US Army Corps of Engineers ®
Chicago District

BUBBLY CREEK, SOUTH BRANCH OF THE CHICAGO RIVER, ILLINOIS
INTEGRATED FEASIBILITY REPORT AND ENVIRONMENTAL ASSESSMENT

FEASIBILITY STUDY

DRAFT REPORT

APRIL 2015

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

INTEGRATED FEASIBILITY REPORT & ENVIRONMENTAL ASSESSMENT

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EXECUTIVE SUMMARY

In response to Congressional study authorization, this draft feasibility report presents the results of a cost-shared feasibility study aimed at evaluating the opportunities for ecosystem restoration. This report identifies a recommended plan for an ecosystem restoration project for the 1.25 mile South Fork of the South Branch of the Chicago River, commonly referred to as "Bubbly Creek" and located entirely within the City of Chicago, Cook County. The recommended project would restore the structure and function of approximately 44 acres of scarce backwater and swamp habitat including channel, wetland and riparian zones in order to improve Bubbly Creek's biodiversity. The recommended ecosystem restoration plan includes substrate restoration, restoration of emergent, submergent and riparian vegetation, and restoration of channel diversity through installation of woody debris structures. The ecosystem of this section of the Chicago River is severely degraded by human activities and no longer provides a diversity of habitats sufficient to support healthy plant and animal communities.

Historically, Bubbly Creek was a prairie slough that drained approximately five square miles of a pristine aquatic and interconnected terrestrial habitat. During industrialization of the area, the slough was channelized; and prior to modern day waste management practices, raw sewage and animal waste from area stockyards was disposed in the creek for conveyance downstream. These wastes created a soft, highly organic, anaerobic material along the channel bed that produces gas and currently suspends the channel's fine-grained sediment. During large storm events, the Racine Avenue Pump Station (RAPS), located at the channel's upstream end, discharges the majority of combined sewer overflows (CSOs) that enter the channel. In 2017, the McCook Stage I Reservoir will become operational and will significantly reduce both the volume and frequency of RAPS events, making sustainable ecosystem restoration possible.

Currently, Bubbly Creek no longer provides a diversity of habitats, nor is the existing habitat quality sufficient to maintain habitat heterogeneity or support healthy plant and animal communities. A set of Problems and Opportunities were developed by the study team, non-Federal Sponsors and supporting stakeholders, which is summarized as the historic loss of significant migratory bird, fish and wildlife aquatic habitat. Restored aquatic habitat within and along Bubbly Creek would provide critical habitat for migratory waterfowl and wetland fishes and has great potential to support two state threatened species, the black-crowned night heron and the banded killifish. Chicago is also located within the Mississippi Flyway, and is one of America's most important migration routes for songbirds, with more than 5 million individuals migrating through annually.

A detailed description of the affected environment is provided in Chapter 2 – Study Area Inventory & Forecasting. Based on data collected, analysis, and modeling conducted for this feasibility study, it was

determined that the physical, chemical and biological conditions of Bubbly Creek constitute a severely degraded aquatic ecosystem. As a result, only species that can tolerate poor habitat, anthropogenic disturbance and poor water quality are present. Slight improvements in water quality that have occurred over the past several decades and are projected to continue will not be sufficient to support the reestablishment of native plant and animal communities on their own. Critical structural habitat components are currently missing from the Bubbly Creek ecosystem, therefore the No Action Plan is synonymous with the Future Without-Project Condition, which are presented in the main report.

Summary Alternative Analysis

Section 4.1 provides discussion on the ecosystem restoration measures that were evaluated. Section 4.2 provides the final list of potential measures that were used to generate a range of potential ecosystem restoration plans. A cost effective and incremental cost analysis was performed on the range of plans, which takes the full range of life-cycle costs and ecosystem outputs into consideration. Ecosystem outputs were measured via two multi-metric indices: the Chicago Area Waterway System Habitat Assessment Index (CAWSHAI) and the Floristic Quality Assessment (FQA). A total of five (5) alternative plans, including the No Action Plan, were further evaluated for project implementation. A range of decision-making criteria, including significance of outputs, acceptability, completeness, effectiveness, risk and uncertainty, and reasonableness of costs was used to identify the recommended ecosystem restoration plan.

- Alternative 0 – No Action
- Alternative 1 – Riparian Planting, Entire Channel (RP2)
- Alternative 2 – Substrate Restoration, Turning Basin (SR2), Submergent Planting, Turning Basin (SP2), and Riparian Planting, Entire Channel (RP2)
- Alternative 3 – Substrate Restoration, Channel/Turning Basin (SR1, SR2), Submergent Planting, Channel/Turning Basin (SP1, SP2), Riparian Planting, Entire Channel (RP2), Emergent Planting (EP), and Woody Debris (WD) ***[NER Plan]***
- Alternative 4 – Substrate Restoration, Channel/Turning Basin (SR1, SR2), Submergent Planting, Channel/Turning Basin (SP1, SP2), Riparian Planting, Exclusive with Bank Restoration (RP1), Emergent Planting (EP), Woody Debris (WD), and Bank Restoration, Downstream/Midstream/Upstream (BR1, BR2, BR3)

Alternative 3 was selected as the National Ecosystem Restoration (NER) Plan, which for the purposes of this Environmental Assessment is termed the NER Plan. The rationale for selecting the NER Plan is presented in Section 4.7.

The NER Plan

The NER Plan is recommended for implementation and consists of five (5) restoration measures as summarized below:

- *Substrate restoration* consisting of placing sand and an armor layer composed of rounded river rock and quarried stone over 30.7 acres within the channel and turning basin.
- *Riparian plant restoration* consisting of invasive species removal, soil amendments and native riparian plantings over 9.3 acres within the channel corridor.
- *Emergent plant restoration* consisting of substrate amendments and native emergent plantings over 1.0 acre within the channel.

- *Submergent plant restoration* consisting of substrate amendments and native submergent plantings over 3.3 acres within the channel and turning basin.
- *Woody debris restoration* consisting of anchoring trees, rootwads, trunks and large branches in areas that experience high velocities in approximately 10 locations within the channel.

A Value Engineering study was conducted on the recommended NER Plan aimed at increasing the value of the project by achieving the required benefits at a minimum cost without sacrificing quality. The estimated total cost of the NER Plan referenced to October 2014 price levels is $15,384,000 with a Federal contribution of $10,000,000 and a non-Federal contribution of $5,384,000 including $5,229,000 in cash and $155,000 in lands, easements, rights-of-way, relocations, and disposal areas (LERRDs). The total project cost includes implementation and a 5-year monitoring and adaptive management period. The estimated first cost is $14,934,000 and monitoring and adaptive management is $450,000. In accordance with the National Environmental Policy Act of 1969, an environmental assessment of the NER Plan found that no significant adverse impacts are expected as a result of project implementation.

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

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List of Acronyms

AAHUs	Average Annual Habitat Units
AGO	America's Great Outdoor
AM	Adaptive Management
ASTM	American Society for Testing and Materials
BCN	Bird Conservation Network
BG	Billion Gallons
BMPs	Best Management Practices
BOD	Biochemical Oxygen Demand
BTEX	Benzene, Toluene, Ethylbenzene and Xylenes
C	Coefficient of Conservatism
CAP	Continuing Authorities Program
CAWS	Chicago Area Waterway System
CAWSHAI	Chicago Area Waterway System Habitat Assessment Index
CAWSHSI	Chicago Area Waterway System Habitat Suitability Index
CCD	Chicago City Datum
CDOT	Chicago Department of Transportation
CE/ICA	Cost Effectiveness/Incremental Cost Analysis
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CFS	Cubic Feet per Second
CH3D	Curvilinear-grid Hydrodynamics Model in Three Dimensions
CPT	Cone Penetrometer Test
CRCW	Chicago River Controlling Works
CSO	Combined Sewer Overflow
CSSC	Chicago Sanitary and Ship Canal
CTA	Chicago Transit Authority
CUP	Chicago Underflow Plan
CWCCIS	Civil Works Construction Cost Index
D&I	Design & Implementation
DDT	Dichlorodiphenyltrichloroethane
DO	Dissolved Oxygen
EA	Environmental Assessment
ECO-PCX	Ecosystem Restoration Planning Center of Expertise
EDDC	Engineering and Design During Construction
EM	Engineering Manual
E.O.	Executive Order
EOPs	Environmental Operating Principals
E.R.	Engineering Regulation
ERDC-CHL	Engineering, Research and Development Center - Coastal Hydraulics Laboratory
ESA	Environmental Site Assessment
FCSA	Feasibility Cost Sharing Agreement
FOG	Fats, Oils and Grease
FONSI	Finding of No Significant Impact
FQA	Floristic Quality Assessment
FWCA	Fish & Wildlife Coordination Act
FWOP	Future Without Project Conditions

FY	Fiscal Year
GLNPO	Great Lakes National Progam Office
HEC-RAS	Hydraulic Engineering Center - River Analysis System
HSI	Habitat Suitability Index
HTRW	Hazardous, Toxic and Radioactive Waste
HUs	Habitat Units
I&M	Illinois & Michigan
IBI	Index of Biotic Integrity
IDC	Interest During Construction
IDEM	Indiana Departmetn of Environmental Management
IDNR	Illinois Department of Natural Resources
IEPA	Illinois Environmental Protection Agency
IHPA	Illinois Historic Preservation Agency
IMCNHC	Illinois & Michigan Canal Heritage National Corridor
IPCB	Illinois Pollution Control Board
IUCN	International Union for Conservation of Nature
IWR-PLAN	Institute for Water Resources Planning Suite Software
LERRDs	Lands, Easements, Rights-of-way, Relocations, and Disposal Areas
MWRDGC	Metropolitan Water Reclamation District of Greater Chicago
NBCR	North Branch of the Chicago River
NEPA	National Environmental Policy Act
NER	National Ecosystem Restoration
NPDES	National Pollutant Discharge Elimination System
NT	Near Threatened
NWHI	Non-wadeable Habitat Index
OMRR&R	Operations, Maintenance, Repair, Replacement and Rehabilitation
PAHs	Polycyclic Aromatic Hydrocarbons
PCB	Polychlorinated Biphenyls
PDT	Project Delivery Team
PED	Pre-construction Engineering and Design
P.L.	Public Law
PM	Particulate Matter
PMP	Project Management Plan
RAPS	Racine Avenue Pumping Station
RCRA	Resource Conservation and Recovery Act
REC	Recognized Environmental Conditions
SBCR	South Branch of the Chicago River
SEPA	Stream Elevated Pool Aeration
SFSB	South Fork, South Branch of the Chicago River
SHPO	State Historic Preservation Office
SOD	Sediment Oxygen Demand
SPT	Standard Penetration Test
SVOCs	Semi-volatile Organic Compounds
SWMM	Storm Water Management Model
TARP	Tunnel and Reservoir Project
TCLP	Toxicity Characteristic Leaching Procedure
TDS	Total Dissolved Solids
TIN	Triangular Irregular Network
TKN	Total Kjedahl Nitrogen
TMDLs	Total Maximum Daily Loads

TNET	Tunnel Network Model
TOC	Total organic carbon
TSCA	Toxic Substances Control Act
USACE	U.S. Army Corps of Engineers
U.S.C.	U.S. Code
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
USTs	Underground Storage Tanks
VE	Value Engineering
VOCs	Volatile Organic Compounds
WQC	Water Quality Certification
WRDA	Water Resources Development Act
WRP	Water Reclamation Plant

CHAPTER 1 – Introduction

1.1 Report Structure

This report presents the results of an ecosystem restoration feasibility study for the South Fork of the South Branch of the Chicago River, also known as "Bubbly Creek," located in the City of Chicago, Cook County, Illinois (the "City"). This Integrated Feasibility Report and Environmental Assessment presents ecological, hydrologic, hydraulic, geotechnical and other technical data the study team gathered regarding historic and current site conditions, and forecasts future without and future with project conditions for Bubbly Creek. This report lays out the formulation and evaluation of several ecosystem restoration plans and provides a recommended plan for the restoration of Bubbly Creek.

The feasibility report is broken down into the following chapters:

Chapter 1 – *Introduction*: provides a description of the study area and a summary of relevant studies and projects underway or completed within the study area prior to the signing of the Feasibility Cost Sharing Agreement (FCSA).

Chapter 2 – *Inventory of Study Area and Forecasting:* contains an inventory and description of the study area which includes an assessment of pertinent historic, current and future without project conditions.

Chapter 3 – *Problems and Opportunities:* discusses the ecosystem impairment problems within the study area, potential opportunities to remedy them, the study goal, planning objectives and limiting constraints.

Chapter 4 – *Plan Formulation and Evaluation:* discusses how plans were formulated, presents the cost effectiveness and ecological benefits of each alternative, and discusses the evaluation process used to identify the National Ecosystem Restoration (NER) plan and select a recommended plan.

Chapter 5 – *Environmental Assessment:* provides a description of potential impacts, both negative and positive, to cultural, ecological and physical resources within the surrounding environment and their significance.

Chapter 6 – *Plan Implementation*: discusses construction sequencing, monitoring and adaptive management, project costs and cost sharing responsibilities.

Chapter 7 – *Recommendation:* provides the District Commander's recommendation for authorization of an ecosystem restoration plan.

1.2 Study Authority

This study is being conducted in accordance with the study resolution adopted by the Committee on Environment and Public Works, United States Senate, July 20, 2005. The study resolution authority reads as follows:

"*Resolved by the Committee on Environment and Public Works of the United States Senate, that, the Secretary of the Army, is requested to review the report of the Chief of Engineers on the Illinois River, Illinois submitted in Senate Document Numbered 126, Seventy-first Congress, second session, and other pertinent reports, to determine whether any modifications to the South Fork of the South Branch of the Chicago River (commonly known as Bubbly Creek) for ecosystem restoration is advisable at this time.*"

1.3 Study Purpose*

One of the U.S. Army Corps of Engineers (USACE) five goals, as outlined in the Civil Works Strategic Plan[1], is to "Restore degraded aquatic ecosystems and prevent future environmental losses." This study addresses the need to identify and restore an ecosystem degraded by past activities. In response to the study authority, the study team completed a 905(b) Reconnaissance Report for the potential ecosystem restoration of Bubbly Creek. The Reconnaissance Report was approved in April 2007 and establishes Federal interest in the ecosystem restoration of Bubbly Creek and recommended cost-sharing of a Feasibility Study to investigate ecosystem restoration improvements to Bubbly Creek. On 16 August 2007, the City of Chicago signed a feasibility cost sharing agreement (agreement) with USACE to complete a Feasibility Study for the ecosystem restoration of Bubbly Creek and to provide fifty percent of the funding per the terms of the agreement.

USACE may carry out aquatic ecosystem restoration projects if the project will improve environmental quality, is in the public's interest, is cost effective and has a committed non-Federal sponsor. The purpose of this Feasibility Study is to identify ecosystem restoration measures that meet these criteria and to document and recommend either 1) "no action" or 2) a project that would restore important habitat at Bubbly Creek. The U.S. Environmental Protection Agency (USEPA), U.S. Fish & Wildlife Service (USFWS), Illinois Environmental Protection Agency (IEPA), Illinois Department of Natural Resources (IDNR), Metropolitan Water Reclamation District of Greater Chicago (MWRDGC), the Audubon Society Chicago, Canal Corridor Association, Openlands Project, Friends of the Chicago River, the Field Museum of Natural History, the John G. Shedd Aquarium, the Chicago Park District and The Wetlands Initiative are all critical and involved stakeholders.

1.4 Study Background*

Before the 1830's, the South Fork of the South Branch of the Chicago River (SFSB), colloquially know as "Bubbly Creek", was a prairie slough that drained five square miles of a pristine aquatic and interconnected terrestrial habitat. Over a period of several decades, this ecosystem was severely altered by human development. The first significant alteration to the Bubbly Creek ecosystem came in 1865 when the Union Stock Yards opened their doors and began disposing animal and other wastes into the slough. In order to facilitate waste drainage, the slough was deepened and widened turning into a drainage channel. The decentralization of the meatpacking industry in 1971 forced the Union Stock Yards to close after 105 years.

[1] U.S. Army Corps of Engineers. 2011. Sustainable Solutions to America's Water Resources Needs - Civil Work Strategic Plan 2011-2015. U.S. Army Corps of Engineers, Washington, D.C.

In the late 1880s and early 1900s, in response to Chicago's burgeoning population, the City of Chicago constructed a vast combined sewer system to collect sewage and storm water runoff. Initially, the untreated combined sewage was routed directly to area waterways including Bubbly Creek. Due to extremely poor conditions in the waterway, a connection to Lake Michigan was built to flush it with fresh Lake Michigan water during dry weather. In 1930, the Stickney Water Reclamation Plant (WRP) was constructed and dry weather flows that originally drained to Bubbly Creek were pumped via the Racine Avenue Pumping Station (RAPS) for treatment at Stickney WRP. Large rain events frequently filled the system to capacity forcing combined sewage overflow (CSO) to Bubbly Creek. However, as a result of improvements made to the Stickney WRP and the construction the first phase of the Tunnel and Reservoir Project (TARP), the frequency and volume of untreated CSO to Bubbly Creek has significantly decreased.

The study area includes the 1.25 mile long channel of Bubbly Creek and its immediate riparian zone. This channel is located entirely within the City of Chicago, Cook County, Illinois (***Figures 1 and 2***). Bubbly Creek is part of the Chicago Area Waterway System (CAWS).

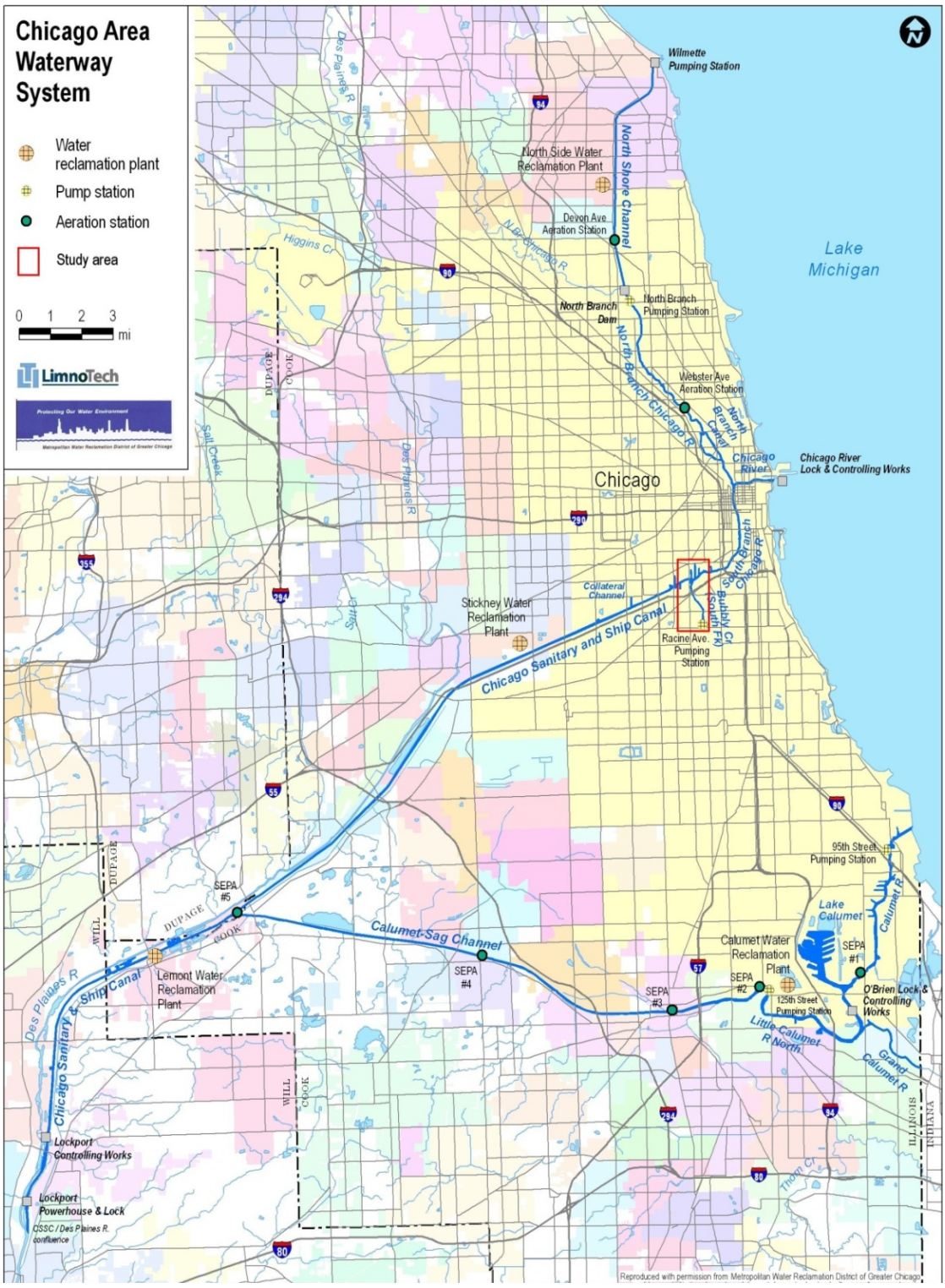


Figure 1: Location of Study Area within the Chicago Region

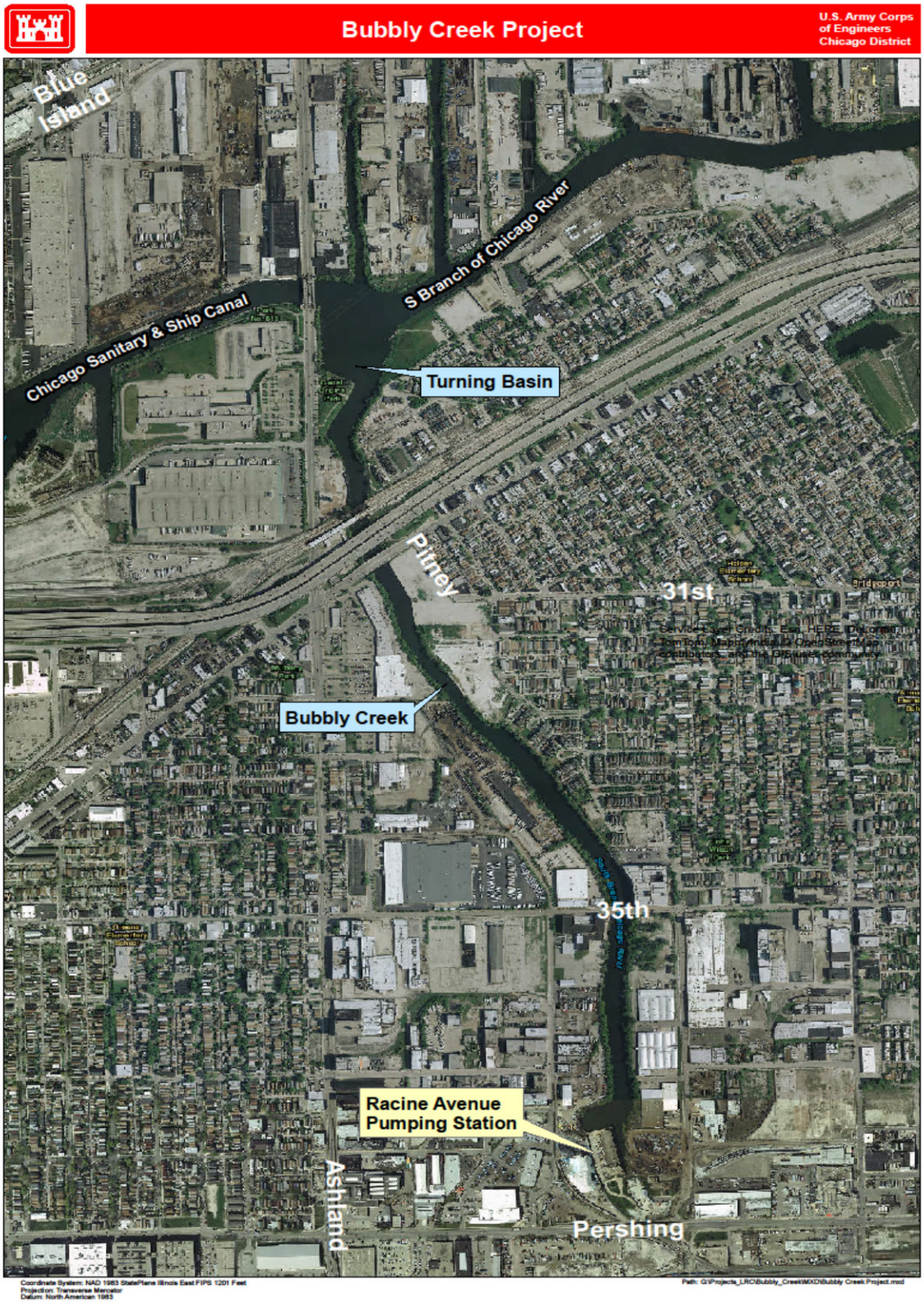


Figure 2: Vicinity Map of South Fork South Branch Chicago River, Bubbly Creek

1.4.1 USACE Federal Projects

The following section describes USACE federal projects that have been implemented or are underway within the study area, which are relevant to the ecosystem restoration of Bubbly Creek.

Bubbly Creek Turning Basin

A turning basin was constructed in 1906 to improve navigation on the Chicago River and is located at the confluence of the South Branch of the Chicago River (SBCR), Chicago Sanitary and Ship Canal (CSSC), and Bubbly Creek. In 1919, the turning basin was deauthorized. Since the deauthorization, the turning basin has been allowed to shoal in with sediment, and current depths range from less than 2 feet to a maximum of 8 feet.

Federal Navigation Channel

A portion of Bubbly Creek was designated as a federally-authorized navigation channel and in 1919, was deauthorized. The previously designated channel extended from approximately the extension of Lyman Street, which is about 900-feet south of Archer Avenue, north to the confluence of the SBCR. Bubbly Creek is no longer utilized for commercial navigation. The last industry to receive or deliver goods via the channel was Prairie Material who received aggregates by barge for a concrete plant located along the channel at the south end of the designated federal navigation channel. Prairie Material ceased operations in about 2005 and moved the equipment to an alternate facility located on a slip off the SBCR just east of the confluence of Bubbly Creek. The site was put up for sale and is currently being planned for residential and commercial development. The previously designated federal navigation channel has not been maintained since deauthorization, but provides sufficient depth for barge navigation. Current depths range from 9 feet to a maximum depth of 16 feet within the previously designated channel.

Tunnel and Reservoir Plan

The TARP was a direct result of the passage of the Clean Water Act in the early 1970s. The TARP was created to address severe water quality problems in the CAWS. The two main objectives of TARP are to improve water quality of area surface waters and to reduce flood damage caused by sewer backup. To do this, the project was broken up into two major phases.

Funded by MWRDGC and USEPA, the tunnel portion of the project, named the "Deep Tunnel" system is the first phase and primarily addresses surface water quality issues. This system consists of 109 miles of tunnel and has a capacity of 2.3 billion gallons. The primary benefit is the reduced volume of CSO discharged to waterways as the tunnels capture the "first flush" from the combined sewers. Drop shafts connect combined sewer systems to a network of underground tunnels at locations where CSOs would normally drain to surface waters. This entire phase of the project was completed in 2006. The second phase of the project, named the Chicago Underflow Plan (CUP), focuses on reducing flood damages caused by combined sewer back-ups that cause basement flooding within the Chicagoland area. This project was recommended by the Chief of Engineers to be implemented under the USACE flood control program and authorized in the Water Resources Development Acts of 1986 and 1988.

The USACE, Chicago District in partnership with the MWRDGC planned and designed three large reservoirs, McCook, Thornton, and O'Hare. These reservoirs will provide a combined 15.2

billion gallons (BG) of storage when completed. The O'Hare Reservoir was completed in 2000 and has a capacity of 0.35 BG. The Thornton Composite Reservoir is currently scheduled for completion in 2015 and will have a capacity of 7.9 BG. The McCook Reservoir is being constructed in two stages. Stage I is currently scheduled to be completed in 2017 followed by Stage II which is scheduled to be completed in 2027, with both stages totaling 7.0 BG of storage. MWRDGC, the local sponsor, has requested the expansion of the McCook Reservoir to a total capacity of 10.0 BG as a locally preferred plan. If approved, it's estimated completion date is 2029. The McCook Reservoir will receive CSOs generated in part within the Bubby Creek drainage basin. A reduction of both volume and frequency of CSO events are projected when Phase 1 of the McCook Reservoir is brought online, resulting in favorable water quality conditions necessary to sustainably restore Bubbly Creek.

1.4.2 Non-Federal Projects

The following section describes non-federal projects that have been implemented or are underway within the study area, which are relevant to the ecosystem restoration of Bubbly Creek.

Racine Avenue Pumping Station

Located at the southern end of Bubbly Creek, the RAPS has the capacity to discharge a maximum of 6,000 cubic feet per second (cfs) of combined sewer overflow (CSO) during an extreme overflow event. During extreme overflow events, the larger component of CSO is stormwater runoff. The facility, shown in ***Figure 3***, is owned and operated by the MWRDGC.

Figure 3: View of Racine Avenue Pumping Station from Bubbly Creek

In 1939, RAPS began operation by discharging raw sewage to Bubbly Creek. A decade later, dry weather sewage was no longer discharged to Bubbly Creek and instead diverted to the West Southwest Sewage Treatment Works, now called the Stickney WRP. The RAPS provides for the drainage of sewage and storm water from a 30 square-mile area that encompasses a significant

portion of the south side of Chicago from downtown to 87th Street. All sanitary waste and storm water from within this area is collected by local sewers and conveyed, by gravity, through four large intercepting sewers. These four large intercepting sewers converge at RAPS. The station originally had six pumps capable of discharging to either the interceptor running west along 39th Street or to Bubbly Creek. The station was expanded in 1954 and currently contains 14 centrifugal pumps with the following capacities: West Side: 3 units at 375-cfs, 2 units at 400-cfs and 2 units at 500-cfs; East Side: 3 units at 375-cfs, 4 units at 500-cfs.

During ordinary dry weather conditions, one pump is sufficient to pump sewage from RAPS to the Stickney WRP, located six miles west. During and following storm activity, combined sewage that exceeds the capacity of the Stickney WRP is first diverted to the TARP tunnels through three drop shafts located adjacent to RAPS. When the TARP tunnels are full, excess flow is diverted directly to Bubbly Creek as CSOs. During intense storms, all 14 pumps at RAPS have been operated in rare instances to discharge combined sewage overflow directly to the channel to prevent local flooding.

Canal Origins Park

Completed in 2004, Canal Origins Park, shown in ***Figure 4***, is located along the western bank of Bubbly Creek just south of the Turning Basin and commemorates the site where the Illinois & Michigan Canal began its connection between the Chicago River and Illinois River. This water connection facilitated the rapid development of Chicago and helped transform the city into a significant regional transportation hub. Canal Origins Park is the only park in Chicago that is an official City of Chicago Landmark. The park includes historical interpretation signage and sculptures depicting pre-settlement conditions and life on the channel around the time the canal was completed in 1848. The park also includes native plantings, fishing stations, and walkways. This park provides greenspace to Pilsen and Little Village hispanic neighborhoods where limited greenspace is available.

Eleanor Street Park and Boat House

A new Chicago Park District park is being developed on the eastern bank of Bubbly Creek at the confluence of the SBCR. The property was a former manufactured gas plant and was remediated by Peoples Gas as part of the USEPA Superfund Alternative Approach program. Currently, a non-motorized boat launch is located on the site and is utilized by high school and college rowing teams. A boat house and park improvements are being planned to serve as an anchor of the area's future river development. This park provides greenspace to Pilsen and Little Village hispanic neighborhoods where limited greenspace is available.

Figure 4: View of the Chicago River from Canal Origins Park[2]

1.5 Prior Studies and Reports

This section summarizes pertinent studies and reports that were completed within the study area and used in conducting this ecosystem restoration feasibility study.

1.5.1 USACE Reports

- USACE, Chicago District, Section 206 Preliminary Restoration Plan for the South Fork of the South Branch of the Chicago River (Bubbly Creek), Chicago Illinois, 2003.

USACE received a letter from the City of Chicago, Department of Environment in July 2002 requesting assistance under Section 206 of the Continuing Authorities Program (CAP) to address problems with degraded aquatic habitat in the Chicago River in the vicinity of Bubbly Creek. The USACE produced a preliminary restoration plan (approved May 2003) for Bubbly Creek recommending further study under the CAP Section 206 authority. Early in the feasibility phase of the Section 206 study, the estimated costs of the project were determined to exceed the Section 206 authority project limits and the project was converted to a specifically authorized project.

[2] Dale Bowman, "Revisting Origins Park," Chicago Sun-Times, July 7, 2008, http://blogs.suntimes.com/bowman/2008/07/revisiting_and_fishing_origins_1.html.

- USACE, Chicago District, 905(b) Analysis Reconnaissance Report, Bubbly Creek, South Branch of the Chicago River, August 2006.

The purpose of this reconnaissance study was to identify ecosystem restoration opportunities that the Federal Government would have an interest in studying further. In response to a Senate study resolution in July 2005, a reconnaissance study was initiated in January 2006. The reconnaissance study identified a Federal interest in the restoration of Bubbly Creek and recommended participation in a cost-shared feasibility study to investigate ecosystem restoration improvements to Bubbly Creek. In April 2007, USACE Great Lakes and Ohio River Division approved the 905(b) Reconnaissance Report. After approval of the reconnaissance report, USACE developed a Project Management Plan (PMP) for the Feasibility Study and in August 2007 executed a FCSA with the City of Chicago as the non-Federal sponsor.

1.5.2 Other Studies and Reports

- USEPA, Great Lakes National Programs Office, October 2000 and August 2002 Survey of Sediment Contamination in the Chicago River, Chicago, Illinois, July 2003.

The USEPA's Great Lakes National Program Office (GLNPO) performed a survey of Bubbly Creek in which they took 12 sediment samples in October 2000 along with five (5) additional samples collected in August 2002. Upon analyses of the data collected, GLNPO recommended that further sampling be done. Bubbly Creek as well as other sections of the Chicago River were found to contain high concentrations of total organic carbon (TOC). The contaminant concentrations in the Bubbly Creek sediment cores were similar to the concentrations found in the other three nearby downstream sediment cores. None of the samples collected and analyzed along the South Branch of the Chicago River, including the Bubbly Creek sample, contained polychlorinated biphenyl (PCB) concentrations above the Toxic Substances Control Act (TSCA) threshold.

- MWRDGC, Research and Development Department, Bubbly Creek Water Quality Improvement Demonstration Project in 2002, Report 03-01, 2003.

This report provides results of a demonstration project performed in the summer of 2002 by the MWRDGC with the goal of improving water quality in Bubbly Creek. The demonstration project involved opening a gate at RAPS to allow water from Bubbly Creek to enter and be pumped to the Stickney WRP, thereby establishing a flow in the channel when otherwise it would have been stagnant. The demonstration project lasted about 3 months and approximately 2.5 billion gallons were drawn through the channel and treated at the WRP at an estimated cost of $625,000. Water quality monitoring showed a marked improvement to dissolved oxygen (DO) concentrations during dry weather flows and recommendations for further demonstration project operations were made.

- MWRDGC, Research and Development Department, 2003 Bubbly Creek Water Quality Improvement Demonstration Project, Report 04-08, 2004.

This report provides results of a second-year demonstration project performed by the MWRDGC with the goal of improving water quality in Bubbly Creek. This additional demonstration project investigated a wider range of flows than the initial study. The demonstration project lasted six months and approximately 2.1 billion gallons were drawn through the channel at an estimated

cost of $525,000. Hydrologic conditions varied more in the second-year demonstration project than in the first-year project in that CSO discharges numbered eight overflow events versus two the previous year. Water quality monitoring showed marked improvements to DO concentrations during dry weather flows and reductions in periods of low DO following CSO events. Recommendations for further study of sediment oxygen uptake and the impact of algal respiration on DO levels were made. The report concluded that the method of artificial flow creation used in this demonstration project cannot be used as a long-term solution for the water quality improvements in Bubbly Creek since it requires capacity at the WRP that may not be available in wet weather along with significant additional operating costs.

- City of Chicago, Department of Planning and Development, Chicago River Corridor Design Guidelines and Standards, April 2005.

The Chicago River Corridor Design Guidelines and Standards provide an outlined framework for the revitalization of the Chicago River as an update to the 1999 City of Chicago, Chicago River Corridor Development Plan. This plan was written with the following five (5) goals in mind:

- Restore and protect natural habitats along the river, particularly fish habitat.
- Create a connected greenway with continuous multi-use paths along at least one side of the river.
- Increase public access to the river through the creation of overlooks and public parks.
- Develop the river as a recreational amenity, attracting tourists and enhancing Chicago's image as a desirable place to live, work and visit.
- Encourage economic development compatible with the river as an environmental and recreational amenity.

The implementation of this plan has helped increase the amount of public and private investment, overall improving the river as Chicago's greatest natural amenity. This document also specifically calls attention to Bubbly Creek and the development needed in the area.

- City of Chicago, Chicago River Agenda, June 2005.

The Chicago River Agenda provides a guide for the City of Chicago for future improvements to the Chicago River and briefly highlights the City's efforts toward revitalizing the Bubbly Creek area. The report outlines four (4) goals, which include the following:

- Improving water quality,
- Protecting nature and wildlife in the city,
- Balancing river uses, and
- Enhancing neighborhood and community life.

- MWRDGC, Chicago Area Waterway System Habitat Evaluation and Improvement Study: Habitat Evaluation Report, Prepared by LimnoTech, November, 2009.

The report summarizes a study of the aquatic habitat within the CAWS. The study included characterizing physical habitat, determining the relative importance of habitat and developing a system for categorizing reaches of the CAWS. Six key variables were determined to be important factors for physical fish habitat and they included maximum depth of channel, off-channel bays, percent of vertical wall banks in each reach, percent of riprap banks in reach, manmade structures in reach, and percent macrophyte cover in reach. These parameters were then used to create a CAWS specific habitat suitability index (HSI).

CHAPTER 2 – STUDY AREA INVENTORY & FORECASTING*

An inventory and forecast of critical resources (physical, demographic, economic, social, etc.) relevant to the problems and opportunities under consideration in the planning area was developed. This information is used to define and characterize problems and opportunities associated with ecosystem degradation. A quantitative and qualitative description of these resources is made, for both current and future conditions, and is used to define existing and future without-project conditions. Existing conditions are those at the time the study is conducted. The forecast of the future without-project condition reflects the conditions expected during the planning period of analysis. The future without-project condition provides the basis from which alternative plans are formulated and impacts are assessed. Since impact assessment is the basis for plan evaluation, comparison and selection, a clear definition and full documentation of the without-project condition is essential. Gathering information about historic and existing conditions requires an inventory. Gathering information about potential future conditions requires forecasts, which should be made for selected years over the period of analysis to indicate how changes in economic and other conditions are likely to have an impact on problems and opportunities. The analysis was broken down in the following three conditions:

- An inventory of relevant *historic* conditions;
- An inventory of relevant *current* conditions and the studies that were completed to establish those conditions; and
- A forecast of *future* without-project conditions.

2.1 Historic Conditions

Historically, the Chicago River system was a wetland complex that flowed sluggishly east into Lake Michigan. Bubbly Creek and its tributaries were once clear, braided prairie sloughs that slowly drained a marshland of about 5 square miles. This ecosystem provided aquatic and terrestrial habitats for many species, both migratory and resident.

