2019

Ravine 10 Ecosystem Restoration

Section 506 Great Lakes Fishery & Ecosystem Restoration (GLFER)

Draft Integrated Detailed Project Report & Environmental Assessment

Chicago District
US Army Corps of Engineers
09/18/2019

Ravine 10 Ecosystem Restoration
Draft Integrated Feasibility Report and Environmental Assessment

Table of Contents

* Sections required for NEPA compliance

List of Tables

List of Figures

Appendices

EXECUTIVE SUMMARY*

The non-Federal sponsors, the City of Highland Park, Park District of Highland Park (PDHP), and the North Shore Water Reclamation District (NSWRD) have requested that the Chicago District USACE initiate a study under the authority of Section 506 Water Resource Development Act of 2000, as amended, 42 U.S.C. § 1962d-22, Great Lakes Fishery and Ecosystem Restoration to determine the feasibility of restoring ecological integrity to Ravine 10. The scope of this study investigates altered stream hydrology and hydraulics, native plant community degradation, habitat connectivity, rare wetland communities and native species richness. The non-federal sponsors are currently implementing ecosystem restoration at various coastal ravines to address habitat degradation and connectivity for the purpose of habitat restoration, fish and wildlife recolonization, water quality improvement and aesthetics for the public. The need for riverine and coastal ecosystem restoration of the study area is based on habitat, organisms, and water quality studies conducted by state, regional, and local agencies and groups, that have shown over the decades, the impairments caused to fish, wildlife, and other natural resources.

The study area is located in Highland Park, Cook County, Illinois, along the Lake Michigan coast. The study area core, Moraine Park, specifically resides west of Lake Michigan, east of Sheridan Road, south of Riparian Road and north of Maple Road. The study area also includes the stream channel (~4,800 feet total) within Moraine Park, upstream to Port Clinton Park, and the riparian slopes within Port Clinton Park. The Lake Michigan coastal zone is one of the most diverse ecosystems in Lake County, Illinois. The unique landforms of ravines, bluffs, and beaches were left behind by glacial movements and the recession of Lake Chicago, a larger pre-historic lake than the present Lake Michigan. These landforms and the special coastal climate combined to induce a diverse ecosystem which host a multitude of migratory and resident bird species. First logging, then agriculture, and finally residential development removed much of the unique vegetation and also altered the landforms. Additionally, extensive watershed development has caused the ravine morphology to change, and has accelerated channel widening and deepening. These past effects establish the need for restoration actions.

Eight (8) plans were generated from the 3 measures input into the IWR-Planning software. The software identified that 1 plan was cost effective, which means that no one plan provided the same benefits as another plan that was less costly. Four (4) plans were revealed as “best buys”, which are deemed the most cost efficient of the 8 plans generated. The NER and recommended plan is Alternative Plan 7, which consists of stream morphology and connectivity improvements as well as ravine and bluff plant community restoration. The NER plan would first perform minor grading and debris removal to prepare the new stream channel and banks for riffle placement. No piping or water diversion structures would be used to divert higher flows. The riffles are designed to specifically handle the larger urban derived flood pulses. Once the stream channel is in place, opportunistic trees and invasive species would be removed by the USACE, all areas will be planted with native species, and establishment activities would commence. Repairs to an existing trail would also be performed as a recreational feature.

The total project cost is about $6,660,000. The estimated Federal cost share of the project is approximately $3,779,455 and the non-Federal share is approximately $2,880,545. The USACE will complete the design and implementation phase, which includes additional design studies, plans and specifications, contract for construction, overall supervision during construction, preparation of an operation and maintenance manual, and participate in a portion of the post construction monitoring.

CHAPTER 1 – INTRODUCTION*

1.1 – Report Organization

This Integrated Detailed Project Report and Environmental Assessment (DPR) presents the results of the Ravine 10 Ecosystem Restoration Study. This report consists of ten (10) parts including a main report and nine appendices with figures and tables. This Feasibility Report and Integrated Environmental Assessment identifies problems and opportunities, evaluates a number of different measures, formulates plans and recommends the most cost effective and feasible solution to the restore ecological integrity to Ravine 10. The report is structured as follows:

Integrated Detailed Project Report and Environmental Assessment
Appendix A – Civil Design Sheets
Appendix B – Cost Engineering
Appendix C – Real Estate Plan
Appendix D – Geotechnical Analysis
Appendix E – Hazardous, Toxic, and Radioactive Waste (HTRW) Report
Appendix F – Monitoring & Adaptive Management Plan
Appendix G – Planning Information
Appendix H – 404(b)(1) Analysis
Appendix I – H&H Analysis

1.2 – Study Authority

GREAT LAKES FISHERY & ECOSYSTEM RESTORATION (SECTION 506 WRDA 2000, as amended, 42 U.S.C. § 1962d-22)

(a) Findings; Congress finds that--

(1) the Great Lakes comprise a nationally and internationally significant fishery and ecosystem;

(2) the Great Lakes fishery and ecosystem should be developed and enhanced in a coordinated manner;

(3) the Great Lakes fishery and ecosystem provides a diversity of opportunities, experiences, and beneficial uses.

(b) Definitions; In this section, the following definitions apply:

(1) Great Lake

(A) In general

The term "Great Lake" means Lake Superior, Lake Michigan, Lake Huron (including Lake St. Clair), Lake Erie, and Lake Ontario (including the St. Lawrence River to the 45th parallel of latitude).

(B) Inclusions

The term "Great Lake" includes any connecting channel, historically connected tributary, and basin of a lake specified in subparagraph (A).

(2) Great Lakes Commission

The term "Great Lakes Commission" means the Great Lakes Commission established by the Great Lakes Basin Compact (82 Stat. 414).

(3) Great Lakes Fishery Commission

The term "Great Lakes Fishery Commission" has the meaning given the term "Commission" in section 931 of Title 16.

(4) Great Lakes State

The term "Great Lakes State" means each of the States of Illinois, Indiana, Michigan, Minnesota, Ohio, Pennsylvania, New York, and Wisconsin.

(c) Great Lakes fishery and ecosystem restoration

(1) Support plan

(A) In general

Not later than 1 year after December 11, 2000, the Secretary shall develop a plan for activities of the Corps of Engineers that support the management of Great Lakes fisheries.

(B) Use of existing documents

To the maximum extent practicable, the plan shall make use of and incorporate documents that relate to the Great Lakes and are in existence on December 11, 2000, such as lakewide management plans and remedial action plans.

(C) Cooperation

The Secretary shall develop the plan in cooperation with--

(i) the signatories to the Joint Strategic Plan for Management of the Great Lakes Fisheries; and

(ii) other affected interests.

(2) Reconnaissance studies

Before planning, designing, or constructing a project under paragraph (3), the Secretary shall carry out a reconnaissance study--

(A) to identify methods of restoring the fishery, ecosystem, and beneficial uses of the Great Lakes;

(B) to determine whether planning of a project under paragraph (3) should proceed.

(3) Projects

The Secretary shall plan, design, and construct projects to support the restoration of the fishery, ecosystem, and beneficial uses of the Great Lakes.

(4) Evaluation program

(A) In general

The Secretary shall develop a program to evaluate the success of the projects carried out under paragraph (3) in meeting fishery and ecosystem restoration goals.

