive management measures may be implemented (see Adaptive Management Section).

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 2***). 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 will be to maintain and improve upon the current total taxa count within Bubbly Creek of 13 by the end of the 10-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.

Table 2: 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	

Other Communities

Ancillary data will 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

[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.
[3] EA Engineering, Science, and Technolocy, 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.

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 will be monitored via a presence/absence during routine monitoring of other species. Failure to meet these criteria will 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

The USACE will currently be responsible for implementing both of the Monitoring Components as described above. Coordination with partner agencies to discuss future monitoring responsibilities is planned.

3.1 Estimated Monitoring Costs & Funding Schedule

Tasks	FY 19 Year 1*	FY 20 Year 2	FY 21 Year 3	FY 22 Year 4	FY 23 Year 5	FY 24 Year 6	FY 25 Year 7	FY 26 Year 8	FY 27 Year 9	FY 28 Year 10	Total
Component 1 -substrate	$20.0	$20.0	$20.0	$20.0	$20.0						**$100.0**
Component 1 -remaining features	$8.0	$8.0	$8.0	$8.0	$8.0						**$40.0**
Component 2		$10.0		$10.0		$10.0		$10.0		$10.0	**$50.0**
Final Report										$10.0	**$10.0**
Total	$28.0	$38.0	$28.0	$38.0	$28.0	$10.0		$10.0		$20.0	**$200.0**

*Year 1 of Monitoring starts when construction of substrate restoration and woody debris measures have been completed.

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 not the same as typical operation and maintenance activities described in the following section. These measures are technically response actions to changes that adversely affect how the system was predicted to respond. In so being adaptive, there are no absolute measures that can be defined prior to the issue arising. However, general concerns and examples of adaptive management processes can be identified at this stage. The primary concerns for this project are the structural integrity of habitat features and dissolved oxygen conditions within Bubbly Creek surface waters. Descriptions of adaptive managements below are brief and will be further detailed once a complete set of plans and specifications are drafted. This is necessary since the adaptive management measures will need to be based upon contracting bid items, final feature designs and predicted adverse responses. It is also noted that these measures have relatively low costs to regain lasting benefits.

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 cost assumption is that additional substrate would be added to approximately 5% of the surface area of the channel. The stone is assumed to be approximately 2 to 3 inches in diameter and placed in a 4 inch lift. Using the same unit costs from the construction of the original substrate, this work is estimated to cost approximately $200,000 including contingency. The addition of stone would repair the areas that experience scour or erosion so future maintenance would not be needed in those areas.

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. If through monitoring it is determined that low dissolved oxygen concentrations were impairing the restored communities, there is the possibility of inducing an artificial flow within Bubbly Creek by pumping channel water through RAPS for a short time to restore more balanced DO conditions. The benefits of this measure were previously demonstrated effective by two demonstration projects performed by MWRDGC in the main report.

Plant Communities – The risk of large scale plant failure is low, mostly due to the species selection of those adapted to backwater quality conditions. Most of the requirements for native plant communities are covered under routine operation and maintenance. If for some reason extensive patches of a 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.

Fish Community – The triggers for adaptive management associated with fish are linked to the Illinois fish IBI. The target IBI for fish at the end of the monitoring period is 30. If the target IBI is not met at the end of the monitoring period 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.

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 O&M costs of the project are estimated to an average annual cost of $48,000 with a 3.75% interest rate over 50 years. A detailed O&M Manual containing all the duties will be provided to the non-Federal sponsor after construction is closed out. The O&M for Chicago District ecosystem projects are practical and minimal due to initial project design efforts and design targets for sustainability. Mostly if not all of the O&M activities are no different than the specific activities that would take place during construction. The O&M described here is not the same as the Adaptive Management measures described in the previous section.

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 estimated to be approximately $20,000/ year but would vary depending on the amount of repairs required. This would provide for minor repairs to the riprap at the culvert outfalls. 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 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 long term monitoring plan provided above will not identify sudden change in the site as would routine inspection by site stewards. 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 will need to be monitored for trash and litter carried by the discharges and wind. Trash removal from the channel and turning basin will cost approximately $15,000/year.

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	$15,000
OMRR&R Total	$48,000