Timelines are a simple tool that can help understand events and trends providing insight into how current conditions were formed along with a sense of how conditions have changed over time. The following timeline is presented as a tool for understanding how the past has shaped Bubbly Creek aquatic habitat of today. A narrative of significant events as they relate to the severe ecological degradation of the creek follows the timeline:

Pre-1830s	Bubbly Creek is a biologically diverse prairie slough.
1830s	First slaughterhouse in Bridgeport constructed.
1836	Illinois & Michigan Canal construction begins.
1840s	Large influx of Europeans immigrate to Chicago.
1848	Illinois & Michigan Canal opens.
1863	Bridgeport annexed into Chicago.
1865	Union Stock Yards opens.
1871	Great Chicago Fire destroys portions of the City.
1889	Stockyards annexed to Chicago.
1900	Chicago Sanitary and Ship Canal is completed.
1906	Turning basin constructed at mouth of Bubbly Creek
1908	Central Manufacturing District is initiated.
1920	Population peaks in communities surrounding Bubbly Creek.
1923	West Arm of Bubbly Creek filled.

1939	RAPS constructed, sewage treated at Stickney WRP, only excess CSOs at Bubbly Creek.
1950s	Stockyards decline.
1960s	Population decline in area.
1971	Union Stock Yards closes.
1979	Friends of the Chicago River is founded.
1980s	Change in business base in area.
1984	Illinois and Michigan Canal named 1st Canal National Heritage Site.
2004	Canal Origins Park constructed.
2005	Last navigation wharf closes and City of Chicago launches the Chicago River Agenda.
2007	Bubbly Creek Reconnaissance Study approved.
Present	Residential use increases in area/community and City of Chicago in partnership with USACE to pursue restoration of Bubbly Creek's former biologically diverse ecosystem.

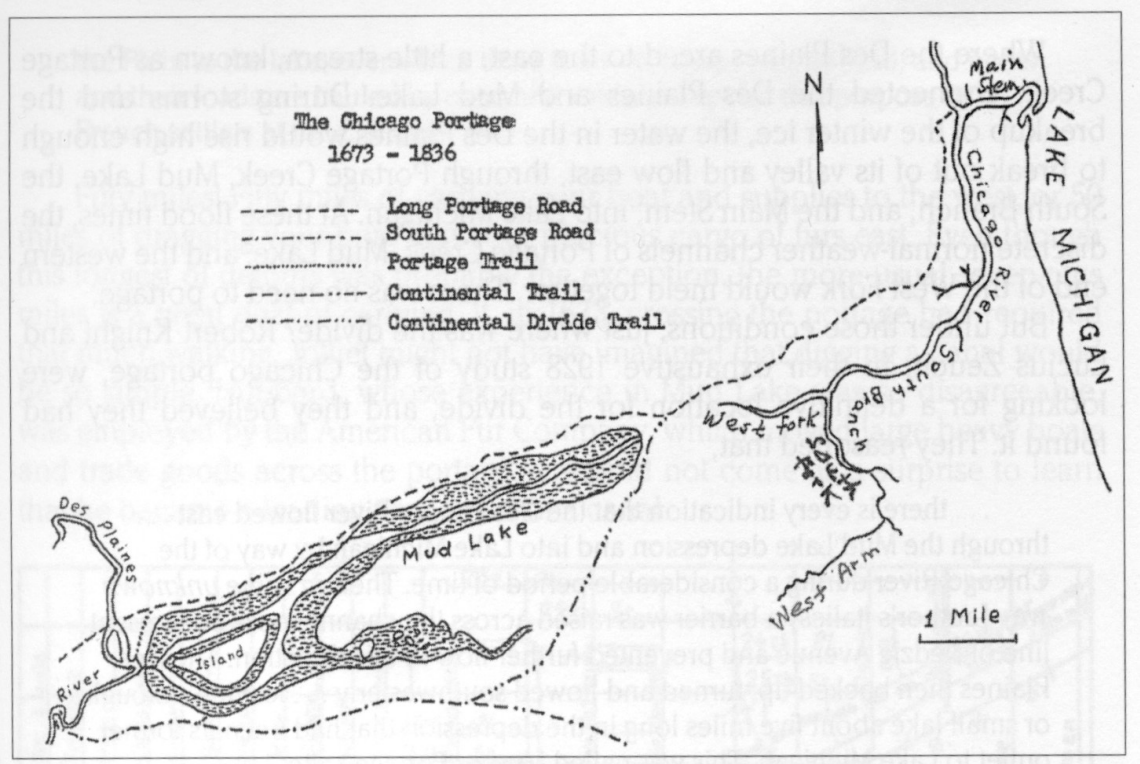
As is evident from the chronology provided above, Bubbly Creek's ecosystem was severely altered by human development over a period of several decades. This development can be loosely grouped as follows:

- Navigation Improvements
- Industrial Development
- Combined Sewer System Construction

The drainage area of the Chicago River was unique in that its boundary with the Des Plaines River to the west formed a continental divide separating the Great Lakes/St. Lawrence River basin from the Mississippi River basin. One location along the continental divide called Mud Lake, just two miles west of Bubbly Creek, was quite flat, allowing sporadic overflows to the Mississippi River basin or Lake Michigan during spring floods, which periodically connected these large basins. This geomorphic feature allowed for a temporal hydrologic connection between the two basins. Chicago's earliest settlers recognized the potential to connect the Chicago River to the Des Plaines River as shown in ***Figure 5***.

Beginning in the early 1800s, thehydrologic regime of the Chicago River and connected tributaries was altered by the construction of several channels for navigation and wastewater conveyance. The Illinois and Michigan (I&M) Canal, originating at the confluence of Bubbly Creek and the SBCR, was completed in 1848. This canal created a continuous water trade route between the Great Lakes and Mississippi River basins by connecting the Chicago River to the Illinois River and sparked the rapid growth and development of the Chicago area. In 1900, a larger connection was created with the completion of the CSSC that connects the SBCR at the confluence with Bubbly Creek to the Des Plaines River at Lockport, Illinois. The completion of the CSSC resulted in the permanent reversal the flow of the Chicago River and its drainage from Lake Michigan to the Illinois River.

In 1865, the Union Stock Yards began operation along the banks of Bubbly Creek. The small stream became the disposal site for animal carcasses from the meatpacking industry. The creek was systematically deepened and widened to allow for drainage and disposal of wastes from the nearby meatpacking industries. In 1919, Bubbly Creek was last maintained by USACE. In 1923, the last tributary to Bubbly Creek, the West Arm of the South Fork, was filled. After 105 years of meat production, the Union Stock Yards closed in 1971. The legacy of the Union Stock Yards continues to impact Bubbly Creek and the surrounding landscape. Today, biochemical reactions caused by decomposing animal waste produces methane and hydrogen sulfide gas. These bubbles float to and break at the water surface, for which the name "Bubbly Creek" is colloquially given.



Courtesy of Philip E. Vierling.

Figure 5: Historic portage choices from Chicago River to Des Plaines River

Beginning in the mid 1800s, a massive combined sewer system was constructed to collect sanitary waste and storm runoff and convey them to the Chicago River and its tributaries. This was the first comprehensive storm sewer system constructed in the United States and was implemented over several decades by first building the sewer system above ground and then raising all of the existing buildings as much as ten feet using an elaborate system of jacks. During this time a sewer system comprising a 30 square mile area of the central and south side of Chicago was constructed to flow by gravity to Bubbly Creek. As a result, conditions in the channel degraded and consequently, a bypass connection was constructed to pump fresh water from Lake Michigan to the channel to flush the waterway during dry weather. In 1939, RAPS began diverting dry weather flows to the newly constructed Stickney WRP for treatment instead of directly discharging sanitary waste to Bubbly Creek. Over the years, increases to the treatment capacity of the WRP and the construction of the deep tunnel system as a part of the TARP have drastically reduced the volume of CSOs diverted to the area's rivers, including Bubbly Creek.

2.2 Physical Resources*

This section presents the current conditions for those physical resources that would be affected by this project, affect the sustainability of this project, or possess reference conditions an ecosystem restoration project would target for replication.

2.2.1 Geology, Glacial Stratigraphy and Soils

The Wisconsinan glaciation and the resulting Glacial Lake Chicago shaped the Bubbly Creek study area. Silurian bedrock in the study area is overlain by as much as 100 feet of till and lacustrine sediments of the Carmi Member of the Equality Formation. The Equality Formation is primarily composed of silts, sands, gravels and clays that resulted from glacial lake deposition[3]. In the study area, this material typically consists of Glacial Lake Chicago sediments; dominantly well-bedded silt, locally laminated and containing thin beds of clay; local lenses of sand and sandy gravel along beaches. The natural soils that formed in the study area developed in silty and clayey lakebed sediments. They typically had a silty loam or silty clay loam surface layer that was dark-colored and relatively high in organic matter. The subsoil and substratum were probably most similar to the Del Rey, Martinton, and Milford soil series. In areas where wetlands occurred, the soils contained freshwater derived layers (sedimentary peat), which were composed predominantly of caprogenous material derived from aquatic animals (i.e. frogs/bird guano). All natural geology, soils, fluvial materials and wetland deposits are currently gone from the study area.

2.2.2 Sediment Quality

The sediment within Bubbly Creek reflects the history of the area. Originally containing a mixture of fine grained materials placed by a combination of glacial, lacustrine, fluvial and aeolian processes, the sediment bed has been highly impacted by past industrial and other urban activities within the drainage area. Discharges of animal waste from the former stockyard industry and urban waters, including CSOs, have resulted in a fine-grained, highly organic, anaerobic material which is known for gas production. Due to the well documented history of this channel several field investigations were conducted that determined chemical and physical properties of the existing sediments; these investigations are summarized below.

Physical Analysis

In September 2008, a geotechnical subsurface exploration and investigation was conducted (Appendix D). Three Standard Penetration Test (SPT) borings were advanced and 179 Cone Penetrometer Tests (CPTs) were completed. Based on information gathered during this investigation, stratigraphy and thickness, water depth, and engineering properties of the subaqueous materials were evaluated. The sediment thickness is considered to be the depth of the non-native material above the natural glacial till layer. The range of sediment depth is approximately 8 to 18 feet with the average sediment depth is approximately 13 feet. The sediment is generally thickest upstream of the 35th Street Bridge and is thinner where the channel constricts at West 34th Street. The thickness of the sediment increases at Canal Origins Park, just south of the turning basin. Generally, the subaqueous material can be divided into a top layer characterized by somewhat coarser materials, and the bottom layer is characterized as layers of very soft silty sand, silt, and clay. Beneath the organic materials is native hardpan, which is significantly denser and stiffer in comparison with the overlying materials and ranges from a silt and sand mixture to a silt and clay mixture. The CPT generally classifies this material as organic peat to clays, clay to silty clay. Visually and supported by grain size analyses, this material was

[3] Willman, H.B. and J.C. Frye. 1971. Pleistocene Stratigraphy of Illinois. Illinois State Geological Survey Bulletin, vol. 94, 162 pp.

classified as layers of silty sand, silt and clay. The majority of the banks areas are classified as clayey glacial till and silt.

Chemical Analysis

The sediment within Bubbly Creek is heavily influenced by meat processing animal wastes and untreated sewage that was once directly deposited into the channel. Biochemical reactions within the material caused by anaerobic organic decomposition produce methane and hydrogen sulfide bubbles that frequently float to the surface sometimes carrying clumps of sediment made buoyant by entrapped gas bubbles as shown in ***Figure 6*** below. These clumps eventually sink when entrained gas vents to the atmosphere. Odors produced by the gases and the appearance of these clumps are aesthetically unpleasing. The IEPA, USEPA, MWRDGC, and USACE have all performed past sampling and bulk chemistry analyses, which are consistent among all sampling results.

Figure 6: Sediment floating on the surface of Bubbly Creek

Sediment Chemistry Sampling and Analysis

The USACE collected the bulk of sediment information in the spring of 2004. Thirteen (13) core samples and five (5) grab samples along the entire length of Bubbly Creek were sampled and analyzed. Results of bulk chemistry and Toxicity Characteristic Leaching Procedure (TCLP) testing show that sampled sediment does not exceed toxicity criteria established under the Resource Conservation and Recovery Act (RCRA), or maximum allowable PCB concentrations established under the Toxic Substance Control Act. Sediment samples all showed elevated levels of Polycyclic Aromatic Hydrocarbons (PAHs) and heavy metals. The sample results were compared to the IEPA's Tiered Approach to Corrective Action Objectives (TACO) residential

and industrial/commercial ingestion levels. Some sediment samples contained semi volatile organic compounds (SVOCs), besides PAHs, and volatile organic compounds (VOCs) below IEPA's Tiered Approach to Corrective Action Objectives (TACO) residential ingestion levels. Some sediment samples also exceeded PAH, PCB, and heavy metal IEPA TACO industrial/commercial ingestion levels. Other detected contaminants included oil and grease and nutrients.

On 24 September 2010, USACE & USEPA collected five samples in the vicinity the original sampling location SF-2004-B02 that tested positive for ignitability. One sample was collected in the area where the original sample was taken and four samples in the areas just upstream and downstream of that original sampling point, between the original sampling point and the two adjacent sampling locations where samples were collected in 2004 that did not exceed the ignitability criteria. None of the samples collected in 2010 tested positive for ignitability.

Results from the 2004 and 2010 analysis indicated that the material was not found to be characteristically toxic, corrosive or reactive per 40 Code of Regulations (CFR) 261.20-24 (Subpart C).

Sediment Gas Ebullition and Flux Analyses

The University of Illinois at Chicago, with MWRDGC's assistance, conducted a series of sediment gas ebullition and flux studies at nine (9) locations within Bubbly Creek over four seasonal periods. The purpose of the gas ebullition studies was to measure how gas production varies spatially across the channel, with temperature and by season. The purpose of the benthic flux study was to measure PAHs, metals, and other dissolved constituent flux from the sediments, as well as measurements of dissolved oxygen flux into the sediments with time. Flux is the rate of transfer of contaminants across the sampled surface. Gas ebullition is the production of bubbles. Details of the analyses can be found in Appendix F and are summarized in the following paragraphs.

The ebullition and flux study results suggest elevated metal fluxes may occur due to particle re-suspension. Higher gas ebullition fluxes result in more sediment re-suspension and higher release of metal contaminants. Both metal and PAH flux to the water column due to gas ebullition varied greatly by season with the highest rates observed in spring. Winter fluxes approached zero to negative values (i.e., flux from the water column into the sediment). In all cases measurable metal fluxes were higher than observed PAH fluxes.

Sediment oxygen demand and ammonia release was highly variable by site, consistent with the observed variation in sediment organic matter content. Ammonia flux was always from sediment to water and sediment oxygen demand was always positive (loss of oxygen from the water column to the sediment).

Overall, methane (CH_4), nitrogen (N), and carbon dioxide (CO_2) comprised 58$\pm$19%, 36$\pm$18%, and 3$\pm$2% of the gas by volume, respectively. These gases are produced by the anaerobic decomposition that takes place in swamps. Swamp gas collected from Minnesota swamps had similar composition (***Table 1***). [4] The majority of these swamps are glacially derived lakes that

[4] Swain, F.M. 1986. Composition of marsh gases in the central and eastern United States. *Applied Geochemistry* 1:301-305.

appear to be supporting diverse fish communities (based on recent fish collection data) that would be representative of a healthy aquatic ecosystem.

Table 1: Swamp gas composition from Minnesota swamps

Location	H	CH_4	C_3H_8	CO	CO_2	N_2	H_2S	Others	pH	Eh
Fish Lake, MN	0.05	55.32	0.00	0.0	3.75	39.97	0.0		5.1	+110
Anderson Pond, MN	0.09	81.18	0.02	0.0	8.87	9.53	0.0		5.9	+20
Cedar Creek Bog Lake, MN	0.06	77.40	0.00	0.0	3.20	18.79	0.0	Ethane-Trace	5.9	0.0
Mille Lacs Lake No. 1, MN	0.06	66.87	Trace	0.0	4.17	28.13	0.0		6.1	+212
Mille Lacs Lake No. 2, MN	0.07	76.40	0.00	0.0	4.45	18.33	0.0	Ethane-Trace n-butane-Trace	-	-
Mille Lacs Lake No. 3, MN	0.08	81.53	0.03	0.0	9.68	8.18	0.0	Ethane-Trace	-	-

†H-Hydrogen; CH_4-Methane; C_3H_8-Propane; CO-Carbon Monoxide; CO_2-Carbon Dioxide; N_2-Nitrogen; H_2S-Hydrogen Sulfide

In sum, ebullition rates at the sample locations varied by site and season (with generally higher ebullition rates in spring and summer), but annual average rates were comparable between the sample locations. The ebullition study results were used to inform the substrate layer design and analysis.

2.2.3 Water Quality

Bubbly Creek is classified for Secondary Use by the Illinois Pollution Control Board (IPCB), which indicates the water is only suitable for limited contact activities such as boating and fishing (Section 35 Illinois Administrative Code Section 303.441). Bubbly Creek is also listed as an impaired stream by IEPA according to Section 303(d)[5] of the Clean Water Act. The listed causes of impairment include high pH, low dissolved oxygen, and high total phosphorus with CSOs as the primary source of impairment. The CSO events carry floatable debris into Bubbly Creek and breaking gas bubbles seriously degrade the visual aesthetics of the water body. The water quality of Bubbly Creek has been improving over the last decade as illustrated in the data sampling. If suitable habitat were available, Bubbly Creek's current water quality would still affect species richness by excluding those aquatic species sensitive to poor water quality degradation.

During dry weather conditions, Bubbly Creek mimics those conditions found in a eutrophic lake. The DO levels are highly indicative of poor water quality. Photosynthetic activity in the water body can cause DO levels to rise above saturation levels (16 mg/L O_2 during the day) and fall to near 0 mg/L at night.[6] Following CSO discharges to Bubbly Creek, periods of low DO can range from one (1) to two (2) weeks in length.[4]

[5]Illinois Environmental Protection Agency. 2012. Illinois Integrated Water Quality Report and Section 303(d) List - 2012. Illinois EPA Bureau of Water, Springfield, IL.

[6] Sopcak, Michael. 2004. 2003 Bubbly Creek Water Quality Improvement Demonstration Project. Report No. 04-8. Metropolitan Water Reclamation District of Greater Chicago, Chicago, IL.

Observations of MWRDGC Water Quality Data

Another way the study team assessed the current water quality conditions in Bubbly Creek was to evaluate water quality data obtained from monthly samples collected by MWRDGC in Bubbly Creek at the Archer Avenue monitoring location (designated Sampling Station 99 by MWRDGC).[7] The samples were collected from 2001 through 2008. Parameters that were analyzed by MWRDGC include general water quality characteristics, nutrients, metals (total and dissolved). Several parameters appear to fluctuate seasonally, with concentrations being lower during the warmer and wetter months (generally May through October). These parameters include: dissolved oxygen, nitrite + nitrate, total phosphorus, sulfate, total dissolved solids, chloride, fluoride, total organic carbon and cyanide. For conservative parameters, those that are not generated or destroyed in the channel (chloride, fluoride, and total dissolved solids) the mechanism for variation in concentrations with the seasons is dilution due to higher precipitation volumes in the warmer months. This also assumes that the precipitation volumes do not have high levels of these parameters, which is generally true for chloride, fluoride, and total dissolved solids (TDS).

The levels of several parameters that are indicators of poor water quality have been decreasing in the channel during the time period of evaluation (2001-2008). These parameters include: cyanide, TOC, ammonia, total Kjedahl nitrogen (TKN), fats, oil, and grease (FOG), and phenol. In addition, average DO levels increased during this period, consistent with improving water quality. The water quality improvements are thought to be the result of Clean Water Act restrictions and the TARP tunnels coming online in the early 2000s. It is also important to note that the average annual concentration of these parameters have shown improvements, but the average annual concentrations do not take into account periods of poor water quality, for example, extended periods of low DO levels in the channel water in the summer.

Although the average DO levels in the channel increased from 2001 through 2008, four (4) incidences of non-compliance of the Secondary Contact Standards for DO levels were measured in the samples collected in 2008 (out of twelve samples). The DO violations had been decreasing prior to 2008, with six violations each in 2001 and 2002, two violations each in 2003 and 2004, and one violation each in 2005, 2006, and 2007. ***Figure 7*** shows levels of DO for Bubbly Creek from 2001 through 2008. Also depicted is the IPCB Secondary Contact Water standard for DO – 4 mg/L. Any measurement below 4 mg/L is in violation of the Secondary Contact Standard.

[7] Data are available at http://www.mwrd.org/irj/portal/anonymous/WQM.

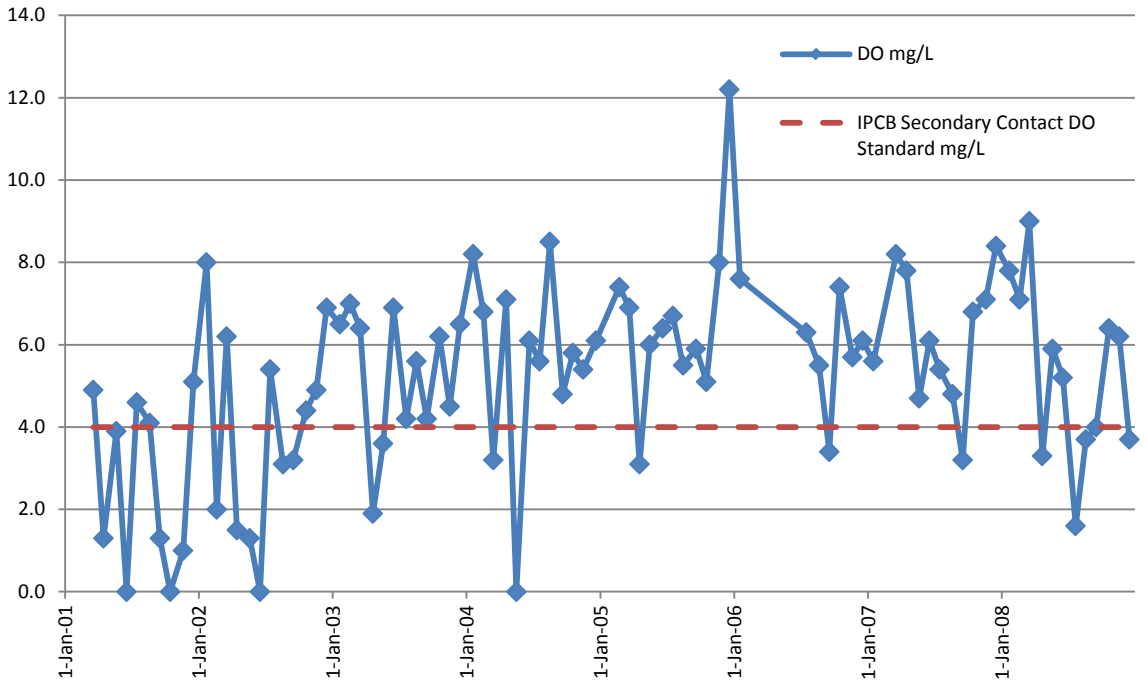


Figure 7: Oxygen Concentrations in Bubbly Creek from 2001 through 2008

There were no observable seasonal trends for most of the metals (total and dissolved). Some metals were observed to decrease during the time period of evaluation (2001 to 2008). These metals included: arsenic, copper, iron, nickel, silver, and zinc. The decrease in the levels of some of the metals is consistent with improving water quality in the channel as discussed above.

2.2.4 Hydrology & Hydraulics & Groundwater Hydrology

Flow in Bubbly Creek occurs only during rain events large enough to cause surface runoff from surrounding impervious areas, CSOs from gravity sewers or overflow pumping from RAPS. The overall contribution of groundwater is expected to be negligible because all available data indicated that the material below the highly organic sediment on the channel bottoms and the majority of the banks areas are clayey glacial till and silt. This means that very little groundwater flow is epxected through these low permeability side slopes and channel bottom. Following light rainstorms, flow in Bubbly Creek is not noticeably changed because most rainfall runoff is captured in the combined sewer system and conveyed to the Stickney WRP. During heavy rainstorms when the capacity of the sewer system is exceeded, CSO is discharged into Bubbly Creek. When CSOs enter the channel, the water level rise forces flow towards the South Branch of the Chicago River. At maximum capacity RAPS can discharge approximately 6,000 cfs, raising the water level at 38th Street about three feet and increasing the channel's water velocity to as much as five feet per second.[8] The river on the downstream side of the Chicago Lock is maintained at -2.0 referenced to the Chicago City Datum (CCD) and Bubbly Creek is typically at -2.3 CCD. During a major storm event, MWRDGC can backflow water within the CAWS to

[8] Lanyon, Richard. 2003. Bubbly Creek Water Quality Improvement: A Demonstration Project in 2002. Report No. 03-1. Metropolitan Water Reclamation District of Greater Chicago, Chicago, IL.

Lake Michigan by opening sluice gates and lock gates at the Chicago River Controlling Works (CRCW) when river stages reach +3.0 CCD. The MWRDGC reduces instances of flooding Chicago neighborhoods by following these procedures, but does not completely safeguard against sewer backups and basement flooding. The completion of the tunnel portion of TARP has reduced the frequency of overflows to Bubbly Creek and when the Phase 1 McCook Reservoir portion is completed, the TARP Project will further reduce the frequency and volumes to Bubbly Creek, but will not eliminate all CSOs.

Bubbly Creek serves as an important conveyance route for CSOs generated within the central and southern neighborhoods of Chicago as it receives RAPS overflows during extreme rainfall events. As a planning constraint, recommendations must not restrict or limit Bubbly Creek's conveyance capacity for RAPS overflows. As such, two conditions were identified 1) current conditions: how RAPS overflows affect Bubbly Creek, and 2) future conditions: how the scheduled completion of the McCook Reservoir will affect RAPS overflows and the hydraulics of Bubbly Creek. Additionally, modeling described in the following sub-sections was used to determine how channel hydrology and hydraulics would be affected by various restoration measures.

Bathymetry

A seamless bottom surface of Bubbly Creek was used to develop the two hydraulic models created for this study. A triangular irregular network (TIN) was created using the following three (3) data sources:

- USACE, Rock Island District Hydrosurvey of Bubbly Creek; collected February 2009
- Illinois U.S. Geological Survey, Bubbly Creek Bathymetry Survey; collected March 2007
- Cook County Light Detection and Ranging data; collected April 2003.

Bubbly Creek water depths vary from approximately six (6) feet near RAPS to 14 feet at its mouth and the channel varies between 120 to 200 feet wide.

Data Collection

Data used to model CSO discharges into Bubbly Creek and evaluate substrate restoration requirements were gathered from a variety of sources. The data included, but were not limited to, a 58 year period of record from the Illinois State Water Survey precipitation records from January 1949 to September 2007; MWRDGC water quality parameters at RAPS and in Bubbly Creek; RAPS operation plans; and geotechnical properties of the sediment. This information was used in developing the models identified in this section.

Storm Water Management Model (SWMM)

To estimate the volume and frequency of overflows that are discharged into Bubbly Creek from RAPS and the nine (9) combined sewer outfalls located along the creek, USACE developed a SWMM for the sewer-shed that drains into RAPS. The model provided the following output: 1) the volume of combined sewage that is discharged into the TARP drop shafts, from RAPS into Bubbly Creek, and from the combined sewer outfalls located along Bubbly Creek; 2) the frequency and volumes at which these discharges are expected to occur; and 3) information on water quality parameters. Both current and future conditions were modeled.

Current conditions included the existing TARP tunnels without the future reservoir. Future conditions took into account changes in discharge volumes, frequencies and water quality parameters due to the scheduled completion of the McCook Reservoir (including Stage 1 and Stage 2). Runs for future conditions included two operational scenarios, one with all drop shafts open during the event and one with selected drop shafts closed during part of the tunnel pressurization phase. This second operational scenario was based on earlier model results that indicated a high potential for geysering unless certain drop shafts were closed during the tunnel pressurization phase and resulted in more conservative results.

Tunnel Network (TNET) Model

The TNET model is a one dimensional unsteady flow hydraulic model that is a unique application of UNET for pressurized flow in conduits. The TNET model simulates the interception of sewer discharges to the drop shafts and routes the flow through the TARP tunnels and into the future McCook Reservoir. It also simulates the operations of the main inlet gates to the reservoir as well as pump down operations of the tunnels and reservoir. For the purpose of this project, the TNET model simulates the TARP tunnel stages. The tunnel stages in the vicinity of RAPS are used as a boundary condition for the SWMM model which uses this data in determining if flows at RAPS are routed into the sewer interceptors, the drop shafts connected to the TARP tunnels, or pumped to Bubbly Creek as CSO discharges.

Hydraulic Engineering Center – River Analysis System (HEC-RAS) Model

A HEC-RAS model was developed for the purpose of determining stage impacts on Bubbly Creek resulting from ecosystem restoration features, primarily restoring the channel substrates and the addition of channel vegetation for the with project condition. The addition of substrate can affect the conveyance area of the channel, which could result in an increase in stage for some storm events. Inclusion of vegetation in the channel could affect channel roughness and possibly result in an increase in stages for some events. The model includes 40 cross sections that define the 1.25 mile reach extending from the Racine Avenue Pump Station (RAPS) north to the confluence with the South Branch of the Chicago River.

Curvilinear-grid Hydrodynamics Model in Three-Dimensions (CH3D) Model

The USACE Engineering Research and Development Center, Coastal and Hydraulics Laboratory (ERDC-CHL) developed a CH3D hydraulic model of the channel. The CH3D model computes flow velocities, water level elevations, water temperature and the residence time of water within Bubbly Creek and generates mixing predictions. This model allowed us to evaluate erosion potential and armoring requirements of the various restoration features. The SWMM model provided model inputs including RAPS pumping information and CSO discharges.

2.2.5 Recognized Environmental Conditions (REC) Investigation

The Phase I Site Investigation Report completed in 2006 (Appendix F) describes the methods employed while conducting the Hazardous, Toxic and Radioactive Waste (HTRW) investigation per Engineering Regulation (ER) 1165-2-132, HTRW Guidance for Civil Works Project; identifies associated environmental issues; and provides conclusions and recommendations regarding potential environmental impacts associated with the proposed restoration project.

Figure 8 compiles the information obtained during the REC investigation to inform plan formulation.

Per the American Society for Testing and Materials (ASTM) E1527-13 – Standard Practice for Environmental Site Assessments, the term recognized environmental condition (REC) means "the presence or likely presence of any hazardous substances or petroleum products in, on, or at a property: (1) due to any release to the environment; (2) under conditions indicative of a release to the environment; or (3) under conditions that pose a material threat of a future release to the environment." The term is not intended to include de minimis conditions that generally do not present a threat to human health or the environment and that generally would not be the subject of an enforcement action if brought to the attention of appropriate governmental agencies. Also per ASTM E1527-13 "De minimis conditions are not recognized environmental conditions."

Bubbly Creek sediment is a REC. The condition of the substrates reflects the anthropogenic impacts to the environment. ***Figure 8*** shows sediment sampling locations from a comprehensive sampling event in 2004. The sediment sample analytical results were compared to Illinois Environmental Protection Agency's Tiered Approach to Corrective Action Objectives (TACO) residential and industrial/commercial levels. The sediment samples returned negligible detections for SVOC and VOC. Some samples exceeded PAH, PCB and heavy metal IEPA TACO industrial/commercial ingestion values. High concentrations of nutrients, oil and grease were also detected. Section 6, Plan Implementation includes a discussion of how the risk associated with this REC were minimized.

Analyses for hazardous waste criteria were completed to determine if Bubbly Creek sediment is characteristically toxic, corrosive, reactive or ignitable per 40 Code of Regulations (CFR) 261.20-24 (Subpart C), and thus is classifiable as “hazardous waste”. Results showed elevated levels of reactive sulfide, and a single sample (SF-2004-B02) with flash point that does not meet RCRA standards (flash point is below 140ºF). Sediments are not considered hazardous waste based on reactivity (reactive sulfide levels) from a regulatory standpoint. Additional sampling of the area surrounding the sample that flashed was conducted in 2010.

Figure 8: REC Results that Informed Plan Formulation

Update to 2006 HTRW Report

A 2013 Memorandum was prepared to provide an update to the HTRW report prepared in May 2006 and can be found in Appendix F. The memorandum includes resolution of the potential ignitability issue identified in the original analysis and developments since the 2006 HTRW report associated with recognized environmental conditions which may impact the Bubbly Creek ecosystem restoration project.

As a follow-up to the findings in the 2006 HTRW report, further investigation was performed to confirm whether or not material is hazardous waste based on ignitability. On 24 September 2010, USACE & USEPA collected five samples in the vicinity the original sampling location SF-2004-B02 that tested positive for ignitability. One sample was collected in the area where the original sample was taken and four samples in the areas just upstream and downstream of that original 2004 sampling point.

None of the samples collected in 2010 tested positive for ignitability. Based on these further investigations, results from the analysis concluded that the Bubbly Creek sediment tested was not found to be characteristically toxic, corrosive or reactive under RCRA.

Bubbly Creek Adjacent Parcels Phase 1 Environmental Site Assessment

In 2011, the City of Chicago conducted a Phase 1 Environmental Site Assessment (ESA) for land parcels adjacent to Bubbly Creek.[9] The purpose of the assessment was to identify the presence of REC on the land adjacent to the Bubbly Creek channel, in support of the ecosystem restoration feasibility study effort. The ESA included a field reconnaissance (restricted to public right-of-ways), a regulatory database search, historical data review (topographic maps, aerial photographs, city directories, Sanborn Maps, chain-of-title and environmental lien search).

Historic activities on parcels adjacent to Bubbly Creek included heavy industry and manufacturing, underground and above ground storage tanks, manufacturing gas plants, service stations, retail manufacturing, auto-repair facilities, stockyards, and illegal dumping. Nearby parcels also had a history of gasoline, metal, iron, paint, and coal manufacturing plants, and lumber, railroad, shipping, freight, and storage yards. Present day use of the parcels adjacent to the channel is primarily residential and light commercial. Information from the adjacent parcel Phase 1 ESA was used to formulate plans for restoration. Specifically, disturbance of property where riparian planting are planned was minimized to avoid issues related to some parcels. It is recommended that the riparian planting areas be reviewed during design phase and modified if needed to avoid RECs, based on the site status at that time.

2.3 Ecological Resources*

Before the 1830's, the South Fork of the South Branch of the Chicago River was a prairie slough that drained five square miles of a pristine aquatic and interconnected terrestrial habitat. Over a period of several decades, this ecosystem was severely altered by human development. Currently, Bubbly Creek no longer provides a diversity of habitats, nor is the existing habitat

[9] Terracon Consultants, Inc. 2011. Phase 1 Environmental Site Assessment, Bubbly Creek – South Fork of the South Branch of the Chicago River, Chicago, Cook County, Illinois.

quality sufficient to maintain 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. However, Bubbly Creek still manages to attract an interesting species from time to time. Despite its current degraded state, more sensitive species have been observed onsite including: state-listed black-crowned night-heron (*Nycticorax nycticorax*), belted kingfisher (*Megaceryle alcyon*), white crappie (*Pomoxis annularis*).

2.3.1 Plants

Bank and riparian areas are representative of an impaired habitat and provide minimal benefit to resident and migrating species. Species along the banks of Bubbly Creek are predominately invasive, non-native species such as: reed canary grass (*Phalaris arundinacea*), garlic mustard (*Alliaria petiolata*), hairy aster (*Aster pilosus*), cut-leaved teasel (*Dipsacus laciniatus*), curly dock (*Rumex crispus)*, Japanese knotweed (*Polygonum cuspidatum*), and buckthorn (*Rhamnus cathartica*). See Appendix B for data of the riparian plant community collected during a survey conducted during the 2008 growing season where 37 native and 17 non-native species were recorded. Assessment of the entire Bubbly Creek plant community concluded that the project site current supports a ruderal (manmade) plant community and highly degraded bank/riparian habitat. Causes of these impairments are modifications to the channel and adjacent banks, modified soils, and modified channel substrates.

2.3.2 Aquatic Macroinvertebrates

The habitat degradation within Bubbly Creek and its riparian zone have caused severe declines in species richness and abundance of aquatic macroinvertebrates. MWRDGC conducted benthic invertebrate sampling in Bubbly Creek in 2010; the results are shown in ***Table 2***. MWRDGC did not find those species associated typically with healthy ecosystems such as: stoneflies (Plecoptera), damselflies and dragonflies (Odonata), true bugs (Hemiptera), beetles (Coleoptera), or mussels and clams (Pelecypoda). One mayfly (Ephemeroptera), *Baetis intercalaris*, and one caddisfly (Trichoptera), Cheumatopsyche, were collected from Bubbly Creek using the Hester-Dendy sampler. The majority of the species collected were true flies (Diptera) and aquatic worms (Oligochaeta) comprised the greatest abundance within Bubbly Creek. Numbers within the table correspond to number of individuals/m^2.

2.3.3 Fishes

Fishes collected at Bubbly Creek are comprised of tolerant and non-native species. Collections from 2002-2006 as part of MWRDGC's Ambient Water Quality Monitoring Program are tabulated in ***Table 3***. Samples were collected across four different sites within Bubbly Creek and included 18 species and one hybrid. Of these 18 species, five were nonnative or introduced (*) and the hybrid was that of two introduced species, goldfish crossed with a common carp. The six introduced species are common carp (*Cyprinus carpio*), Coho salmon (*Oncorhynchus kisutch*), goldfish (*Carassius auratus*), mosquitofish (*Gambusia affinis*), white perch (*Morone americanus*) and Nile tilapia (*Oreochromis niloticus*). The remaining 12 native species are gizzard shad (*Dorosoma cepedianum*), bluegill (*Lepomis macrochirus*), bluntnose minnow (*Pimephales notatus*), channel catfish (*Ictuluras punctatus*), emerald shiner (*Notropis atherinoides*), golden shiner (*Notemigonus crysoleucas*), green sunfish (*Lepomis cyanellus*), largemouth bass (*Micropterus salmoides*), pumpkinseed (*Lepomis gibbosus*), spotfin shiner(*Cyprinella spiloptera*), white crappie (*Poxomis annularis*), and yellow bullhead (*Ameiurus natalis*).

Table 2: Total number of benthic invertebrates collected in 2010

Taxonomy	Hester-Dendy	Ponar Grab
Oligochaeta	439.5	64,223.7
Baetis intercalaris	1.8	-
Cheumatopsyche	1.8	-
Ceratopogonidae	5.4	-
Hyalella azteca	-	7.2
Procladius	-	14.4
Cricotopus sylvestris grp.	-	14.4
Mesosmittia	-	7.2
Chironomus	1.8	107.6
Dicrotendipes lucifer	1.8	107.6
Parachironomus	1.8	-
Tipula	-	7.2
Physa	-	21.5
Total	453.9	64,403.1

†Table re-constructed using data from MWRD Chicago data[10]

[10] 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.