(B) Studies

Evaluations under subparagraph (A) shall be conducted in consultation with the Great Lakes Fishery Commission and appropriate Federal, State, and local agencies.

(5) Recreation features

A project carried out pursuant to this subsection may include compatible recreation features as determined by the Secretary, except that the Federal costs of such features may not exceed 10 percent of the Federal ecosystem restoration costs of the project.

(d) Cooperative agreements

In carrying out this section, the Secretary may enter into a cooperative agreement with the Great Lakes Commission or any other agency established to facilitate active State participation in management of the Great Lakes.

(e) Relationship to other Great Lakes activities

No activity under this section shall affect the date of completion of any other activity relating to the Great Lakes that is authorized under other law.

(f) Cost sharing

(1) Development of plan

The Federal share of the cost of development of the plan under subsection (c)(1) shall be 65 percent.

(2) Project planning, design, construction, and evaluation

Except for reconnaissance studies, the Federal share of the cost of planning, design, construction, and evaluation of a project under paragraph (3) or (4) of subsection (c) shall be 65 percent.

(3) Non-Federal share

(A) Credit for land, easements, and rights-of-way

The Secretary shall credit the non-Federal interest for the value of any land, easement, right-of-way, dredged material disposal area, or relocation provided for carrying out a project under subsection (c)(3).

(B) Form

The non-Federal interest may provide up to 100 percent of the non-Federal share required under paragraphs (1) and (2) in the form of services, materials, supplies, or other in-kind contributions.

(4) Operation and maintenance

The operation, maintenance, repair, rehabilitation, and replacement of projects carried out under this section shall be a non-Federal responsibility.

(5) Non-Federal interests

In accordance with section 1962d-5b of this title, for any project carried out under this section, a non-Federal interest may include a private interest and a nonprofit entity.

1.3 – Study Purpose & Background

The Lake Michigan coastal zone is one of the most diverse ecosystems in Lake County, Illinois. The unique landforms of ravines, bluffs, and beaches were left behind by glacial movements and the recession of Lake Chicago, a larger pre-historic lake than the present Lake Michigan. These landforms and the special coastal climate combined to induce a diverse ecosystem that included densely wooded ravines and uplands, sloped wetlands, clay bluffs and sand beaches, which host a multitude of migratory and resident bird species. First logging, then agriculture, and finally residential development removed much of the unique vegetation and also altered the landforms. Additionally, extensive watershed development has caused the ravine morphology to change, and has accelerated channel widening and deepening. These past effects establish the need for restoration actions.

The non-Federal sponsors, the City of Highland Park, Park District of Highland Park (PDHP), and the North Shore Water Reclamation District (NSWRD) have requested that the Chicago District USACE initiate a study under the authority of Section 506 Water Resource Development Act of 2000, as amended, 42 U.S.C. § 1962d-22, Great Lakes Fishery and Ecosystem Restoration to determine the feasibility of restoring ecological integrity to Ravine 10. The scope of this study investigates altered stream hydrology and hydraulics, native plant community degradation, habitat connectivity, rare wetland communities and native species richness. The non-federal sponsors are currently implementing ecosystem restoration at various coastal ravines to address habitat degradation and connectivity for the purpose of habitat restoration, fish and wildlife recolonization, water quality improvement and aesthetics for the public. The need for riverine and coastal ecosystem restoration of the study area is based on habitat, organisms, and water quality studies conducted by state, regional, and local agencies and groups, that have shown over the decades, the impairments caused to fish, wildlife, and other natural resources.

1.4 – Study Area

The study area is located in Highland Park, Cook County, Illinois, along the Lake Michigan coast. The study area core, Moraine Park, specifically resides west of Lake Michigan, east of Sheridan Road, south of Riparian Road and north of Maple Road (**Figure 1**). The study area also includes the stream channel (~4,800 feet total) within Moraine Park, upstream to Port Clinton Park, and the riparian slopes within Port Clinton Park. Study area parcels are owned by the PHPD, City of Highland Park and the NSWRD.

Figure 1– Ravine 10 Study Area Location along Illinois' Lake Michigan North Shore

1.5 – Pertinent Reports, Studies & Projects

Reports & Studies

- Chicago Wilderness and Its Biodiversity Recovery Plan 1999

The ravine bluff ecosystem occurs along the Highland Park moraine from approximately Wilmette to North Chicago, Illinois. Although much of this system is in private ownership, the finest examples and highest-quality remnants occur on publicly owned property in Lake Forest, Highland Park and other North Shore communities. These remnants include Moraine Park in Highland Park. These sites contain examples of the rich diversity of the eastern deciduous hardwood forest intermixed with northern boreal forest relics that botanists theorize are left behind from the post-glacial ecosystem.

- Lake County Comprehensive Stormwater Management Plan 2002

Reduce or mitigate the environmentally detrimental effects of existing and future runoff in order to improve and maintain water quality and protect water related environments.

- Great Lakes Regional Collaboration Strategy to Restore and Protect the Great Lakes, released on December 12, 2005.

The lake-run brook trout (coaster brook trout) is either severely depleted or extirpated from most of its former range. Implement habitat rehabilitation initiatives in-stream and at watershed scale where riverine habitat conditions are currently unsuitable and do not support coasters.

- Ravine Systems in the Lake Michigan Watershed, Illinois: Illinois Coastal Management Program Issue Paper, February 2009

Streams flowing through the ravines are in need of restoration. Restoration methods utilizing bioengineering, clearance of invasive plant species and re-establishment of native plants, and installation of riffles would also improve habitat for aquatic species and improve the quality of water flowing into Lake Michigan. Restoration of streams and stream banks improves water quality within the ravine as well as in receiving waters downstream and can potentially increase seasonal or year-round habitat availability.

- Alliance for the Great Lakes. October 2009. Stresses and Opportunities in Illinois Lake Michigan Watersheds Strategic Sub-Watershed Identification Process (SSIP) Report for the Lake Michigan Watershed Ecosystem Partnership.

This report is organized around three aspects of the Lake Michigan land and water ecology: the water quality of Lake Michigan and the streams and rivers feeding into it; the level of erosion in ravines along the coast of the lake and the range and quality of habitat in the region. Water quality and habitat were analyzed in terms of sub-watershed boundaries, whereas ravine erosion was analyzed ravine-by-ravine. The immediate goals of the study are to 1) prioritize sub-watersheds based on their potential to negatively impact water quality or 2) the quality and extent of habitat within their boundaries; and 3) to rank ravines based on their potential for erosion. The larger goal of the study is to serve as a tool for Lake Michigan Ecosystem Partnership, municipalities and other interested groups, such as private landowners, to make informed decisions about where to focus restoration efforts and resources in order to improve the ecology of the Lake Michigan region.

- Park District of Highland Park. September 2015. Sustainable Coastal Planning Millard and Moraine Parks.

This study was prepared by AECOM for the Park District of Highland Park. The report describes ravine conditions at Moraine Park and provides conceptual and highly engineered methods for ravine bank stabilization, fish stream passage and habitat, protection of existing infrastructure, and maintaining / improving the public access to the site.