Table 3: Fish collected within Bubbly Creek by species and year

Location	Species	Year					
		2001	2002	2003	2004	2005	Total
RAPS	Gizzard Shad	.	.	97	42	498	637
	Coho Salmon*	.	.	1	.	.	1
	Carp*	.	.	28	8	6	42
	Carp x Goldfish*	.	.	10	3	9	22
	Golden Shiner	.	.	.	8	.	8
	Bluntnose Minnow	.	.	.	1	.	1
	Channel Catfish	.	.	.	1	1	2
	Pumkinseed	.	.	9	20	3	32
	Bluegill	.	.	5	10	.	15
	Largemouth Bass	.	.	1	3	.	4
	Nile Tilapia*	.	.	.	1	.	1
RAPS Count		.	.	*151*	*97*	*517*	*765*
35th Street	Gizzard Shad	.	.	15	9	103	127
	Goldfish*	.	.	.	1	.	1
	Carp*	.	.	9	6	4	19
	Carp x Goldfish*	.	.	.	.	4	4
	Golden Shiner	.	.	.	2	1	3
	Bluntnose Minnow	.	.	.	1	.	1
	Pumkinseed	.	.	11	3	.	14
	Bluegill	.	.	3	4	.	7
	Largemouth Bass	.	.	1	1	2	4
35th Street Count		.	.	*39*	*27*	*114*	*180*
I-55	Gizzard Shad	.	.	6	19	125	150
	Goldfish*	.	.	.	.	1	1
	Carp*	.	.	1	8	3	12
	Golden Shiner	.	.	.	2	.	2
	Spotfin Shiner	.	.	.	7	.	7
	Channel Catfish	.	.	.	1	.	1
	Green Sunfish	.	.	4	1	.	5
	Pumpkinseed	.	.	11	7	.	18
	Bluegill	.	.	7	4	.	11
	Largemouth Bass	.	.	2	10	9	21
	White Crappie	.	.	.	1	.	1
	Black Crappie	.	.	.	.	1	1
I-55 Count		.	.	31	60	139	230

Table 3 (continued): Fish collected within Bubbly Creek by species and year

Archer Ave.	Gizzard Shad	.	9	.	.	.	9
	Carp*	.	4	.	.	.	4
	Emerald Shiner	.	2	.	.	.	2
	Pumpkinseed	.	3	.	.	.	3
	Largemouth Bass	.	3	.	.	.	3
Archer Ave. Count		.	*21*	.	.	.	*21*

†Table re-constructed using data from MWRDGC[11]

2.3.4 Reptiles and Amphibians

The common snapping turtle (*Chelydra serpentina*) is the only amphibian or reptile known to be observed in Bubbly Creek.[12]

2.3.5 Birds

Bird data for Bubbly Creek was requested from the Bird Conservation Network (BCN). The BCN did have data for the South Branch of the Chicago River, Canal Origins Park (located at the turning basin of Bubbly Creek), Palmisano Park (located within 0.8 mile radius of Bubbly Creek turning basin), and McKinley Park (located within 1.5 mile radius of Bubbly Creek turning basin). The first three sites had three observations from 1989, one observation from 2006, and 35 observations from 2013. McKinley Park had a total of 1,028 observations from 1990 to 2013. In all, one hundred nine species of birds have been observed within a 1.5 mile radius of Bubbly Creek since 1989 by BCN (***Table 4***). Of those 109 species, 28 were residents, 31 were migratory, 43 were breeding (summer residents), and 9 were non-breeding (winter residents). Two species, the chimney swift (*Chaetura pelagica*), a breeding summer resident in the Chicago Region, and the golden-winged warbler (*Vermivora chrysoptera*) are listed as near threatened (NT) by the International Union for Conservation of Nature (IUCN). A taxon receives a NT rating when it has been evalueated against the criteria but does not qualify for critically endangered, endangered or vulnerable now, but is close to qualifying for or is likely for a threatened category in the near future. In addition, the following four species observed were listed by the Audubon Society as one of the top 20 common birds in decline: common grackle (*Quiscalus quiscula*), field sparrow (*Spizella pusilla*), greater scaup (*Aythya marila*) and little blue heron (*Egretta caerulea*). Also, the state endangered black-crowned night-heron (*Nycticorax nycticorax*) and little blue heron (*Egretta caerulea*) as well as the state threatened peregrine falcon (*Falco peregrinus*) were observed.

In addition, some observations of avian species have been recorded at Bubbly Creek by the USACE Chicago District, but they have been made primarily during sampling events that have been part of the Monitoring and Response Plan for Asian Carp in the Upper Illinois River and Chicago Area Waterway System. Recently, a restoration ecologist from the USACE Chicago District sampling for fish within Bubbly Creek on 30 July 2014 noted through photos and videos

[11] Metropolitan Water District of Greater Chicago. Fish Data Chicago Area Waterways 2001-2005. Accessed September 9, 2014. https://www.mwrd.org/irj/portal/anonymous/WQM.
[12] Sulski, Rob. Illinois Environmental Protection Agency. Personal Communication. Observations made between April -August 2007 visits to Bubbly Creek.

of various bird species utilizing the area. The state threatened black-crown night-heron (*Nycticorax nycticorax*) (***Figure 9***) was observed hunting beneath woody overhang and snag habitat. Over 15 black-crown night-herons were observed just east of Bubbly Creek hunting along the shallow project areas that are proposed to be enhanced via emergent plantings and woody debris measures. Double-crested cormorants (*Phalacrocorax auritis*) were observed diving, hunting, and consuming fish.

Additionally, Bubbly Creek is located within the Western Great Lakes migratory corridor, and warblers and other birds use Bubbly Creek as a stop-over during fall and spring migration. Being within the Western Great Lakes migratory corridor of the Mississippi Flyway, the City of Chicago is striving to be a bird-friendly city. These efforts include resident education and other outreach programs. The city developed Chicago's Bird Agenda[13] in 2006 which includes initiatives that are consistent with ecosystem restoration for Bubbly Creek. A letter by the Audubon Society of Chicago was provided to the USACE Chicago District in July 2013 (Appendix B) indicating the importance of restoring Bubbly Creek habitat for migratory birds within the Lake Michigan portion of the Mississippi Flyway. For more on Migratory Waterfowl and birds see Section 4.7.3 Significance of Ecosystem Outputs.

Figure 9: State threatened black-crown night-heron (*Nycticorax nycticorax*)

Table 4: Bird species observed within Douglas Park in 2014

Scientific Name	Common Name	Resident	Migratory	Summer (Breeding)	Winter (Non-breeding)
Fulica americana	American Coot*			X	
Corvus brachyrhynchos	American Crow*	X			
Spinus tristis	American Goldfinch*	X			
Falco sparverius	American Kestrel	X			
Setophaga ruticilla	American Redstart			X	
Turdus migratorius	American Robin*	X			
Icterus galbula	Baltimore Oriole			X	

[13] City of Chicago. 2006. Bird Agenda. Accessed September 9, 2014. http://www.cityofchicago.org/city/en/progs/env/protecting_and_enjoyingbirds.html

Table 4 (continued): Bird species observed within Douglas Park in 2014

Scientific Name	Common Name	Resident	Migratory	Summer (Breeding)	Winter (Non-breeding)
Hirundo rustica	Barn Swallow			X	
Setophaga castanea	Bay-breasted Warbler		X		
Megaceryle alcyon	Belted Kingfisher*	X			
Mniotilta varia	Black-and-white Warbler		X		
Setophaga fusca	Blackburnian Warbler		X		
Poecile atricapillus	Black-capped Chickadee	X			
Nycticorax nycticorax	Black-crowned Night-Heron*			X	
Setophaga striata	Blackpoll Warbler		X		
Setophaga caerulescens	Black-throated Blue Warbler		X		
Setophaga virens	Black-throated Green Warbler		X		
Cyanocitta cristata	Blue Jay	X			
Polioptila caerulea	Blue-gray Gnatcatcher			X	
Anas discors	Blue-winged Teal			X	
Buteo platypterus	Broad-winged Hawk			X	
Certhia americana	Brown Creeper				X
Toxostoma rufum	Brown Thrasher			X	
Molothrus ater	Brown-headed Cowbird	X			
Bucephala albeola	Bufflehead*				X
Branta canadensis	Canada Goose*	X			
Cardelina canadensis	Canada Warbler		X		
Setophaga tigrina	Cape May Warbler		X		
Hydroprogne caspia	Caspian Tern		X		
Bombycilla cedrorum	Cedar Waxwing	X			
Setophaga pensylvanica	Chestnut-sided Warbler		X		
Chaetura pelagic	Chimeny Swift			X	
Spizella passerina	Chipping Sparrow			X	
Quiscalus quiscula	Common Grackle	X			
Gavia immer	Common Loon*		X		
Mergus merganser	Common Merganser			X	
Chordeiles minor	Common Nighthawk			X	
Geothlypis trichas	Common Yellowthroat*			X	
Accipiter cooperii	Cooper's Hawk*	X			
Junco hyemalis	Dark-eyed Junco*				X
Phalacrocorax auritus	Double-crested Cormorant*		X	X	
Picoides pubescens	Downy Woodpecker*	X			
Sialia sialis	Eastern Bluebird			X	
Tyrannus tyrannus	Eastern Kingbird			X	
Sayornis phoebe	Eastern Phoebe			X	
Contopus virens	Eastern Wood-Pewee			X	
Spizella pusilla	Field Sparrow	X			
Passerella iliaca	Fox Sparrow		X		
Regulus satrapa	Golden-crowned Kinglet*				X

Table 4 (continued): Bird species observed within Douglas Park in 2014

Scientific Name	Common Name	Resident	Migratory	Summer (Breeding)	Winter (Non-breeding)
Vermivora chrysoptera	Golden-winged Warbler			X	
Dumetella carolinensis	Gray Catbird			X	
Ardea herodias	Great Blue Heron*	X			
Myiarchus crinitus	Great Crested Flycatcher			X	
Ardea alba	Great Egret		X		
Aythya marila	Greater Scaup*		X		
Butorides virescens	Green Heron			X	
Anas crecca	Green-winged Teal		X		
Picoides villosus	Hairy Woodpecker	X			
Catharus guttatus	Hermit Thrush		X		
Larus argentatus	Herring Gull*				X
Lophodytes cucullatus	Hooded Merganser	X			
Haemorhous mexicanus	House Finch	X			
Passer domesticus	House Sparrow*	X			
Passerina cyanea	Indigo Bunting			X	
Charadrius vociferous	Killdeer			X	
Melospiza lincolnii	Lincoln's Sparrow		X		
Egretta caerulea	Little Blue Heron		X		
Parkesia motacilla	Louisiana Waterthrush			X	
Setophaga magnolia	Magnolia Warbler		X		
Anas platyrhynchos	Mallard*	X			
Cistothorus palustris	Marsh Wren			X	
Zenaida macroura	Mourning Dove	X			
Oreothlypis ruficapilla	Nashville Warbler		X		
Cardinalis cardinalis	Northern Cardinal*	X			
Colaptes auratus	Northern Flicker*	X			
Setophaga Americana	Northern Parula		X		
Stelgidopteryx serripennis	Northern Rough-winged Swallow			X	
Parkesia noveboracensis	Northern Waterthrush		X		
Oreothlypis celata	Orange-crowned Warbler		X		
Seiurus aurocapilla	Ovenbird*			X	
Setophaga palmarum	Palm Warbler*		X		
Falco peregrinus	Peregrine Falcon*	X			
Poldilymbus podiceps	Pied-billed Grebe*			X	
Setophaga discolor	Prairie Warbler			X	
Sitta canadensis	Red-breasted Nuthatch				X
Vireo olivaceus	Red-eyed Vireo			X	
Buteo jamaicensis	Red-tailed Hawk	X			
Agelaius phoeniceus	Red-winged Blackbird	X			
Larus delawarensis	Ring-billed Gull*		X	X	
Pheucticus ludovicianus	Rose-breasted Grosbeak			X	
Regulus calendula	Ruby-crowned Kinglet			X	
Passerculus sandwichensis	Savannah Sparrow			X	
Piranga olivacea	Scarlet Tanager			X	

Table 4 (continued): Bird species observed within Douglas Park in 2014

Scientific Name	Common Name	Resident	Migratory	Summer (Breeding)	Winter (Non-breeding)
Melospiza melodia	Song Sparrow*	X			
Actitis macularius	Spotted Sandpiper			X	
Catharus ustulatus	Swainson's Thrush		X		
Melospiza georgiana	Swamp Sparrow*	X			
Oreothlypis peregrine	Tennessee Warbler		X		
Tachycineta bicolor	Tree Swallow			X	
Cathartes aura	Turkey Vulture			X	
Vireo gilvus	Warbling Vireo			X	
Zonotrichia leucophrys	White-crowned Sparrow				X
Zonotrichia albicollis	White-throated Sparrow*				X
Empidonax traillii	Willow Flycatcher			X	
Cardellina pusilla	Wilson's Warbler		X		
Hylocichla mustelina	Wood Thrush			X	
Setophaga petechia	Yellow Warbler			X	
Sphyrapicus varius	Yellow-bellied Sapsucker		X		
Setophaga coronate	Yellow-rumped Warbler*		X		

*Bird species observed specifically from South Branch of the Chicago River, Canal Origins Park, and Palmisano Park. Un-denoted birds were observed from McKinley Park.

2.3.6 Mammals

Due to the absence of favorable native vegetation and cover, only the most common urban mammals are expected to inhabit the area. Those include the cottontail rabbit (*Sylvilagus flordianus*), gray squirrel (*Sciurus carolinensis*), beaver (*Castor canadensis*), opossum (*Didelphis virginiana*), raccoon (*Procyon lotor*), and Norway rat (*Rattus norvegicus*). Though not directly observed in Bubbly Creek, river otters (*Lontra canadensis*) have been seen in the SBCR[14].

2.3.7 Threatened and Endangered Species

Federally-listed Threatened, Endangered, Proposed and Candidate Species were reviewed for the project area by the Chicago District (http://www.fws.gov/midwest/endangered/section7/index.html). The following federally listed species, status and their critical habitats are identified by the USFWS as occurring within Cook County:

- Piping plover (*Charadrius melodus*) – Endangered – Wide, open, sandy beaches with very little grass or other vegetation

[14] Hauser, Mark. "Riverlife." *The River Reporter* Spring/Summer 2008: 6. Print.

- Eastern massasauga (*Sistrurus catenatus*) – Candidate – Graminoid dominated plant communities (fens, sedge meadows, peat lands, wet prairies, open woodlands, and shrublands)
- Hine's emerald dragonfly (*Somatochlora hineana*) – Endangered – Spring fed wetlands, wet meadows and marshes
- Eastern prairie fringed orchid (*Platanthaera leucophaea*) – Threatened – Moderate to high quality wetlands, sedge meadow, marsh, and mesic to wet prairie.
- Leafy-prairie clover (*Dalea foliosa*) – Endangered – Prairie remnants on thin soil over limestone
- Mead's milkweed (*Asclepias meadii*) – Threatened – Late successional tallgrass prairie, tallgrass prairie converted to hay meadow, and glades or barrens with thin soil
- Prairie bush clover (*Lespedeza leptostachya*) – Threatened – Dry to mesic prairies with gravely soil

Based on the information listed above and site assessments, federally endangered and threatened species or their critical habitats do not occur within the study area. Coordination under the Fish and Wildlife Coordination Act (FWCA) of the NER Plan would continue through the National Environmental Policy Act (NEPA) process and would be concluded before signing of a Finding of No Significant Impact (FONSI) or other determinations.

There are 141 state-listed species in Cook County including the state threatened black-crown night-heron (*Nycticorax nycticorax*) which is known to hunt along the banks of Bubbly Creek. Nesting habitat does not occur within the Bubbly Creek study area.

2.4 Cultural & Architectural Environment*

2.4.1 Commercial Navigation

In 1848, commercial navigation was greatly expanded in the SBCR with completion of the I&M Canal. By connecting the Chicago River to the Illinois River, the I&M Canal linked the Mississippi River with the Great Lakes. In 1900, the I&M Canal was replaced by the wider and deeper CSSC. The CSSC continues to be an important connection for barge traffic along the Chicago River. A portion of Bubbly Creek was authorized as a Federal-authorized navigation channel in 1902, but it was subsequently deauthorized in 1919. Bubbly Creek is no longer utilized for commercial navigation.

2.4.2 Infrastructure

39th Street Sewage Pumping Station

This station is no longer in service, but currently serves as the Chicago Park District's maintenance facility with parts of the original structure remaining visible. The station was built in 1905 to handle the storm water drainage and sanitary waste between 39th Street and 87th Street. The station is eligible for the National Register of Historic Places. The City of Chicago also built the 16-foot lakefront intercepting sewer, which received sanitary waste that once drained to the lake. The station was also capable of pumping lake water for dilution of the sanitary waste and flushing of the East Arm of the South Fork of the South Branch of the Chicago River, which was later filled in, and Bubbly Creek.

The Chicago Sanitary District, now named the MWRDGC, paid the City of Chicago for the portion of the station used for pumping and flushing water. In 1910, the station and 20 foot conduit at 39th Street were turned over to the MWRDGC for operations and maintenance. The area drained was 22 square miles and the pumping rate varied from 100 to 1500 cubic feet per second. In 1939, operations at the 39th Street Pumping Station were discontinued.

39th Street Conduit Extension

The MWRDGC constructed a 2,700 foot long extension from 1923 to 1926. This conduit extension served as an outlet for southeast neighborhoods and part of the Union Stock Yards. The conduit was built in the bed of the East Arm (Stockyards Slip). The construction made the filling-in of the Stockyards Slip and the paving of 39th Street possible. A temporary diversion channel was provided to the south of the slip to maintain the outlet for the 39th Street conduit. The conduit has been modified and is not eligible for the National Register of Historic Places.

Racine Avenue Pumping Station

The RAPS is not historic; and consequently, not eligible for the National Register of Historic Places. A detailed description of RAPS is contained in previous sections.

City of Chicago Bridge Structures

Archer Avenue Bridge – In 1906, this bridge was constructed, and in 2006, the City of Chicago completed a major rehabilitation. The bridge has an overall length of 218.3 feet and a 77 foot wide deck with two, 7 foot sidewalks.

35th Street Bridge – In 1969, the City of Chicago constructed this bridge. The bridge has an overall length of 200 feet and an overall width of 66 feet.

I-55 Bridge – Built in 1957, the bridge has a total length of 1,405 feet and underwent rehabilitation in 1997.

Chicago Transit Authority (CTA) Bridge – The CTA Orange Line Bridge crosses Bubbly Creek close to Archer Avenue. The Orange Line was open for service from the Loop to Chicago's Midway Airport in 1993.

2.4.3 Social, Cultural and Archaeological Resources

Bubbly Creek forms the border between two of Chicago's south side neighborhoods: McKinley Park to the west and Bridgeport to the east. The Pilsen neighborhood also borders Bubbly Creek to the west and north. Both the McKinley Park and Bridgeport neighborhoods were originally settled by Irish workers brought into the area for construction of the I&M Canal, while Pilsen was originally settled by German and Irish immigrants.

Bridgeport, originally known as Hardscrabble, developed early into a cargo landing point and warehouse district because of its location at the eastern end of the I&M Canal. McKinley Park, originally known as Canalport, was incorporated as the town of Brighton in 1851 and annexed to Chicago in 1863. Its eastern edge along Bubbly Creek was known as Ducktown (historic evidence of slough primarily dominated by waterfowl). The coming of the Chicago and Alton

Railroad in 1863 combined with the community's location on the I&M Canal helped establish McKinley Park as an early industrial center. By 1871, McKinley Park contained 11 iron & steel mills and 27 brickyards.

All three communities grew rapidly with the increased need for immigrant labor caused by the development of the Chicago stockyards. Employment in the stockyards dominated the area for almost a hundred years. As the stockyards closed, employment in the neighborhoods diversified into other areas. All three neighborhoods retain a mixture of residential, commercial, and industrial use, and now serve as bedroom communities for downtown Chicago.

Currently all three neighborhoods have ethnically and racially diverse urban populations. McKinley Park has a median household income of approximately $37,600 with a median home price of $149,900. Bridgeport has a similar median household income level at $37,600; however, housing costs are higher with a median home price in Bridgeport of $224,200. Newer single-family homes along South Throop Street near Bubbly Creek are in the range of $400,000 to $700,000. These single-family homes along the eastern side of Bubbly Creek have signaled a change in the area, from industrial to residential use as people take advantage of its good transportation links and proximity to downtown Chicago. Pilsen has a median household income of approximately $40,553 with a median home price of $182,144. In contrast, the median household income for Chicago as a whole is approximately $38,600 with median home price of $167,000[15].

Recreational facilities in the McKinley Park neighborhood are located on the 69 acre McKinley Park which includes baseball diamonds, soccer fields, swimming pool and ice-skating rink. Armour Square Park in Bridgeport has a swimming pool, recreation center, boxing ring, tennis courts, soccer and baseball fields, and hiking paths. Other Bridgeport parks include Bosley Park, McGuane Park, and Wilson Park housing soccer and baseball fields, and basketball courts. Pilsen recreational facilities are primarily available at Dvorak Park and Harrison Park Field House which feature gymnasiums, swimming pools, baseball fields, basketball courts, athletic fields, tennis courts, and playgrounds. Recreation focused on the SBCR and Bubbly Creek is limited but not unknown. Both the SBCR and Bubbly Creek are popular with fishermen. Pleasure boaters in motor boats, canoes, kayaks, and the occasional excursion boat also utilize this portion of the Chicago River, as well as the northern deeper portions of Bubbly Creek. There is a boat launch along the banks one local rowing club practices in Bubbly Creek.

Completed in 1848, the I&M Canal had a major impact on the commercial and regional development of the Upper Midwest. In recognition of this historic significance, the Illinois & Michigan Canal National Heritage Corridor (IMCNHC) was established by the U.S. Congress in 1984. The historic corridor extends for 62.5 miles, and includes the Turning Basin at the mouth of Bubbly Creek. In 2012 the length of the I&M Canal, including the Turning Basin, was also added to the National Register of Historic Places.

The actual junction of the I&M Canal and the Chicago River has been filled, and the approximate location on the west side of the mouth of Bubbly Creek is recognized as a Chicago City Landmark, "The Site of the Origins of the I&M Canal." In 1996, this landmark was dedicated and encompasses the 2800 block of South Ashland. Approximately one half mile southeast of

[15] U.S. Census. 2010. 2010 Census Data. Accessed September 9, 2014. http://www.census.gov/2010census/data/.

this landmark is the Old Stone Gate to the Chicago Stockyards. The Old Stone Gate is a Chicago City Landmark dedicated in 1972 and was also listed on the National Register of Historic Places that same year (***Figure 10***). The area contains no archaeological properties.

Figure 10: Photo of Old Stone Gate entrance

2.5 Habitat Quality Forecasting

The purpose of this feasibility study is to evaluate the ecosystem restoration potential of Bubbly Creek. Various habitat restoration measures were formulated that would improve the quality and increase the quantity of viable habitat within the project area. To determine if a project would be successful in providing increased ecosystem benefits, USACE used ecological indices that appropriately reflected the system of interest. Restoration outputs in terms of increased habitat quality and quantity are measured in non-monetary units called Habitat Units, which are then averaged across a planning period of analysis. Average Annual Habitat Units (AAHUs) are used to 1) quantitatively measure current and future without project (FWOP) conditions, and 2) quantitatively capture future improvements to habitat resulting from proposed restoration measures.

The level of habitat suitability, which takes into account the structure of the ecosystem, is calculated by developing a HSI. The HSI is an algebraic function that uses various habitat structure indicators. Physical habitat and plant community based indices were employed since the aim is to restore the system as a whole; whereas species specific indices may preclude habitat requisites for a multitude of other species. Two (2) HSIs, the Floristic Quality Assessment (FQA) and the CAWS Habitat Assessment Index (CAWSHAI), were used to evaluate existing ecological conditions, future without project conditions and future with project conditions for the Bubbly Creek study area. A list of metrics and a range of values associated with the two HSIs utilized for this study are shown in ***Table 5***.

Table 5: Summary of HSI Models

HSI Model	Model Acronym	Metrics	Range of Values	
			Min	Max
(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	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

2.5.1 Plant Communities Assessment

The Coefficient of Conservatism (C) methodology was chosen for the assessment of the Bubbly Creek plant communities. The C value of a plant species can be used to evaluate the quality of native habitat in the project area[16] on a scale of 0 - 10 and was approved for regional use by the USACE National Ecosystem Planning Center of Expertise (ECO-PCX)[17]. The C value is the basic tool of the FQA method. The number reflects the fidelity of the species to specific habitat integrity and conversely, its lack of tolerance to unnatural disturbance factors. A C value of 0 is assigned to species that are highly tolerant to disturbance and are considered general in their habitat distribution. A C value of 1 indicates a very weedy species and a 10 indicates a very conservative one. The mean C is the average for a site and reflects the amount of degradation or improvement as it changes. Around 90% of the plants in a region have a C value of 4 or higher and occupy a wide array of specialized hydro-geomorphic features. The other 10 percent are found in many plant communities. Generally, if a site has a mean C of 3.5 or higher, it has at least marginal ecological quality. Numbers under 3.5 reflect areas with a lesser degree of ecosystem function. Areas with a mean C of 6 and above are only found in remnant natural areas. ***Figure 11*** provides an example of remnant quality habitat at Powderhorn Ridge & Swale Nature Preserve, which exhibits a mean C of 5.1, which is a metric of the FQA. The quality of the existing Bubbly Creek site was rated as low quality with the mean C value at 2.5.

[16] Swink, F. and G. Wilhelm. 1979. Plants of the Chicago Region. 3rd edition. Indiana Academy of Science. Indianapolis, IN. 922pp.

[17] U.S. Army Corps of Engineers. 2014. Ecosystem Restoration Gateway: Ecosystem Restoration Model Library. Accessed September 9, 2014. http://cw-environment.usace.army.mil/model-library.cfm?CoP=Restore&Option=View&Id=318

Figure 11: Remnant Buttonbush Swamp, Powderhorn Nature Preserve, August 2013

2.5.2 Aquatic Habitat Assessment

The CAWSHAI was developed based on the Michigan Non-Wadable Habitat Index (NWHI)[18], to more accurately reflect the vastly altered conditions of the CAWS. The CAWSHAI was approved for regional use by the ECO-PCX[19]. The application of the CAWSHAI will be used to quantify the conditions of the physical habitat of the channel. Detailed data collection on the biological communities (e.g., fish, macrophyte coverage) within the CAWS were used to calibrate the index based models. The habitat assessment index was used to evaluate the effect of proposed habitat improvement measures (e.g., off-channel bays, large substrate) on the suitability of habitat for fish. The information on the effect of poor substrate quality on macroinvertebrates

[18] Wilhelm, J.G., J.D. Allan, K.J. Wessell, R.W. Merritt, and K.W. Cummins. 2005. Habitat Assessment of Non-wadeable Rivers in Michigan. Environmental Management 36(4):592-609.
[19] U.S. Army Corps of Engineers. 2014. Ecosystem Restoration Gateway: Ecosystem Restoration Model Library. Accessed September 9, 2014. http://cw-environment.usace.army.mil/model-library.cfm?CoP=Restore&Option=View&Id=58

(measured by deformities of head capsules) was also used to help gauge the effect of proposed restoration measures. The following two equations were formulated for the CAWS Habitat Assessment Index. The CAWSHAI Equation 2a provides a raw score and CAWSHAI Equation 2b normalizes the raw score to determine a final index value.[2021]

CAWSHAI Equation 2a:

$$CAWS_{RAW} = 14.7 - 0.47 \times MAX_{DEP} + 1.4 \times \ln(OFF_{CH_{BAY}} + 1) - 2.51 \times \text{asin}(BNK_{WALL})^{\frac{1}{2}} - 1.42 \times \ln(BNK_{RIPRAP} + 1) - 6.54 \times \ln(MAN_{MADE_{STRUC}} + 1) + 0.178 \times MCRPH_{CHAN} + 0.1 \times PER_{COV_{ALT}} + 0.05 \times BANK_{POC_{AREA}} + 0.005 \times BIG_S + 0.005 \times BIG_D - 0.08 \times CAWS_{ORGSLG}$$

Where:

$CAWS_{RAW}$ = raw Chicago Area Waterway Index
MAX_{DEP} = the maximum channel depth in reach
$OFF_{CH_{BAY}}$ = the number of areas in the reach that function as off channel bays, providing refuge for fish
BNK_{WALL} = the percentage of banks, by length, occupied by vertical walls (percent, as a decimal, e.g., 10% is 0.10)
BNK_{RIPRAP} = the percentage of riprap banks in reach, by length (%, e.g. 10%)
$MAN_{MADE_{STRUC}}$ = the number of manmade structures in the reach
$MCRPH_{CHAN}$ = the percentage of macrophyte cover in the reach (%, e.g. 10%)
$PER_{COV_{ALT}}$ = the percent overhanging vegetation (%, e.g. 10%)
$BANK_{POC_{AREA}}$ = the number of bank pocket areas
BIG_S = the percentage of large substrate (gravel, cobbles, boulders) in the shallow part of the channel (%, e.g. 10%)
BIG_D = the percentage of large substrate (gravel, cobbles, boulders) in the deep part of the channel (%, e.g. 10%)
$CAWS_{ORGSLG}$= the percentage of organic sludge in sediment samples (%, e.g. 10%)

CAWSHAI Equation 2b:

$$CAWS_F = 100\left[\frac{(CAWS_{RAW} + 22.38)}{44.67}\right]$$

Where:

$CAWS_F$ = final Chicago Area Waterway Index
$CAWS_{RAW}$ = raw Chicago Area Waterway Index

Total habitat output, in terms of habitat units (HUs) are calculated by multiplying the habitat suitability index by the area of habitat affected as shown in the following HU Equation 3:

Habitat Unit Equation 3:

$$HU = Area\ x\ HSI$$

[20] LimnoTech. 2010. Chicago Area Waterways System Habitat Evaluation and Improvement Study: Habitat Evaluation Report. Metropolitan Water Reclamation District of Greater Chicago, Chicago, IL.
[21] Bell, Scott and Doug Bradley to Jennifer Wasik. July 16, 2014. Documentation of Revised CAWS Habitat Index [Memorandum]. Appendix B.

Where:

HU = habitat unit of output, expressed in acres
HSI = aggregate habitat suitability index value

No assumptions have been made regarding the specific importance of the different model outputs. Restoration of the ecological structure of this system needs to incorporate measures to address the results of different stressors and drivers that affect the system. No one biological community is assumed to be more important than the other within the system and increased biodiversity is an overarching goal of the proposed restoration project.

2.5.3 Reference Sites

Using the CAWSHAI and FQA as the basis for evaluation of the measures for Bubbly Creek, the project delivery team (PDT) used its experiences within the CAWS to select realistic attainable goals for the restoration project and identify features that would be sustainable in Bubbly Creek. The PDT used the Grand Calumet River, for selection of submergent plant species, Eugene Field Park restoration site, for selection of emergent plant species, and the North Shore Channel, as an indication that if better habitat was available in Bubbly Creek, Bubbly Creek would support greater fish diversity and abundance and fish health would improve.

The landscape of the Calumet region has changed dramatically during the past 100 years. It was once described as being more like a bayou than a river (***Figure 12***), but it has since been channelized and redirected to flow into the Mississippi River Basin.

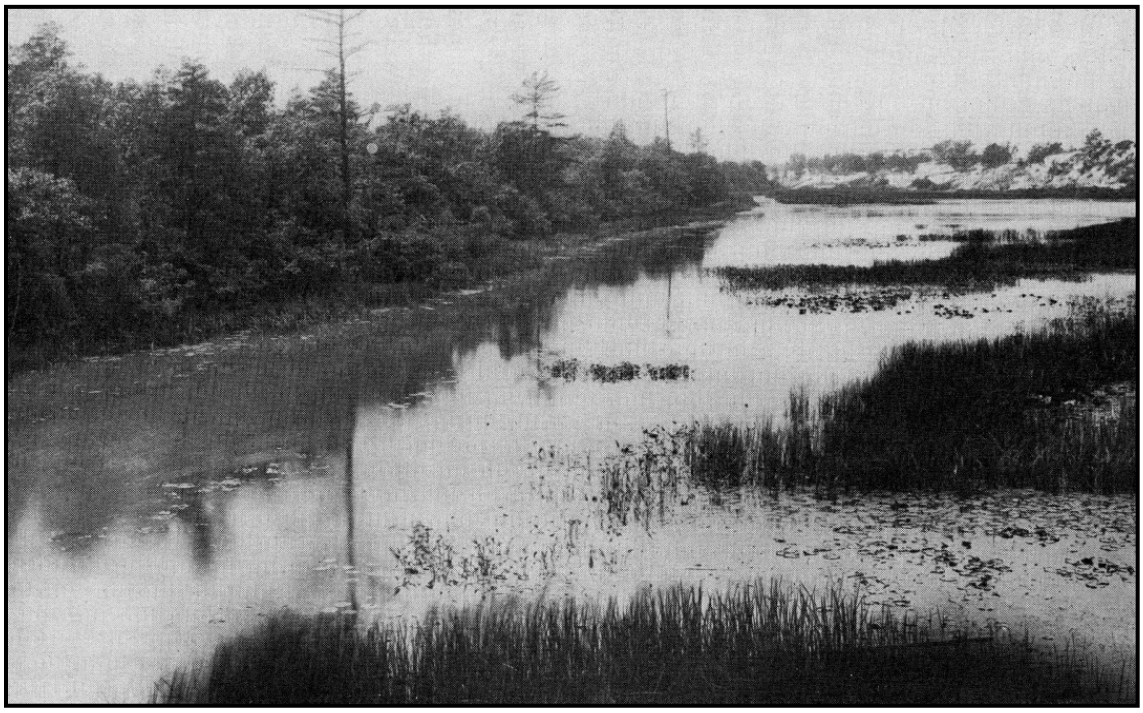


Figure 12: Grand Calumet Slough before Channelization[22]

[22] Pepoon, H.S. 1927. An Annotated Flora of the Chicago Area. Chicago Academy of Sciences, Chicago IL. 554pp.

Today, roughly ninety percent of water flowing through the Grand Calumet channel comes from industrial and municipal discharges. The sandy soils of the riverbed were replaced by sediments contaminated with the residue of urban industrial activities and in some areas of the river, produced bubbles. Due to its historic use, the Grand Calument River has been classified as part of a USEPA-listed Great Lakes Area of Concern (AOC) that includes the Indiana Harbor and Canal and Grand Calumet River.[23] Despite decades of industrial activity, remnants of a natural system still existed along the river corridor and throughout the Grand Calumet River watershed. During an assessment of the Grand Calumet River prior to its remediation, USACE, Chicago District and the Indiana Department of Environmental Management (IDEM) identified native aquatic plants thriving in the river. The PDT selected five of the ten species identified during the assessment for the Bubbly Creek project. Those species are the following: yellow pond lily (*Nuphar advena*), white water lily (*Nymphea tuberose*), pickerel weed (*Pontederia cordata*), common arrowhead (*Sagittaria latifolia*) and water celery (*Vallisneria americana*).

To confirm whether channel velocities associated with a RAPS discharge would uproot proposed aquatic plants, the velocity of the Grand Calumet River during flood conditions was compared to velocities of Bubbly Creek during a RAPS discharge. During dry conditions, the Grand Calumet River is a slow moving river but during flood conditions, channel velocities in the Grand Calumet River were as high as 3 feet per second. During RAPS events, over 75% of the Bubbly Creek channel has a velocity of less than 3 feet per second.

The North Shore Channel is within the CAWS and is upstream of Bubbly Creek (***Figure 1***). The North Shore Channel has better habitat structure when compared with Bubbly Creek[24] and has a more rich and abundant assemblage of fish. An additional twenty-three species have been collected from the North Shore Channel as compared to Bubbly Creek, nineteen of which are native species.

Table 6 lists the species have been found in North Shore Channel and the Bubbly Creek Channel by MWRDGC as well as other agencies.

Table 6: Fish Found in Bubbly Creek and North Shore Channel

Species	Common Name	Bubbly Creek				North Shore Channel
		RAPS	35TH STREET	I-55	ARCHER AVE.	
Alosa pseudoharengus	Alewife*					X
Fundulus diaphanus	Banded Killifish					X
Ameiurus melas	Black Bullhead					X
Pomoxis nigromaculatus	Black Crappie					X
Fundulus notatus	Blackstripe Topminnow					X
Lepomis macrochirus	Bluegill	X	X	X	X	X
Pimephales notatus	Bluntnose Minnow	X	X		X	X
Ameiurus nebulosus	Brown Bullhead					X

[23] United States Environmental Protection Agency. 2014. Great Lakes Areas of Concern. Accessed September 7, 2014. http://www.epa.gov/glnpo/aoc/.
[24] LimnoTech. 2010. Chicago Area Waterway System Habitat Evaluation and Improvement Study: Habitat Evaluation Report. Metropolitan Water Reclamation District of Greater Chicago, Chicago, IL.

Table 6 (continued): Fish Found in Bubbly Creek and North Shore Channel

Species	Common Name	Bubbly Creek				North Shore Channel
		RAPS	35TH STREET	I-55	ARCHER AVE.	
Salmo trutta	Brown Trout*					X
Cyprinus carpio	Common Carp*	X	X		X	X
Carassius auratus auratus	Carp x Goldfish*	X	X			X
Ictalurus punctatus	Channel Catfish	X		X	X	X
Oncorhynchus tshawytscha	Chinook Salmon*					X
Oncorhynchus kisutch	Coho Salmon*	X				
Semotilus atromaculatus	Creek Chub					X
Notropis atherinoides	Emerald Shiner				X	X
Pimephales promelas	Fathead Minnow					X
Notropis buchanani	Ghost Shiner					X
Dorosoma cepedianum	Gizzard Shad	X	X		X	X
Carassius auratus	Goldfish*					X
Notemigonus crysoleucas	Golden Shiner	X	X	X		X
Lepomis cyanellus	Green Sunfish			X	X	X
Micropterus salmoides	Largemouth Bass	X	X	X	X	X
Gambusia affinis	Mosquitofish*				X	
Oreochromis niloticus	Nile Tilapia*	X				
Lepomis humilis	Orangespotted Sunfish					X
Lepomis gibbosus	Pumpkinseed	X	X	X	X	X
Carpiodes cyprinus	Quillback					X
Ambloplites rupestris	Rock Bass					X
Notropis stramineus	Sand Shiner					X
Micropterus dolomieu	Smallmouth Bass					X
Cyprinella spiloptera	Spotfin Shiner			X	X	X
Notropis hudsonius	Spottail Shiner					X
Lepisosteus oculatus	Spotted Gar					X
Lepomis gulosus	Warmouth					X
Pomoxis annularis	White Crappie			X		
Morone americana	White Perch*				X	X
Catostomus commersonii	White Sucker					X
Morone mississippiensis	Yellow Bass					X
Ameiurus natalis	Yellow Bullhead				X	X
Perca flavescens	Yellow Perch					X

†Table re-constructed using data from MWRDGC[25] and the Chicago District Fish Database
*Non-native species

[25] Metropolitan Water District of Greater Chicago. Fish Data Chicago Area Waterways 2001-2005. Accessed September 9, 2014. https://www.mwrd.org/irj/portal/anonymous/WQM.

The PDT assessed whether after restoration, water quality in Bubbly Creek would be a limiting factor for fish response. The current water quality in Bubbly Creek was compared to that in the North Shore Channel. Both waterbodies are on the IEPA's 303(d) list for impaired waterbodies. Data reviewed include monthly samples collected from 2008 through 2012 at one location in Bubbly Creek, and at two locations in North Shore Channel. Water quality is generally comparable between the two waterbodies for pH and nitrate/nitrite. North Shore Channel water generally had higher DO levels and lower turbidity. When compared to Bubbly Creek, the North Shore Channel and the North Branch of the Chicago River has a more diverse and abundant assemblage of fish. To improve the habitat for fish and consequently improve their health and increase their diversity and abundance, Bubbly Creek's restoration should result in an increase in the dissolved oxygen concentration in the water column and a decrease its turbidity.

Eugene Field Park is a 13 acre restoration project completed by USACE, Chicago District along the North Branch of the Chicago River (NBCR). Plant selection for Bubbly Creek should take into account plants that have been found to thrive in other restoration projects along the CAWS. The thriving restored area of Eugene Field Park includes a marsh and the frequently inundated banks of the NBCR. The BCN observed 39 species of birds in 2012 at Eugene Field. Of those 39 species, 22 were residents, seven were migratory, 5 were breeding (summer residents), and six were non-breeding (winter residents). One species, the chimney swift (*Chaetura pelagica*), a breeding summer resident in the Chicago Region, is listed as near threatened by the IUCN. In addition, the following two species observed were listed by the Audubon Society as one of the top 20 common birds in decline: common grackle (*Quiscalus quiscula*) and field sparrow (*Spizella pusilla*).