- Lake Michigan Environmental Objectives Great Lakes Fishery Commission

Establish a diverse, native fishery and fish community. Many native lacustrine fishes are dependent upon access to rivers and streams for spawning and nursery habitats. Lake Michigan Environmental Objectives, Environmental Objective #5 - Protect and restore fish community structure by promoting native species abundance and diversity and avoid further exotic species introductions.

Projects

- Rosewood Park Section 506 – Constructed Project

Rosewood Park is located on the shores of Lake Michigan in Highland Park, Illinois. It is located near Roger Williams Avenue and Sheridan Road in the Ravinia neighborhood. The project restored approximately 7-acres of unique beach, bluff, ravine, stream, and oak savanna habitat. The non-Federal sponsor is the Park District of Highland Park.

- Ravine 8 Section 506 – Construction Phase

This USACE and City of Highland Park project is currently in the construction phase. Activities include naturalizing stream velocities within the ravine, restoring connectivity to Lake Michigan, restoring the stream channel with alluvial material and riffles, removing invasive plant species and reestablishing native ravine, bluff and dune plant species within a 3.66-acre project area.

- Ft. Sheridan Section 506 – Construction Phase

This USACE, Lake County Forest Preserve District, Lake Forest Open lands, Openlands, and City of Lake Forest project is currently in construction; restoring the ecological integrity of the combined Ft. Sheridan natural areas. The project is addressing issues of altered hydrology and hydraulics, native plant community preservation, invasive species, connectivity, rare wetland communities, native species richness, and encourages public education.

CHAPTER 2 – INVENTORY AND FORECASTING*

The purpose of this step of the planning process is to develop an inventory and forecast of critical resources (physical, environmental, social, etc.) relevant to the problems and opportunities under consideration in the planning area. This information is used to define and characterize the problems and opportunities. 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 (EX) conditions are those at the time the study is conducted. The forecast of the future without-project (FWOP) condition reflects the conditions expected during the 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, clear definition and full documentation of the without-project condition are 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 and other conditions are likely to have an impact on problems and opportunities. Information gathering and forecasts will continue throughout the planning process. As such, Chapter 2 contains the following:

- An inventory of relevant historic conditions;
- An inventory of relevant current conditions and the studies that have been completed to identify those conditions; and
- A forecast of future without-project conditions.

2.1 – Historic Setting

Coastal Lake Michigan's natural environment has undergone many changes since the glaciers retreated about 14,000 years ago. More than 90 percent of the land within the coastal zone was formerly moraine and old lakebed that over centuries evolved into gently rolling grasslands, savannas, bluffs, dunes and the ravines, which were created by streams. At the time of European exploration in the late 1600s, native plant communities characterized the area, with dunes, ridge and swale, beaches and ravines prevalent near the lakeshore. With the arrival of permanent European settlers in the 1770s, the area's landscape and associated native plant communities underwent numerous changes induced by two centuries of rapid population growth. While the ecosystem, hydrology, and natural habitat of coastal Lake Michigan was radically altered and degraded within the last 200 years as a whole, there remain remnant pockets and naturalized areas to restore and preserve. Ravine 10, inclusive of Moraine and Port Clinton Parks, provide this opportunity.

2.2 – Physical Resources

2.2.1 – Geology

Silurian Age Bedrock – The underlying regional bedrock is Silurian-age dolomite, most likely of the Niagaran Series (Willman 1971). This rock resulted from marine deposition when all of northeastern Illinois and much of the neighboring Great Lakes region was the floor of a tropical sea from about 440 to 410 million years ago.

Wadsworth Till Member – The dominant material in the Illinois coastal zone is a compact, gray, silty and clayey till of the Wadsworth Till Member. The till may contain discontinuous layers of sand and gravel mixed with sand. This till, which is ubiquitous across the coastal zone, was deposited by glacial ice during the most recent (Wisconsinan) glacial episode. The till is exposed along the coastal bluffs, as well as the material first encountered beneath most of the soils in the area. It also occurs beneath the beach

sand and it occurs on the nearshore lake bottom either beneath the nearshore sand or exposed where sand cover is absent. The cohesion of the till has contributed to the near-vertical bluffs along parts of the bluff coast.

Highland Park Moraine – Along the coast between North Chicago and Winnetka, the lakeshore's Zion City and Highland Park Moraines dead-end into Lake Michigan. These end moraines formed about 14,000 years ago just prior to glacial ice permanently receding into the Lake Michigan basin. These are the youngest end moraines in Illinois. The entire study area is encompassed within the Highland Park Moraine. Long-term wave erosion along this morainal unit has resulted in bluffs that form the highest and steepest landscape along the Illinois coast. Maximum bluff heights of about 90-feet occur along the southern Highland Park lakeshore. The bluff slopes range from near vertical to about 45 degrees. There is considerable local variability in slope, and many segments of the bluff slope have been graded or terraced for erosion control along private lakeshore property as well as public lakeshore. A discontinuous bluff face results from a series of steep-sided, V-shaped ravines that open to the lakeshore. These ravines, or gullies, are cut into the morainal upland and originate as much as one mile inland from the shore. The ravines typically have intermittent streams that discharge to Lake Michigan.

2.2.2 – Soils

Natural soils within the Ravine 10 study area have been altered for the most part. Areas of natural soil are currently present in the ravines and down the bluffs.

Beach Sands – Beach sediments along the Illinois coast consist of mixed sand, sandy gravel, and gravel. The primary source for beach sediments is erosion of the coastal sandy bluffs in Wisconsin.

Ozaukee – These soils are typically found on ground moraines, in this case the Highland Park moraine. Slopes on the plateaus range from 2 to 6% and in the ravines from 20 to 35%. These soils formed in thin loess and in the underlying loamy dense till. These soils are moderate to well-drained and the potential for surface runoff ranges from medium to very high. Permeability is slow. These soils have a perched seasonal high water table at a depth of 1.5 to 3.5-feet for 1 month or more per year in 6 or more out of 10 years. Native vegetation is mixed hardwood forest of northern red oak, American basswood, white ash, and sugar maple.

2.2.3 – Fluvial Geomorphology & Topography

Ravine 10 developed as a result of the unique geology of the Highland Park moraine intersecting with the coastline of Lake Michigan. This abrupt intersection formed a bluff as Lake Michigan's waves eroded the front face of the moraine. Rainwater falling on the moraine flowed east over this bluff and gradually carved out the ravine. Local relief is about 578-feet above sea level at the beach/water interface and a maximum elevation of 666-feet is reached along the crest of the Highland Park moraine (**Figure 2**).

Ravine Formation: As the ravines continued to deepen and widen overtime, the depth of the stream bed toward the mouth of the ravine began to attain the level of Lake Michigan. As the slope of the channel flattened out, the speed of water flowing through it slowed. The rate of channel incision and bank slumping declined, but even in mature ravines this process never stops completely; an equilibrium is maintained from sediment/detritus influx equal to the amount discharged. The heads of the ravines continue to extend landward until they run into non-erosive materials or lose their erosive power. In newly forming ravines, channel incision and mass wasting make it difficult for a diverse plant community to establish as the ravine widens and the slope of the banks decrease. Once stable, a diverse ravine specific plant community can then establish, replacing the pioneer species. Roots help to further stabilize ravine slopes by decreasing surface erosion and absorbing ground water. As the ravine further matures

and widens, the rate of slumping declines, furthering the abundance of plants and trees. This positive feedback cycle eventually results in a mature ravine capable of supporting a diverse community of fungi, plants, and animals.