Water quality at Bubbly Creek was compared to North Branch Chicago River. Both waterbodies are on the IEPA's 303(d) list for impaired waterbodies. The listed impairments for the NBCR are dissolved oxygen, total dissolved solids, phosphorus (total), and total suspended solids. Data reviewed included monthly samples collected from 2008 through 2012 in Bubbly Creek at one sample location and two sample locations in the North Branch Chicago River.[26] Water quality is generally comparable between the two waterbodies for several parameters: pH, sulfate, suspended solids and turbidity. NBCR water had higher DO levels; however, Bubbly Creek had lower levels of nitrate/nitrite and total phosphorus. As stated above, Bubbly Creek's restoration should result in an increase in the dissolved oxygen concentration in the water column and decrease its turbidity. With improved conditions, Bubbly Creek would be expected to provide for sustainable habitat for plants.

Based on a 2008 assessment of these waterways, Bubbly Creek was found to have 0% macrophyte cover, and the North Shore Channel's cover was found to range from 9 to 13%[27]. The restored area of Eugene Field Park includes the frequently inundated banks of the North Shore Channel and marsh.

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[26] Metropolitan Water Reclamation District of Greater Chicago. Chicago Area Waterways Ambient Water Quality Monitoring Program. Accessed September 9, 2014. http://www.mwrd.org/irj/portal/anonymous/WQM.

[27] LimnoTech. 2010. Chicago Area Waterways System Habitat Evaluation and Improvement Study: Habitat Evaluation Report.Metropolitan Water Reclamation District of Greater Chicago, Chicago, IL.

2.6 Future Without-Project Conditions

The success and cost effectiveness of formulated ecosystem restoration plans are evaluated against future site conditions assuming no project is implemented. These conditions, known as FWOP conditions, are forecasted by examining the important or limiting conditions of the study area and evaluating possible actions by others that may influence or change these limiting conditions.

2.6.1 Sediment Quality

Based on investigations conducted during this feasibility study and coordination with other Federal, State and local governmental agencies and academia, it is anticipated that the sediment conditions in Bubbly Creek within the foreseeable future would not change in terms of their physical, chemical, or biological properties. Since fluvial processes are not associated with this system, substrate movement, sorting and replenishing do not occur naturally, and are not expected to occur in the future. This precludes the potential for substrates within Bubbly Creek to naturally become healthy once again.

2.6.2 Water Quality

Based on data collection, analysis, and modeling conducted for this feasibility study and routine monitoring performed by the MWRDGC, the water quality conditions in Bubbly Creek within the foreseeable future would improve somewhat, but would still be negatively affected by the sediment oxygen demand (SOD) from sediments given that substrate/sediment quality are expected to remain unchanged. When the McCook Reservoir is online, it is anticipated that periods of low DO concentration would be reduced as the number of overflow events are expected to dramatically decrease from an average of 26 events to about 2 events per year. However, the channel is still expected to experience periods of low DO concentrations that would range from 1 to 2 weeks in length following CSO events due to the high biochemical oxygen demand (BOD) in the CSO discharge and the high SOD present in the existing sediments. These water quality conditions preclude the Bubbly Creek ecosystem from naturally reestablishing. In addition, if the draft rules titled the "Water Quality Standards and Effluent Limitations for the Chicago Area Waterway System and the Lower Des Plaines River: Proposed Amendments to 35 Ill. Adm. Code Parts 301, 302, 303 and 304" are amended, the rules may impose stricter limits on discharges to the CAWS and subsequently further improve water quality.

2.6.3 Hydrology & Hydraulics

Based on data collection, analysis, and modeling conducted for this feasibility study, the hydrology and hydraulic conditions in Bubbly Creek within the foreseeable future are expected to show a significant reduction in CSO events. The implementation of Stage 1 McCook Reservoir, which is scheduled to be online in 2017, is expected to have a positive effect on water quality and less effect on other physical and biological resources due to other limiting factors affecting these resources. The anticipated reductions in CSOs would also allow the waterway to more closely mimic the hydrology of a backwater.

When complete in 2027, the total storage capacity of the authorized McCook Reservoir will equal 7 billion gallons and will capture and store combined sewage that would have otherwise been released untreated into the CAWS, a portion of which would have entered Bubbly Creek through

RAPS. As the storage capacity for CSOs increases, the frequency of CSO events entering Bubbly Creek from RAPS pumping events and discrete CSOs along the channel will decrease, as shown in ***Table 7***. Though nine (9) CSOs outfalls are located along Bubbly Creek, RAPS contributes approximately 96 % of the CSO volume to the creek. Based on the hydrologic modeling analysis of the 57-year continuous period of record, the volume of CSO released to Bubbly Creek is estimated to decrease by approximately 85% when the McCook Reservoir is fully on-line. Also, when the McCook Reservoir is fully on line, based on a review of records for five years, the frequency of overflow events from RAPS and each combined sewer outfall along Bubbly Creek is estimated to decrease by approximately 89%.

Table 7: Effect of McCook Reservoir on Bubbly Creek CSO Discharges (2006 Calendar Year)

CSO Location[1]	Volume (MG)		Number of Events	
	Modeled Existing Conditions	Modeled Future Conditions [w/McCook]	Modeled Existing Conditions	Modeled Future Conditions [w/McCook]
RAPS	8,961	712	26	2
CSO-190	14.2	0.6	16	2
CSO-191	0.4	11.1	6	2
CSO-192	0.7	0.7	2	2
CSO-193	0.8	0	5	0
CSO-194	239.8	1.5	14	2
CSO-195	0.1	0.2	3	3
CSO-196	5.2	5.0	16	13
CSO-197	0.1	0	2	3
CSO-198	0	0	0	0
TOTAL	9,222	731		

Note: CSO-190 thru CSO-198 located along the channel are not gauged, therefore monitoring data is not available.

[1] Figure 13 contains a map of the CSO locations.

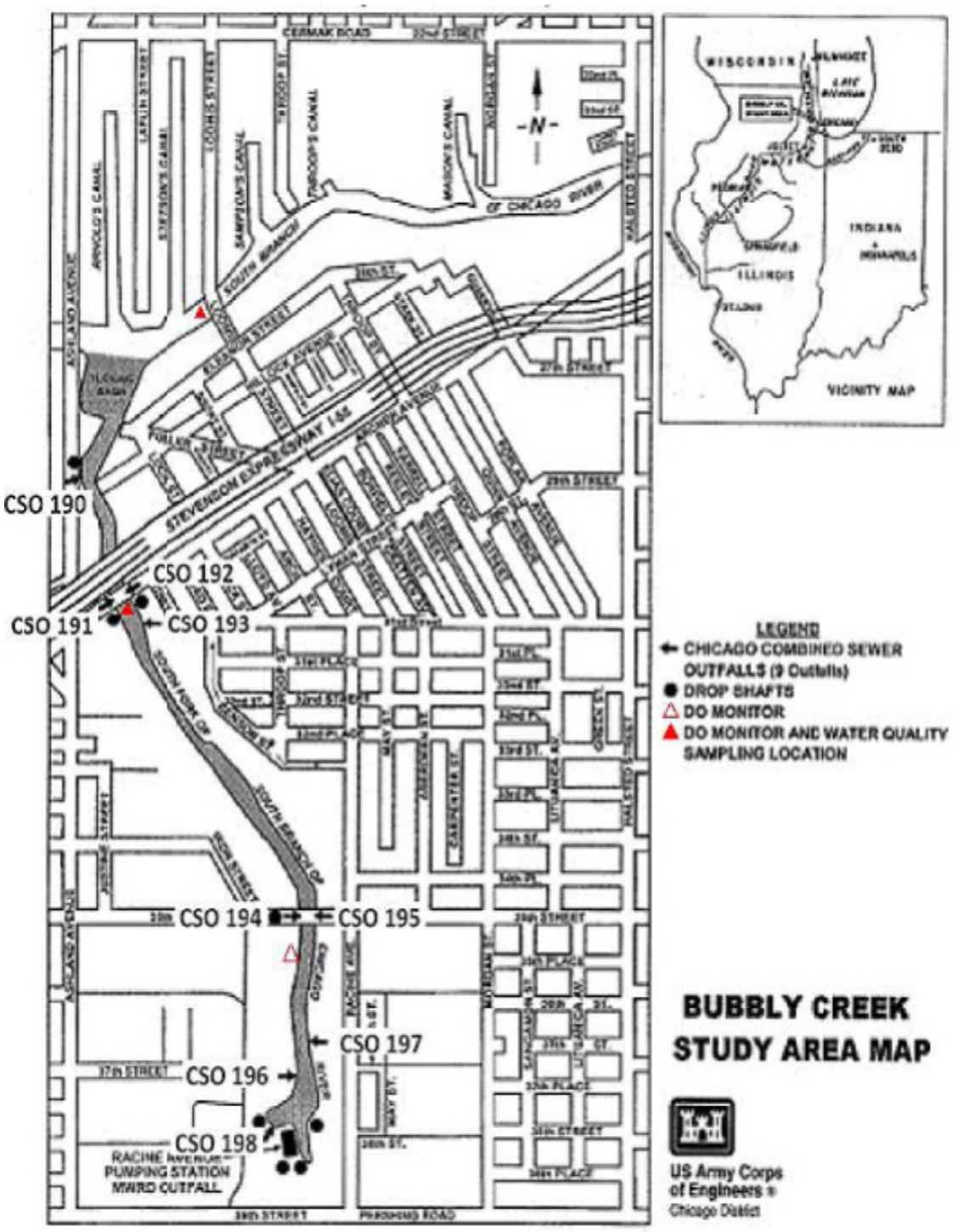


Figure 13: CSO locations within Bubbly Creek.

2.6.4 Ecological Resources

Based on data collection, analysis, and modeling for various physical, chemical and biological properties conducted for this feasibility study, conditions in Bubbly Creek within the foreseeable future are expected to remain the same. Expected improvements to water quality from the implementation of the McCook Reservoir would not be sufficient for native plant and animal communities to reestablish given that physical habitat structure is the limiting factor. Critical habitat components would still be missing and the continued persistence of the highly organic materials in the channel bottom would still preclude plant growth and more sensitive aquatic organisms from utilizing the channel. As such the FWOP habitat quality is projected to be the same as Existing Conditions.

Historically, the South Fork of the South Branch of the Chicago River (Bubbly Creek) was a small prairie slough that drained about 5-square miles of marshy land. The prairie slough was a sluggishly flowing wetland complex, lacking a defined channel including mixed soils that supported an immense diversity of flora and fauna. The original substrates would have been sand, lacustrine clays and detritus from decomposing plant material. This substrate was significantly impacted by the disposal of waste from the meat packing industry and other industrial uses. Currently, the limited macroinvertebrate and fish assemblages in the channel are comprised of non-native and very tolerant species. The riverbanks and side-stream vegetation pockets are impaired as well and are dominated by non-native and invasive plant species. The entire ecosystem is impacted from lowest to highest order species and the physical environment is severely damaged. The current ecosystem is unable to support a diversity of native plant and animal species due to the lack of physical habitat.

Future without-project habitat conditions are not expected to change significantly without a large-scale ecosystem restoration project. State and local governmental activities are not expected to provide the type of large scale changes needed to significantly affect the ecosystem and restore ecological structure. While there have been significant efforts to date to address water quality by Federal and state agencies, there has been no systematic effort to address the physical habitat conditions within Bubbly Creek. It is anticipated that the City of Chicago and local groups would most likely undertake minor terrestrial restoration efforts within the riparian zone of Bubbly Creek. This work may include removing invasive plant species, providing roosting habitat for water birds, and removal of foreign debris and refuse from bank areas. Although these measures would be visually pleasing, the aquatic ecosystem within the study area would not be noticeably improved due to the limited size and spatial coverage available for riparian buffer restoration. Even though there are improvements to water quality predicted from the future reductions in CSO discharges, and accounting for the minor riparian restorations expected to be implemented by local groups, the significant limiting factor causing the ecosystem degradation remains. The physical habitat structure within the aquatic portion of the Bubbly Creek is currently lacking and is expected to remain that way without this project. As such, the habitat assessment evaluation of the forecasted future without-project condition results in the same aquatic habitat unit outputs as the current condition scores as shown in ***Table 8***. Therefore, the aquatic ecosystem of Bubbly Creek would remain severely impaired and would not provide sufficient habitat to sustain even a minimal community structure of macroinvertebrates and fish throughout the planning period of analysis due to the lack of appropriate substrates, aquatic vegetation, and heterogeneous physical structure.

The CAWSHAI was assessed for Bubbly Creek to include the channel and turning basin. A site assessment was completed; values/counts of the habitat structure variables were recorded; and then used to calculate the CAWS Habitat Suitability Index (CAWSHSI) for this channel. The CAWSHSI was then multiplied by the total surface area of the channel. When new habitat structure is planned for the Bubbly Creek, the CAWSHSI is recalculated and then the changes in the CAWSHSI. The CAWSHSI does not include a variable for emergent and riparian plants. As noted above, no emergent species were found in the channel, and only tolerant and invasive plants were found along the channel banks. Being on a 1 to 10 scale, the FQA score was normalized by multiplying the rating by 10 to match the 1 to 100 scale of the CAWSHSI. The FQA was then multiplied by the acres assessed. The results of the analysis are summarized in ***Table 8***, below.

Table 8: Projected Future without Project Condition Habitat Output

Habitat	Location	FQA Mean C /1	CAWSHSI	HSI	AAHSI	Acres	FWOP AAHUs
Substrate	Channel		12.7	12.7	12.7	30.7	389.5
	Turning Basin		12.7	12.7	12.7	30.7	389.5
Riparian	Bank Area	25.0		25.0	25.0	9.3	232.5
Emergent /2	Channel	NA /1		0.00	0.00	1.0	0.00
Submergent/3	Channel	NA /1		0.00	0.00	30.7	0.00
	Turning Basin	NA /1		0.00	0.00	30.7	0.00

/1 The FQA value (possible ratings from 1 to 10) was normalized by multiplying the score by 10 to match the 0 to 100 rating scale of the CAWSHSI.
/2 No FQA value was recorded for these habitat zones because emergent habitats are not present in the channel and turning basin areas.
/3 No CAWSHSI index score was recorded for submergent vegetation (MACRPH_CHAN) because this habitat is not present in the channel or turning basin.

2.6.5 FWOP Summary

Although it is expected that other ongoing and anticipated activities to improve the ecosystem will continue within the Bubbly Creek study area, the overall health of the aquatic ecosystem will not substantially improve from the existing conditions without addressing the lack of physical habitat as the limiting factor. Due to expected water quality improvements from the reduction of future CSOs, the abundance of the fish community may slightly improve within the study area; however, the species richness will be limited without a healthy benthic and plant community structure. The current substrates within Bubbly Creek are not expected to ever provide sufficient habitat, therefore the impairment and suppression of the aquatic ecosystem will continue unabated without a substantial effort to reestablish physical habitat. The limited long-term water quality improvements forecasted for the future without-project conditions are not expected allow the ecosystem to rebound within the planning period of analysis due to the absence of physical habitat structure within Bubbly Creek.

CHAPTER 3 – Problems & Opportunities

This chapter provides a description of identified problems within the study area along with opportunities for improvement. Identification of problems and opportunities begins at the outset of the study and forms the foundation of the planning process. These problems and opportunities can be expressed through an overall project goal.

These problems, opportunities and overall project goal give rise to specific planning objectives and constraints. The objectives state the intended outcome of the planning process and the constraints describe the limitations that restrict plan formulation. Measures and alternative plans are formulated and evaluated with respect to these criteria.

3.1 Problems and Opportunities

3.1.1 Study Area Problems

Many of the problems associated with ecosystem degradation within Bubbly Creek have been studied in depth by a variety of agencies and academia. Currently, Bubbly Creek no longer provides a diversity of habitats nor is the habitat quality sufficient to maintain ecological functions that support healthy and diverse plant and animal communities. The health of the Bubbly Creek ecosystem has severely declined in response to a loss of structural habitat that would support various life stages of aquatic and terrestrial biota. Physical alterations of channel morphology and the lack of low-flow hydraulics have changed the system to one that resembles the backwater of a large river. The structure and composition of substrates are significantly impaired, and no longer allow for benthic organisms such as crayfish, mussels, aquatic insects, fishes and some reptiles and amphibians to utilize this as habitat. Due to the impaired substrates, the channel is lacking of native aquatic vegetation that provides essential habitat for fish, insects, and bird species.

Recent water sampling suggests that water quality in Bubbly Creek has improved. Modeling further predicts that these improvements, while beneficial to the health of the aquatic ecosystem, leaves a critical and overarching problem: an ecosystem cannot recover if only the water quality component of the system is improved. This overarching problem is nested in the inability for the Bubbly Creek to "naturally" recover due to the anthropogenic constraints placed on the system's watershed, geomorphology, hydrology and hydraulics. The following specific ecosystem problems resulting from this overarching problem were identified collaboratively among the study partners and resource agencies:

- Presence of impacted substrates that preclude plant and macroinvertebrate survival
  - Absence of interstitial pores and micro-channels
  - Presence of animal derived detritus and muck that cause root mortality
- Absence of physical aquatic structure (habitat)
  - Absence of aquatic beds and emergent fringes
  - Absence of large woody debris
  - Absence of natural substrates
- Impaired riparian zone structure
  - Altered and disturbed geomorphology (conglomerate fill, sheet pile, riprap, concrete)
  - Presence of unsatisfactory soils for native plant establishment

  - Domination by invasive and weedy plant species
- Impaired water column
  - Presence of animal detritus and muck causing high SOD
  - Presence of highly tolerant detrivores that cause bioturbation and plant mortality
  - Presence of adverse gas production and flux
- Lack of diverse native aquatic and riparian plant communities
- Lack of requisite composite habitats for:
  - local and regional fungi, flora, and fauna
  - rare and endangered species, such as fat mucket, banded killifish, green heron, black-crown night-heron
- Does not contribute habitat to the Great Lakes portion of the Mississippi Flyway
  - Absence of physical habitat structure including migratory bird resting, hunting and forage habitats

3.1.2 Opportunities

Backwater Habitat for Increased Biodiversity

Currently, Bubbly Creek no longer functions as a slough that drains a vast wetland, and instead is a lentic (non-flowing) system that experiences occasional flood pulses. The condition created by this change in the hydrologic regime very closely mimics the backwater of a large river. This hydrologic regime cannot be effectively changed back into its historic conditions; however, the current hydrologic regime can quite easily be taken advantage of to restore critical habitat for migratory birds, fishes, reptiles and other aquatic species by creating a backwater habitat. As identified earlier, the natural condition of Bubbly Creek provided critical habitat for a variety of aquatic plants and animals and migratory fowl.

As an example of the opportunity gained on the Chicago River by restoration of wetland habitat, the recently completed Eugene Field Park restoration project is now providing aquatic habitat for dragonflies, frogs, turtles, green herons, great blue herons, egret, and a multitude of small migratory birds in an area that was once used as a soccer field (***Figure 14***). The project included the removal of unnatural fill to expose the natural soils beneath, thus restoring the proper substrates for the wetland. Now, conservative plants such as pickerel weed and water plantain are thriving. The North Branch of the Chicago River is upstream of Bubbly Creek. After restoration, it is anticipated that Bubbly Creek's biodiversity would significantly increase and similar results would occur in and along its channel (***Figure 1***).

Additionally, a recently completed restoration project at 63rd Street Beach saw an increase in the number of bird species utilizing the site during migration. From October 2010 to 2013, high quality dune and swale habitat was restored as part of a USACE Section 506 aquatic ecosystem project. Prior to restoration, 45 species of birds were recorded at the site from 2002 to September 2010 by the BCN. During construction and as construction was being completed (October 2010 through 2013), 129 birds species were recorded by BCN. This equated to a 65% increase in the total number of species in just 3 years, and this increase occurred during construction of the ecosystem project (e.g., while plants were becoming established).

Figure 14: Eugene Field Park Wetland & Stream Restoration Project, August 2013

Substrate Restoration for Increased Biodiversity

The hydrologic regime in place is conducive to restoring a backwater condition, and this includes the large flood pulses that a natural backwater would experience. In many areas of the channel, the forces exerted by these flows are not powerful enough to purge fine substrates downstream; therefore, this becomes a great opportunity to restore benthic habitat for macroinvertebrates, crayfish, mussels, fishes and some reptile species through the addition of new substrates, woody debris and aquatic plants. For the purpose of this report, substrate restoration means covering the existing sediment with new substrates that are appropriate for this restoration project. If the substrate can be restored using larger particle-sized sands and gravels, it will not be relocated during flood pulses. Adding new substrates would significantly improve habitat for aquatic life. Woody debris is considered an effective means of providing substrate for biological functions to occur, for example, a dead tree snag above the water provides nesting habitat for herons, while the same dead tree is providing underwater spawning habitat for darter and minnow species that stick their eggs to wood. Aquatic plants, macroinvertebrates and fishes would especially benefit from changing the substrate quality. As a result, fish and birds within the surrounding ecosystem would also benefit from improved substrate quality.

As an example of the opportunity gained by restoration of channel substrates, another recently completed Red Mill Pond restoration project is now providing aquatic habitat for aquatic plants, chestnut lamprey, lake chubsucker, northern starhead topminnow and a multitude of benthic

macroinvertebrates in an area that was previously impounded by a dam (***Figure 15***). This project removed the dam and placed a new stream bed on top of the trapped natural muck, which was somewhat comparable in geotechnical properties to those found in Bubbly Creek. Once Bubbly Creek is restored, it is anticipated that species will migrate from other portions of the CAWS to inhabit Bubbly Creek (***Figure 1***).

Figure 15: Red Mill Pond Substrate Changed from Muck to Gravel and Cobble, August 2011

3.2 Goals, Objectives and Constraints

3.2.1 Goal

The principal goal of a resulting ecosystem restoration project is to restore a functional backwater habitat and riparian buffer zone for resident and migratory birds and spawning fishes in Bubbly Creek.

3.2.2 Objectives

Federal Ecosystem Objectives

The Federal objective of water and related land resources planning is to contribute to national economic and/or ecosystem development in accordance with national environmental statutes, applicable executive orders, and other Federal planning requirements and policies. The use of the term "Federal objective" should be distinguished from planning/study objectives, which are more specific in terms of expected or desired outputs, whereas the Federal objective is a National goal. Plans shall be formulated to alleviate problems and take advantage of opportunities in ways that contribute to study objectives and to the Federal objective. Contributions to national improvements are increases in the net value of the national output of goods, services and ecosystem integrity.

Restoration of the Nation's environment is achieved when damage to the environment is reversed, lessened, eliminated or avoided and important cultural and natural aspects of our nation's heritage are preserved. Various environmental statutes and executive orders assist in ensuring that water resource planning is consistent with restoration of the environment. The objectives and requirements of applicable laws and executive orders are considered throughout the planning process in order to meet the Federal objective. The following laws and executive orders that specifically provided guidance for this study are not limited to, but include:

- Endangered Species Act of 1973, as amended (16 U.S. Code (U.S.C.) 1531 et seq.)
- Fish and Wildlife Coordination Act, as amended (16 U.S.C. 661)
- Migratory Bird Treaty Act of 1918, as amended (16 U.S.C. 703 et seq.)
- Responsibilities of Federal Agencies to Protect Migratory Birds (Executive Order (E.O.) 13186)
- Clean Water Act of 1977, as amended (33 U.S.C. 1251 et seq.)
- National Environmental Policy Act of 1969 (42 U.S.C. 4321 et seq.)
- Invasive Species (E.O. 13112)
- Nonindigenous Aquatic Nuisance Prevention & Control Act of 1990, as amended (16 U.S.C. 4701 et seq.)
- National Invasive Species Act of 1996 (Public Law 104 – 332)
- Protection of Wetlands (E.O. 11990)
- Protection and Enhancement of Environmental Quality (E.O. 11514)
- Protection and Restoration of the Great Lakes (E.O. 13340) (Bubbly Creek is within the State Coastal Zone Management Area for Lake Michigan)
- Floodplain Management (E.O. 11988)

Responsibilities of Federal Agencies to Protect Migratory Birds (E.O. 13186)

"Migratory birds are of great ecological and economic value to this country and to other countries. They contribute to biological diversity and bring tremendous enjoyment to millions of Americans who study, watch, feed, or hunt these birds throughout the United States and other countries. The United States has recognized the critical importance of this shared resource by ratifying international, bilateral conventions for the conservation of migratory birds. Such conventions include the Convention for the Protection of Migratory Birds with Great Britain on behalf of Canada 1916, the Convention for the Protection of Migratory Birds and Game Mammals-Mexico 1936, the Convention for the Protection of Birds and Their Environment-

Japan 1972, and the Convention for the Conservation of Migratory Birds and Their Environment-Union of Soviet Socialist Republics 1978.

These migratory bird conventions impose substantive obligations on the United States for the conservation of migratory birds and their habitats, and through the Migratory Bird Treaty Act, the United States has implemented these migratory bird conventions with respect to the United States. This EO directs executive departments and agencies to take certain actions to further implement the Act:

> *(g) "Federal agency" means an executive department or agency, but does not include independent establishments as defined by 5 U.S.C. 104.*
> *(h) "Action" means a program, activity, project, official policy (such as a rule or regulation), or formal plan directly carried out by a Federal agency. Each Federal agency will further define what the term "action" means with respect to its own authorities and what programs should be included in the agency-specific Memoranda of Understanding required by this order. Actions delegated to or assumed by nonfederal entities, or carried out by nonfederal entities with Federal assistance, are not subject to this order. Such actions, however, continue to be subject to the Migratory Bird Treaty Act."*

The ecosystem restoration of Bubbly Creek has great potential to provide critical migratory bird habitat as identified by the Chicago Audubon Society in a letter dated July 2013, which is provided in Appendix B.

Planning Objectives

As part of the USACE Civil Works mission, the federal objective of ecosystem restoration projects is to restore the structure, function and dynamic processes of impaired ecosystems to a more natural condition. The non-Federal sponsor has an ecosystem restoration objective that partners well with the federal objective stated above. Study objectives are statements that describe the desired results of the planning process by solving the problems associated with the study purpose of ecosystem restoration. These objectives were used for the formulation and evaluation of alternative plans. Objectives must be clearly defined and provide information on the effect desired, the location where the expected result will occur, the timing of the effect, and the duration of the effect.

Two (2) planning objectives were developed through a collaborative process that included various stakeholders and resource agencies and were used in the formulation of alternatives:

Objective 1 – Restore Diverse Habitat Structure within Bubbly Creek

Currently, the only plant and animal species found in Bubbly Creek are those that are tolerant of disturbed site conditions, poor water quality and habitat loss.. The necessary physical structure and aquatic vegetation are not present. Impaired substrates and a lack of a natural fluvial source prevent natural recovery of physical habitat. Additionally, the poor physical properties of the current substrate and a lack of stable structure (large woody debris/coves/plant beds) further create a homogenous aquatic system. This lack of natural structure prevents a diverse community of fishes and macroinvertebrates from utilizing the system. In sum, the system is dominated by a very small number of tolerant species due to primarily the lack of habitat structure and secondarily by temporal water quality impacts.

This objective seeks to increase the quantity and improve quality of backwater habitat within Bubbly Creek, inclusive of critical physical habitat and biological components.

Objective 2 – Restore a Viable Foundation for Plant Growth and Aquatic Habitats

Currently, the highly organic and urbanized materials within Bubbly Creek have difficulty in supporting aquatic life. The organic materials within the channel and urbanized soils in bank areas were once altered by 1) excavation and deepening, 2) filling and mixing, 3) influx of animal-based wastes such as carcasses, hair, and offal from the meat processing plants that previously lined its banks, and 4) untreated sewage that once directly dumped into the channel. All of these degrading activities have long since ceased. Measures addressing this objective must target habitat restoration.

This objective seeks to increase the quantity and the improve quality of substrate and growth mediums, as it would be the foundation for the restoration of backwater habitat of Bubbly Creek.

3.3 Planning Constraints

Planning constraints are items of consideration that limit the planning process and are used along with the objectives in the formulation and evaluation of alternative plans. The establishment of planning constraints is done in cooperation with stakeholders. Following is a list of constraints associated with the restoration of Bubbly Creek:

- Maintain conveyance capacity of the channel for CSOs
- Minimize disturbance to surrounding land uses
- Avoid areas with environmental conditions that restrict USACE involvement
- Avoid impacts to historic properties and the I&M Canal Heritage Corridor
- Comply with local land use and development plans

Maintain Channel Conveyance Capacity

Bubbly Creek conveys combined sewage overflows from RAPS and adjacent locations to the South Branch of the Chicago River and the CSSC during flood events. These overflows provide additional capacity to the combined sewer system that drains a major portion of the central and south sides of Chicago, thus addressing local flooding and basement backups. The conveyance capacity of Bubbly Creek must be maintained so that additional flooding is not induced. Therefore, restoration measures, such as substrate restoration and submergent macrophytes plantings must not limit the established conveyance capacity of Bubbly Creek.

Minimize Disturbance to Surrounding Land Uses

In many areas, development exists right up to the edge of the channel. Riparian restoration efforts should be limited to those areas with real estate availability. Impacts to existing residential homes and businesses adjacent to Bubbly Creek should be minimized.

Avoid Areas with Environmental Conditions that Restrict USACE Involvement

The historic land use of Bubbly Creek and neighboring parcels was industrial. Informed through data collected on historic and current land uses and field sampling and analysis, areas with

recognized environmental conditions were either avoided or only measures and construction methods that minimize disturbance to those lands were selected.

Avoid Impacts to Historic Properties and the I&M Canal Heritage Corridor

The Bubbly Creek area has a rich history. Completed in 1848, the Illinois & Michigan Canal originated at the mouth of Bubbly Creek connecting Chicago to the Mississippi River. In recognition of this historic significance, IMCNHC was established by the U.S. Congress in 1984. Restoration efforts should avoid impacts to historic properties including the viewscape of the turning basin as designated by the IMCNHC.

Comply with Local Land Use and Development Plans

Restoration features should be formulated in accordance with the City of Chicago land use and development plans. The City of Chicago is currently developing an urban renewal plan for the neighborhood that surrounds Bubbly Creek. The restoration of Bubbly Creek is a centerpiece of that plan and project features should complement these efforts.

CHAPTER 4 – Plan Formulation & Evaluation

The formulation, evaluation, and comparison of alternative plans comprise the third, fourth, and fifth steps of the USACE planning process. These steps are often referred to collectively as plan formulation. Plan formulation is an iterative process that involves cycling through these steps by formulating preliminary alternatives comprised of a range of measures, screening the preliminary alternatives until a reasonable range of alternative plans is developed, and then evaluating and comparing those plans to determine if a feasible plan exists that can selected to be recommended for implementation.

Plan formulation for ecosystem restoration presents a challenge because alternatives have non-monetary benefits. To facilitate the plan formulation process, the following methodology outlined in USACE Engineering Regulation, ER 1105-2-100, Planning Guidance Notebook was utilized:

1. Identify a primary project purpose. For this study, ecosystem restoration is identified as the primary purpose.
2. Formulate and screen management measures to achieve planning objectives and avoid planning constraints. Measures are the building blocks of alternative plans.
3. Formulate, evaluate, and compare an array of alternatives to achieve the primary purpose and identify cost effective plans.
4. Perform an incremental cost analysis on the cost effective plans to determine the National Ecosystem Restoration (NER) plan.

4.1 Measure Identification & Screening*

The Reconnaissance Study that was approved in 2007 provided a list of measures that could possibly restore or support ecosystem restoration. This reconnaissance-level assessment identified and evaluated various potential measures with a recommendation for those that should continue to be assessed during the feasibility study (***Table 9***). Additional assessment conducted during the feasibility utilized newly developed models, habitat restoration concepts, system constraints and USACE ecosystem restoration policies to further evaluate and screen the measures identified during the reconnaissance study. A revised suite of potential restoration measures was developed and used in formulating restoration plans.

Table 9: Screening of Potential Ecosystem Restoration Measures

Measure Description	Discussion	Reconnaissance Screening Decision	Feasibility Screening Decision
Separate sewers and collect stormwater from adjacent properties for controlled release during low-flow conditions	Numerous small sewersheds at one time drained directly into Bubbly Creek via the nine CSO outfalls currently along the channel. These sewersheds currently drain into interceptors and are pumped for treatment. Due to the small size of these sewersheds, the possibility of sewer separation and collection of stormwater for controlled release exists.	**Retain**, could support habitat restoration features.	**Eliminate**, this measure only addresses water quality and would not specifically restore habitat. It was determined that the nine CSOs that discharge into the channel are negligible compared to RAPS. Local initiatives to reduce or eliminate CSOs should continue.

Table 9 (continued): Screening of Potential Ecosystem Restoration Measures

Measure Description	Discussion	Reconnaissance Screening Decision	Feasibility Screening Decision
Inflow water from Bubbly Creek at RAPS for treatment at Stickney WRP	This measure was implemented during a two year demonstration project by MWRDGC that concluded although water quality showed marked improvements this method cannot be used as a long term solution due to increased wet-weather capacity requirements at the WRP and significant additional operating costs.	**Eliminate**, not sustainable or cost effective.	**Eliminate**, this measure only addresses water quality and would not specifically restore habitat. However, this measure could be an effective adaptive management measure should water quality in the Bubbly Creek temporally dip below required conditions to support ecosystem health.
Pump water from the South Branch to the upstream end of Bubbly Creek near RAPS to restore low-flow conditions	The possibility of pumping water from the South Branch and discharging it at the upstream end of Bubbly Creek to restore low flow conditions exists.	**Retain**, could support habitat restoration features.	**Eliminate**, this measure is not sustainable and would not be cost effective. It was not determined sustainable nor feasible to restore Bubbly Creek to a flowing stream.
Pump water from Lake Michigan to the upstream end of Bubbly Creek near RAPS to restore low-flow conditions	A pump station at the lake and a tunnel along 39th Street were constructed in the early 1900's and this measure was utilized for many years to flush raw sewage out of Bubbly Creek. This method was abandoned after the introduction of sewage treatment practices and the construction of RAPS to convey sewage to the WRP. According to Section 1109(b)(4) of Water Resources Development Act (WRDA) 1986 as amended, any Federal agency is prohibited from undertaking any studies that would involve the transfer of Great Lakes water for any purpose for use outside the Great Lakes basin, therefore this measure was not retained.	**Eliminate**, may have legal implications. Although technically effective idea to improve flow and water quality, this is not a sustainable or cost effective measure.	NA
Separate sewers within the RAPS sewershed	During the comprehensive feasibility study that justified the Chicago Underflow Plan this measure was found too costly and infeasible.	**Eliminate**, not cost effective or technically feasible for a habitat restoration project.	NA
Diverte stormwater within the RAPS sewershed to another	During the comprehensive feasibility study that justified the Chicago Underflow Plan this measure was found too costly and infeasible.	**Eliminate**, not cost effective or technically feasible for a habitat restoration project. May also have legal implications to connected watersheds.	NA
Local sewer separation and elimination of CSOs in areas adjacent to Bubbly Creek	As stated above, due to the small size of adjacent sewersheds, the possibility of sewer separation exists. In addition, CSO outfalls along the channel could possibly be bulk headed or removed.	**Retain**, could support habitat restoration features.	**Eliminate**, this measure only addresses water quality and would not specifically restore habitat. It was determined that the nine CSOs that discharge into the channel are negligible compared to RAPS. Local initiatives to reduce or eliminate CSOs should continue.
Creation of detention storage for the RAPS sewershed	This measure was recommended and approved under the Chicago Underflow Plan. The McCook reservoir, currently under construction, along with the completed TARP tunnel system has created detention storage for large areas of the Chicago area including the RAPS sewershed. Additional storage in the RAPS sewershed is not feasible.	**Eliminate**, this concept is already being implemented on a grand scale for water quality improvement and flood control purposes.	NA

Table 9 (continued): Screening of Potential Ecosystem Restoration Measures

Measure Description	Discussion	Reconnaissance Screening Decision	Feasibility Screening Decision
Creation of detention storage for areas adjacent to Bubbly Creek	As stated above, due to the small size of adjacent sewersheds, the possibility of creating additional detention storage exists.	**Retain**, could support habitat restoration features.	**Eliminate**, this measure only addresses water quality and would not specifically restore habitat. It was determined that the nine CSOs that discharge into the channel are negligible compared to RAPS. Local initiatives to reduce or eliminate CSOs should continue.
Water treatment/disinfectant of CSOs from RAPS	This measure would involve treatment of CSO discharges by such means as chlorination/dechlorination, filtration, ultraviolet disinfection, or other means. The flows requiring treatment would be large volumes of CSOs during a sudden and short-term discharge episode.	**Eliminate**, currently not feasible based on water treatment technology and capacities. These techniques are feasible in consistently flowing systems, but the periodic treatment of a sudden large volume of CSO is not feasible. It is not feasible to have a treatment operation that only works occasionally and then for very large flows.	NA
Water treatment/disinfectant of CSOs from areas adjacent to Bubbly Creek	As stated above, this measure would involve treatment of CSO discharges by a variety of means. Since CSO discharges from areas adjacent to Bubbly Creek are minimal in comparison to RAPS the possibility of treating the CSOs prior to contact with Bubbly Creek exists.	**Retain**, could support habitat restoration features.	**Eliminate**, this measure only addresses water quality and would not specifically restore habitat. It was determined that the nine CSOs that discharge into the channel are negligible compared to RAPS. Local initiatives to reduce or eliminate CSOs should continue.
Bypass discharge directly to South Branch	The possibility of diverting CSO discharge from RAPS directly to the South Branch via diversion pipes exists. The large costs to implement this measure must be weighed against the ecological benefits from the elimination of CSOs from RAPS.	**Retain**, could support habitat restoration features.	**Eliminate**, this measure would not provide needed requirements to restore a healthy ecosystem at Bubbly Creek. It was determined the CSO discharges are no different than large river flood pulses. Based on in-channel hydraulic modeling, these flood pulses are not limiting habitat structure from developing.
Remove sediments	The possibility of removing existing sediments through dredging and disposal of Bubbly Creek exists.	**Retain**, could support habitat restoration features.	**Eliminate**, removal of sediments would not restore habitat because there is not a healthy substrate layer to expose. Additionally, removal of all organic sediment present would result in a channel that is too deep to provide appropriate aquatic habitat and remaining sediments would be clayey tills that are also unsuitable substrates for aquatic habitat.
Cap existing sediments with a confining clay layer or other material	The possibility of capping bottom sediments Bubbly Creek exists.	**Retain**, could support or provide habitat restoration features.	**Eliminate**, this measure primarily addresses water quality impairments and is not necessary to achieve sustainable ecosystem restoration. Capping techniques that only address improving water quality do not meet the project objective of restoring habitat for plants, fish and wildlife.

Table 9 (continued): Screening of Potential Ecosystem Restoration Measures

Measure Description	Discussion	Reconnaissance Screening Decision	Feasibility Screening Decision
In-stream aeration	The possibility of creating in-stream aeration to improve the water quality of Bubbly Creek exists. MWRDGC has constructed several side stream elevated pool aeration (SEPA) stations along the Chicago Waterway System to improve water quality by lifting canal water and allowing it to drop over a series of weirs to create a waterfall and add oxygen to the waterway.	**Retain**, could support habitat restoration features.	**Eliminate**, this measure only addresses water quality, and then potentially only some parameters, and would not specifically restore habitat. It was also determined that aeration to support ecosystem functions is unnecessary and not sustainable.
Implementation of Best Management Practices (BMPs)	The possibility of implementing best management practices (BMPs) such as bioswales, bio-infiltration basins, and wetponds to divert clean stormwater into Bubbly Creek exists. The City of Chicago has established a 60-foot stormwater setback to allow implementation of stormwater BMPs along the channel.	**Retain**, could be incorporated into habitat features.	**Eliminate**, would be implemented per Section 401 Certification and NPDES permitting requirements. These measures would not be formulated for since they would not significantly restore habitat.
Reconfigure channel cross-sectional form	The possibility of reconfiguring the channel geometry to create flow diversity exists. Special attention in regards to sediment disturbance, handling, and disposal must be carefully considered with this measure.	**Retain**, would physically restore habitat.	**Retain**, would provide areas to restore aquatic beds and emergent wetlands.
Streambank recontouring, native plantings, and restoration	The possibility of stream bank restoration through recontouring and establishment of native plant communities exist.	**Retain**, would physically restore habitat.	**Retain**, would provide additional emergent wetland acres for Bubbly Creek.
In-channel wetland restoration	The possibility of restoring wetlands within the channel exists. Current high flow conditions caused by CSOs from RAPS constrain the restoration of in-channel wetlands.	**Retain**, would physically restore habitat.	**Retain**, this measure would be confined to those sections of Bubbly Creek where water velocities do not exceed 3ft/s .
Substrate introduction and streambed restoration	The possibility of restoring the natural substrate diversity exists. This measure could be incorporated with sediment removal or capping measures stated above.	**Retain**, would physically restore habitat.	**Retain**, this measure, after further analysis of the system, proves to be corner stone in restoring aquatic beds, emergent wetlands and substrate for macroinvertebrates and spawning fishes.
Placement of snags and large woody debris	The possibility of restoring natural structure diversity in the form of snags or large woody debris exists.	**Retain**, would physically restore habitat.	**Retain**, this measure would provide habitat for plants, macroinvertebrates, reptiles, amphibians, fishes and water birds.
Riparian native plant restoration	The possibility of restoring natural plant communities along the riparian areas of Bubbly Creek exists.	**Retain**, would physically restore habitat.	**Retain**, this measure would provide habitat and seclusion for water birds and shoreline habitat for aquatic species. It would also remove invasive plant species from the immediate surrounds of Bubbly Creek.
Repair or replace deteriorated bank treatments	Due to the ecosystem restoration authority of this project, repair or replacement of existing deteriorated bank treatments such as steel sheet pile and concrete walls is not considered appropriate. Measures to restore streambanks through recontouring and native plant restoration as stated above are recommended.	**Eliminate**, replacement of features would not restore habitat.	NA

4.2 Final Array of Restoration Measures

Based on further analysis of restoration measures identified during the Reconnaissance Study, a final array of sustainable and effective restoration measures were developed to target the identified problems, opportunities, and planning objectives. Certain constraints and design choices were informed by conditions found in the Grand Calumet prior to its remediation (see Section 2.5.3 Reference Sites). The measures include plant species found in the Grand Calumet River and planting is specified where Bubbly Creek channel velocities were modeled as being less than 3 feet/second, the maximum velocity of the Grand Calumet River. The following is the final array of measures that ecosystem restoration alternative plans were generated from:

No Action (NA)

The No Action measure/alternative is always considered per the Council on Environmental Quality's (CEQ) requirements under the NEPA. The No Action Alternative is synonymous with Future Without-Project conditions and forms the basis by with each plan is compared.

Substrate Restoration (SR)

The substrate restoration measure seeks to provide a viable growth medium for submergent and emergent plants and habitat structure for macroinvertebrates, crayfish, mussels, turtles and spawning fishes. Design of the substrate restoration measure has evolved as more site-specific engineering information was gathered resulting in an optimized design; early designs included thicker substrate layers and larger and uniform armor stone. In February 2014, a Value Engineering (VE) Study was completed that optimized the design of this measure (Appendix I). Substrate restoration would be targeted to areas where existing substrates do not provide adequate habitat structure, which includes the entire in-water project area, the Bubbly Creek channel (24.3 acres) and the turning basin (6.4 acres). Substrate restoration would involve placing an approximately 6-inch thick sand layer over the existing sediment. A 6-inch thick rounded river rock or quarried stone layer would be placed on top to armor the sand layer from erosive forces. The quarried stone, a mixture of CA-7 and CA-9, would be placed in deep areas of the channel. The rounded river stone, with an approximate a D_{50} of 20mm (3/4-in) in diameter, would be placed in shallower areas where plants are expected to grow. The substrate would be placed by broadcasting it from barge platforms. Due to the soft nature of the existing sediments, each layer would have to be broadly spread across Bubbly Creek in increments (This methodology for placing sediment covers has been used in other locations throughout the Great Lakes.). To create heterogenous habitat, pebble and cobble beds would be created along the banks in existing wood cribs. There are structures within the Bubbly Creek channel, such as bridge abutments, outfalls, protruding revetments and other areas where hydraulic forces vary. A few of these areas may require additional armoring with larger cobbles and boulders, which would provide diversity of habitat as well as prevent erosion.

Bank Restoration (BR)

The bank restoration measure seeks to provide recessed, off-channel areas along the Bubbly Creek channel to provide additional wetland and riparian habitat for fish and wildlife species. Bank restoration would be targeted to open areas along the channel where the bank could be cut-back, which includes three areas of the channel: downstream (0.5 acres), midstream (0.8 acres), and upstream (0.1 acres). The existing bank areas would be excavated and graded back

approximately 60-feet from the existing channel edge to allow for two to three terraces to be placed that would support aquatic bed, emergent zone and mesic-shrub prairie.

Riparian Planting (RP)

The riparian planting restoration measure seeks to remove invasive plant species and establish a native riparian zone along the channel banks. Riparian plantings would only be implemented in those areas conducive for establishment (e.g., vertical banks would be excluded) and where other restoration measures were not considered. As such, two options were considered: along the entire length of the channel (9.3 acres) or only in those areas where bank restoration was not considered (7.8 acres). This zone includes from the water's edge to the top of banks, generally not exceeding 60-feet. All invasive plant species would be physically removed from the area with woody species being chipped on site. In order to minimize disturbance to existing ground, the remaining root mass would not be removed, but rather treated with herbicide to prevent resprouting. Loose surface foreign debris would be removed and disposed. The banks would be topped with a 6-inch layer of new soil mixed with the chipped wood worked into the top three inches of the existing soil layer. Native riparian plant species to be established would generally be a transition zone mix, but would primarily include a shrub prairie community with wildflowers, prairie grasses, butterfly weeds, and clumps of New Jersey tea (*Ceanothus americanus*) and early wild rose (*Rosa blanda*).

Emergent Planting (EP)

The emergent planting restoration measure seeks to establish a native emergent zone where plant life currently does not exist. Emergent plantings would only be implemented in shallow areas where normal water depth is less than 2-feet (1.0 acres) and this measure is dependent on the restoration of substrates to provide the appropriate substrate for aquatic plant growth. Organic leaf litter compost would be worked into the rounded river rock or quarried stone layer to further provide an adequate planting medium. Native emergent zone species to be established include swamp loosestrife (*Decodon verticillatus*), pickerel weed (*Pontederia cordata*) and pond lilies such as yellow pond lily (*Nuphar advena*) and white water lily (*Nymphaea tuberosa*).

Submergent Planting (SP)

The submergent planting restoration measure seeks to establish a native aquatic zone where plant life currently does not exist. Submergent plantings would only be implemented in areas where maximum water velocities are less than 3-feet per second and good sunlight penetration is present. As such, two options were considered: within the channel (1.4 acres) and within the turning basin (1.9 acres). Submergent planting is dependent on the restoration of substrates to provide the appropriate substrate for aquatic plant growth. Over time it is expected that the aquatic beds would shift and expand throughout the channel. Organic leaf litter compost would be worked into the rounded river rock or quarried stone layer in the areas to be planted to further provide an adequate planting medium. Native aquatic bed species to be established include eel grass (*Vallisneria americana*), and pondweeds such as leafy pondweed (*Potamogeton foliosus*) and American pondweed (*Potamogoten nodosus*).

Woody Debris (WD)

The introduction of woody debris measure seeks to provide flow diversity and increase habitat complexity within the channel to support fish, macroinvertebrates, turtles, and birds. This

measure which includes the introduction of whole trees, rootwads, trunks, and/or large branches would be anchored in areas that experience increased flow, at points were erosion is predicted to occur, and also randomly throughout the channel to increase habitat complexity. Three types of snags would be introduced to target different suites of species: 1) submerged rootwads, trunks and branches would target macroinvertebrates and fishes, 2) flat lying, partially submerged trunks and branches for macroinvertebrates, fishes and basking turtles and 3) vertical trunk and branches for roosting herons. In addition, large non-native trees could be girdled in place to provide riparian habitat for woodpeckers and bats. Approximately 10 woody debris areas to be placed within the channel were identified.

Scales of Restoration Measures Evaluated

From the seven types of restoration measures considered, specific restoration measures were formulated to address the ecosystem degradation of Bubbly Creek. Where practical, varied scales of each measure were formulated and evaluated in order to identify the most efficient restoration plan. A summarized list of restoration measures specifically formulated to address ecosystem impairments in Bubbly Creek are shown in ***Table 10***. These measures were utilized to formulate a range of alternative plans.

Table 10: Summary of Restoration Measures Evaluated.

Measure /Scale	Type	Description
Baseline	No Action	No Action Plan as required
SR1	Substrate Restoration	Place sand layer and armor layer over 24.3 acres within Bubbly Creek channel.
SR2		Place sand layer and armor layer over 6.4 acres within the turning basin.
BR1	Bank Restoration	Cut-back a downstream bank area to create 0.5 acres of protected channel, plant 0.5 acres of emergent wetland in the channel, and plant 0.4 acres of riparian shrub prairie along the newly formed terraced bank (total area 0.9 acres).
BR2		Cut-back a downstream bank area to create 0.8 acres of protected channel, plant 0.8 acres of emergent wetland in the channel, and plant 0.6 acres of riparian shrub prairie along the newly formed terraced bank (total area 1.4 acres).
BR3		Cut-back a downstream bank area to create 0.1 acres of protected channel, plant 0.1 acres of emergent wetland in the channel, and plant 0.2 acres of riparian shrub prairie along the newly formed terraced bank (total area 0.3 acres).
RP1	Riparian Plantings	Remove invasives, place an amended soil layer, and plant native riparian species over 7.8 acres within the Bubbly Creek corridor.
RP2		Remove invasives, place an amended soil layer, and plant native riparian species over 9.3 acres within the Bubbly Creek corridor.
EP	Emergent Plantings	Amend substrate with organic material and plant native emergent species over 1.0 acres within the Bubbly Creek channel.
SP1	Submergent Plantings	Amend substrate with organic material and plant native submergent species over 1.4 acres within the Bubbly Creek channel.
SP2		Amend substrate with organic material and plant native submergent species over 1.9 acres within the Bubbly Creek turning basin.
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.

4.3 Restoration Measure Costs & Assumptions

Conceptual, planning-level cost estimates were prepared for each restoration measure and are used to provide an economic basis for the evaluation of alternative plans (***Table 11***). These

conceptual, planning-level (or "economic") costs are used for the economic analysis of alternative plans and reflect the opportunity costs of direct or indirect resources consumed by project implementation. It should be noted that these costs are solely used for economic analysis and differ from financial costs used in determining total project and associated cost sharing. All economic costs were referenced to October 2014 price levels.

Economic cost estimates were developed using parametric cost data from recent construction contracts and other studies. First NER costs include construction, lands, easements, rights-of-way, relocations and disposal areas (LERRDs), preconstruction engineering and design (PED), construction management, engineering and design during construction (EDDC), and project management and associated contingencies. The PED costs include any future sampling, testing and modeling, as well as more typical design analysis activities. All of these additional costs are estimated based on a percentage of implementation costs. Estimated monitoring and adaptive management (AM) costs were also included.

In addition to first costs associated with implementing each restoration measure, interest foregone during construction was determined as another direct cost. Interest during construction (IDC) is based on estimated implementation duration for each measure and compounded monthly using current discount rate. Since the true economic cost of implementation can vary over time depending on restoration measure, first costs and IDC were distributed accumulated over the entire 50-year period of analysis and discounted based on the current FY2014 federal discount rate of 3.5% as per Economic Guidance Memorandum 14-01, Federal Interest Rates for Corps of Engineers Projects. It was assumed that the project would be implemented once McCook Stage 1 Reservoir was brought online in 2017. [The commencement of operation of the McCook Stage 1 Reservoir will result in a reduction in CSO discharges to Bubbly Creek, and thus will result in more suitable project implementation conditions.] As such, the baseline for when an ecosystem restoration plan would be implemented was set at 2018. Once all implementation distributed costs were converted to present values, the annual equivalent cost of implementing each measure was determined.

Annual operations, maintenance, repair, replacement and rehabilitation (OMRR&R) costs, which are the responsibility of the non-Federal sponsor, were estimated for each measure based on experience with similarly implemented features and projected operational requirements. Annualized OMRR&R costs were added to annualized first and IDC costs to establish the total annual equivalent cost of each measure used in the economic evaluation of plans using cost effectiveness and incremental cost analyses. A summary of total economic costs for each measure is shown in ***Table 11***.

Table 11: Summary of Planning-Level Economic Costs per Measure.

Scale	Total First Cost/1	Monitoring & Adaptive Management	IDC/2	Annual Equivalent Worth	Annual Equivalent OMRR&R	Total Annualized Cost
SR.1	$5,124,100	$248,000	$86,500	$231,700	$24,500	$256,200
SR.2	$1,506,300	$64,600	$25,300	$67,800	$6,500	$74,300
BR.1	$3,178,600	$18,900	$51,500	$143,200	$900	$144,100
BR.2	$6,316,400	$29,700	$102,100	$284,200	$1,300	$285,500
BR.3	$1,205,300	$4,100	$19,500	$54,200	$200	$54,400
RP.1	$2,488,700	$57,600	$41,000	$110,100	$4,400	$114,500
RP.2	$2,967,300	$68,600	$48,900	$131,200	$5,300	$136,500
EP.1	$139,200	$14,000	$2,500	$6,600	$1,100	$7,700
SP.1	$192,200	$10,300	$3,300	$8,700	$800	$9,500
SP.2	$261,100	$16,200	$4,500	$11,900	$1,200	$13,100
WD.1	$62,700	$2,400	$1,000	$2,800	$200	$3,000

/1 Total first cost includes costs associated with implementation, contingencies, LERRDs, PED, construction management, EDDC, and project management referenced to October 2014 price level. Costs associated with project planning and feasibility study are sunk costs and are not included in total first costs.
/2 The IDC was compounded monthly using current FY14 federal discount rate of 3.5% and estimated implementation duration for each measure.

4.4 Restoration Measure Benefits*

The evaluation of habitat benefits is a comparison of the with-project and without-project conditions for each restoration measure (***Table 12***). Ecosystem restoration "outputs" are the desired or anticipated habitat value of restoration measures and alternative plans. The term "outputs" is often used interchangeably with "benefits" and is measured using habitat units (HUs). Ecosystem restoration plans may possess multiple output categories, as well as other effects that may need to be considered, but the evaluation must at least address cost and an output category that has been determined to represent the range of ecosystem restoration benefits. A comparison of the future without-project and future with-project HUs was performed in order to determine if a measure, or group of measures, would have beneficial effects to the Bubbly Creek ecosystem. The suite of restoration measures were evaluated using the two habitat suitability index (HSI) models: FQA and CAWSHAI developed for this study.

The CAWSHSI is a tool to characterize reaches within the CAWS for purposes of comparing the range of habitat quality within the CAWS and for prioritizing locations for potential habitat improvement measures. Increases to the CAWSHSI due to proposed implementation of structural habitat measures when compared to the score for current conditions indicate there is a benefit to adding those measures to the assessed portion of the channel. Improvements due to measures SR1, SR2, BR1, BR2, BR3, SP1, SP2 and WD were calculated using CAWSHSI. Each index score is multiplied by the surface area of assessed portion of the channel. For measures SR1, SR2, SR3, SP1, SP2 and WD, the surface area of the channel assessed is 30.7 acres. The bank restoration measures, however, increase the surface area of the channel. For each bank restoration measure, this increased channel surface area is equal to the acres of emergent plantings. The assessed surface area for BR1 is equal to 30.7 acres (channel's current surface area) plus the additional channel surface area created by the cutback, 0.5 acres (emergent plantings acres) for a total of 31.6 acres. The increased surface area for BR2 is 0.8 acres (emergent planting acres) plus the current surface area of 30.7 acres for a total acres of 31.5 acres.

The increased surface area for BR3 is 0.1 acres (emergent planting acres) plus the current surface area of 30.7 acres for a total of 30.8 acres.

The CAWSHSI does not contain variables for RP1, RP2 and EP. The improvements due to the these measures were calculated using the FQA. The FQA index is multiplied by the acres planted. This score indicates the benefits of adding those plants to the system. R2 represents the plantings along entire available length of the channel (9.3 acres). RP1 represents the plantings in areas where bank restoration was not considered (7.8 acres).

The outputs of each plan in terms of AAHUs were calculated for each plan using the two HSI models over a 50-year planning period of analysis. It was assumed that the project would be implemented shortly after Stage 1 of the McCook Reservoir becomes operational in 2017 because conditions would then be more suitable for ecosystem restoration. As such, a baseline year of 2018 was selected as the year when an ecosystem restoration plan would be implemented and the projected outputs would begin to accrue.

Table 12: Summary of Restoration Measure Habitat Outputs

Measure /Scale	FQA Mean C /1	CAWSHAI	HSI	AAHSI	Acres /2	Output AAHUs	FWOP AAHUs /3	Net AAHUs
SR1		20.6	20.6	20.3	30.7	622.2	389.5	232.7
SR2		15.8	15.8	15.7	30.7	480.9	91.4	42.22
BR1 /4	59.0 - rp 54.0 - em	19.9	59.0 - rp 54.0 - em 13.5 - ch	55.9 - rp 54.0 - em 13.5 - ch	0.4 - rp 0.5 - em 31.2 - ch	22.4 - rp 24.6 - em 419.9 - ch	399.5	67.4
BR2 /4	59.0 - rp 54.0 - em	19.9	59.0 - rp 54.0 - em 13.5 - ch	55.9 - rp 54.0 - em 13.5 - ch	0.6 - rp 0.8 - em 31.5 -ch	33.6 - rp 39.3 - em 424.0 - ch	404.5	92.3
BR3 /4	59.0 - rp 54.0 - em	12.8	59.0 - rp 54.0 - em 12.8 - ch	55.9 - rp 54.0 - em 12.8 - ch	0.2 - rp 0.1 - em 30.8 -ch	11.2 - rp 4.9 - em 393.9 - ch	394.5	15.4
RP1	59.0		59.0	55.9	7.8	436.3	195.0	241.3
RP2	59.0		59.0	55.9	9.3	520.2	232.5	287.7
EP	54.0		54.0	49.1	1.0	49.1	0.0	49.1
SP1		14.6	14.6	14.4	30.7	442.8	389.5	53.3
SP2		15.2	15.2	15.0	30.7	459.5	389.5	70.0
WD		13.8	13.8	13.8	30.7	422.0	389.5	32.5

/1 The FQA value (possible ratings from 1 to 10) was normalized by multiplying the rating by 10 to match the 0 to 100 rating scale of the CAWSHAI.
/2 Acreage for measures utilizing the CAWSHAI included total acreage for Bubbly Creek channel
/3 The FWOP conditions for each habitat zone is shown in Table 5. No FWOP habitat units are recorded for emergent, submergent, and woody debris because these habitats are not present in the channel.
/4 Bank restoration measures include restoration of riparian (rp), emergent (ep) and channel (ch) habitat zones areas which require the use of both FQA (rp, ep) and CAWSHAI (ch) habitat indices. AAHUs are separately calculated for each zone and then summed to provide an overall output for the restoration measure.

4.5 Alternative Plan Generation*

Eleven (11) specific measures, including the No Action measure, were used to formulate restoration alternative plans of varying scales by utilizing the certified USACE Institute for Water Resources Planning Suite Software (IWR-PLAN) version 1.0.9.0. The software generates a set of

alternatives based on the types of measures and scales provided. The annualized costs and net average annual habitat units for each of the measures are input for analysis. Plan dependencies were specified to ensure unrealistic combinations were not generated as outlined below:

- Bank Restoration (BR1, BR2, *or* BR3) *is not combinable* with Riparian Planting (RP2)
- Riparian Planting (RP1) *is not combinable* with Riparian Planting (RP2)
- Riparian Planting (RP1 *is dependent on* Bank Restoration (BR1, BR2, *or* BR3)
- Emergent Plantings (EP) *is dependent on* Substrate Restoration (SR1)
- Submergent Plantings (SP1) *is dependent on* Substrate Restoration (SR1)
- Submergent Plantings (SP2) *is dependent on* Substrate Restoration (SR2)
- Woody Debris (WD) *is dependent on* Substrate Restoration (SR1)

Based on these inputs and criteria, the IWR-PLAN generated 432 alternative plan combinations for ecosystem restoration. These alternative combinations were evaluated for cost-effectiveness and incremental cost as presented in the following sections.

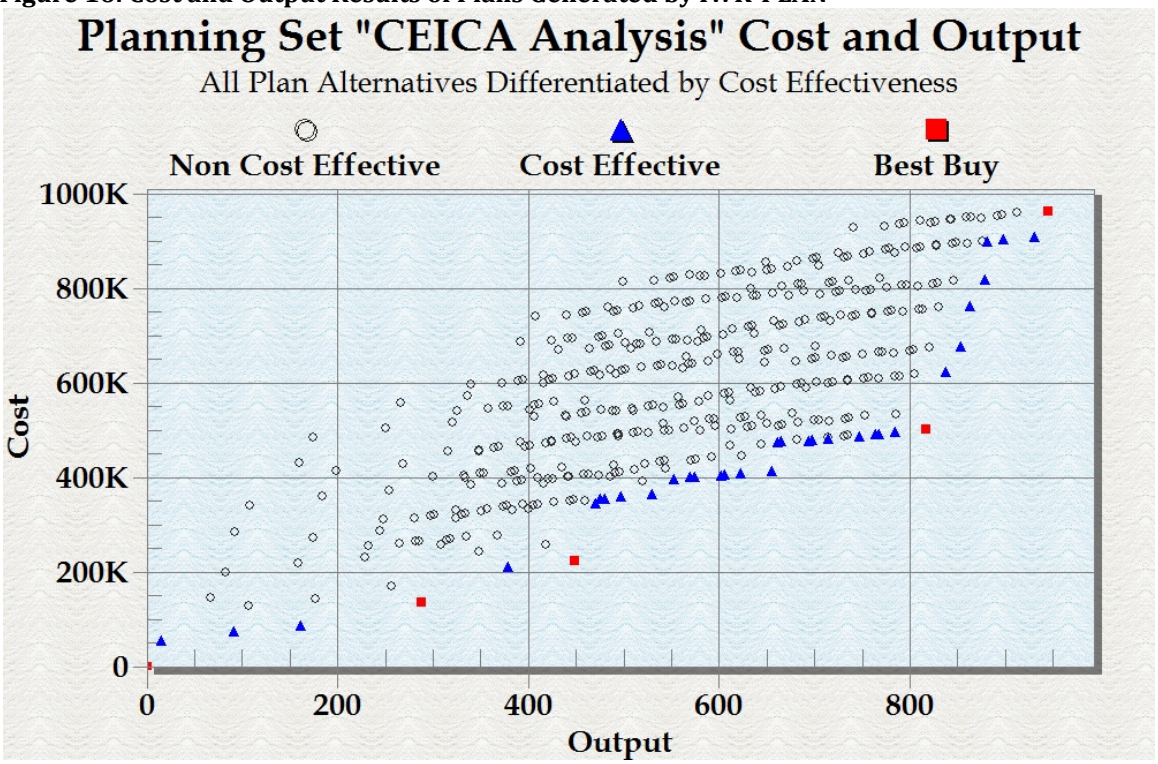
4.6 Cost Effectiveness/Incremental Cost Analysis

Cost effectiveness and incremental cost analysis (CE/ICA) are two distinct analyses that are conducted to evaluate the effects of options / alternative plans. First, it must be shown through cost effectiveness analysis that a restoration plan's output cannot be produced more cost effectively by another means. *Cost effective* means that, for a given level of non-monetary output, no other plan costs less and no other plan yields more output at a lower cost. Subsequently, *incremental cost analysis* takes the cost effective plans and identifies the increment of additional cost required for an additional output. The subset of cost effective plans are examined sequentially (by increasing scale and increment of output) to ascertain which plans are most efficient in the production of environmental benefits. Those most efficient plans are called "best buys." They provide the greatest increase in output for the least increases in cost. They have the lowest incremental costs per unit of output. In most analyses, there will be a series of best buy plans, in which the relationship between the quantity of outputs and the unit cost is evident. As the scale of best buy plans increases (in terms of output produced), average costs per unit of output and incremental costs per unit of output increase as well. Usually, the incremental analysis by itself does not point to the selection of any single plan. The results of the incremental analysis must be synthesized with other decision-making criteria (i.e., significance of outputs, acceptability, completeness, effectiveness, risk and uncertainty, reasonableness of costs) to aid in selecting a particular plan for recommendation.

4.6.1 Cost Effectiveness

The cost effectiveness analysis was used to screen plans that produced the same amount or less output at a greater cost when compared to all other plans. Four hundred thirty-two (432) alternative plans were analyzed for cost effectiveness. Of these, 37 cost-effective plans were identified (***Figure 16)***, of which 5 were designated as "best-buy" plans denoting these plans had the least incremental cost per scale of output. It should be noted that the No Action and alternative plan with the largest output is always deemed both cost effective and a "best-buy" plan by IWR-PLAN. Three hundred ninety-five (395) alternative combinations were screened out as non-cost effective.

Figure 16: Cost and Output Results of Plans Generated by IWR-PLAN



4.6.2 Incremental Cost Analysis

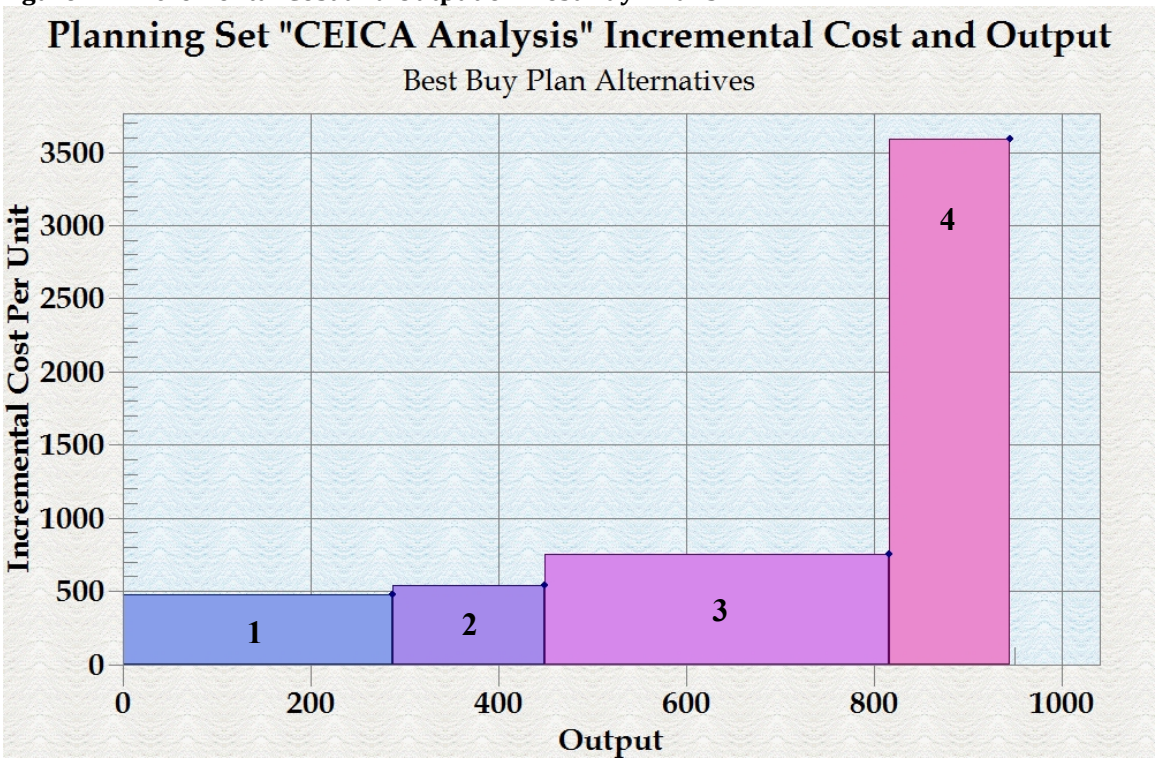
An incremental cost analysis was performed on the five (5) "best-buy" plans identified from the cost effectiveness analysis. The objective of the incremental cost analysis is to assist in determining whether the additional output provided by each successive plan is worth the additional cost. This incremental cost analysis (***Table 13*** and ***Figure 17)*** compares five alternatives deemed "best buy" plans and are considered in the selection of the NER Plan:

- Alternative 0 – No Action
- Alternative 1 – Riparian Planting, Entire Channel (RP2)
- Alternative 2 – Substrate Restoration, Turning Basin (SR2), Submergent Planting, Turning Basin (SP2), and Riparian Planting, Entire Channel (RP2)
- Alternative 3 – Substrate Restoration, Channel/Turning Basin (SR1, SR2), Submergent Planting, Channel/Turning Basin (SP1, SP2), Riparian Planting, Entire Channel (RP2), Emergent Planting (EP), and Woody Debris (WD),
- Alternative 4 – Substrate Restoration, Channel/Turning Basin (SR1, SR2), Submergent Planting, Channel/Turning Basin (SP1, SP2), Riparian Planting, Entire Channel (RP1), Emergent Planting (EP), Woody Debris (WD), and Bank Restoration, Downstream/Midstream/Upstream (BR1, BR2, BR3)

Table 13: Summary of CE/ICA "Best Buy" Plans.

	"Best Buy" Plan	Average Annual Output (AHHUs)	Average Annual Cost ($)	Cost per Output ($/AAHUs)	Inc. Cost ($)	Inc. Output (AAHUs)	Inc. Cost per Output ($)
0	No Action	0.00	$0	$0	-	-	-
1	RP2	287.7	$136,495	$474	$136,495	287.7	$474
2	SR2,RP2,SP2	449.1	$223,939	$499	$87,444	161.4	$542
3	SR1,SR2,RP2,SP1,SP2,EP,WD	816.7	$500,366	$613	$276,427	367.6	$752
4	SR1,SR2,RP1,SP1,SP2,EP,WD,BR1,BR2,BR3	945.4	$962,314	$1,018	$461,948	128.7	$3,589

Figure 17: Incremental Cost and Output of "Best Buy" Plans.



4.7 NER Plan Evaluation*

The alternative plan(s) that qualified for further consideration were assessed in order to identify whether the benefits are worth Federal investment. The effects include a measure of how well the plan(s) achieve the planning objectives; the scale of ecosystem output (benefits); the level of life-cycle costs, which include implementation, adaptive management, and operations and maintenance; and the incremental cost of the plan's output in comparison to other plans. Previously in the evaluation process, the positive effects of each plan on Bubbly Creek's ecosystem were considered individually and compared to the without-project condition. In this step, supportive information is presented to determine whether a plan should be designated the NER Plan and be recommended for implementation. The supportive information includes the

reliability of the projected ecosystem outputs; significance of the ecosystem outputs; completeness, acceptability, effectiveness and efficiency of the potential plan, and any associated risks or uncertainties that may affect or result from the potential plan.

4.7.1 Validity of Ecological Benefits

The following two planning objectives were used to assess whether or not an alternative plan would accomplish the goal of ecosystem restoration.

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

Objective 2 – Restore a Viable Foundation for Plant Growth and Aquatic Habitats - This objective seeks to increase the quantity and improve the quality of substrate and growth mediums, as it would be the foundation for providing backwater habitat to the Bubbly Creek.

The following provides an assessment of how each of the Best Buy Plans meets the objectives of the study.

- Alternative 0 takes no action, and since the future without-project conditions do not foresee natural recovery of this system, this plan does not meet either of the planning objectives.

- Alternative 1 would only restore the riparian plant communities along 9.3 acres of the Bubbly Creek channel. This plan only partially meets the planning objectives by restoring some diverse habitat structure, but at a small scale limited to only the Bubbly Creek riparian corridor.

- Alternative 2 would only restore the substrates and submergent plant communities within the 6.4 acre turning basin of Bubbly Creek in addition to the measures included as part of Alternative 1. The addition of substrate and submergent plant restoration within the turning basin when compared to Alternative 1 more effectively meets the planning objectives by restoring additional habitat structure and growth medium for aquatic habitats, but still only on a limited scale.

- Alternative 3 would effectively restore the entire stream corridor by restoring substrates within 30.7 acres of both the channel and turning basin. The plan restores habitat structure and growth medium for aquatic plants; restores the riparian habitat along 9.3 acres of the channel; restores submergent plant habitat within 3.3 acres of the channel and turning basin; restores emergent plant habitat over 1.0 acre of the channel; and restores habitat complexity through the introduction of woody debris. This plan effectively meets both planning objectives as it provides all of the ecosystem components necessary to sustainably restore a backwater system.

- Alternative 4 includes the restoration of 1.4 acres of stream bank habitat, 1.4 acres of emergent habitat and 1.2 acres of riparian habitat in addition to the measures included as part of Alternative 3. This plan also effectively meets both planning objectives since it provides all of the ecosystem components necessary to sustainably restore a backwater

system; however, the additional features of this plan result in substantially greater incremental costs as compared to Alternative 3.

4.7.3 Significance of Ecosystem Outputs

Due to the challenges associated with comparing plans with non-monetary benefits, the concept of output significance plays an important role in ecosystem restoration evaluation. Along with information from cost-effectiveness and incremental cost analyses, information on the significance of ecosystem outputs helps in determining whether a proposed environmental investment is worth its cost and whether a particular alternative plan should be recommended for implementation. Statements of significance provide qualitative information to help decision makers evaluate whether the value of the ecosystem outputs are worth the costs incurred to produce them. The significance of the Bubbly Creek restoration outputs are herein recognized in terms of institutional, public, and/or technical importance.

Institutional Recognition

Institutional recognition means that the importance of an environmental resource is acknowledged in the laws, adopted plans, and other policy statements of public agencies, tribes, or private groups. Sources of institutional recognition include public laws, executive orders, rules and regulations, treaties, and other policy statements of the Federal Government; plans, laws, resolutions, and other policy statements of states with jurisdiction in the planning area; laws, plans, codes, ordinances, and other policy statements of regional and local public entities with jurisdiction in the planning area; and charters, bylaws, and other policy statements of private groups.

Migratory Bird Treaty Act (1918) - The Migratory Bird Treaty Act is the domestic law that implements the United States' commitment to four international conventions for the protection of migratory birds and their habitats. The Act protects species or families of birds that live, reproduce, or migrate within or across international borders at some point during their annual life cycle. The four Migratory Bird Conventions include:

- Convention for the Protection of Migratory Birds with Great Britain on behalf of Canada (1916)
- Convention for the Protection of Migratory Birds and Game Mammals - Mexico (1936)
- Convention for the Protection of Migratory Birds and Their Environment - Japan (1972)
- Convention for the Protection of Migratory Birds and Their Environment - Union of Soviet Socialist Republics (1978)

The Mississippi Flyway is part of four principal North American flyways: the Atlantic, Mississippi, Central and Pacific. Except along the coasts, such as Lake Michigan, the flyway boundaries are not always sharply defined. Its eastern boundary runs along western Lake Erie and the western boundary is ambiguous, as the Mississippi Flyway merges unnoticeably into the Central Flyway. The longest migration route in the Western Hemisphere lies in the Mississippi Flyway; from the Arctic coast of Alaska to Patagonia, spring migration of some shorebird species fly this nearly 3,000 mile route twice. Parts of all four flyways merge together over Panama.

This route is ideal for migratory waterfowl because it is uninterrupted by mountains, dotted with tens of thousands of lakes, wetlands, ponds, streams and rivers, and is well

timbered in certain reaches. Chicago is located within the Mississippi Flyway and approximately 250 species of birds pass along Lake Michigan's shoreline annually. The Chicago reach is also one of America's most important migration routes for songbirds, with more than 5 million individuals passing through during the migration season. Illinois and Indiana farmland consists of corn and soybean fields, which do not provide the type and variety of food and shelter required by nearly all migrating birds. In comparison, Lake Michigan's shoreline provides a variety of plant life and habitat for resting and refueling. Chicago's parks and even residential backyards are particularly important, because they are the only patches of habitat left within a highly developed landscape. The preservation of parkland along water bodies is critical to the survival of millions of birds that migrate through Chicago every spring and fall. The Bubbly Creek restoration project has great potential to provide critical migratory bird habitat as identified by the Chicago Audubon Society in a letter dated 31 July 2013. Additionally, in its Fish and Wildlife Coordination Act Report dated July 2, 2014, the USFWS state "[t]he natural areas of the Chicago region are a magnet for migratory landbirds, squeezed as they are by urban development, the lake to the east and treeless agricultural lands to the west and south. Recent studies have demonstrated that the river systems of Chicago are also important for migratory landbirds, including many migratory landbirds of conservation concern. The most recent version of the Partners in Flight Species Assessment database identifies no fewer that sixty-one migrant landbirds that are either of conservation concern, in steep decline, or in need of stewardship, that regularly migrate along the Chicago River." One can easily envision a small flock of American pelicans (*Pelecanus erythrorhynchos*) stopping within a restored Bubbly Creek based on the type of habitat proposed for restoration and this species recent frequenting of the Chicago Region.

Alternative Plan 0 does not support the Migratory Bird Treaty Act because it does not include measures that improve the habitat for migratory birds. Alternative Plans 1 and 2 partially support this role and responsibility because they improve the riparian habitat by providing additional forage and roosting areas; however, Alternative Plan 1 does not restore the substrate within the channel and Alternative Plan 2 only restores the turning basin portion of the channel. Substrate restoration is ecpected to increase the diversity and abundance of fish and thereby benefit piscivorous birds. Alternative Plans 3 and 4 are in full support of the Migratory Bird Treaty Act because they would effectively restore Bubbly Creek to a complete backwater system.

America's Great Outdoors (AGO) Initiative – is aimed at reconnecting Americans, especially children, to America's rich outdoor treasures, building upon public, private, and tribal priorities for conservation and recreation lands, and using science-based management practices to restore and protect our lands and waters for future generations. The AGO Initiative consists of the following five conservation and outdoor recreation initiatives:

- Landscapes, the protection of America's large, rural landscapes
- Recreation, the support of outdoor recreation access and opportunities to connect Americans to the outdoors
- Rivers, the restoration of our country's rich legacy of rivers and waterways
- Urban, the connection of city-dwelling Americans to urban parks and green spaces
- Youth, the development of the next generation of environmental stewards

This initiative calls upon governmental agencies to support innovative community efforts to provide safe, healthy and accessible outdoor spaces. Alternative Plan 0 does not support this initiative because it proposes no improvements to the channel. Alternative Plans 1 and 2 partially support this initiative because native plants are proposed for the riparian banks and for Alternative Plan 2, the turning basin would be restored with new substrate and submergent plants. Alternative Plans 3 and 4 would meet the initiatives of the AGO through the restoration of Bubbly Creek. In an effort to increase the recreational benefits this project provides to the neighboring community, the City has constructed a park on the banks of Bubbly Creek which contains fishing stands and has plans to build a nonmotorized boat house also on the banks of Bubbly Creek. Bubbly Creek is not used for commercial navigation and is an optimal place for boating, canoeing, kayaking and rowing. Subsequently, this would provide outdoor recreational opportunities for citizens of the Chicago metropolitan area, including youth.

Urban Waters Federal Partnership – USACE is in partnership with USEPA, U.S. Department of the Interior, and other federal agencies to revitalize urban waters and the communities that surround them. The goal of the program is to help urban and metropolitan areas, particularly those that are under-served or economically distressed, connect with their waterways and work to improve them. Collective efforts would reverse past neglect of waterways, energize existing programs aimed at restoring and protecting urban waters, and engage new partners. In its letter of support, USEPA noted that restoring Bubbly Creek furthers USEPA's and USACE's common mission under this partnership.