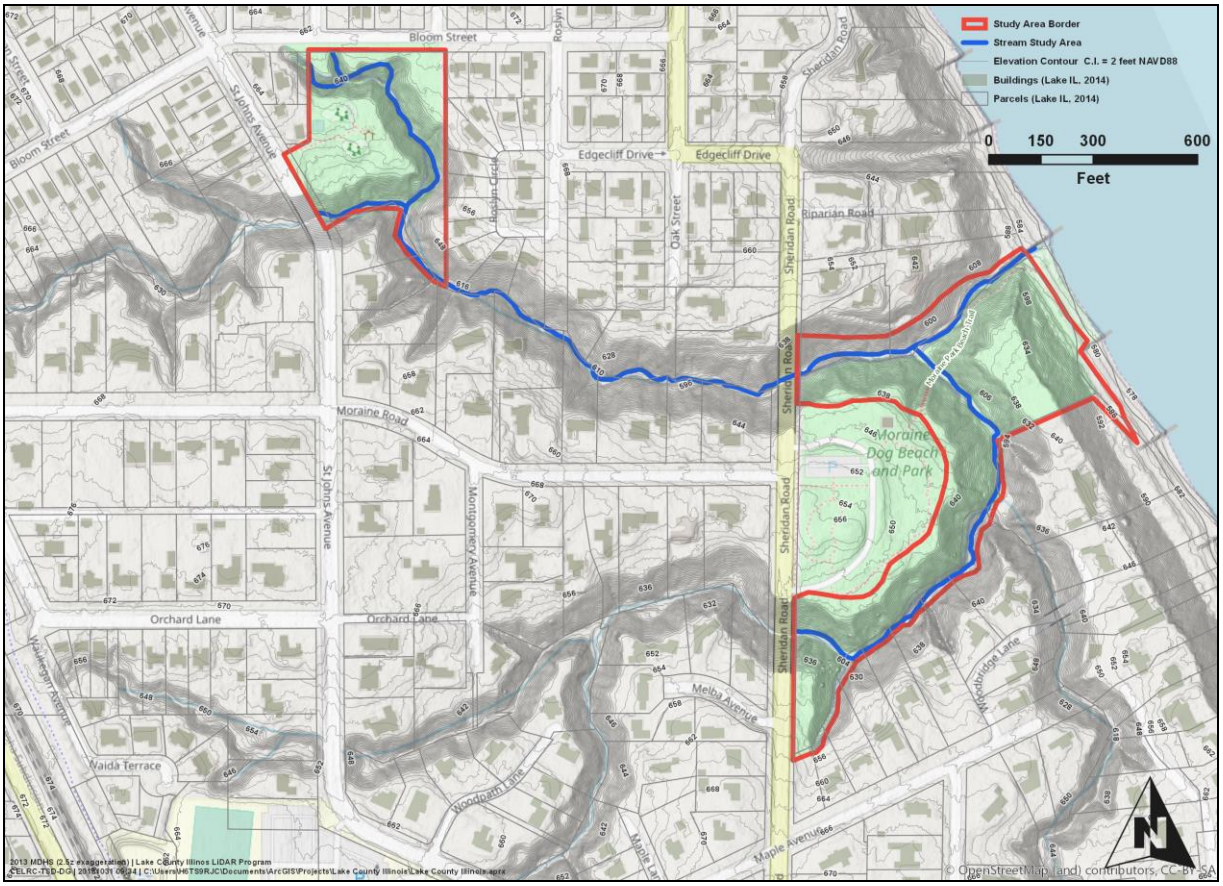


Figure 2 - Ravine 10 Geomorphology

2.2.4 – Littoral Processes

Seasonal variations in the dominant wind direction result in variability to the waves and currents experienced along the Lake Michigan shoreline. During the majority of the year, winds blow across the long axis of the lake from the southeast, resulting in a regional circulatory pattern moving along the Illinois shoreline in a counterclockwise direction. The resultant wave climate along this reach during this time is relatively benign. Beginning in late fall and continuing until spring, however, these trends reverse. Northerly winds drive wave fields towards the southern end of Lake Michigan, generating a significantly larger wave climate. The dominant influence of northerly waves results in a net southward littoral transport along the entire Illinois coast. Waves from the southeast can influence a northward movement of beach and nearshore sediment. However, this project is not expected to affect littoral process, but littoral processes will play a role in opening and closing the ravine mouths with sand in which coastal fishes have adapted. When open during spring flood pulses, various species spawn in the ravines (Lake Chub/White Sucker). When the ravine mouth becomes closed from the lake, nursery habitat can form within deep pools; thus the importance of large woody debris in the ephemeral system.

2.2.5 – Land Use, Hydrology & Hydraulics

Originally formed by the erosive forces of storm water interacting with the bluffs, the ravines within the project area are the natural pathways by which watershed runoff reaches Lake Michigan. It should be recognized that many of the ravines are still in the process of forming and as a result are naturally unstable. The alterations to the hydrologic system due to urbanization, however, have resulted in accelerated channel evolution (erosion, widening, deepening, deposition) of this ravine system. As a result of the development, the overall volume and peak discharges of storm water runoff have increased due to an increase in impervious surfaces and the introduction of permitted storm sewer outfalls (**Photo 1**).

Photo 1: Stormwater Discharge at Head of Ravine

The increased volume of runoff from the subwatersheds has resulted in increased discharges to the ravines, which is resulting in more rapid change to the ravine's morphology and associated habitat functions. These geomorphological changes and the rates at which they are now occurring are detrimental to manmade infrastructure, and do not have adverse effect to the ravine's ecosystem, but pushes towards the climax community much faster.

2.3 – Ecological Resources

In-stream habitat of the ravines have been adversely impacted over the last 100-years due to the use for stormwater discharge and infrastructure associated with waste water collection, and prevention of natural channel meanders. Also, base flows during low periods may have been reduced due to development in uplands where rainwater can no longer recharge groundwater stores. The following is a description of the ecotypes that occur within the study area of this project. Dominant vegetation and organisms that inhabit the particular ecotype are presented.

2.3.1 – Fishes

Deep Water – There are no measures evaluated within this study that directly address restoring deep water habitats of Lake Michigan; however, species that occur in the deep waters are presented to put the project into a greater context. Some of the species that primarily are found in the profundal zone and natural reefs of Lake Michigan do utilize littoral zones as well, such as the Lake Chub (*Couseuis plumbeus*), and the state endangered Longnose Sucker (*Catostomus catostomus*).

Fish data collected and specimens vouched at the Illinois Natural History Survey are presented in **Table 1**. Deep water specimens were collected from both Julian's and the Highland Park reefs. Julian's Reef is 14 miles directly east of Ft. Sheridan and the Highland Park reef is 3 miles east. Julian's Reef substrates include primarily bedrock with rubble, sand and small amounts of silt (Horns 1991), whereas the Highland Park reef consists of bedrock and cobble with its interstitial spaces filled in with sand and silt (Chotkowski & Mardsen 1995). The remaining deep water areas off the coast are primarily sand flats.