Alternative Plans 0 and 1 would not further the mission under this program because no improvements are made within the channel. Alternative Plan 2 partially addresses the mission because 6.4 acres within the turning basin would be restored; however, 24.3 acres within the channel would remain unchanged. Alternative Plans 3 and 4 further the mission under this program of helping urban and metropolitan areas by restoring the entire channel and turning basin, particularly those that are underserved or economically distressed, connect with their waterways and work to improve them.

Responsibilities of Federal Agencies to Protect Migratory Birds (E.O. 13186) – "Federal agencies shall restore or enhance the habitat of migratory birds and prevent or abate pollution or detrimental alteration of the environment for migratory birds." This project would restore backwater, riparian plant communities, and fish habitat, thus providing forage and shelter for numerous migratory bird species. This project lies within a significant portion of the Mississippi Flyway along the coast of Lake Michigan that particularly favors both ecological and economically valuable waterfowl species. Since 1989, 109 species of birds have been observed within a 1.5 mile radius of Bubbly Creek. Two species, the chimney swift (*Chaetura pelagica*) and the golden-winged warbler (*Vermivora shrysoptera*) are listed as near threatened by the IUCN. In addition, the following four species observed were listed by the Audubon Society as one of the top 20 common birds in decline: common grackle (*Quiscalus quiscula*), field sparrow (*Spizella pusilla*), greater scaup (*Aythya marila*) and little blue heron (*Egretta caerulea*). Also, the state-endangered black-crowned night-heron (*Nycticorax nycticorax*) and little blue heron (*Egretta caerulea*) as well as the state threatened peregrine falcon (*Falco peregrinus*) were observed.

Alternative Plan 0 does not fulfill USACE's role and responsibility because it does not utilize its ecosystem restoration mission, authority and supporting polices to restore backwater habitat for migratory waterfowl and the plants and fishes that support these bird species. Alternative Plans 1 and 2 partially support this role and responsibility because they improve the riparian habitat by providing additional forage and roosting areas; however, Alternative Plan 1 does not restore the substrate within the channel and Alternative Plan 2 only restores the turning basin portion of the channel. Substrate restoration increase the diversity and abundance of fish and thereby benefits piscivorous birds. Alternative Plans 3 and 4 fulfill the USACE's role and responsibility by utilizing its Ecosystem Restoration Mission, authority and supporting polices to restore backwater habitat for migratory waterfowl and the plants and fishes that support these bird species.

Fish and Wildlife Conservation Act of 1980 – all Federal departments and agencies to the extent practicable and consistent with the agency's authorities should promote the conservation of non-game fish, wildlife, and their habitats. Alternative Plan 0 does not support the act because no restoration takes place in or along the channel. Alternative Plans 1 and 2 partially support the act because each improves the riparian habitat by providing additional forage and roosting areas; however, Alternative Plan 1 does not restore the substrate within the channel and Alternative Plan 2 only restores 6.4 acres within the turning basin; however, 24.3 acres within the channel would remain unchanged. These improvements are expected to increase the diversity and abundance of fish and plants within the channel. Alternative Plans 3 and 4 would restore physical characteristics of Bubbly Creek's substrate (particle size, cohesiveness, interstitial spacing, detritus ratio), structure (woody debris, snags, deadfall, overhanging vegetation, aquatic plant beds) and native backwater plant communities, which is in full support of this Act.

E.O. 11514 Protection and Enhancement of Environmental Quality – the Federal Government shall provide leadership in protecting and enhancing the quality of the Nation's environment to sustain and enrich human life. Alternative Plan 0 does not enhance the quality of the environment. Alternative Plan 1 and 2 partially enhance the quality of the environment by restoring riparian vegetation along the banks. Additionally, Alternative Plan 2 restores a portion of the channel; therefore, only partially meeting this decree. Significant improvements to both the habitat and water quality of Bubbly Creek would be achieved by Alternative Plans 3 and 4. This project would provide leadership by providing an example to other large metropolis and urban areas that once thought altered channels, slips, harbors, and waterways can be reclaimed for the public and nature to enhance environmental quality.

E.O. 11990 Protection of Wetlands – each agency shall provide leadership and shall take action to minimize the destruction, loss or degradation of wetlands, and to preserve and enhance the natural and beneficial values of wetlands. Alternative Plan 0 and 1 do not preserve or enhance wetlands. Alernative Plan 2 partially restores the channel's substrate and plants submergent and emergent vegetation and therefore partially addresses this protection decree. Alternative Plans 3 and 4 would effectively restore Bubbly Creek to a physically and visually healthy ecosystem, which takes action to further support the enhancement of the Chicago River.

E.O. 13112 Invasive Species – prevent the introduction of invasive species and provide for their control and to minimize associated economic, ecological, and human health

impacts. Alternative Plan 0 does not remove invasive plants from the shores or encourage native fish or other animals to the channel because condition within the channel would remain unchanged. Alternative Plan 1 and 2 partially address invasive species by removing the invasives along the banks and planting native vegetation. Alternative Plan 2 partially encourages aquatic native species by restoring the turning basin within Bubbly Creek and would reduce the effects nonnative common carp (*Cyprinus carpio*) and white perch (*Morone americana*) have on habitat by preventing these species from continually resuspending the fine-grained, highly organic, anaerobic sediment. Implementation of Alternative Plan 3 and 4 however would effectively remove nonnative and invasive plant species from a 1.25-miles water body and as a result of restoring the substrate in the channel bottom, would reduce the impact nonnative common carp (*C. carpio*) and white perch (*M. americana*) have on the entire channel.

Endangered Species Act of 1973 – all Federal departments and agencies shall seek to conserve endangered species and threatened species. The purpose of the act is to provide a means whereby the ecosystems upon which endangered and threatened species depend may be conserved and to provide a program for the conservation of such endangered and threatened species. Alternative Plan 0 does not meet the purpose of this act. Alternative Plans 1 and 2 partially meet the purpose of this act by removing the invasives along the banks and planting native plants. The native plants would provide forage and roosting areas for endangered birds. Alternative Plan 2 partially restores Bubbly Creek's turning basin by planting native submergent plants in the restored substrate within its 6.4 acres. This restored section of the channel would provide spawning and foraging habitat for endangered fish; however, continuing the restoration of substrate throughout the channel would provide an additional 24.3 acres of continuous waterway for the restoration. Implementation of Alternative Plans 3 and 4 would improve hunting habitat for the state threatened black-crowned night-heron (*Nycticorax nycticorax*) and may attract the state threatened banded killifish (*Fundulus diaphanus*) by providing spawning and foraging habitat.

Clean Water Act – restore the chemical and biological integrity of the Nation's waters. Although water quality improvement is not within the USACE Mission, policy acknowledges that habitat restoration provides incidental water quality improvements most of the time. The Clean Water Act also has provisions for wetland and biological integrity protection. The No Action Alternative does not support this Act by denying opportunity to improve water quality and increase viable wetland acres. Alternative Plan 0 does not include habitat restoration and therefore does not support the Clean Water Act. Alternative Plans 1 and 2 partially support the Clean Water Act by restoring the banks along the channel with native plants that will filter stormwater runoff and also stabilize the banks to prevent bank erosion into the channel. Additionally, Alternative Plan 2 includes substrate restoration within the turning basin. The restorated substrate would provide incidental water quality improvements by covering the current sediment and in part, preventing common carp (*Cyprinus carpio*), white perch (*Morone americana*) and black bullheads (*Amieurus melas*) from stirring and distributing the sediment into the water column. When suspended, the existing sediments increase turbidity and degrade water quality. Alternative Plans 3 and 4 are in full support of the Clean Water Act because they stabilize the riparian banks with native plants and also restore the substrate within the entire channel.

Public Recognition

Public recognition means that some segment of the general public recognizes the importance of an environmental resource, as evidenced by people engaged in activities that reflect an interest or concern for that particular resource. Such activities may involve membership in an organization, financial contributions to resource-related efforts, and providing volunteer labor and correspondence regarding the importance of the resource. The non-Federal Sponsor and various stakeholders all support the restoration of the entire reach of Bubbly Creek. They want Bubbly Creek to be a destination for the community as well as all of Chicago. The City of Chicago is investing its resources to build parks adjacent to Bubbly Creek that will provide access to the channel. In this area of the city, Bubbly Creek is the only portion of the CAWS that does not maintain commercial navigation. Due to this distinction, the restoration opportunities for Bubbly Creek are more diverse and extensive when compared to portions of the system where commercial navigation is prevalent.

The Non-Federal Sponsor

The City of Chicago believes that Alternative Plan 3 would most effectively restore a viable urban ecosystem that connects nature to a part of the city severely lacking in natural space and provides important recreational opportunities. The City of Chicago has expressed a great interest in revitalizing Bubbly Creek, as stated by the City of Chicago River Agenda. Additionally, their "Chicago River Corridor Design Guidelines and Standards" states that "special measures are necessary at Bubbly Creek to restore the degraded conditions of the waterway and its banks." The City of Chicago believes that a revitalized Bubbly Creek would invigorate the extensive network of organizations, agencies, and individuals interested in Chicago's waterways. Working to revitalize the community surrounding Bubbly Creek, the City of Chicago has constructed Canal Origins Park located on the west bank of Bubbly Creek at the confluence with the South Branch of the Chicago River. This 1.8-acre park is currently one of the largest tracts of green space in the busy industrial district of Bridgeport, and visitors can view Bubbly Creek from the park. By reestablishing a natural aquatic environment, this project could create improved vistas and educational opportunities at this park. The City of Chicago is currently planning another park on the eastern bank of Bubbly Creek at the confluence of the South Branch of the Chicago River. This park, which will feature a boat house, will be located across the river from Canal Origins Park, and serve as an anchor of the area's greenspace and future recreational development

Stakeholder Support

In addition to the non-Federal cost-sharing sponsor, City of Chicago, a number of stakeholders have been involved in the planning process and support the ecosystem restoration of Bubbly Creek as presented in this report. The USEPA, USFWS, IEPA, IDNR, MWRDGC, the Chicago Park District, the Audubon Society Chicago, Canal Corridor Association, Openlands Project, Friends of the Chicago River, the Field Museum of Natural History, the John G. Shedd Aquarium, and The Wetlands Initiative are all critical and involved stakeholders. It should be noted that the Audubon Society, Field Museum, and the Shedd Aquarium all have National and Global interests in persevering and restoring biodiversity.

In a letter of support, the Audubon Society specifically states that it supports the restoration of Bubbly Creek due to the importance of the project for migratory bird conservation and public engagement. Audubon's letter includes the following: "…[t]he location [Bubbly Creek] just a few miles from the lakefront and along the riparian corridor of the south branch of the Chicago River places Bubbly Creek at the junction of two of the region's highest priority features for neotropical migrants. The Chicago Lakefront has been designated an Illinois Important Bird Area by Audubon because it is one of the state's best sites for migratory birds. Birds migrating over the lake at night concentrate along the shore at daybreak and move inland to find habitat. The lakefront and the region's riparian corridors were also ranked priority 5 on a scale of 1-5 for migratory landbirds in the report, Defining Conservation Issues for Bird Migration Stopover Sites in the Chicago Wilderness Region (Margaret A. Byrne, The Nature Conservancy, June 2008, Chicago Wilderness Trust Grant)…." Friends of the Chicago River also provided a letter of support of the restoration noting the time is ripe for restoration projects along the Chicago River due to improvements in water quality. The U.S. Environmental Protection Agency and IEPA both submitted letters in support of the Bubbly Creek restoration project and noted their commitment to facilitate restoration of urban waterways.

Friends of the Chicago River

Since 1979, the Friends of the Chicago River (Friends) has worked to improve the health of the Chicago River for the benefit of people and wildlife; and by doing so, has laid the foundation for the river to be a beautiful, continuous, and easily accessible corridor of open space in the Chicago region. Friends' work spans the entire 156-mile Chicago River system and its surrounding watershed. The Friends focus on a greener river with healthy habitat, an accessible river that people can use and enjoy, and a river cared for by a broad group of supporters. Friends work in partnership with municipalities, businesses, community groups, schools, peer organizations, government agencies and individuals on projects that benefit the river. The Friends "believe the river can be both ecologically healthy and a catalyst for community revitalization." In 2006, Friends opened the seasonal McCormick Bridgehouse & Chicago River Museum in a landmarked bridgehouse on the Chicago Riverwalk at Michigan Avenue to provide new access and understanding of the dynamic relationship between Chicago and its river.

Technical Recognition

Technical recognition means that the resource qualifies as significant based on its "technical" merits, which are derived from scientific knowledge or judgment of critical resource characteristics. Whether a resource is determined to be "significant" may vary based on differences across geographical areas and spatial scale. While technical significance of a resource may depend on whether a local, regional, or national perspective is undertaken, typically a watershed or larger (e.g., ecosystem, landscape, or ecoregion) context should be considered. Technical significance should be described in terms of one or more of the following criteria or concepts: scarcity, representation, status and trends, connectivity, limiting habitat, and biodiversity as defined below.

Scarcity is a measure of a resource's relative abundance within a specified geographic range. Generally, scientists consider a habitat or ecosystem to be rare if it occupies a narrow geographic range (i.e., limited to a few locations) or occurs in small groupings.

Unique resources, unlike any others found within a specified range, may also be considered significant, as well as resources that are threatened by interference from both human and natural causes.

Representation is a measure of a resource's ability to exemplify the natural habitat or ecosystems within a specified range. The presence of a large number and percentage of native species, and the absence of exotic species, implies representation as does the presence of undisturbed habitat.

Status and Trend measures the relationship between previous, current and future conditions.

Connectivity is the measure of a resource's connection to other significant natural habitats.

Limiting Habitat is the measure of resources present supporting significant species.

Alternative Plan 3 and 4 focuses on restoring Bubbly Creek to a backwater system, which is *representative* of a *scarce* habitat resource within the Chicago River system. This backwater system would essentially be an open backwater with snags, rootwads and limbs to mimic deadfall (all trees or tree parts used for habitat); patches of shrub swamp; large beds of eel grass and pondweeds; patches of emergent reeds and grasses; bank zone buffers of native, yet hardy prairie plants, shrubs and trees. This type of system is *scarce* within the Chicago Region, currently being found primarily in the Kankakee River system to the south. These habitats were known to naturally occur in the Chicago and Calumet River systems; however, there are no known areas of this type of backwater habitat left in the current Chicago River system.

In terms of *connectivity*, this project adds to the increasing patches of habitat within the Chicago River system, lessening the distance species have to travel between inhospitable reaches of river. The Chicago River is trending towards wide spread improvement and connectivity, indicative of projects such as Eugene Field Park CAP 206 (USACE), Horner Park CAP 206 (USACE), Ronan Park Riparian Restoration (Chicago Park District), Miami Woods Riparian Restoration (Cook County Forest Preserve District and volunteers), and the Chick Evans, Tam O'Shanter and Wilmette Road dam removal project (Cook County Forest Preserve District/IDNR).

Restoring viable habitat within and along Bubbly Creek has great potential to support two state-threatened species, the black-crowned night heron (*Nycticorax nycticorax*) and the banded killifish (F*undulus diaphanous*). Additionally, the increase in aquatic habitat is expected to support an increased abundance of fish species such as largemouth bass (*Micropterus salmoides*), grass pickerel (*Esox americanus*), mudminnow (*Umbra limi*), warmouth (*Lepomis gulosus*), black crappie (*Pomoxis nigromaculatus*), and other species which currently can be found inhabiting the North Shore Channel (Section 2.5.3 Reference Sites). The increased abundance of fish species would provide an increase in food for piscivirous bird species foraging along Bubbly Creek. In turn, by providing an increase in forage, the abundance of piscivirous bird species such as the state-threatened black-crowned night-heron (*Nycticorax nycticorax*), double-breasted cormorant (*Phalacrocorax auritus*), great blue heron (*Ardea herodias*), great egret (*Ardea alba*), green heron (*Butorides virescens*), and little blue heron (*Egretta caerulea*) is expected to increase.

4.7.4 Acceptability, Completeness, Effectiveness & Efficiency

Acceptability, completeness, effectiveness, and efficiency are the four evaluation criteria USACE uses in evaluating alternative plans[28]. Plans considered for recommendation in any planning study, not just ecosystem restoration studies, should meet these criteria in order to qualify for further consideration and comparison with other plans.

Acceptability

An ecosystem restoration plan should be acceptable to state and Federal resource agencies and local governments. There should be evidence of broad-based public consensus and support for the plan. The recommended plan must be acceptable to the non-Federal cost-sharing partner.

The suite of restoration measures and plans outlined within this study were developed in a collaborative fashion with input from several stakeholders, regulatory agencies and the non-federal sponsor. Habitat restoration measures were proposed, screened, refined and retained for further consideration through a series of collaborations including brain-storming sessions and planning charrettes. The Federal, State and local groups that participated in these activities are previously discussed. Alternative Plan 0 provides no ecosystem improvements and is not acceptable to the Federal Objective, the non-Federal sponsor's goals and stakeholder desires. Alternative Plans 1 and 2 provide limited ecosystem restoration benefits but generally leave Bubbly Creek remaining in an impaired state, making them unacceptable and not worth the investment. Alternative Plans 3 and 4 are the most acceptable in terms of the Federal Objective and non-Federal sponsor/stakeholder vision for reestablishing a sustainable and viable ecosystem within the Bubbly Creek study area. Taking the Federal Objective, study objectives, and non-Federal sponsor/stakeholder needs into consideration, Alternative Plans 3 and 4 provide the most diverse habitat restoration possible and thus are acceptable.

Completeness

A plan must provide and account for all necessary investments or other actions needed to ensure the realization of the planned restoration outputs. This may require relating the plan to other types of public or private plans if these plans are crucial to the outcome of the restoration objective. Real estate, operations and maintenance, monitoring and adaptive management, and sponsorship factors must be considered. Where there is uncertainty concerning the functioning of certain restoration features an adaptive management plan should be proposed and must be accounted for in the implementation plan.

All of these factors were considered in the evaluation of alternative plans. Alternative Plan 0 does not provide any action to restore degraded habitats and therefore is incomplete in realization

[28] U.S. Army Corps of Engineers. 2000. Planning Guidance Notebook: ER 1105-2-100, Section 2-3. Accessed September 9, 2014. http://planning.usace.army.mil/toolbox/library/ERs/entire.pdf. These guidelines provide the overall direction by which the Corps of Engineers civil works projects are formulated, evaluated and selected for overall implementation. The guidelines are based on the Economic and Environmental Principles for Water and Related Land Resources Implementation Studies, Water Resources Council, March 10, 1983. These principles are intended to ensure proper and consistent planning by certain Federal agencies in the formulation and evaluation of water and related land resources implementation.

of ecosystem improvements. Alternative Plan 1 only includes riparian plants along the channel and is incomplete because it does not include restoration measures within the channel. Alternative Plan 2 includes restoring the substrate and submergent planting only within the turning basin and riparian plantings along the channel. This plan is also incomplete because restoring the substrate and the submergent planting in only a portion of the Bubbly Creek channel does not address restoration of the entire channel. Alternative Plans 3 and 4 would restore Bubbly Creek from an impacted channel to a backwater system full of native vegetation and home to a more diverse community of fish and birds, these plans are not complete. In order for these plans to be complete, Alternative Plans 3 and 4 must be implemented after McCook Stage 1 Reservoir is on line, which will reduce the volume and the frequency of CSO events to the channel. Implementation is scheduled to occur after the McCook Stage I Reservoir comes on-line. Consequently, the measures included in Alternative Plans 3 and 4 along with the timing of their implementation create a complete plan.

Effectiveness

An ecosystem restoration plan must make a significant contribution to addressing the specified restoration problems or opportunities (i.e. restore important ecosystem structure or function to some meaningful degree). The problems identified for this study as stated earlier generally include those adverse affects resulting from the lack of physical habitat within the aquatic and riparian zones of the system. In addition to focusing on the identified problems, opportunities were also considered when establishing study objectives. Taking into account how each Alternative Plan meets the planning objectives and how engineering analyses were utilized to validate the functionality and sustainability of plan habitat output, Alternative Plans 0, 1 and 2, do not fully restore the riparian and aquatic ecosystem; consequently, these plans are not as effective at addressing the entire impaired channel. Alternative Plan 3 and 4 would be the most effective at restoring habitat that makes a significant contribution to Migratory Bird, fish and wildlife habitat within a biogeographically significant region.

Efficiency

An ecosystem restoration plan must represent a cost-effective means of solving habitat problems and seizing opportunities to improve the environment. It must be determined that the plan's restoration outputs cannot be produced more cost effectively than any other plan.

Initial screening of habitat restoration measures removed those measures and concepts that could be easily produced for less cost or required intensive operation and maintenance activities to sustain outputs. Six (6) types of restoration measures were then formulated to seize site specific opportunities, address specific conditions found within the Chicago River, and to utilize lessons learned through the restoration of similar ecosystems within the Chicago area. Using the USACE (IWR-PLAN software, several hundred alternative plan combinations were generated from the eleven (11) site-specific habitat restoration measures formulated. Through cost effectiveness and incremental cost analysis, 38 plans were identified as cost-effective and 5 plans were identified as "best buy" plans having the least incremental increase in cost per unit habitat output. All inefficient options were removed from further consideration and only the five (5) "best-buy" plans presented within were retained for further consideration.

Alternative Plans 0, 1 and 2 do not fully meet the study's planning objectives, and Alternative Plans 3 and 4 fully meet the objectives. In comparing the incremental cost and scale of output associated with those Alternative Plans that fully meet the planning objectives, Alternative Plan 3

provides the least incremental cost of all plans which fully meet the planning objectives and is therefore the most efficient.

4.7.5 Risk and Uncertainty

When the costs and outputs of alternative restoration plans are uncertain or there are substantive risks that outcomes will not be achieved, the selection of a recommended alternative plan becomes more complex. It is essential to document the assumptions made and uncertainties encountered during the course of the planning analyses. Restoration of some types of ecosystems may have relatively low risk. For example, removal of drainage tiles to restore hydrology to a wetland area is straightforward with little risk. Other activities may have higher associated risks such as restoration of coastal marsh in an area subject to hurricanes. When recommending a plan for implementation, the associated risk and uncertainty of achieving the projected level of outputs must be considered. For example, if two plans have similar outputs but one plan costs slightly more, according to cost effectiveness guidelines, the more expensive plan would be eliminated from further consideration. However, it might be possible that, due to uncertainties associated with the output of the less expensive plan, the slightly more expensive plan could actually produce greater ecological output than originally estimated, in effect qualifying it as a cost effective plan. But without taking into account the uncertainty inherent in the estimate of outputs, that plan would have been excluded from further consideration.

Overall, for this project there is low risk associated with the Alternative Plans under consideration not performing as projected. Early in the planning process efforts were made to identify areas of risk and uncertainty where project output could be affected and potential mitigation efforts that could be employed to reduce risk and uncertainty. Given the highly disturbed and complex urban nature of the Bubbly Creek ecosystem, a suite of risks and uncertainties were identified and used in formulating restoration measures, namely: a) ensure the restored substrate would not be eroded or be allowed to degrade once again, b) lessons learned from constructed habitat restoration projects along the channel and banks of the Chicago River, c) designing habitat structures and plant communities to the hydrology and hydraulic conditions present, i.e. the design mimicking a large river backwater, and d) a dedicated non-Federal sponsor that will maintain the project as constructed with intended ecological benefits.

Complete eradication of invasive species always presents a certain level of risk and uncertainty as the chances of reinvasion are likely to occur without proper management especially when native species have not yet established. A prominent issue is that invasive plant species are adapted for colonizing areas that are disturbed and have impacted soils. Measures that restore soil properties by incorporating soil amendments such as leaf litter compost will decrease bulk density, hold moisture longer and increase organic matter and microbial activity. These practices further the soil's ability to sustain native plants and reduce the vulnerability of the plant community to noxious weed invasion. On the other hand overly organic substrates can also impair native species. In these cases, the addition of inorganic material is needed to reverse the overly organic material currently in place. The plans and specifications will require that soil amendments will be tested for weed/invasive/non-native plant seeds prior to placement in order to manage the potential introduction and/or spread of these species.

Native plantings also have an associated risk of not establishing due to a variety of unforeseen events. Herbivory is likely since common carp and Canada geese are quite abundant in the Chicago River system. Weather also plays a large role in the establishment success of new

plantings. Periods of drought, flood or early frost can alter reduce the chance of survival of new plantings. Planting would still occur during these conditions; however, the planting plan would be adjusted per field conditions. To mitigate these risks, planting over several years, overplanting and/or adaptive management and monitoring may be incorporated into the overall plan to mitigate for any inclement weather years. Plants to be installed were also chosen based on their hardiness and their ability to survive weather typical of the Chicago Region (e.g., extended periods of freezing temperatures, excessive heat, etc.) In addition, climate change may or may not affect project outcomes. If a historic drought were to occur, the planting plan would be adapted (e.g., different species) to match the drier conditions. To compensate for climatic shifts, the plant selection includes a diverse array of functionally similar and complementary plant species originating from multiple genetically distinct and diverse source locations.

4.8 NER Plan Recommendation

When selecting a single alternative plan for recommendation from the range of plans that have been considered, the criteria used to select the National Ecosystem Restoration (NER) Plan include all the evaluation criteria discussed above. Selecting the NER Plan requires careful consideration of the plan that meets planning objectives and constraints and reasonably maximizes environmental benefits while passing tests of cost effectiveness and incremental cost analyses, significance of outputs, acceptability, completeness, efficiency, and effectiveness

This ecosystem restoration project was planned in cooperation with the non-Federal sponsor, the City of Chicago, and various Federal, State and local stakeholders and makes a significant contribution to regional, national, and international programs that include the North American Waterfowl Management Plan, Lake-wide Management Plans, and the Coastal Zone Management Plan. This study included several occasions for open dialog to ensure all stakeholders have had equal opportunity for contribution.

All costs associated with a plan were considered, and tests of cost effectiveness and incremental cost analysis have been satisfied for the alternative plans analyzed. Having established confidence in the estimated implementation costs, the remaining test of reasonableness is to assess the value of the resource to be improved based on the cost to implement the improvement. The importance of Migratory Birds in terms of human uses and aesthetics has been documented through numerous sources, most importantly the Migratory Bird Treaty Act (1918) and Executive Order 13186 Responsibilities of Federal Agencies to Protect Migratory Birds.

The plan that reasonably maximizes net NER benefits and is consistent with the Federal objective, authorities and policies, is identified as the NER plan. Alternative Plan 0 does not meet the study objectives. Alternative Plans 1 and 2 partially meet the study objectis; however, Alternative Plans 3 and 4 both meet the study objectives as noted in Section 4.7.1. Alternative plans 3 and 4 also provided significant habitat outputs as described in Section 4.7.2. Alternative Plans 3 and 4 meet the acceptability, completeness and effectiveness criteria as described in Section 4.7.3.

To evaluate the efficiency of the plans, the incremental cost per average annual habitat unit is referenced. Alternative 3 Plan's incremental cost per average annual habitat unit equals $752, and Alternative Plan 4's equals $3,589. See Table 12. When comparing the incremental cost and scale of output associated with the plans that fully meet the planning objectives, Alternative Plan 3 provides the least incremental cost; consequently, Alternative Plan 3 is more efficient when

compared to Alternative Plan 4. As a more efficient plan, Alernative Plan 3, as described in ***Table 14*** and shown in ***Figures 18 – 22,*** is identified as the NER Plan. The direct, indirect and cumulative effects assessment under the National Environmental Policy Act (NEPA) outlined in the following Chapter is based on Alternative Plan 3, the NER Plan.

The NER Plan includes a variety of ecological benefits. The NER Plan would provide important stop-over habitat for birds traveling along the Great Lakes portion of the Mississippi Flyway, a migratory route recognized as nationally significant by the Audubon Society. In addition, the native habitat types would also benefit native resident species. A variety of aquatic species such as fish, macroinvertebrates, and amphibians would greatly benefit through the addition of important foraging, refuge, and spawning aquatic habitat. The NER Plan would markedly increase the ecological integrity of the surrounding area and is well worth the investment.

Table 14: Summary Description of NER Plan.

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.

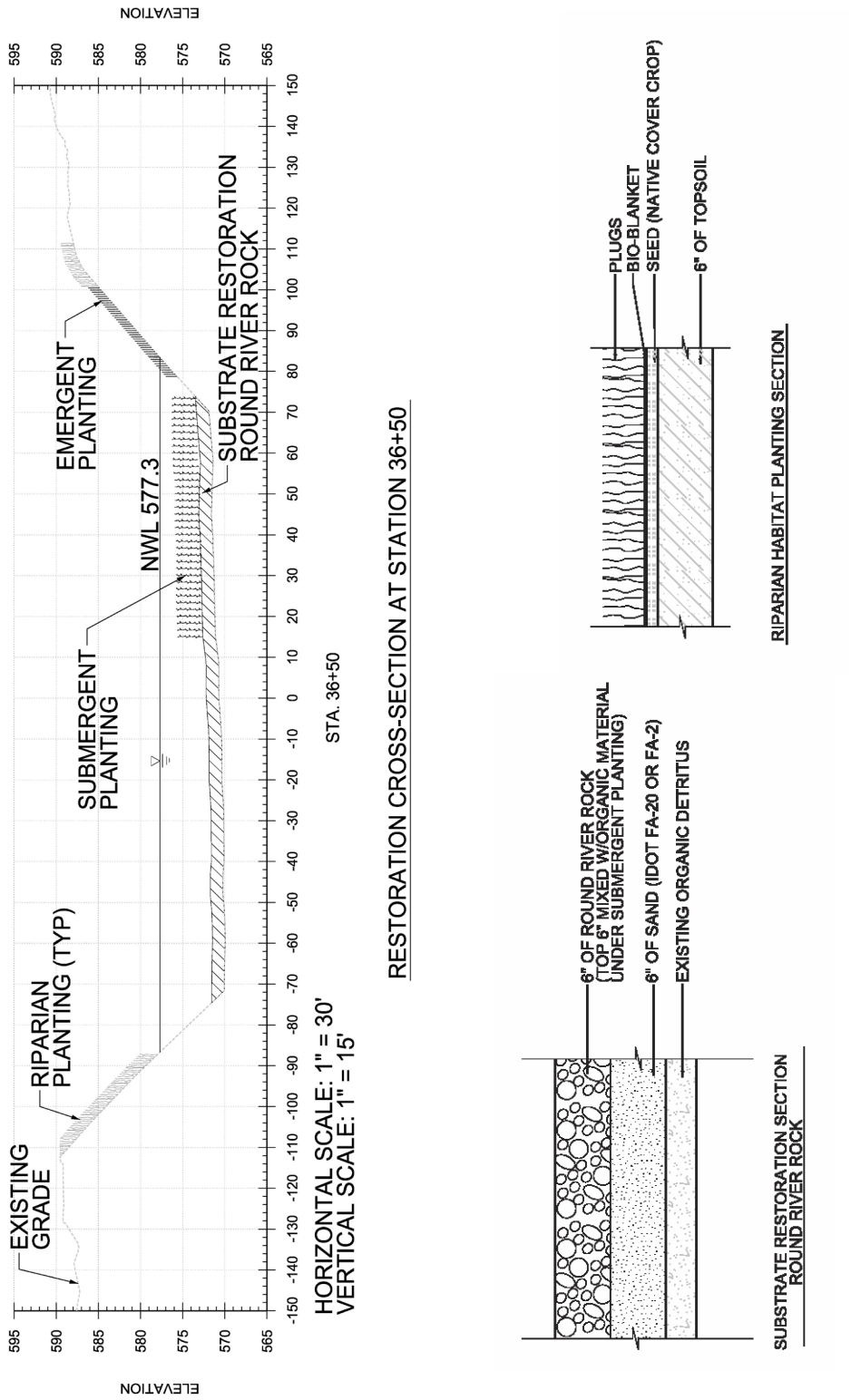


Figure 18: NER Plan Typical Section Layout

Figure 19: NER Plan Overview Map

Figure 20: NER Plan – Upstream Reach 1

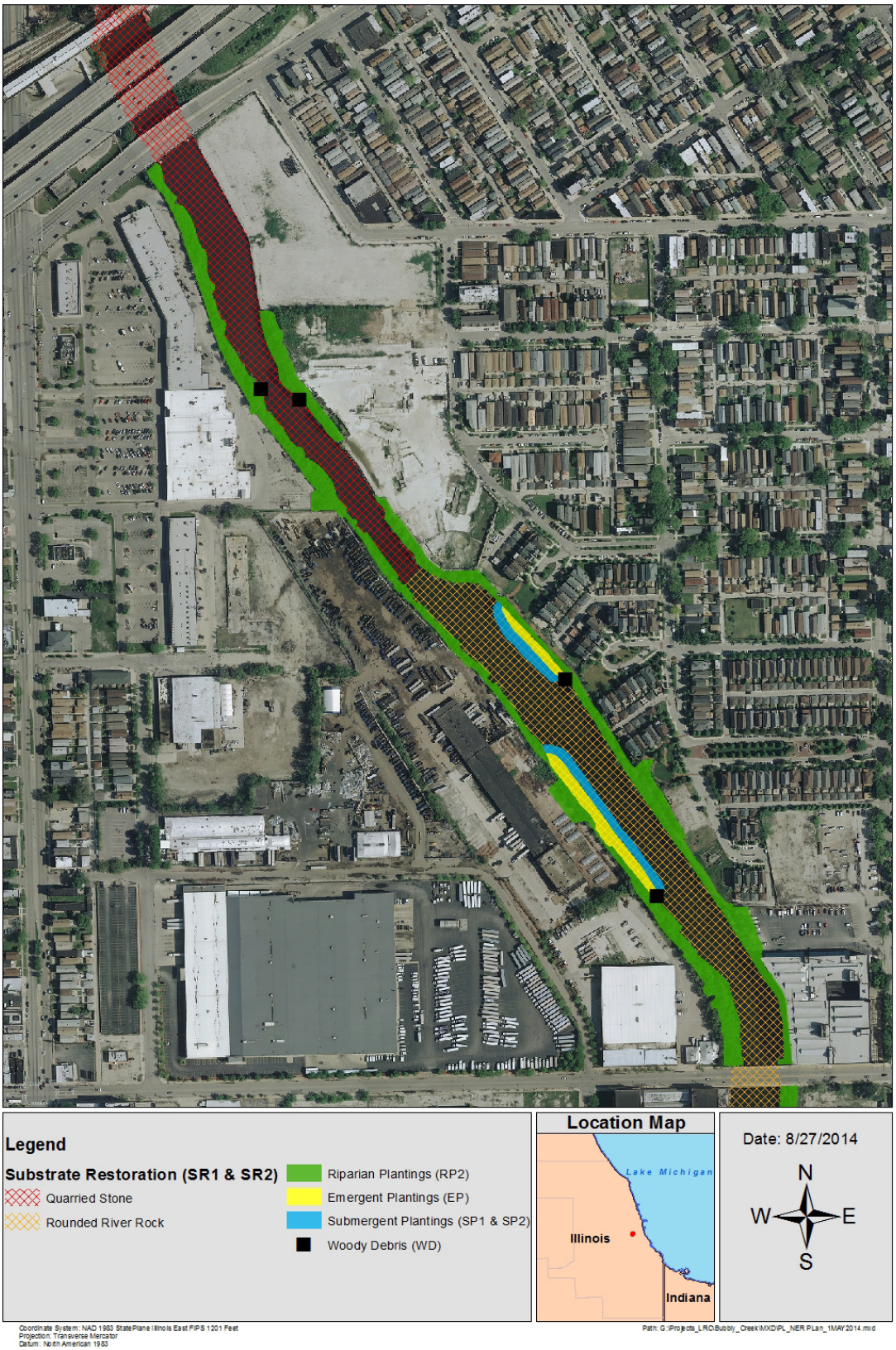


Figure 21: NER Plan – Middle Reach 2

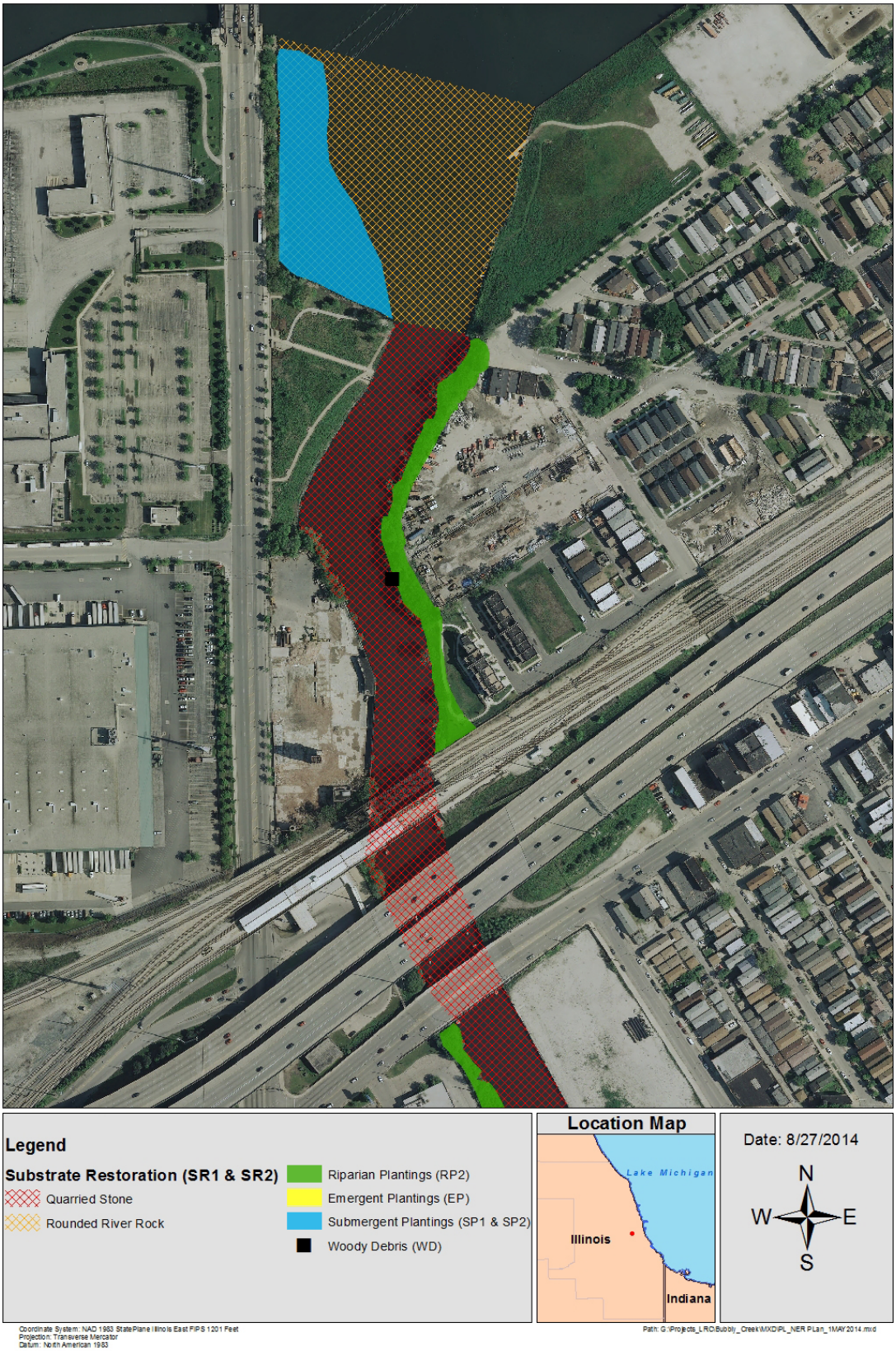


Figure 22: NER Plan – Downstream Reach 3

4.7.2 Sustainability and Long-Term Effectiveness

In order to ensure that habitat restoration measures would be viable and sustainable within the hydrologic, hydraulic, environmental and geotechnical conditions of Bubbly Creek, various analyses were conducted. In summary, the findings were that:

1) Plans are optimized for restoring physical habitat structure
2) Plans do not significantly impact channel conveyance
3) Plans remain stable and would not erode during high flow events
4) Plans maintain substrate integrity while compressing existing sediments
5) Plans improve water quality
6) Plans are not negatively affected by sediment gas production (ebullition)

1) Optimization of Physical Habitat Structure – The substrate restoration design is based on the need to provide a stable and naturalistic sediment base for building a viable habitat, construction limitations and optimization to provide the most appropriate physical habitat structure and growth medium for aquatic macrophytes. The target substrate restoration thickness is 12 inches, comprised of an armor layer of six inches of washed quarried stone or rounded river stone underlain by six inches of sand. The sand layer is of sufficient depth to maintain a discrete layer above the existing sediment, to filter biologically produced sediment gas that passes through the system and to serve as part of the rooting zone. The six inches of rounded river rock or quarried stone satisfies the required armor thicknes and the establishment of bioactive and rooting zones.

Taking system engineering requirements and construction limitations into consideration, the selected species of submergent plants, which include eel grass (*Valisneria americana*), pondweeds (*Potamogeton* spp.), and buttonbush (*Cephalanthus occidentalis*) thrive in approximately 12 inches of healthy substrate. The sand and stone layers provide this thickness. To provide appropriate organic carbon levels for emergent and submergent vegetation growing conditions, the plan includes the addition of organic leaf litter mixed into the upper substrate layer. The washed quarried stone would be placed in the deep areas of the channel where rooted plants are not expected to grow. The rounded river stone would be placed in the shallower areas of the channel where rooted plants are expected and are included in the plan. Additional optimization would be conducted during the design phase and take into consideration construction limitations that may refine the submergent and emergent planting schemes.

2) Maintenance of Channel Conveyance – Hydrologic analysis of with-project conditions confirms that flow conditions in the channel and turning basin are conducive to the restoration of a backwater habitat with both submergent and emergent plant beds. The hydrology mimics that of a backwater: stagnant and stable for most of the year with occasional flood pulses (caused by CSO discharge events), which are driven by natural weather events. Once Stage 1 of the McCook Reservoir is brought online, the frequency and volume of CSO events are greatly reduced, lessening the anticipated low dissolved oxygen concentrations that occur in Bubbly Creek after CSO events. Plant species that are found in a natural backwater system in this region were selected for the measures as they are able to adapt to these hydrologic conditions. The impact to channel hydraulics and conveyance from the introduction of new substrate and aquatic plants was evaluated. Modeling indicates that the addition of 12 inches of substrate does not significantly reduce the conveyance of the channel and is extremely unlikely to induce basement flooding in the RAPS catchment area (Appendix A). Geotechnical analyses confirm that the introduction of

substrates would, over a relatively short period of time, compress the existing soft sediment bed reducing the effects to channel geometry and channel conveyance (Appendix D).

3) Channel Stability – Hydraulic analysis of with-project conditions confirms that it is feasible to support a backwater habitat without eroding the substrate layer or flushing the restored in-channel physical habitat structures. The substrate restoration measure includes an armor layer that was designed with consideration that high flow events will continue. To account for movement of the armor layer after high flow events, the Adaptive Management Plan includes monitoring the substrate and placement of larger armor stone, if needed. As for submergent plantings, the hydraulic analysis indicates that channel velocities exist throughout areas of the channel that would support aquatic vegetation during high flow conditions. As supporting evidence, the Grand Calumet River, which is primarily located in Northwest Indiana, possesses similar hydrologic characteristics as Bubbly Creek. The Grand Calumet River is a slow moving river except during flood events. Prior to remediation, the Grand Calumet River was filled with a dense population of about 6 species of pondweeds (*Potamogenton* spp.) and several other species. Velocities in the Grand Calumet River do not exceed 3-ft/s. Velocity grids from hydraulic modeling produced for Bubbly Creek show that over 90% of the channel experiences velocities under 3-ft/s at maximum discharge. As such, it is expected that the shallower portions of the channel would become vegetated over time if substrate conditions conducive to supporting the plants were introduced.

4) Substrate Integrity and Settlement – Geotechnical sampling and analysis confirms a habitat substrate layer comprised of sand and rounded river rock or quarried stone can be placed as a discrete layer on the soft organic sediments existing within Bubbly Creek. The substrates would be placed in the channel by broadcast spreading. Broadcasting the substrates allows the substrate weight to be loaded slowly and uniformly across the bed to confine the sediment; permits the bed to release excess pore water pressure uniformly without failures; and limits differential loadings on the sediment which could cause geotechnical failure of the sediment. Settlement analyses confirm that the existing sediments would significantly compress over a relatively short period and well within the monitoring period. Differential consolidation is expected along the length and width of the channel due to the variability in the existing sediment properties. The magnitude of consolidation would be expected to range from as little as a fraction of an inch to nearly the thickness of the newly placed substrate; however, the non-cohesive substrate being placed can readily shape to the new contour of the sediment bed without exposing the original sediment bed. The changes in slope are expected to be subtle; however the integrity of the substrate layer would be monitored and, if necessary, repaired through adaptive management. The introduction of variability in the substrate elevation due to settling is not an issue, since the new conditions will mimic the variability found in natural systems.

5) Water Quality Improvements – Recent water sampling, analysis and modeling suggests that water quality in Bubbly Creek has improved. Modeling further predicts that after Stage 1 McCook Reservoir is operational in 2017, the number of CSO events contributing periodic BOD loadings will be reduced and water quality will improve. Modeling for the 2003 water year (Oct-2002 through Sep-2003) shows that RAPS discharges 15 times with an average discharge of approximately 2,400 cfs. With the Stage 1 McCook Reservoir on line, modeling results of the 2003 water year show RAPS discharges reduce to 3 overflow events with an average discharge of only 100 cfs. With the addition of Stage 2 McCook Reservoir, model results of water year 2003 [considered a characteristic 'wet year' for modeling] indicate that all overflow events for that period would be eliminated but these additional reductions would be mostly realized during large and infrequent storms. With the addition of the McCook Reservoir, the water quality in the

channel will marginally improve due to the reduced number of CSO events; however in spite of the McCook Reservoir, the current sediments will exert an elevated SOD on the water column and negatively impact the creek's DO (Appendix A).

In addition to providing currently absent habitat structure, the new substrate would provide an ancillary benefit of significantly improving water quality (Appendix A). The new substrate would isolate the water column from the highly organic sediment and from the SOD generated by the sediment. By reducing SOD, the DO levels in the channel will generally increase; moreover, the channel's dissolved oxygen concentration will rebound more quickly after a CSO event when compared with current conditions.

After the new substrate is placed, organic matter discharged during a RAPS event will utilize oxygen from the water column to decompose. Settled particulate matter is anticipated to be dislodged and flushed by future RAPS events. Additionally, aquatic macrophytes, gizzard shad and crayfish (native saprophytes) are anticipated to reestablish in the channel. These organisms digest organic material that settles on channel bottoms, and consequently, would aid in reducing the BOD and SOD in the channel. With new substrates, common carp, white perch and black bullhead would no longer have the ability to stir up, distribute and ingest the channel's highly organic sediments. When suspended, those existing sediments increase turbidity and further degrade water quality. The new coarser grained and less organic sediment will settle more quickly with less turbidity and less water quality impact.

Strong evidence suggests significant periods of very low DO occur naturally in backwater ecosystems and yet they still retain their biological integrity and species richness. Water quality sampling conducted within two state designated nature preserves within the Chicago Area supports this assertion. Data collected within a buttonbush swamp portion of the Powderhorn State Nature Preserve, Illinois showed DO concentrations below the 4 mg/L threshold healthy aquatic life. Species observed during these periods included an abundance of juvenile yellow perch (*Perca flavescens*), soft-shell turtle (*Apolone mutica*) and osprey (*Pandion haliaetus*). Data collected in a well vegetated marsh portion of the Red Mill Pond State Nature Preserve, Indiana, showed DO concentrations around 1.5 mg/L. Species observed during these periods included chestnut lamprey (*Ichthyomyzon castaneus*), dragonfly larvae (*Odonata*), and northern starhead topminnow (*Fundulus dispar*).

6) Effects of Gas Ebullition – Gas ebullition processes are expected to continue in the underlying sediment after substrate placement. Gas ebullition is the process whereby fine particles and organic matter attach to gas bubbles and are transported through the water column. Contaminant flux from the sediment bed, however, would be reduced by the placement of a clean substrate. The clean substrate would prevent the resuspension of existing sediments into the water column by filtering sediment from the gas bubbles, by preventing scour from CSO discharges or boat prop wash and by preventing nonnative common carp and white perch from continually resuspending the existing fine-grained into the water column. Substrate restoration would also significantly reduce the existing flux of dissolved contaminants because the substrate provides some minor capacity to adsorb or bind contaminants, filters sediment from the gases, as well as increases the length of the diffusion pathway.

CHAPTER 5 – ENVIRONMENTAL ASSESSMENT*

This chapter involves identification of direct, indirect and cumulative environmental effects to current conditions stemming from the NER Plan if implementation occurred.

5.1 Need & Purpose

Before the 1830's, the 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, this ecosystem was severely altered by human activities. 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. To date, there have been numerous studies and assessments describing and characterizing the Bubbly Creek study area. Based on these and additional information and modeling produced by the USACE, a set of Problems and Opportunities were developed by the study team, non-Federal Sponsors and supporting stakeholders. These drive the need for action, which is summarized as the historic loss of significant migratory bird, fish and wildlife aquatic habitat. The purpose of this study and environmental assessment is to identify the most environmentally beneficial, cost effective and publicly supported habitat restoration project to restore resources lost by the alteration of the South Fork, South Branch of the Chicago River.

5.2 Alternatives Considered

Section 4.1 provides discussion on alternative measures that were screened out for various reasons of infeasibility. Section 4.2 provides the final list of technically effective measures that were processed through the IWR Planning Suite software program to identify cost effective plans. The cost effective and incremental cost analysis takes a full account of life-cycle costs and ecosystem outputs into consideration. Ecosystem outputs were measured via two multi-metric indices: the CAWSHAI and the FQA. Five (5) alternative plans, including the No Action Plan, were deemed best case scenarios for project implementation. Alternative 3 was selected as the NER Plan, which for the purposes of this Environmental Assessment is termed the NER Plan. Rationale for selecting the NER Plan is presented in Section 4.7.

- Alternative 0 – No Action
- Alternative 1 – Riparian Planting, Entire Channel (RP2)
- Alternative 2 – Substrate Restoration, Turning Basin (SR2), Submergent Planting, Turning Basin (SP2), and Riparian Planting, Entire Channel (RP2)
- Alternative 3 – Substrate Restoration, Channel/Turning Basin (SR1, SR2), Submergent Planting, Channel/Turning Basin (SP1, SP2), Riparian Planting, Entire Channel (RP2), Emergent Planting (EP), and Woody Debris (WD) ***[NER Plan]***
- Alternative 4 – Substrate Restoration, Channel/Turning Basin (SR1, SR2), Submergent Planting, Channel/Turning Basin (SP1, SP2), Riparian Planting, Entire Channel (RP1), Emergent Planting (EP), Woody Debris (WD), and Bank Restoration, Downstream/Midstream/Upstream (BR1, BR2, BR3)

5.3 The Affected Environment

A detailed description of the affected environment can be found in Chapter 2 – Study Area Inventory & Forecasting. Based on data collection, analysis, and modeling conducted under this

feasibility study and coordination with Federal, State and local governmental agencies and academia, it was determined that the physical, chemical and biological conditions of Bubbly Creek are in a state of severe habitat degradation. As a result, only species tolerant to habitat loss, anthropogenic disturbance and poor water quality are present. Slight improvements in water quality have recently occurred, but are not enough for native plant and animal communities to reestablish. Critical structural habitat components are currently missing from the Bubbly Creek ecosystem. The No Action Alternative conditions are synonymous with the Future Without-Project Conditions, which are presented in Section 2.6.

5.4 Direct & Indirect Effects of the NER Plan

In addition to the effects discussed in the following sections, a 404(b)(1) analysis is provided in Appendix B. This appendix provides additional analysis of the potential effect to the waters of the United States resulting from the discharge of fill material including direct, indirect and cumulative impacts.

5.4.1 Physical Resources

Geology, Glacial Stratigraphy & Soils

There are no longer any natural geologic, glacial deposits or soils present within the Bubbly Creek study area. The NER Plan would replicate the physical features of a backwater system. Since there are no natural geomorphic features or materials present, there would be no adverse effects resulting from implementation of the NER Plan. Geomorphic features and composition effects resulting from the implementation of the NER Plan are considered to be beneficial.

Sediment Quality

The NER Plan would improve sediment conditions by placing sand topped with a mixture of rounded river rock and sandy silt on the existing channel bottom. The sand and rock were selected to mimic those found in river backwaters and would isolate the current channel bottom. Past urban and industrial activities in the local drainage area have impacted Bubbly Creek. The channel was channelized and historically received untreated, highly organic waste from stockyards and slaughterhouses and additional waste from industrial sites. The sediment's fine-grained structure resulting from the decaying animal-derived organic matter prevents the colonization of plants and animal life. The NER Plan proposes to cover the channel bottom and reestablish the substrate to support a healthy benthic life and plants. Adverse impacts to Bubbly Creek's sediment quality from implementation of the NER Plan are not expected.

Water Quality

The NER Plan would improve the water quality of Bubbly Creek. As an ancillary benefit to placing sand and rounded rock on the bottom of the channel, these materials would isolate the oxygen-depleting sediments from the water column.

The IEPA currently lists the "South Fork South Branch Chicago River" (Bubbly Creek) on the 303(d) list of impaired waterways. The listed causes of impairment include high pH, low dissolved oxygen, and high total phosphorus with CSOs as the primary source of impairment. These water quality impacts reflect the current conditions in the channel and the point and non-

point pollution inputs into the waterway. The highly organic sediment in the channel depletes dissolved oxygen in the water column. Periodic discharges of CSOs add organic matter and nutrients, including phosphorus, to the system. The implementation of the tunnel portion of the TARP to manage local storm water and sewer flows has resulted in improvements to the creek's water quality, due to fewer discharges. Further improvement to the water quality in Bubbly Creek is expected to occur as the Stage 1 McCook Reservoir is put on line in 2017, and fewer CSO events and lower volumes are expected to be discharged to the channel. With the existing sediment isolated from the water column, the dissolved oxygen concentration has been modeled to show faster improvements in these concentrations after CSO events when compared with current conditions are anticipated.

The NER Plan would have ancillary water quality benefits, because the sand and rounded river rock or quarried stone would isolate the water column from the existing poor quality sediment thus eliminating an oxygen sink that currently degrades water quality. It is anticipated that the full implementation of the NER Plan, including plantings, would generally improve water quality by providing multiple chemical, biological, and physical processes that naturally occur in backwaters. Water quality impacts within the channel are anticipated to be beneficial. Water quality downstream in the Chicago River may also be slightly beneficially impacted.

Hydrology & Hydraulics

The South Fork of the South Branch of the Chicago River was formerly a prairie slough that sluggishly meandered through prairie wetlands. The development of Chicago and certain industrial activities eventually altered this prairie slough and surrounding watershed. The resulting hydrology and the hydraulics of Bubbly Creek are indicative of a manmade system that generally mimics a backwater within an active zone of a large river floodplain. The usual stagnant conditions are coupled with flood pulses during large storms. The NER Plan proposes to utilize the current hydrology and hydraulics that are largely managed by MWRDGC's operation of the RAPS. Based on this, there would be no adverse effects to hydrology or hydraulics within Bubbly Creek or downstream in the Chicago River resulting from implementation of the NER Plan.

Recognized Environmental Conditions

A phase I investigation of the project area and a phase II investigation of sediment quality were conducted. In light of the impacts due to historical activities, the sediment represents a REC. The intent of the NER is to restore a substrate layer of sand and rounded river rock or quarried stone over the existing sediment in order to provide structural habitat for plants, macroinvertebrates and fishes. Disturbance to existing sediments within the Bubbly Creek channel will be minimized. Substrate restoration would be introduced through the use of broadcasting to ensure an even layer is placed across the existing bed to minimize geotechnical failure and a subsequent release from the existing sediment bed. The use of best management practices, such as in-water silt fences, would be utilized to minimize temporary impacts to downstream water quality, when needed. Several potential sites of concern were identified along the riparian area and excluded from consideration during the planning process. Based on these precautions, it is not anticipated that there would be significant adverse effects resulting from the disturbance of RECs within or adjacent to Bubbly Creek or downstream in the Chicago River resulting from implementation of the NER Plan.

5.4.2 Ecological Resources

The South Fork, South Branch of the Chicago River was formerly a prairie slough that sluggishly meandered through prairie wetlands. The development of Chicago and certain industrial activities eventually transformed this prairie slough into a channel. The adjacent areas and immediate riparian zone were also entirely developed, completing the disruption of the natural stream.

Plant Communities

There are currently no plant species identified from the aquatic portions of Bubbly Creek. Plant species identified from bank/riparian areas for ruderal communities are generally comprised of non-native, Eurasian species. The NER Plan recommends the removal of invasive, nonnative plants species and the reestablishment of tough, native plant communities adapted to the backwater like conditions of Bubbly Creek. Based on this, there would be no adverse effects to plant communities within Bubbly Creek or downstream in the South Branch of the Chicago River resulting from implementation of the NER Plan. Plant community effects resulting from the implementation of the NER Plan are considered to be very beneficial.

As part of the NER Plan, a staging area for storage of construction materials would likely be established in the general vicinity of Bubbly Creek and adjacent to the Chicago Area Waterway System. The area in the vicinity of Bubbly Creek is predominately industrialized and is primarily either paved or comprised of turf grass. Impacts to the staging site are unlikely but if they occurred would be temporary (the duration of the construction activities). Any impacts would be replaced in-kind by the contractor as part of the construction contract. No long-term adverse impacts towards plant communities are expected.

Aquatic Macroinvertebrates

Currently, the species richness and abundance of macroinvertebrates is very low and only tolerant species are found within the project area. There is currently no physical habitat for a diverse assemblage to colonize and temporal water quality issues exacerbate the issue. The NER Plan recommends providing a substrate layer, comprised of sand, and rounded river rock or quarried stone, large woody debris, submergent plants and buffering trees, shrubs and herbaceous plants. The new substrate would cover the macroinvertebrates that are currently found in the channel. Though placement of the substrate may increase the turbidity of the water, construction methods call for broadcast spreading of the new substrates to minimize disturbance to the sediment. Best management practices would be taken to control the suspension of sediment and minimize increases in turbidity. It is anticipated that there would be no adverse effects to aquatic macroinvertebrate communities downstream in the South Branch of the Chicago River due to implementation of the NER Plan. Macroinvertebrate effects resulting from the implementation of the NER Plan are considered to be very beneficial.

Fishes

Currently, the species richness and abundance of fishes is very low and only tolerant species are found within in the project area. There is currently no physical habitat for a diverse assemblage to colonize and temporal water quality issues exacerbate the issue. The NER Plan recommends providing a substrate layer, comprised of sand and rounded river rock or quarried stone, large

woody debris, submergent planting and buffering tree, shrubs and herbaceous plants. Though placement of the substrate may increase the turbidity of the water, construction methods call for broadcast spreading of the new substrates to minimize disturbance to the sediment. Best management practices would be taken to control the suspension of sediment and minimize increases in turbidity. It is anticipated that there would be no adverse effects to fish communities within Bubbly Creek or downstream in the South Branch of the Chicago River resulting from implementation of the NER Plan. Fish community effects resulting from the implementation of the NER Plan are considered to be very beneficial.

Reptiles & Amphibians

Currently, only one species of turtle, the snapping turtle, has been observed within in the project area. There is currently no physical habitat for a diverse assemblage to colonize. Reptiles are not typically affected by poor water quality, but amphibians are. The NER Plan recommends providing a substrate layer, comprised of sand and rounded river rock or quarried stone, large woody debris, submergent plants and buffering trees, shrubs and herbaceous plants. It is anticipated that there would be no adverse effects to reptile and amphibian communities within Bubbly Creek or downstream in the SBCR resulting from implementation of the NER Plan. Reptile and amphibian community effects resulting from the implementation of the NER Plan are considered to be very beneficial.

Birds

Although Bubbly Creek is currently in a degraded state, the study area is located within a federally significant migratory flyway, the Great Lakes portion of the Mississippi Flyway. This Flyway is nationally recognized as an important route for many migratory and resident birds. In addition, since 1989 one hundred nine (109) species of birds have been observed within 1.5 mile radius of Bubbly Creek. Of those 109 species, 28 were residents, 31 were migratory, 43 were breeding (summer residents), and 9 were non-breeding (winter residents). Two species, the chimney swift (*Chaetura pelagica*) and the golden-winged warbler (*Vermivora chrysoptera*) are listed as near threatened by the IUCN. In addition, the following four species observed were listed by the Audubon Society as one of the top 20 common birds in decline: common grackle (*Quiscalus quiscula*), field sparrow (*Spizella pusilla*), greater scaup (*Aythya marila*) and little blue heron (*Egretta caerulea*). Also, the state endangered black-crowned night-heron (*Nycticorax nycticorax*) and little blue heron (*Egretta caerulea*) as well as the state threatened peregrine falcon (*Falco peregrinus*) were observed. The NER Plan recommends providing a substrate layer, comprised of sand and rounded river rock or quarried stone, large woody debris, submergent plants, buffering trees, shrubs and herbaceous plants, all which provides habitat for organisms and support migratory birds and in particular, water birds (herons, ducks, mergansers, grebes, etc). Based on this, there would be no adverse effects to migratory and residential birds within Bubbly Creek or downstream in the South Branch of the Chicago River resulting from implementation of the NER Plan. Bird species effects resulting from the implementation of the NER Plan are considered to be very beneficial.

Mammals

Currently, only those mammal species indicative of urban life are present within the Bubbly Creek study area. There are not anticipated adverse effects to small or large mammals within Bubbly Creek resulting from implementation of the NER Plan. Mammal species effects resulting from the implementation of the NER Plan are considered to be beneficial, but minor.

Threatened and Endangered Species

Federal – Currently, there are no Federally Endangered or Threatened Species, or their critical habitats within the Bubbly Creek study area. Based on this, there would be no adverse effects to Federally Listed Species resulting from implementation of the NER Plan.

State – Currently, the only known state listed species occurring within Bubbly Creek is the threatened black-crowned night-heron (*Nycticorax nycticorax*). This species typically hunts along the banks of Bubbly Creek. This species does not nest within the Bubbly Creek study area. In addition, the BCN has observed the state endangered little blue heron (*Egretta caerulea*) and state threatened peregrine falcon (*Falco peregrinus*) within a 1.5 mile radius of Bubbly Creek. It is not believed that either of these species nest within the study area. Based on this, no adverse effects are expected to affect the state threatened and endangered species within Bubbly Creek resulting from implementation of the NER Plan. Black-crowned night-heron, little blue heron, and peregrine falcon effects resulting from the implementation of the NER Plan are considered to be very beneficial. USACE will coordinate with the Illinois Department of Natural Resources on the black-crowned night-heron, little blue heron, and peregrine falcon during detailed design.

5.4.3 Cultural Resources

Archaeological

Currently, no archaeological properties or artifacts have been identified or thought to exist within the Bubbly Creek study area. Based on this, there would be no adverse effects to archaeological properties within Bubbly Creek resulting from implementation of the NER Plan.

Historical Properties

All historic properties and structures within the study area are not located within the footprint of the NER Plan's limits except for the Turning Basin, which is part of the IMCNHC. Coordination with State Historic Preservation Office (SHPO) early in the plan formulation of restoration measures helped to ensure the project would not cause adverse affects to the visual conditions of this historic feature. To be in compliance with SHPO, all aquatic macrophyte plantings must not extend above the surface of the water within the turning basin area. As such, only submergent aquatic vegetation was included for consideration for that area. Concurrence from Illinois Historic Preservation Agency was received July 6, 2012. There would be no adverse effects to historical properties within Bubbly Creek, including the Turning Basin, resulting from implementation of the NER Plan.

Social Properties

Currently, the industrialized conditions of the Bubbly Creek riparian and bank areas limit human interaction with the channel. The NER Plan recommends restoring a backwater that would take the place of an aesthetically degraded channel and would enhance the public's access to the water. Based on this, there would be no adverse effects to social properties within Bubbly Creek resulting from implementation of the NER Plan. Social effects resulting from the implementation of the NER Plan are considered to be beneficial.

Recreational Activities

Currently, the industrialized conditions of the Bubbly Creek riparian and bank areas make it difficult for human interaction with the channel; however, there are a few good access points for fishing that are utilized. The channel is also used for rowing and canoeing. The NER Plan recommends restoring a backwater that would take the place of an aesthetically degraded channel and would enhance the public's access to the water. Based on this, there would be no adverse effects on recreation or the public use of the Bubbly Creek resulting from implementation of the NER Plan except during construction. Construction is estimated to last one construction season. During this time, access to Bubbly Creek would be restricted. A staging area would be created adjacent to the waterway to allow for storage of materials and easy transfer of those materials to and from barges. If the staging area is not within Bubbly Creek, increased navigation traffic between the staging area and Bubbly Creek is anticipated.

To provide greater access to the waterway, the City of Chicago is currently building a boathouse at the confluence of the Chicago Sanitary and Ship Canal and Bubbly Creek. The restoration of Bubbly Creek into a backwater with a thriving and diverse plant and animal population is an important part of the master plan for this area. Recreational effects resulting from the implementation of the NER Plan are considered to be very beneficial.

5.4.4 17 Points of Environmental Quality

The 17 points are defined by Section 122 of the Rivers, Harbors & Flood Control Act of 1970 (Public Law (P.L.) 91-611) from (ER 1105-2-240 of 13 July 1978). Effects to these points are discussed as follows:

Noise – Any of the alternative plans would cause minor and temporary increases in noise levels beyond the current conditions. The minor noise effects would stem from machinery utilized to place substrate for substrate restoration, grade shoreline topography, and tree planting activities.

Displacement of People – None of the alternative plans would displace any people.

Aesthetic Values – Currently, Bubbly Creek is aesthetically unpleasing. Gases produced by the sediment suspend sediment through the water column, and the suspended sediment increases the turbidity of the water. The banks of the channel are dominated by non-native and invasive plants. All alternative plans are expected to benefit the aesthetic values of the channel.

Community Cohesion – Any of the alternative plans would not disrupt community cohesion, but provide restored open space for community activities.

Desirable Community Growth – Any of the alternative plans would not adversely affect community growth and would potentially attract people to a more aesthetically pleasing area based on project restoration measures.

Desirable Regional Growth – Any of the alternative plans would not adversely or beneficially affect regional growth.

Tax Revenues – Any of the alternative plans would not adversely or beneficially affect tax revenues.

Property Values – Any of the alternative plans would not have adverse effects on property values, but have the potential to increase surrounding land values since the aesthetics would improve due to project restoration measures.

Public Facilities – Any of the alternative plans would not adversely affect public facilities within the study area.

Public Services – Any of the alternative plans would not adversely or beneficially affect public services.

Employment – Any of the alternative plans would not adversely affect employment and would temporarily increase employment during construction activities.

Business and Industrial Activity – The channel is no longer utilized or maintained for commercial navigation. As such, any of the alternative plans would not adversely or beneficially affect local commerce.

Displacement of Farms – Any of the alternative plans would not adversely affect farmland since restoration areas do not occur on agricultural fields.

Man-made Resources – Any of the alternative plans would not adversely or beneficially affect man-made resources.

Natural Resources – The No Action Alternative allows for the Bubbly Creek ecosystem to remain degraded. The NER Plan would not adversely affect natural resources, but improve them greatly.

Air Quality – The local air quality in Chicago and Cook County are considered 'non-attainment' under the Clean Air Act for ozone, particulates (Particulate matter (PM)-10 and PM-2.5), and lead. The project is within the non-attainment zone. Once implemented, the project itself would be neutral in terms of air quality, with no features that either emit or sequester air pollutants to a large degree. During the project construction, heavy equipment would cause minor, temporary air quality impacts, however all equipment would be in compliance with current air quality control requirements for diesel exhaust, fuels, and similar requirements.

Water Quality – As discussed previously, any of the alternative plans would not adversely affect water quality. The alternative plans would have the ancillary benefit of improving water quality and water resources within the area by preventing SOD and providing materials for biological activities that aid in water quality improvements.

5.5 Cumulative Effects of the NER Plan

Consideration of cumulative effects requires a broader perspective than examining just the direct and indirect effects of a proposed action. It requires that reasonably foreseeable future impacts be assessed in the context of past and present effects to important resources. Often it requires consideration of a larger geographic area than just the immediate "project" area. One of the most important aspects of cumulative effects assessment is that it requires consideration of how actions by others (including those actions completely unrelated to the proposed action) affect the same resources. In assessing cumulative effects, the key determinant of importance or significance is

whether the incremental effect of the proposed action would alter the sustainability of resources when added to other present and reasonably foreseeable future actions.

Cumulative environmental effects for the proposed ecosystem restoration project were assessed in accordance with guidance provided by the CEQ and the U.S. Environmental Protection Agency (USEPA 315-R-99-002). This guidance provides an eleven-step process for identifying and evaluating cumulative effects in NEPA analyses.

5.5.1 Scope of Cumulative Effects Analysis

Through this environmental assessment, the cumulative effects issues and assessment goals are established, the spatial and temporal boundaries are determined, and the reasonably foreseeable future actions are identified. Cumulative effects are assessed to determine if the sustainability of any of the resources is adversely affected with the goal of determining the incremental impact to key resources that would occur should the proposal be permitted. The spatial boundary for the assessment was broadened to consider watershed effects. The spatial boundary being considered is normally in the general area of the proposed ecological restoration; however, the area may be expanded on a case-by-case basis if some particular resource condition necessitates broadening the boundary. The analysis includes Bubbly Creek and a 1.5 mile radius around the project site.

Three temporal boundaries were considered:

- Past –1830s because this is the most recent approximate time that the landscape was in its natural state, a vast prairie/wetland/woodland mosaic.
- Present – 2018 when ecological restoration benefits from the NER Plan would begin.
- Future – 2068, the year used for determining project life end, although the ecological restoration should last until a geologic event disturbs the area.

Projecting the reasonably foreseeable future actions is difficult. The proposed action (ecosystem restoration) is reasonably foreseeable; however, the actions by others that may affect the same resources are not as clear. Projections of those actions must rely on judgment as to what are reasonable based on existing trends and where available, projections from qualified sources. Reasonably foreseeable does not include unfounded or speculative projections. Some future projections were taken from watershed and specific studies generated for the general project area. In this case, reasonably foreseeable future actions include:

- Further improvements in water quality due to large-scale projects, small BMPs and education
- Further improvements in aquatic and riparian habitat in and along the Chicago River system
- Further improvements in connectivity between Chicago River system habitats

5.5.2 Cumulative Effects on Resources

The plan formulation process took into account existing and planned projects, watershed studies and known ecological restoration projects in the study area. Existing Projects were identified in Section 1.4.1 and Section 1.4.2 that have the potential for affecting or being affected by a potential Bubbly Creek restoration project. Prior studies and reports, listed in Section 1.5 were reviewed to ensure that the modeled conditions are the best possible representation of actual

conditions. The Technical Recognition Section also takes existing and future habitat restoration projects into consideration for assessing project effects. Finally, the study team also worked with Federal, State and local agencies to coordinate ongoing planning to address local environmental and infrastructure issues.

Physical Resources

The past has brought much alteration to the physical resources of the Bubbly Creek watershed. Geology, soils, topography, hydrology, and fluvial geomorphology have all been modified. All but a few patches of the landscape were modified from their natural states. As a result, water and sediment quality are impacted due to site-specific and watershed-scale alterations, as well as daily activities such as road salting, industrial and municipal discharge. It is reasonably foreseeable that small projects within the Chicago River system for ecological restoration purposes would occur. These projects begin to address human impacts to the ecosystem. Implementation of the NER Plan would result in no irrecoverable loss of resources identified in terms of geology, soils, substrates, topography, hydrology, water quality and fluvial geomorphology. Cumulative beneficial effects to the Chicago River system are anticipated in terms of soils, substrates, hydrology, hydraulics, and water quality.

Ecological Resources

The ecological diversity of the South Fork, South Branch of the Chicago River watershed was eliminated by previous significant physical resource alterations. The watershed was once a diverse mosaic of marsh, prairie, savanna, woodland, and glacial ponds that had a steady and dependable hydrology. Extreme landscape modification converted the surrounding land to impervious surfaces, and the original slough was channelized and dredged. Currently, plant and animal species found in the channel are mostly those that are tolerant and non native. Implementation of the NER Plan is not anticipated to result in irrecoverable losses of ecological resources such as plant, insect, fish, amphibian, reptile, bird, and mammal taxa. Cumulative beneficial effects to the Chicago River system are anticipated in terms of submergent, emergent and riparian plants, fish, birds and other wildlife and their preferred habitats.

Cultural & Historic Resources

Cumulative effects are not expected to archaeological or cultural resources.

Cumulative Effects Summary

The cumulative effects of the NER Plan are highly beneficial and environmentally important, but not significant from the cumulative/watershed effects perspective. The environment and its human community is expected to benefit from replacing an ecologically hostile and visually unpleasing channel with a backwater that supports native plants, fish and wildlife.

5.6 Compliance with Environmental Statutes

The NER Plan presented in this integrated Environmental Assessment are in compliance with appropriate statutes, executive orders and memoranda (***Table 15***) including the Natural Historic Preservation Act of 1966; the Endangered Species Act of 1973; the Fish and Wildlife Coordination Act; Executive Order 12898 (environmental justice); Executive Order 11990

(protection of wetlands); Executive Order 11988 (floodplain management); and the Rivers and Harbors Act of 1899. The potential project is in compliance with the Clean Air Act; the Clean Water Act, and the National Environmental Policy Act of 1969.

Environmental Justice

Executive Order 12898 (environmental justice) requires that, to the greatest extent practicable and permitted by law, and consistent with the principles set forth in the report on the National Performance Review, each Federal agency make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations in the United States and its territories and possessions, the District of Columbia, the Commonwealth of Puerto Rico, and the Commonwealth of the Mariana Islands.

A database search of the USEPA EJView mapping tool[29], revealed that within the portion of Chicago containing the Bubbly Creek project site, that majority of the population (30-100%) is considered below the poverty line. Similarly, the majority of the population (30-100%) is considered as a minority. Since the overall project and the NER Plan is considered ecosystem restoration, no adverse human health effects or environmental effects on minority populations and/or low income populations are expected. It is anticipated that this habitat restoration project would have beneficial affects to local communities in terms of aesthetics, wildlife, green open space, recreational opportunity,and cleaner surface waters.

Clean Air Act

The local air quality in Chicago and Cook County are considered 'non-attainment' under the Clean Air Act for ozone, particulates (PM-10 and PM-2.5), and lead. The project is within the non-attainment zone. Once implemented, the project itself would be neutral in terms of air quality, with no features that either emit or sequester air pollutants to a large degree. During the project construction, heavy equipment would cause minor, temporary air quality impacts, however all equipment would be in compliance with current air quality control requirements for diesel exhaust, fuels, and similar requirements.

Section 401 of the Clean Water Act

A Section 404(b)(1) analysis was completed for the NER Plan and is located in Appendix B. Features addressed by the 404 include the fill materials for the substrate restoration measure in which sand, rounded river rock, quarried stone, cobble and woody debris would be placed to provide substrate for the backwater restoration. No adverse effects were determined.

USFWS Coordination

Coordination with the USFWS commenced with a project scoping letter dated 21 April 2008. In a letter dated March 26, 2014, USACE requested that USFWS review its NER plan and prepare a Fish and Wildlife Coordiation Act Report pursuant to the U.S. Fish and Wildlife Coordination Act. In a letter report dated July 2, 2014, USFWS recommended the NER Plan for the project

[29] U.S. Environmental Protection Agency. 2013. EJView. Accessed May 9, 2013. http://epamap14.epa.gov/ejmap/entry.html.

and stated that the Bubbly Creek "ecosystem restoration offers a unique opportunity to restore and enhance an important fish and wildlife resource. The proposed riparian restoration that includes planting with native shrubs, has the opportunity to provide significant benefit to migrating birds."

State of Illinois Historic Preservation Act

In a letter dated March 29, 2010, the Illinois Historic Preservation Agency (IHPA) informed USACE that no historic properties are affected by the NER Plan.

In a letter dated July 6, 2012, the Illinois Historic Preservation Agency reviewed the two concepts proposed for the restoration of the Turning Basin. The turning basin is part of the IMCNHC; therefore, any proposed restoration as part of the Bubbly Creek ecosystem restoration project, should not encroach upon the original design either physically or visually. One of the designs submitted was considered to negatively alter the visual characteristics of the turning basin; therefore, it was omitted from further consideration. The second design for the turning basin included floating and submerged aquatic vegetation that would have less impact on the character of the turning basin and thus the IHPA indicated they would have no objection to its implementation. This tentatively approved design by the IHPA is part of the recommended plan.

Table 15: Compliance with Environmental Statutes and Regulations

Reference	Environmental Statutes/Regulations	Project Compliance
16 U.S.C. 1531, et seq.	Endangered Species Act, as amended	C
16 U.S.C. 470a, et seq.	National Historic Preservation Act, as amended	C
16 U.S.C. 661	Fish and Wildlife Coordination Act, as amended	In Progress
16 U.S.C. 703 et seq.	Migratory Bird Treaty Act of 1918, as amended	C
16 U.S.C. 469, et seq.	Archaeological and Historical Preservation Act, as amended	C
25 U.S.C. 3001, et seq.	Native American Graves Protection and Repatriation Act	C
33 U.S.C. 1251 et seq.	Clean Water Act, of 1977, as amended	C
42 U.S.C. 1962	Water Resources Planning Act of 1965	C
42 U.S.C. 1996	American Indian Religious Freedom Act of 1978	C
42 U.S.C. 201	Safe Drinking Water Act of 1986, as amended	C
42 U.S.C. 4321, et seq.	National Environmental Policy Act (NEPA), as amended	C
42 U.S.C. 4901, et seq.	Quiet Communities Act of 1978	C
42 U.S.C. 6901, et seq.	Resource Conservation and Recovery Act of 1976, as amended	C
42 U.S.C. 7401	Clean Air Act of 1970 as amended	C
42 U.S.C. 9601	Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980	C
E.O. 11514	Protection and Enhancement of Environmental Quality	C
E.O. 11593	Protection and Enhancement of the Cultural Environment	C
E.O. 11988	Floodplain Management	C
E.O. 11990	Protection of Wetlands	C
E.O. 12088	Federal Compliance with Pollution Control Standards	C
E.O. 12898	Federal Actions to Address Environmental Justice in Minority and Low-Income Populations	C

Table 15 (continued): Compliance with Environmental Statutes and Regulations

Reference	Environmental Statutes/Regulations	Project Compliance
E.O. 13007	Indian Sacred Sites	C
E.O. 13045	Protection of Children from Environmental Health Risks and Safety Risks	C
E.O. 13186	Responsibilities of Federal Agencies to Protect Migratory Birds	C
E.O. 13340	Great Lakes Designation of National Significance to Promote Protection	C
P.L.79-525	Rivers and Harbors Act of 1946	C

C = compliance NA = not applicable U.S.C. = United States Code
CEQ = Council on Environmental Quality E.O. = Executive Order P.L. = Public Law

5.7 Finding of No Significant Impact (FONSI)

An Environmental Assessment was completed for the proposed habitat restoration of the South Fork of the South Branch of the Chicago River, Illinois, commonly referred to as Bubbly Creek. The Environmental Assessment has found that there would be no adverse affects resulting from implementation of the NER Plan. A 30-day Public Review period was held from XX XX XXXX to XX XX XXXX. A draft FONSI is included in Appendix B.