Littoral Zone –Currently, habitat consists of extensive sand flats and minor non-conformities provided by small manmade groins. Species already present within the study area are presented in **Table 1**. The most common species found along the surf zones of the beaches are the Longnose Dace (*Rhinichthys cataractae*), Emerald Shiner (*Notropis atherinoides*) and Spottail Shiner (*Notropis hudsonius*).

Table 1 - Fishes Collected near Ravine 10 Study Area between 1951 - 2004

Species	Common name	Deep Water	Littoral Zone	Ravine Use**
*Petromyzon marinus**	sea lamprey	X		
*Alosa pseudoharengus**	alewife		X	
*Cyprinus carpio**	common carp		X	
Couesius plumbeus	lake chub	X	X	X
Rhinichthys cataractae	longnose dace		X	X
Pimephales notatus	bluntnose minnow		X	X
Notropis atherinoides	emerald shiner		X	X
Notropis hudsonius	spottail shiner		X	X
Catostomus catostomus	longnose sucker	X	X	X
*Osmerus mordax**	rainbow smelt		X	
*Salmo trutta**	European brown trout	X	X	
Salvelinus namaycush	lake trout	X	X	
Coregonus artedi	lake cisco	X		
Coregonus hoyi	bloater cisco	X		
Lota lota	burbot	X		
Myoxocephalus thompsonii	deepwater sculpin	X		

* non-native species

Stream - Currently, the ravine stream can become fragmented from Lake Michigan unnaturally by the Lake Michigan Sewer Interceptor. This structure consists of a large diameter pipe, concrete box/chamber and steel sheetpile. Also, in-stream habitat and fluvial morphology of this ravine is moderately impaired due to measures implemented to abate natural fluvial processes of channel evolution (**Photo 2**). Fish species that could utilize the newly connected ravines are presented in **Table 1**. The most common species found within other ravines along the coast of Lake Michigan are the White Sucker (*Catostomus commersonii*), Longnose Dace, and the ever expanding state threatened Banded Killifish (*Fundulus diaphanus*).

Photo 2: Failed Bank Stabilization Measure Impairing Stream Recovery & Associated Habitat

2.3.2 – Macroinvertebrates

The most common species found within other ravines along Lake Michigan are swimming mayflies (Ephemoptera) and midges (Diptera). Both the mayflies and midges are tolerant to habitat and water quality degradation. Implemented restoration measures should improve conditions enough to increase the presence and abundance of more intolerant species such as stoneflies (Plecoptera) and caddisflies (Trichoptera). Taxa collected from Millard Park Ravine in 2011 included:

- Amphipoda — scud
- Odonata: Anisoptera — dragonfly
- Odonata: Calopterygidae — broadwinged damselfly
- Ephemeroptera: — Baetidae/Siphlonuridae swimming mayfly
- Trichoptera: Hydropsychidae — hydropsychid caddisfly
- Trichoptera — caddisfly
- Coleoptera: — Elmidae/Dryopidae riffle beetle
- Diptera: Tipulidae — crane fly
- Diptera: Chironomidae — midge
- Diptera: Simuliidae — black fly
- Gastropoda — left-handed snail

Three nearby ravines, McCormick Ravine, Bartlett Ravine and Schenck Ravine, were surveyed on October 4, 2012 for woodland arthropods. Schenck and McCormick both had close canopy represented by *Acer* (maple), and *Quercus* (oak) and *Betula* (Birch). A total of 73 taxonomic species were identified in this course survey, varying between Class, Order, Family, Genus, and Species. McCormick ravine had the largest richness of taxonomic species with a total of 56, while Schenck had 55 and Bartlett had 44. Bartlett represented a large contrast form both Schenck and McCormick, representing the smallest taxonomic richness of the three sites. This is due to the lack of accumulation of litter mass at the base of

the ravine. The cement drainage ditches and the vehicle road at the base of Bartlett limits the accumulation of leaf litter and detritus, a key habitat and food source for a large detrital arthropod community. These same stressors impact Ravine 10 within the study footprint and may be addressed through restoration actions to help improve the quality and quantity of habitat on site. The potential arthropod community could be reestablished within Ravine 10 if restoration measures were to be implemented.

2.3.3 – Resident & Migratory Birds

The Ravine 10 study area resides within a band of important state natural areas and parks that span Lake County, Illinois. These natural areas serve as a crucial foraging and breeding grounds along the Lake Michigan flyway, which is a globally significant migration route for many songbirds. The flyway provides a visual north-south sight line, the coast of Lake Michigan, which the birds have evolved to follow as they undergo migration. During the migration periods, March to May and September to mid-October, more than five million song birds are believed to traverse this flyway.

Over seventy four (74) species of bird were recorded within the North Shore Ravine area during lakefront bird surveys at various points of the year (**Appendix G Planning Information**). Of these species, Bald Eagle, Brewer's blackbirds, Broad-winged Hawk, Golden Eagle, Grasshopper Sparrow, Gyrfalcon, Long-Tailed Duck, Mississippi Kite, Red Headed Woodpecker, and Smith's Longspurs are listed as species of concern of the National Audubon Society.

2.3.4 – Mammalian Community

The Ravine 10 study area provides suitable habitat for common "urban" wildlife species, including whitetail deer (*Odocoileus virginianus*), coyote (*Canis latrans*), raccoon (*Procyon lotor*), possum (*Didelphis marsupialis*), thirteen-lined ground squirrel (*Citellus tridecemlineatus*), gray squirrel (*Sciurus carolinensis*), cottontail rabbit (*Sylvilagus floridanus*), and striped skunk (*Mephitis mephitis*). During the Fall 2018 site visit, a Hoary Bat (*Lasiurus cinereus*) was observed hanging from tree branch (**Photo 3**).

Photo 3: Bat Species Observed at Port Clinton Park

2.3.5 – Plant Communities

Ravine – The evolution of ravines has shaped a unique environment with impressive flora. A multitude of factors contribute to the high diversity of plant species found within higher quality ravines which include the underlying glacial substrate, close proximity to Lake Michigan, varying slope inclinations and natural instabilities, and presence of groundwater seeps. The following descriptions are indicative of high quality ravine systems surrounding the project area and help set a goal for the restoration of floristic structure and function at Ravine 10.

The wide range of niches provided by the ravines support a suite of rare and conservative plant species including graminoids such as long-awned wood grass (*Brachyelytrum erectum*), black-seeded rice grass (*Oryzopsis racemosa*), silky wild rye (*Elymus villosus*), purple-sheathed graceful sedge (*Carex gracillima*), long-stalked hummock sedge (*Carex pedunculata*), and slender satin grass (*Muhlenbergia tenuifolia*); forbs such as seneca snakeroot (*Polygala senega*), big leaved aster (*Aster macrophyllus*), yellow pimpernel (*Taenidia integerrima*), red baneberry (*Actaea rubra*), bishop's cap (*Mitella diphylla*), large-leaved shinleaf (*Pyrola elliptica*), broad-leaved goldenrod (*Solidago flexicaulis*), and spikenard (*Aralia racemosa*); and ferns such as spinulose sheath fern (*Dryopteris spinulosa*), maidenhair fern (*Adiantum pedatum*), and lady fern (*Athyrium filix-femina michauxii*). However, high quality areas harboring these conservative species within the study area have been significantly degraded because of increased runoff, fire suppression, and exacerbated rates of soil erosion which has caused an increase in bare ground and invasive species establishment – areas becoming dominated by common buckthorn (*Rhamnus cathartica*), exotic honeysuckles (*Lonicera* spp.), garlic mustard (*Alliaria petiolata*), black locust (*Robinia pseudoacacia*), Norway maple (*Acer platanoides*), and Japanese barberry (*Berberis thunbergii*).

A diverse canopy of trees and shrubs exists within the ravines, allowing various amounts of sunlight over different slope inclinations to reach the ravine's understory. Red oak (*Quercus rubra*), white oak (*Quercus alba*), sugar maple (*Acer saccharum*), blue beech (*Carpinus caroliniana virginiana*) and hop hornbeam (*Ostrya virginiana*) make up the majority of trees, while the shrub strata consists of witch hazel (*Hamamelis virginiana*), alternate-leaved dogwood (*Cornus alternifolia*), round-leaved dogwood (*Cornus rugosa*), serviceberry (*Amelanchier arborea*), and maple-leaved arrow wood (*Viburnum acerifolium*). The ravine's understory, dependant on an open canopy of trees, has suffered from an increasing amount of shade as invasive and opportunistic woody species have become more dominant.

The ravines are also known for their abundance of spring ephemerals including sharp-leaved hepatica (*Hepatica acutiloba*), early meadow rue (*Thalictrum dioicum*), large-flowered trillium (*Trillium grandiflorum*), red trillium (*Trillium recurvatum*), bellwort (*Uvularia grandiflora*), bloodroot (*Sanguinaria canadensis*), and jack-in-the-pulpit (*Arisaema triphyllum*). Excessive and accelerated rates of soil erosion, fire suppression, and an increase in invasive species have also significantly impacted populations of spring ephemerals.

The current conditions of Ravine 10 as compared to the higher quality ravines described in the preceding paragraphs is significantly less rich and diverse as evident from the difference in species composition. Common invasive species include garlic mustard (*Alliaria petiolata*), Norway maple (*Acer platanoides*), Canadian thistle (*Cirsium arvense*), European buckthorn (*Rhamnus cathartica*), and European privet (*Ligustrum vulgare*). High quality native species present are minimal, but do include large-leaf wood aster (*Eurybia macrophylla*), sweet-scented joe-pye-weed (*Eutrochium purpureum*), American witch hazel (*Hamamelis virginiana*), northern red oak (*Quercus rubra*), and zig-zag golden rod (*Solidago flexicaulis*).

Photo 4: Ravine 10 Current Vegetation Cover

Bluff – The unique climate and erosive-prone clay bluff areas welcomes an interesting suite of native plants that have evolved to withstand its harsh conditions. Rare northern boreal species have found suitable habitat within the bluff such as paper birch (*Betula papyrifera*), buffalo berry (*Shepherdia canadensis*), and common juniper (*Juniperus communis*). The wooded areas on the bluff inhabit species such as eastern white cedar (*Thuja occidentalis*), red oak (*Quercus rubra*), hop hornbeam (*Ostrya virginiana*), ninebark (*Physocarpus opulifolius*), golden alexanders (*Zizia aurea*), white baneberry (*Actaea pachypoda*), red honeysuckle (*Lonicera dioica*), wood betony (*Pedicularis canadensis*), and common oak sedge (*Carex pensylvanica*).

Just as the ravines have become heavily shaded, the study area's bluff has degraded from fire suppression, in turn degrading the rich herbaceous understory which has increased rates of soil erosion. Invasive and native species are for the most part the same for the bluff as the ravine.

Photo 5: Bluff in Winter Showing Dense Canopy Structure

Beach and Dune – The study area has little space between the shore of Lake Michigan and the bluff's toe, but in places where enough sand accumulates, small formations of beach communities can be found. Where the beach is disturbed by winter waves and less so by waves of summer, a collection of annual plants begin colonizing the area including winged pigweed (*Cycloloma atriplicifolium*), sand grass (*Triplasis purpurea*), and the state listed seaside spurge (*Chamaesyce polygonifolia*) and sea rocket (*Cakile edentula*). More stable areas further inland, but still within active moving sand are stands of state listed, dune-forming marram grass (*Ammophila breviligulata*).

2.3.6 – Threatened & Endangered Species

The distribution of federally-listed Threatened, Endangered, Proposed and Candidate Species and their critical habitats for Lake County, IL are as follows:

- Piping plover (*Charadrius melodus*) – Endangered – Wide, open, sandy beaches with very little grass or other vegetation
- Red knot (*Calidris canutus rufa*) – Threatened – Sparsely vegetated sandy areas/dunes
- Eastern massasauga (*Sistrurus catenatus*) – Threatened – Graminoid dominated plant communities (fens, sedge meadows, peat lands, wet prairies, open woodlands, and shrublands)
- Karner blue butterfly (*Lycaeides melissa samuelis*) – Endangered – Pine barrens and oak savannas on sandy soils and containing wild lupines (*Lupinus perennis*), the only known food plant of the larvae
- Hine's emerald dragonfly (*Somatochlora hineana*) – Endangered - Shallow, calcareous seepage marshes; or marshy margins of small, sluggish, calcareous streams overlaying dolomite bedrock

- Rusty patched bumble bee (*Bombus affinis*) – Endangered – Habitat generalist, includes dunes, marshes, forests, farmland and urban areas

- Northern Long-Eared Bat (*Myotis septentrionalis*) – Threatened – Hibernates in caves and mines; roosts and forages in upland forests

- Eastern prairie fringed orchid (*Platanthaera leucophaea*) – Threatened – Moderate to high quality wetlands, sedge meadow, marsh, and mesic to wet prairie.

- Pitcher's thistle (*Cirsium pitcheri*) – Threatened – Lakeshore dunes

In addition to the species known from Lake County, the project area was entered into the USFWS Information for Planning and Consulting (IPaC) system on September 4, 2019. The resulting IPaC letter is included in Appendix G.

Habitats that would be restored through this project include stream, ravine, bluff, and foredune. Recent observational surveys done by the USACE Chicago District, the non-federal sponsors and other state and local agencies found no federally threatened or endangered species or viable critical habitats within the restoration site. For these reasons, we conclude the Ravine 10 Section 506 Restoration Project will have "no effect" on listed species or proposed or designated critical habitat.

Two (2) plants, 3 fish and 1 bird species are threatened or endangered species in Illinois. The Marram Grass (*Ammophila breviligulata* SE) is specific to the foredune and Sea Rocket (*Cakile edentula* ST) is specific to the zone between the surf and the foredune. The Longnose Sucker (*Catostomus catostomus*) and Lake Herring (*Coregonus artedi*) are specific to deeper water and littoral zone of Lake Michigan; however, it is possible that Longnose Sucker would utilize the ravines as spawning habitat, as they are known to spawn in confluent streams in other parts of their range. The Banded Killifish (*Fundulus diaphanus* ST) is most likely present along the beach and jetties within the study area. The Common Tern (*Sterna hirundo* ST) is specific to the littoral zone for foraging and it appears there is no suitable breeding habitat currently within the study area for this species, especially since the small strip of beach habitat is utilized as a dog park.