CHAPTER 6 – PLAN IMPLEMENTATION

This chapter outlines details for implementing the NER Plan, if authorized by Congress. Plan implementation details include sequencing, environmental assessment findings, mitigation requirements, permit requirements, agency and stakeholder views, project schedule, total project costs and cost sharing requirements.

6.1 Project Authorization

Congressional authorization is required for the implementation of this project. Authorization for construction is typically provided through legislative language contained in a Water Resources Development Act. Following approval of this feasibility study by the Division Engineer, USACE implementing guidance allows the Chicago District to enter into a Preconstruction Engineering and Design (PED) agreement and initiate PED activities. Upon approval by the Civil Works Review Board and the Assistant Secretary of the Army (Civil Works), the project may be considered for implementation in accordance with existing budgetary policies and procedures.

6.2 NER Plan Implementation & Sequencing

The NER Plan is the recommended plan, which is Alternative 3. This alternative consists of five (5) measures: Substrate Restoration, Channel/Turning Basin (SR1, SR2), Submergent Planting, Channel/Turning Basin (SP1, SP2), Riparian Planting, Entire Channel (RP2), Emergent Planting (EP), and Woody Debris (WD). The implementation of all of these measures would restore a backwater community within Bubbly Creek. The implementation of these features is generally described as follows and according to the measures descriptions in Section 4.2. Additional design and analysis would be conducted should this project commence to the PED phase, for example, specifying spatial distribution of native plugs within a given zone and species clumping, planting centers, soil amendment percentages, temporary herbivore controls, and establishment activities. The original construction activity sequencing was optimized by the February 2014 VE Study (Appendix I) and would include:

1) Site Preparation – The first task would be to install safety fencing, signage and other safety features in order to keep the public out of the site during heavy construction. Staging areas and access roads would be demarcated; temporary erosion controls and other termporary construction features would be installed.

2) Riparian Native Plant Community Preparation – All invasive plant species would be physically and if necessary chemically eradicated from the riparian planting zones to minimize disturbance to existing bank areas. Next, the zone areas would be prepared for planting with soil amendments. All woody invasive species removed too small for snag habitat would be chipped into small pieces and spread over bank areas to be planted. Based on lessons learned from similar restoration projects, the addition of these wood chips greatly aids in establishing a native plant community, reduces costs by avoiding hauling and disposal, and is environmentally preferred over burning the material.

3) Substrate Placement– Channel and turning basin substrates would be placed as soon as site preparation is completed. First, a survey and subsequent removal of any large pieces of foreign debris would be removed if it is determined they would impeded substrate layer placement. A small barge(s) would be used to place substrate. Sand would be broadcasted in thin layers to a 6-

inch total thickness within the channel and turning basin. This would then be followed by the placement of an 6 inch thick layer of rounded river rock or quarried stone in areas requiring armoring. Cobbles and boulders would then be placed around any structures or non-conformities (e.g. bridge abutments, outfalls, protruding revetments, etc.) to provide additional protection against high flow velocities in and around these structures. All visible stone would be of glacial or fluvial material since quarried, angular stone is not indicative and detrimental to natural stream and aquatic habitats.

4) Large Woody Debris– Various types of large woody debris or snag habitats would be placed within the Bubbly Creek channel. Trees would be primarily derived from invasive tree species removal; Siberian elm, box elder, and potentially a few cotton woods. Parts utilized would be the rootwad, trunk, and limbs over 6-inches in diameter. All small branches and leafs would be chipped and used as soil amendment. Fish and turtle snags would consist of trunks and large limbs to be place in 5 to 2 feet of water, about ¾ submerged and ¼ emergent. Heron snags would consist of the trunk and limbs vertically placed into the channel as to mimic a drowned standing tree. These would be placed in more secluded and near-bank areas. Rootwads would be used to provide both submerged habitat and stability to establishing aquatic bed and emergent zones. Rootwads can be lined up and wedged together to form a barrier for these planting zones. Certain plant species would grow on top of the root wads as well. Finally, certain trees would be selected to be girdled (terminated) in place and would not be removed. Tree girdling provides heron and woodpecker habitat by mimicking what would happen to a drown tree.

5) Submergent and Emergent Native Plant Community Preparation – The aquatic bed and emergent wetland zone areas would be prepared for planting with soil amendments. Certain patches of aquatic bed and emergent zone, depending on specie clumping locations, would receive organic leaf litter compost to provide adequate conditions for growth. Certain species of *Potamogeton* would establish sufficiently in sandy gravel.

6) Native Plant Community Establishment – Native plant communities within the submergent aquatic bed, emergent, transition bank, and riparian zone would be established over the remainder of the construction period, which would consist of 4 of the 5 years of construction. Specific planting lists by habitat zone are shown in ***Table 16*** below. Zones would be seeded and planted with live plugs. Live plug areas would require herbivore control, primarily stringing and caging to prevent Canada goose and common carp herbivory. The remaining duration of the construction contract would primarily be set aside for spot herbicide application to remove invasives and additional planting to ensure establishments.

Table 16: Native Plant Community Species List

Habitat	Physiognomy	Scientific Name	Common Name
Submergent Zone	Forb	*Potamogeton foliosus*	LEAFY PONDWEED
	Forb	*Potamogeton natans*	COMMON PONDWEED
	Forb	*Potamogeton nodosus*	AMERICAN PONDWEED
	Forb	*Potamogeton pectinatus*	COMB PONDWEED
	Forb	*Ceratophyllum demersum*	COONTAIL
	Forb	*Vallisneria americana*	EEL GRASS
Emergent Zone	Nt P-Forb	*Acorus calamus*	AMERICAN SWEET FLAG
	Nt P-Forb	*Alisma subcordatum*	COMMON WATER PLANTAIN
	Nt P-Forb	*Asclepias incarnata*	SWAMP MILKWEED
	Nt P-Grass	*Calamagrostis canadensis*	BLUE JOINT GRASS
	Nt P-Forb	*Caltha palustris*	MARSH MARIGOLD
	Nt Shrub	*Cephalanthus occidentalis*	BUTTONBUSH
	Nt Shrub	*Decodon verticillatus*	SWAMP LOOSESTRIFE
	Nt P-Forb	*Eupatorium perfoliatum*	COMMON BONESET
	Nt P-Forb	*Hibiscus laevis*	HALBERD-LEAVED ROSE MALLOW
	Nt P-Forb	*Iris virginica shrevei*	BLUE FLAG
	Nt P-Forb	*Mimulus ringens*	MONKEY FLOWER
	Nt P-Forb	*Nuphar advena*	YELLOW POND LILY
	Nt P-Forb	*Nymphaea tuberosa*	WHITE WATER LILY
	Nt P-Forb	*Polygonum amphibium stipulaceum*	WATER KNOTWEED
	Nt P-Forb	*Pontederia cordata*	PICKEREL WEED
	Nt P-Forb	*Sagittaria latifolia*	COMMON ARROWHEAD
	Nt P-Sedge	*Scirpus atrovirens*	DARK GREEN RUSH
	Nt P-Sedge	*Scirpus fluviatilis*	RIVER BULRUSH
	Nt P-Sedge	*Scirpus pungens*	CHAIRMAKER'S RUSH
	Nt P-Sedge	*Scirpus validus creber*	GREAT BULRUSH
	Nt P-Forb	*Sparganium eurycarpum*	COMMON BUR REED
Riparian Zone	Nt Shrub	*Amorpha canescens*	LEAD PLANT
	Nt P-Grass	*Andropogon gerardii*	BIG BLUESTEM GRASS
	Nt P-Grass	*Andropogon scoparius*	LITTLE BLUESTEM GRASS
	Nt P-Forb	*Anemone canadensis*	MEADOW ANEMONE
	Nt P-Forb	*Asclepias tuberosa*	BUTTERFLY WEED
	Nt P-Forb	*Aster azureus*	SKY-BLUE ASTER
	Nt P-Forb	*Aster ericoides*	HEATH ASTER
	Nt P-Forb	*Aster laevis*	SMOOTH BLUE ASTER
	Nt P-Forb	*Aster novae-angliae*	NEW ENGLAND ASTER
	Nt P-Forb	*Baptisia leucantha*	WHITE WILD INDIGO
	Nt P-Grass	*Bouteloua curtipendula*	SIDE-OATS GRAMA
	Nt A-Forb	*Cassia fasciculata*	PARTRIDGE PEA
	Nt Shrub	*Ceanothus americanus*	NEW JERSEY TEA
	Nt P-Forb	*Desmodium illinoense*	ILLINOIS TICK TREFOIL
	Nt P-Grass	*Elymus canadensis*	CANADA WILD RYE
	Nt P-Forb	*Eryngium yuccifolium*	RATTLESNAKE MASTER
	Nt P-Forb	*Helenium autumnale*	SNEEZEWEED
	Nt P-Forb	*Helianthus mollis*	DOWNY SUNFLOWER
	Nt P-Forb	*Helianthus rigidus*	PRAIRIE SUNFLOWER
	Nt P-Forb	*Heliopsis helianthoides*	FALSE SUNFLOWER
	Nt P-Forb	*Heuchera richardsonii*	PRAIRIE ALUM ROOT
	Nt P-Grass	*Koeleria cristata*	JUNE GRASS
	Nt P-Forb	*Kuhnia eupatorioides corymbulosa*	FALSE BONESET
	Nt P-Forb	*Lespedeza capitata*	ROUND-HEADED BUSH CLOVER
	Nt P-Forb	*Liatris aspera*	ROUGH BLAZING STAR
	Nt P-Forb	*Liatris spicata*	MARSH BLAZING STAR
	Nt P-Forb	*Monarda fistulosa*	WILD BERGAMOT
	Nt P-Grass	*Panicum virgatum*	SWITCH GRASS
	Nt P-Forb	*Parthenium integrifolium*	WILD QUININE
	Nt P-Forb	*Penstemon digitalis*	FOXGLOVE BEARD TONGUE
	Nt P-Forb	*Petalostemum purpureum*	PURPLE PRAIRIE CLOVER

Table 16 (continued): Native Plant Community Species List

Habitat	Physiognomy	Scientific Name	Common Name
Riparian Zone	Nt P-Forb	*Potentilla arguta*	PRAIRIE CINQUEFOIL
	Nt P-Forb	*Ratibida pinnata*	YELLOW CONEFLOWER
	Nt Shrub	*Rosa blanda*	EARLY WILD ROSE
	Nt P-Forb	*Rudbeckia hirta*	BLACK-EYED SUSAN
	Nt P-Forb	*Rudbeckia subtomentosa*	SWEET BLACK-EYED SUSAN
	Nt A-Forb	*Rudbeckia triloba*	BROWN-EYED SUSAN
	Nt P-Forb	*Silphium integrifolium*	ROSIN WEED
	Nt P-Forb	*Silphium laciniatum*	COMPASS PLANT
	Nt P-Forb	*Silphium terebinthinaceum*	PRAIRIE DOCK
	Nt P-Forb	*Solidago nemoralis*	OLD-FIELD GOLDENROD
	Nt P-Forb	*Solidago rigida*	STIFF GOLDENROD
	Nt P-Forb	*Solidago speciosa*	SHOWY GOLDENROD
	Nt P-Grass	*Sorghastrum nutans*	INDIAN GRASS
	Nt P-Grass	*Sporobolus heterolepis*	PRAIRIE DROPSEED
	Nt P-Grass	*Stipa spartea*	PORCUPINE GRASS
	Nt P-Forb	*Thalictrum dasycarpum*	PURPLE MEADOW RUE
	Nt P-Forb	*Tradescantia ohiensis*	COMMON SPIDERWORT
	Nt P-Forb	*Verbena stricta*	HOARY VERVAIN
	Nt P-Forb	*Zizia aurea*	GOLDEN ALEXANDERS

6.3 Recognized Environmental Condition (REC) Considerations

It was determined through sampling and analysis that the sediment within the channel and turning basin are classified as a Recognized Environmental Condition (REC). To minimize the risk associated with the sediment, sediment samples were collected and analyzed. The analytical results indicated the sediment contains levels of polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), and heavy metals above Illinois Environmental Protection Agency's (IEPA) Tiered Approach to Corrective Action Objectives (TACO) Commercial/Industrial ingestion levels. Other detected contaminants included low levels of semi volatile organic compounds (SVOCs), volatile organic compounds (VOCs), oil and grease, and nutrients. The detected concentrations of SVOCs (besides PAHs) and VOCs were below IEPA's TACO Residential ingestion levels. Through sampling and testing, the District was able to confirm the sediment was not characteristically toxic, corrosive, or reactive under the RCRA.

In addition to sediment sampling and analysis, investigations assessing the sediment's geotechnical properties were completed, and the results informed construction methods. To minimize disturbance of the sediment during implementation of the new substrate, the substrates will be broadcast spread in thin lifts verses placement from a bucket or scow. Broadcasting limits the disturbance of the sediment which lowers the risk of a relaese to the environment. The broadcasting also allows the substrate weight to be loaded slowly and uniformly across the bed to confine the sediment; permits the sediment to release excess pore water pressure uniformly without failures; and limits differential loadings on the sediment. Geotechnical analysis confirmed that the existing sediment will significantly compress over a relatively short period of time and well within the five year monitoring and adaptive management period. During placement of the new substrate materials, downstream turbidity control and/or turbidity monitoring will be included as appropriate.

In formulating plans for bank restoration, only measures that minimize land disturbance were selected for further evaluation. Bank cutbacks, requiring soil excavation along the banks, were considered during plan formulation but are not included as part of the NER plan. The

NER plan calls for riparian plantings only on banks that do not require soil excavation or removal of current bank stabilization features. The plan includes the removal of invasive species by hand-cutting and herbiciding to avoid soil disturbances. Leaf compost would be used as surface application of soil amendments to further minimize the disturbance of soil. Plugs would be planted and seeds spread over the soil amendments.

6.4 Real Estate Considerations

The Real Estate Plan identifies and describes the area proposed for construction, adaptive management and OMRR&R of the project, in addition to the real estate requirements and procedures for implementation of the recommended NER Plan (Appendix G).

The primary real estate required for the project consists of 33.37 acres of channel bottomland. The required real estate for the bottomland restoration is fee simple. While the project lies within a navigable waterway, navigation servitude would not be invoked due to the lack of a nexus to navigation or commerce. Ownership of the bottom of the Chicago River is typically challenging to verify. A detailed review of title commitments is being conducted to verify ownership of Bubbly Creek. The Federal government acquired the real estate to construct the turning basin in 1903 and continues to own it in fee simple (approximately 4.3 acres). The balance of the channel bottom is owned by either the City of Chicago or Metropolitan Water Reclamation District of Greater Chicago. The non-Federal sponsor would be required to acquire rights to any portion of Bubbly Creek that does not fall under its ownership.

The secondary land required for the project is 6.56 acres of Ecosystem Easement for restoration of the Bubbly Creek banks. The area of restoration is on the steep slope bank on multiple private properties. A request for approval of a non-standard estate is included in the Real Estate Plan due to the challenges associated with acquiring fee title to the project lands. The non-Federal sponsor would be responsible for all easements and is capable of performing the acquisitions.

A gross appraisal was conducted by the USACE, Detroit District Real Estate Division and found the total value of LERRDs required for the project to be $155,000, not including administrative costs. This value is primarily derived from the Ecosystem Easement as the channel itself has little, if any, positive economic value.

6.5 Permit Requirements

The following required permits are anticipated and would be obtained prior to implementation of plan components:

- Section 401 Water Quality Certification (WQC) – IEPA
- NPDES General Permit (327 IAC 15) – IEPA
- Coastal Zone Management Act Federal Consistency Determination – Illinois Department of Natural Resources

6.6 Monitoring, Adaptive Management and OMRR&R

6.6.1 Monitoring

Section 2039 of WRDA 2007 directs the Secretary to ensure that when conducting a feasibility study for a project (or a component of a project) for ecosystem restoration that the recommended project includes a plan for monitoring the success of the 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.

Monitoring of the proposed project would focus on two components: structural sustainability and biological response. A five (5) year monitoring plan for each component would be implemented as part of this project following completion of construction of the features of each component.

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 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 of parameters that would be visually assessed:

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

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:

1. Plant Communities
    a. FQA
    b. Species Richness
2. Macroinvertebrate & Fish Community
    a. IBI
3. Other Communities
    a. Species Richness
4. Supporting Data (DO, pH, temperature, nutrients)

Monitoring Schedule of Costs

The monitoring schedule and associated costs are found in ***Table 17***.

Table 17: Monitoring Schedule and Costs (in thousands)

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" notes the monitoring years.

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

6.6.2 Adaptive Management

Adaptive management measures are response actions to changed conditions that would adversely affect how the system was predicted to respond. In so being adaptive, there are no absolute measures that can be defined prior to an issue arising. The primary concerns for this project are the structural integrity of habitat features, and water quality conditions (namely dissolved oxygen levels following CSO events). Below are brief descriptions of potential adaptive management measures that could be implemented to address issues that may arise during the establishment 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 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 these 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 as discussed earlier.

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 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 $50,000 has been added to the estimate to cover the cost of adaptive management of native plantings.

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 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.

6.6.3 Operations & Maintenance Considerations

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 period. Most, if not all, of the projected OMRR&R activities are no different than the specific activities that would take place during construction. The following are a list of projected OMRR&R activities that the non-Federal Sponsor would be responsible for to ensure project success:

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 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 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.

Table 18: OMRR&R Costs

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

6.7 Implementation of Environmental Operating Principles

In assessing the environmental effects, USACE implemented the following Environmental Operating Principles (EOPs)[30] as part of this Feasibility Study.

Foster sustainability as a way of life throughout the organization.

Originally, restoration of Bubbly Creek aimed to manipulate the human-induced hydrology, hydraulics and geomorphology of the system to mimic that of a perennial stream. By restoring features conducive to the existing flat geomorphology and the pulse-like nature of the hydrology and hydraulic forces currently in place, the missing physical components can be restored to mimic a large backwater system. This design creates sustainability by avoiding the use of pumps, pipes and features with high operation and maintenance costs. The backwater habitat would be sustainable because it will not fill in as the flood pulses keep the bed elevation static. Natural backwaters are stagnant most of the time and species that naturally inhabit them are adapted to these conditions.

Proactively consider environmental consequences of all Corps activities and act accordingly.

Potential environmental consequences of proposed restoration features and construction activities were considered. A cumulative effects assessment was completed to ensure all facets of environmental consequences were considered. Participation from Federal, state and local agencies and stakeholders ensured the most environmentally-beneficial project. Negative impacts to the Bubbly Creek study area are not anticipated based on the restorative nature of the project, which would establish a healthy native backwater having many characteristics of the former prairie slough.

Create mutually supporting economic and environmentally sustainable solutions.

Potential restoration plans were formulated to determine what the most cost-effective solution for ecosystem restoration is; however, appropriate engineering studies and biological assessments were performed to ensure that an implemented plan would be sustainable. Ecosystem restoration measures avoided costly and unsustainable features such as pumps, pipes, weirs, and other fabricated structures. These types of features require continual operation and maintenance to ensure they are providing the ecosystem's specified conditions. Designs for the Bubbly Creek NER Plan rely on predicted future without project conditions.

Continue to meet our corporate responsibility and accountability under the law for activities undertaken by the Corps which may impact human and natural environments.

This project is exemplary for meeting USACE corporate responsibility and accountability. Detailed environmental analyses were completed and reviewed to ensure construction activities would not result in an unlawful release of contamination (Appendix F). After determining that a habitat restoration project would not have any adverse affects to the human environment, the

[30] U.S. Army Corps of Engineers. Environmental Operating Principles. Accessed September 9, 2014. http://www.usace.army.mil/Missions/Environmental/EnvironmentalOperatingPrinciples.aspx

Laws, Compliance Statues and Executive Orders support the NER plan and do not support the No Action Plan.

Consider the environment in employing a risk management and systems approach throughout life cycles of projects and programs.

Risks associated with ecosystem restoration projects are typically low, for example, if certain portions of the project were to fail, other portions could be simultaneously successful. Habitat restoration is not an all or nothing scenario. Project failure has little chance to cause impact to human life. In the case of Bubbly Creek, placing sand, rounded river rock or quarried stone, woody debris and native plants within the study area would only have beneficial affects to people and the environment. Risk considerations for this project primarily are those associated with the cost obligated to restore the environment and possiblility of receiving no benefits in return. Extensive engineering analyses were conducted to ensure the physical resilience of the habitat features, and the project team has also weighed the biological conditions against other natural areas and similar restoration projects to ensure the plan will function as expected.

Leverage scientific, economic, and social knowledge to understand the environmental context and effects of Corps actions in a collaborative manner.

This study was conducted in a manner that leveraged previous studies and scientific knowledge from a variety of stakeholders including USEPA, University of Illinois at Chicago, ERDC and previously USACE constructed ecosystem restoration projects. In addition, during the May 2008 NEPA scoping meeting, various project meetings, issue specific meetings with governmental agencies, a design charrette, and VE study, the study team met with governmental agencies, local industry, and environmental interest groups to gather scientific, economic and social information that pertains to the Bubbly Creek study area.

Employ an open, transparent process that respects views of individuals and groups interested in Corps activities.

During the May 2008 NEPA scoping meeting, the study team met with governmental agencies, local industry, and environmental interest groups to discuss the potential project and obtain information and opinions of what Bubbly Creek could be restored to and used for (Appendix B). Throughout the study process, the study team engaged local, state and federal agencies seeking needed information and also asking for input on the concept and design of the NER Plan. This study process and subsequent Feasibility Report were drafted in a manner that has reduced redundancies, excessive and inconsequential information, and confusing engineering and policy discussions. Presentation of this study was done in a clear sequential order to show what the natural condition of Bubbly Creek was historically, what the existing conditions are now, what they are projected to be if left alone, what could be done, and what should be done based on considerations of ecosystem improvement and associated costs.

6.8 NEPA Compliance*

The President's Council on Environmental Quality guides public participation opportunities with respect to Feasibility Reports and Environmental Assessments, Engineering Regulations, and procedures for implementing NEPA. Coordination and compliance for this feasibility study included comprehensive public involvement, agency coordination, and review of and inclusion of

compliance with applicable Federal statues per the USACE Engineering Regulation 1105-2-100, Planning Guidance Notebook.

6.8.1 Mitigation Requirements

Since this is an ecosystem restoration project, once lost resources would be recovered by the Federal Action; therefore, mitigation is not warranted.

6.8.2 Public/Agency Comments & Views

To facilitate public coordination, the study team developed a project website, http://bubblycreekstudy.org, which contains project information and status updates. Public scoping letters dated April 21, 2008 were mailed to federal, state and local elected officials, federal, state and local governmental agencies, individuals and organizations, and local businesses along Bubbly Creek. A copy of this letter along with the distribution list can be found in Appendix B. On May 15, 2008, the study team held a public scoping meeting near Bubbly Creek within the Bridgeport neighborhood of Chicago. The meeting minutes are posted on the project website and are also included in Appendix B.

Regarding agency coordination, the study team included members of USEPA, USFWS, IEPA, IDNR, and MWRDGC. Representatives participated in study team meetings and were contacted for information and guidance. In addition to routine team meetings, USEPA and IEPA participated in the project's two-day September 2012 design charrette which focused on developing measures for the project, and USEPA sediment expert participated in the project's February 2014 VE Study.

During plan formulation, USACE coordinated initial plan concepts with the Illinois Historic Preservation Agency. In a letter dated July 6, 2012, the agency noted that proposed new construction including plants should not encroach upon the original design either physically or visually of the Bubbly Creek turning basin (Appendix B). Therefore, plants selected for the turning basin are ones that do not break the water's surface.

In a letter dated March 26, 2014, USACE requested that USFWS review its tentatively-selected plan and prepare a FWCA Report pursuant to the U.S. Fish and Wildlife Coordination Act. In a letter report dated July 2, 2014, USFWS recommended the NER Plan and stated the Bubbly Creek "ecosystem restoration offers a unique opportunity to restore and enhance an important fish and wildlife resource. The proposed riparian restoration that includes planting with native shrubs, has the opportunity to provide significant benefit to migrating birds."

Formal coordination and agency views will be summarized in this section after the NEPA public/agency review is completed.

Public Review of the Draft Environmental Assessment (EA)

This section will be furnished when the public input generated is analyzed.

Public Meeting on the Draft EA

This section will be furnished when the public input generated is analyzed.

Publication of the FONSI

The FONSI will be signed and this section will be furnished following OASA(CW) review by either the ASA(CW) or District Commander.

6.9 Project Schedule & Costs

6.9.1 Project Schedule

An estimated schedule for project implementation is shown in ***Table 19***.

Table 19: Project Implementation Schedule

Schedule Item	Completion Date
Feasibility Report Approved by Division Engineer	August 2015
Preconstruction Engineering and Design agreement signed	November 2016
PPA Signed	December 2017
Real Estate Acquisitions Complete	March 2018
Contract Award [1]	April 2018
Implementation Complete	April 2028

[1] Assumes congressional authorization provided prior to contract award

6.9.2 Total Project Costs

Total project costs include costs for study, design, implementation, contingencies, construction management, EDDC and project management. Costs for design and management are estimated based on a percentage of estimated implementation costs and contingencies. These costs will be revised prior to the execution of a PPA and actual costs for these activities will be used to remedy final cost sharing responsibilities during project close-out.

Total project costs were escalated to the mid-point of estimated construction using factors contained in EM 1110-2-1304, Civil Works Construction Cost Index System (CWCCIS). ***Table 20*** provides a summary of total project costs for the NER Plan in both current constant October 2014 and escalalated fully funded price levels. Using the fully funded escalated costs and the implementation schedule, a summary of funding requirements by fiscal year is presented in ***Table 21***.

Table 20: NER Plan Implementation Schedule and Costs

Activity/Measure	Cost (Oct 2014) /2	Implementation Schedule /1											% Esc. /3	Escalated Cost /2
		FY2017		FY2018				FY2019 - 2022				FY2023		
		3Q	4Q	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q		
01 Lands & Damages LERRDs	$155,000												1.6%	$159,000
09 Channels & Canals/4 Substrate Restoration-Ch (SR1) Substrate Restoration-Tb (SR2) Submergent Planting-Ch (SP1) Submergent Planting-Tb (SP2) Woody Debris (WD)	$8,414,000					xxx	xxx	xxx	xxx	xxx	xxx	xxx	1.6%	$9,049,000
16 Bank Stabilization/4 Riparian Planting-Entire Ch (RP2) Emergent Planting (EP)	$3,688,000					xxx	xxx	xxx	xxx	xxx	xxx	xxx	1.6%	$4,004,000
30 Planning, Engineering and Design/5	$2,336,000	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	2.2%	$2,504,000
31 Construction Management/6	$790,000	xxx	xxx	xxx		xxx	xxx	xxx	xxx	xxx	xxx	xxx	2.2%	$913,000
Total First Cost	$15,384,000	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	xxx	varies	$16,629,000

/1 Each 'x' in the schedule indicates one month of construction. Fiscal years (FY) begin in October and end in September. Implementation schedule does not include five years of post construction monitoring. See Table 15 for more information on monitoring schedule.
/2 To reflect uncertainties in the cost estimates, the following contingencies are added: Channels & Canals 26% and Bank Stabilization 26%
/3 Costs are escalated based on estimated mid-point of construction [Engineering Manual (EM) 1110-2-1304, CWCCIS]
/4Implementation for plantings includes a 5-year establishment period.
/5 Costs for these activities were estimated based on percentages applied to implementation costs including contingencies but without LERRDs: Project Management 2.5%; Preconstruction Engineering & Design 8.5%; Engineering During Construction 2.0%; and Construction Management 7.5%. Monitoring and adaptive management, which continue through 2028, have been included in the Planning, Engineering and Design account.
/6 Construction may be required in years 2024 through 2028, depending on adaptive management needs which are uncertain at this time.

Table 21: NER Plan Funding Schedule (Oct 2014 PL) in thousands

Measure	FY 17	FY 18	FY 19	FY 20	FY 21	FY 22	FY 23	FY 24	FY 25	FY 26	FY 27	FY 28	Total
01 Lands and Damages													
LERRDS	$155												$155
09 Channels and Canals		$8,414											$8,414
16 Bank Stabilization		$3,688											$3,688
30 PED /1	$1,558	$328	$28	$38	$28	$38	$28	$210		$10	$50	$20	$2,336
31 Constr. MGMT /2	$60	$600	$50	$8	$8	$8	$8	$32			$16		$790
Total	$1,773	$13,030	$78	$46	$36	$46	$36	$242		$10	$66	$20	$15,384
Fed 65%	$1,152	$8,470	$51	$30	$23	$30	$23	$157		$7	$43	$13	$10,000
Non-Fed 35%	$621	$4,560	$27	$16	$13	$16	$13	$85	0	$3	$23	$7	$5,384

/1 Monitoring and adaptive management costs have been included in this account.
/2 Costs for these activities were estimated based on percentages applied to implementation costs including contingencies but without LERRDs: Project Management 2.5%; Preconstruction Engineering & Design 8.5%; Engineering During Construction 2.0%; and Construction Management 7.5%

6.9.3 Cost Apportionment

This feasibility study was initiated in 2007 as a result of an approved reconnaissance report that determined federal interest in studying opportunities to restore the aquatic ecosystem of Bubbly Creek. This is as a specifically authorized study authorized by resolution of the Senate Committee on E&PW adopted on July 20, 2005. Financing for the feasibility study is being equally cost-shared 50/50 as per a feasibility cost sharing agreement executed with the City of Chicago on 16 August 2007.

Per Section 210 of the WRDA of 1996, the non-Federal share of the implementation costs for ecosystem restoration projects will be 35 percent of the project unless project authorization specifies otherwise. The non-Federal share includes PED, implementation, construction management, EDDC and project management costs. Non-Federal sponsors shall provide 100 percent of the LERRDs and OMRR&R. The value of LERRD shall be credited as part of the non-Federal 35 percent share.

A summary of the constant price level and fully funded total project costs for the NER Plan are shown in ***Table 22***. A breakdown of Federal and non-Federal contributions to the total project cost for the NER Plan is provided in ***Table 23***.

Table 22: Summary of NER Plan Project Costs

	Oct 2014 Price Level	Fully Funded
Estimate of Total Project Costs /1		
01 Lands and Damages		
LERRDs	$155,000	$159,000
09 Channels & Canals		
Substrate Restoration-Channel (SR1) Substrate Restoration-Turning Basin (SR2) Submergent Planting-Channel (SP1) Submergent Planting-Turning Basin (SP2) Woody Debris (WD)	$8,414,000	$9,049,000
16 Bank Stabilization		
Riparian Planting-Entire Channel (RB2) Emergent Planting (EP)	$3,688,000	$4,004,000
30 Planning, Engineering & Design	$2,336,000	$2,504,000
31 Construction Management /2	$790,000	$913,000
Total Implementation Costs	$15,384,000	$16,629,000
OMRR&R	$48,000	

/1 Total project costs are determined by escalating estimated first costs at 1Q2015 (Oct-Dec) price levels to the estimated mid-point of construction using EM 1110-2-1304, CWCCIS

/2 Costs for these activities were estimated based on percentages applied to implementation costs including contingencies but without LERRDs: Project Management 2.5%; Preconstruction Engineering & Design 8.5%; Engineering During Construction 2.0%; and Construction Management 7.5%

Table 23: Cost Apportionment of NER Plan (Oct 2014 PL)

NER Total Project Cost:	$15,384,000
Federal (65%)	$10,000,000
Non-Federal (35%)	$5,384,000
Total Federal Contribution	$10,000,000
Total non-Federal Contribution	$5,384,000
Cash	$5,229,000
LERRDs	$155,000

6.9.4 Financial Capability of Non-Federal Sponsor

In accordance with regulation ER1105-2-100, Appendix D, where the non-Federal sponsor's capability is clear, as in the instances where the sponsor has sufficient funds currently available or has a large revenue base and a good bond rating, the statement of financial capability need only provide evidence of such. The non-Federal sponsor is committed to its specific cost share of the Design & Implementation (D&I) Phase, and expresses willingness to share in the costs of construction to the extent that can be funded.

In accordance with the CECW-PC Memorandum dated 12 June 2007, Non-Federal Sponsor's Self-Certification of Financial Capability, the City of Chicago certifies they are aware of the financial obligations of the non-Federal sponsor and have the financial capability to satisfy obligations for the project. A signed copy of Enclosure 3 will be included in the final document. The non-Federal sponsor is committed to its specific cost share of the PED phase, and expresses willingness to share in the costs of construction to the extent that can be funded.

CHAPTER 7 – RECOMMENDATION*

I have considered all significant aspects of the problems and opportunities as they relate to the Bubbly Creek study area's resource problems. Those aspects include environmental, social, and economic effects, as well as engineering feasibility. The NER Plan is Alternative 3, which consists of restoring a diverse, backwater habitat within Bubbly Creek. The NER plan has a total project cost of approximately $15,384,000 (October 2014 price levels). This plan provides 816.7 net average annual habitat units over 30.7 acres of backwater habitat.

I recommend that the NER Plan be authorized for implementation as a Federal project, with such modifications thereof as in the discretion of the Chief of Engineers, USACE may be advisable. The estimated total cost of the NER Plan referenced to October 2014 price levels is $15,384,000 with a Federal contribution of $10,000,000 and a non-Federal contribution of $5,384,000 including $5,229,000 in cash and $155,000 in lands, easements, rights-of-way, relocations, and disposal areas (LERRDs). The total project cost includes implementation and a 5-year monitoring and adaptive management period. The estimated first cost is $14,934,000 and monitoring and adaptive management is $450,000.

As established in P.L.99-662, as amended, project costs are shared with the non-Federal sponsor in accordance with project outputs. The City of Chicago has agreed to serve as the local cost-sharing sponsor for the Bubbly Creek, South Branch of the Chicago River, Illinois Ecosystem Restoration project. The cost-sharing requirements and provisions will be formalized with the signing of the PPA between the local sponsor and USACE prior to initiation of contract award activities. In this agreement, the local sponsor will agree to pay 35 percent of the total project costs. Federal implementation of the recommended project would be subject to the non-Federal sponsor agreeing to comply with applicable Federal laws and policies, including but not limited to:

a. Provide 35 percent of total project costs as further specified below:
    a. Provide 35 percent of design costs in accordance with the terms of a design agreement entered into prior to commencement of design work for the project;
    b. Provide all lands, easements, and rights-of-way, including those required for relocations, the borrowing of material, and the disposal of dredged or excavated material; perform or ensure the performance of all relocations; and construct all improvements required on lands, easements, and rights-of-way to enable the disposal of dredged or excavated material all as determined by the Government to be required or to be necessary for the construction, operation, and maintenance of the project;
    c. Provide, during construction, any additional funds necessary to make its total contribution equal to 35 percent of total project costs;

b. Shall not use funds from other Federal programs, including any non-Federal contribution required as a matching share therefor, to meet any of the non-Federal obligations for the project unless the Federal agency providing the funds verifies in writing that the funds are authorized to be used to carry out the project;

c. Prevent obstructions or encroachments on the project (including prescribing and enforcing regulations to prevent such obstructions or encroachments) such as any new developments on project lands, easements, and rights-of-way or the addition of facilities which might reduce the outputs produced by the project, hinder operation and maintenance of the project, or interfere with the project's proper function;

d. Shall not use the project or lands, easements, and rights-of-way required for the project as a wetlands bank or mitigation credit for any other project;

e. Comply with all applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, as amended (42 U.S.C. 4601-4655), and the Uniform Regulations contained in 49 CFR Part 24, in acquiring lands, easements, and rights-of-way required for construction, operation, and maintenance of the project, including those necessary for relocations, the borrowing of materials, or the disposal of dredged or excavated material; and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act;

f. For so long as the project remains authorized, operate, maintain, repair, rehabilitate, and replace the project, or functional portions of the project, including any mitigation features, at no cost to the Federal Government, in a manner compatible with the project's authorized purposes and in accordance with applicable Federal and State laws and regulations and any specific directions prescribed by the Federal Government;

g. Give the Federal Government a right to enter, at reasonable times and in a reasonable manner, upon property that the non-Federal sponsor owns or controls for access to the project for the purpose of completing, inspecting, operating, maintaining, repairing, rehabilitating, or replacing the project;

h. Hold and save the United States free from all damages arising from the construction, operation, maintenance, repair, rehabilitation, and replacement of the project and any betterments, except for damages due to the fault or negligence of the United States or its contractors;

i. Keep and maintain books, records, documents, or other evidence pertaining to costs and expenses incurred pursuant to the project, for a minimum of 3 years after completion of the accounting for which such books, records, documents, or other evidence are required, to the extent and in such detail as will properly reflect total project costs, and in accordance with the standards for financial management systems set forth in the Uniform Administrative Requirements for Grants and Cooperative Agreements to State and Local Governments at 32 CFR Section 33.20;

j. Comply with all the requirements of applicable Federal laws and implementing regulations, including, but not limited to: Title VI of the Civil Rights Act of 1964, P.L. 88-352, as amended (42 U.S.C. 2000d), and Department of Defense Directive 5500.11 issued pursuant thereto; the Age Discrimination Act of 1975 (42 U.S.C. 6102); the Rehabilitation Act of 1973, as amended (29 U.S.C. 794), and Army Regulation 600-7 issued pursuant thereto; and all applicable Federal labor standards requirements including, but not limited to, 40 U.S.C. 3141- 3148 and 40 U.S.C. 3701 – 3708 (revising, codifying and enacting without substantial change the provisions of the Davis-Bacon Act (formerly 40 U.S.C. 276a *et seq.*), the Contract Work Hours and Safety Standards Act (formerly 40 U.S.C. 327 *et seq.*), and the Copeland Anti-Kickback Act (formerly 40 U.S.C. 276c *et seq.*);

k. Perform, or ensure performance of, any investigations for hazardous substances that are determined necessary to identify the existence and extent of any hazardous substances regulated under the CERCLA, P.L. 96-510, as amended (42 U.S.C. 9601-9675), that may exist in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be required

for construction, operation, and maintenance of the project. However, for lands that the Federal Government determines to be subject to the navigation servitude, only the Federal Government shall perform such investigations unless the Federal Government provides the non-Federal sponsor with prior specific written direction, in which case the non-Federal sponsor shall perform such investigations in accordance with such written direction;

l. Assume, as between the Federal Government and the non-Federal sponsor, complete financial responsibility for all necessary cleanup and response costs of any hazardous substances regulated under CERCLA that are located in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be required for construction, operation, and maintenance of the project;

m. Agree, as between the Federal Government and the non-Federal sponsor, that the non-Federal sponsor shall be considered the operator of the project for the purpose of CERCLA liability, and to the maximum extent practicable, operate, maintain, repair, rehabilitate, and replace the project in a manner that will not cause liability to arise under CERCLA; and

n. Comply with Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended (42 U.S.C. 1962d-5b), and Section 103(j) of the Water Resources Development Act of 1986, Public Law 99-662, as amended (33 U.S.C. 2213(j)), which provides that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof, until each non-Federal interest has entered into a written agreement to furnish its required cooperation for the project or separable element.

The recommendations contained herein reflect the information available at this time and current departmental policies governing formulation of individual projects. They do not reflect program and budgeting priorities inherent in the formulation of a national Civil Works construction program nor the perspective of higher review levels within the Executive Branch. Consequently, the recommendations may be modified before they are transmitted to the Congress as proposals for authorization and implementation funding. However, prior to transmittal to the Congress, the non-Federal sponsor, the States, interested Federal agencies, and other parties will be advised of any modifications and will be afforded an opportunity to comment further.

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Christopher T. Drew
Colonel, U.S. Army
District Commander