2.3.7 – Climate Change

USACE is undertaking its climate change preparedness and resilience planning and implementation in consultation with internal and external experts using the best available and actionable climate science. As part of this effort, the USACE has developed concise reports summarizing observed and projected climate and hydrological patterns, at a HUC2 watershed scale cited in reputable peer-reviewed literature and authoritative national and regional reports. Trends are characterized in terms of climate threats to USACE business lines. The reports also provide context and linkage to other agency resources for climate resilience planning, such as downscaled climate data for sub-regions, and watershed vulnerability assessment tools.

The USACE literature review report focused on the Great Lakes Region was finalized in April 2015 (USACE, April 2015). The Ravine 10 watershed is located in the Great Lakes Region. According to the Fourth National Climate Assessment's (NCA4), 42% more precipitation is falling in the Great Lakes Region now as compared with the first half of the 20th century, and that the precipitation is concentrated in larger events.

The USACE literature review document summarizes several studies which have attempted to project future changes in hydrology. Based on a review of four studies, the projected total annual precipitation is expected to have a small increase when compared to the historic record and the precipitation extremes are projected to see a large increase. It is noted that consensus between the studies is low, and although most studies indicate an overall increase in observed average precipitation, there is variation in how these trends manifest both seasonally and geographically.

For the Great Lakes Regions, increase in temperatures have been observed and additional increases in temperature are predicted for the future. In addition, for the Great Lakes Region, "nearly all studies note an upward trend in average temperatures, but generally the observed change is small. Some studies note seasonal differences with possible cooling trends in fall or winter." There is a strong consensus within the literature that temperatures are projected to continue to increase over the next century.

In some parts of the region increases in streamflow have been observed. Future projections of streamflow rates are highly variable. For the Great Lakes region, trends in observed low and annual streamflow were variable, with slight streamflow increases observed at some gages, but other gages showing no significant changes. "Significant uncertainty exists in projected runoff and streamflow, with some models projecting increases and others decreases. Changes in runoff and streamflow may also vary by season. Projections of water levels in the Great Lakes also have considerable uncertainty, but overall lake levels are expected to drop over the next century." Detailed discussion on climate change is presented in Appendix I.

2.4 – Cultural Resources

2.4.1 – Social Properties

The City of Highland Park is located about 25 miles north of Chicago in Lake County, Illinois. Communities surrounding Highland Park include Highwood, Glencoe, Deerfield and Bannockburn. Highland Park is primarily a white upper middle-class residential community of about 12.5 square miles and about 31,300 residents. In 2010 the median home value was $467,500; and the median household income was $157,700.

2.4.2 – Archaeological & Historical Properties

There are no archaeological or historic properties within the study area boundaries. The Illinois Historic Preservation Agency (IHPA) was consulted with a letter dated 04 April 2019. Native American groups having an historic cultural interest in northeast Illinois were consulted with letters dated 04 April 2019 as well. In the event that cultural remains are discovered during the project, the Chicago District will be notified immediately and work will cease to allow for consultations with the Illinois State Historic Preservation Agency to take place.

There are 43 properties and four historic districts listed on the National Register of Historic Places located within Highland Park. Only two properties, the Granville-Mott House (listed in 1982) and the Mary W. Adams House (listed in 1982) are located near the project area. Neither of these properties will be affected by this project.

2.4.3 – Land Use History

The Highland Park area was settled primarily by people from Ohio and New York State in the early 1840s. The area that now comprises Highland Park was originally two separate settlements, Port Clinton and St. Johns. The area remained a farm and lake port based community until 1855 when the Chicago and

Milwaukee Railroad were constructed through the area. This attracted additional settlement, and in 1869 the two settlements were merged and incorporated as Highland Park. The town became a popular area for summer homes with the Chicago elite. Today it remains an upscale bedroom community for Chicago.

2.4.4 – Recreational Activities

The Park District of Highland Park, founded in 1909, operates and manages over 650-acres of land in 44 park areas, and offers approximately 3,000 recreation and seasonal programs. Facilities include an indoor ice arena, tennis and racquetball complex, two recreation centers, a nature center, an 18-hole golf course, driving range, adventure golf, aquatic park, indoor pool, beaches, boat launch ramp and yacht club on Lake Michigan. None of these features are within the study area boundaries.

Beach Open Space – Central Park is located north of Ravine 10 where there is beach access; however, beach use is low in this area. Beach combing with machinery does not occur and only requires minor flotsam and jetsam to be removed by hand.

Ravine Open Space – The city's Steep Slope Ordinance Article XIX states that:

"The topography of the City of Highland Park is occupied by an abundance of ravines and bluffs. These areas exhibit steep slopes which may contain unstable sediment, rock and soils. Development on potentially unstable soils or other rock can be hazardous to life and property. Development in these areas should utilize construction methods which minimize the impact upon or removal of vegetation, including trees, and ensure slope stabilization and minimize erosion.

The City's ravines and bluffs are valuable scenic resources which should be preserved and the steep slopes associated with these areas should be protected in order to preserve the City's unique visual setting, promote its economic well-being, and encourage architectural splendor.

Regulating the intensity of development according to the natural characteristics of steep slope terrain, such as degree of sloping, significant vegetation, and soil stability and existing drainage patterns, will allow for suitable development while minimizing the physical impact of such development on sensitive ravine and bluff steep slope areas. (Ord. 38-01, J.27, p. 146-167, passed 6/25/01; Ord. 26-08, J. 34, p. 050-068, passed 4/14/08)."

The main intent for the ravines in Highland Park is to maintain them as a natural and open space resource. Although people are allowed to own the ravines, they are protected enough to maintain them as natural areas. This green space would benefit from an ecological restoration project via visual aesthetic improvement and an increase in migratory and local bird activities. Bird watching is a significant activity that occurs along the entire coastline of Lake Michigan in Illinois since it is a significant route of the Mississippi Flyway.

2.5 – Hazardous, Toxic & Radioactive Waste (HTRW) Analysis

An HTRW Phase I Environmental Site Assessment (ESA), completed in accordance with ASTM E-1527-13, is presented in Appendix E. The purpose of the investigation is to determine if any Recognized Environmental Conditions (RECs) are present in the study area, or surrounding area, that have impacted the project site or will impact implementation of an ecosystem restoration project. According to ER 1165-2-132, non-HTRW environmental issues that do not comply with federal, state, and local regulations should be discussed in the HTRW evaluation along with HTRW issues. The HTRW investigation considers existing information, historical topographic maps and aerial photographs, database

research, and a site visit. Hardscape features, such as gabion baskets, stone, bricks, concrete, and/or drainage materials may be present in the ravine. No HTRW, or RECs, were identified in the ESA; a Phase II ESA is not recommended.

2.6 – Problems and Opportunities

The overall problem within the study area is the decrease in biodiversity. Biodiversity is used to describe aspects of biological variety including species richness, ecosystem complexity and genetic variation. Biodiversity is degraded as a result of hydrogeomorphic function, fluvialgeomorphic function, littoral processes and land use change.

Ecosystem is a term used to describe organisms and their physical and chemical environments and can be described and delineated at various scales. For example, a pond or an ocean can be equally referred to as an ecosystem. Communities are naturally occurring groups of species that live and interact together as a relatively self-contained unit, such as a sedge meadow. Habitat refers to the living space of an organism or community of interacting organisms, and can be described by its physical or biotic properties, such as substrate, woody debris or a depression. Ecosystems may contain many communities and habitat types. These are usually assessed by describing and/or quantifying the physical structure, function and/or present organism community contained in the area of interest. They may also be assessed at various scales, depending on the level of resolution needed to answer specific questions. To achieve the objectives of the proposed project, the different types of ecosystems or communities contained in the study area were described and delineated based on their respective geomorphic position, soils series, dominant species assemblages and physical structure of respective habitats.

Historically, the Highland Park moraine was dominated by several naturally occurring communities including wetlands, forests, savannas and prairies. By the late 1800s, many of these communities, particularly prairies, savannas and wetlands, were converted to agricultural, urban or industrial use. Subsequently, there was a significant loss of biodiversity and adverse physical effects such as an increase in flooding events and a decrease in water quality. Human induced disturbances to the remaining natural areas include fire suppression, altered hydrology and hydraulics, increase colonization of invasive species, urbanization pressures and fragmentation. While plant communities can be described in terms of dominant organisms, the quality of their habitat is directly related to the level at which natural processes function, such as groundwater discharge, fire or fluvial erosion and deposition. Habitat quality displays a negative relationship to the amount of human disturbance, in which the disturbance affects natural areas in direct or indirect ways.

Dune & Bluff – Recreational activities and development has allowed invasive nonnative species to colonize these altered areas that no longer provide suitable life requisites for native species. Lacustrine process of littoral drift and wave/current patterns have been altered from their natural state through shoreline development; the construction of harbors, break walls, jetties, piers, etc. Coastal habitat can no longer rely on the natural replenishment and movement of sand down the coast since source areas have been armored and structures intercept a great deal of the material. Near shore, beach, dune and bluffs are dramatically affected by these altered conditions. Specific problems with primary ecosystem drivers include:

- Altered hydraulics and littoral drift from manmade infrastructure
- Altered ravine geomorphology from manmade infrastructure and land use
- Altered ravine geomorphology from non-native plant species colonization

Based on these problems with the ecosystem drivers the following are specific resulting ecological problems for the Ravine 10 study limits:

- Reduced richness and abundance (quality) of native species per community type
- Reduced richness and abundance of higher level organisms including insects, amphibians, reptiles, birds and mammals

Based on the problems for the Ravine 10 study limits, the following opportunities exist to improve ecological diversity within the beach, dune and bluff communities:

- Address invasive plant species issues to increase the quality of dune and bluff habitat
- Increase quantity and improve quality of habitat for hundreds of migratory and resident birds

Ravine – Watershed development and encroachment of infrastructure has both accelerated fluviogeomorphic processes; and fragmented the stream from sections of itself, and overall from Lake Michigan. Specific problems with primary ecosystem drivers include:

- Altered watershed hydrology from urbanization
    - Increases in the amount of water entering the ravine, which accelerates channel evolution as it seeks dynamic equilibrium (faster rates of erosion, channel widening and floodplain terrace creation)
- Altered stream hydraulics from infrastructure encroachment
    - Gabion armoring and sanitary sewer altering sediment transport and substrate sorting
- Degraded substrate composition
    - Entrained dolomitic riprap, riprap shards, gabion basket, filter fabrics, clay piping, and other trash items have degraded substrate quality for macroinvertebrate and migratory fishes
- Altered ravine wall hydrology and geomorphology from invasive tree species
    - Excessive canopy of weedy trees suppressing mid and understory plant communities
    - Accelerates ravine wall erosion from overland flow, not riverine
    - Evapotranspiration irregularities of sloped wetlands
- Fragmentation of stream habitats
    - Fragmentation of stream from Lake Michigan by sanitary interceptor
    - Fragmentation of stream segments by exposed sanitary pipe and gabion armoring

Based on these problems with the ecosystem drivers identified above, the following are specific ecological problems for Ravine 10:

- Reduced length (quantity) of accessible stream habitat (fragmentation)
- Reduced richness and abundance (quality) of the native ephemeral migratory fishes
- Reduced richness and abundance of higher level organisms including macroinvertebrates, amphibians, reptiles, birds and mammals

Opportunities to remedy these issues and return stability in terms of ravine incision exist. Based on the problems for the Ravine 10 study limits, the following opportunities exist to improve ecological diversity within the ravine and riparian communities:

- Manipulation/removal of manmade structures to increase length of accessible stream to fishes
- Manipulation of geomorphic functions within stream channel to repair connectivity, sediment transport and channel evolution
- Address invasive tree species issues to increase quality sloped wetlands and rare understory
- Increase quantity and improve quality of habitat for migratory and resident birds

Recreational Features – An opportunity exists to restore and protect a trail under this project. The trail provides incidental recreational benefits.

2.7 – Habitat Assessment Methodology

A Habitat Suitability Index (HSI) was used to calculate predicted change in habitat quality. The HSI is an algebraic function that typically uses various habitat structure components as indicators, such as cover, food, and natural processes, or biological components of species richness, abundance, evenness, etc. Two HSIs that were certified by the USACE's Center of Expertise for Ecosystem Restoration were used for this study. The Qualitative Habitat Evaluation Index (QHEI) reflects the stream's physical habitat quality, and the Floristic Quality Assessment (FQA) reflects the quality of plant community as habitat. The QHEI and FQA were utilized to quantify Existing (EX), Future Without-Project (FWOP) and Future With-Project (FWP) conditions for the riverine and riparian portions of the study area. Fish and wildlife are highly indicative of habitat quality for riverine and riparian health, since they are highly responsive to primary (hydrology/hydraulics/geomorphology) and secondary (plants/habitat structure) ecosystem driver changes. Changes in habitat will directly affect the richness, abundance and distribution of study area fish and wildlife.

2.7.1 – Qualitative Habitat Evaluation Index (QHEI)

The QHEI is a physical habitat index designed to provide an empirical, quantified evaluation of the lotic (flowing) macrohabitat characteristics that are important to fish communities (Ohio EPA 2006). A detailed analysis of the development and use of the QHEI is available in Rankin (1989) and Rankin (1995). The QHEI is composed of six principal metrics each of which are briefly described below. The maximum possible QHEI score is 100, and the lowest (0) zero; however, the likelihood that even the most impaired drain would not achieve a (0) zero. Each of the metrics are scored individually and then summed to provide the total QHEI segment score. This was completed once in March 2019 for the study area. The QHEI protocol also standardizes definitions for riverine habitats, for which a variety of existing definitions and perceptions exist. Consistency for these was derived from Platts et al. (1983). The USACE utilized the Ohio EPA protocol to collect data and score QHEI for Ravine 10.

QHEI Riverine Habitat Metrics

1. **Substrate:** This metric includes two components, substrate type and substrate quality and notes the presence of all substrate types present in pools/glides and riffles/runs that each comprise sufficient quantity to support species that may commonly be associated with that substrate type. This metric awards points to those sites with a diversity of high quality substrate types, including concepts of siltation and embeddedness (the degree that cobble, gravel, and boulder substrates are surrounded, impacted in, or covered by fine materials). Maximum points are 20.
2. **In-stream Cover**: This metric scores presence of in-stream cover types and amount of overall in-stream habitat cover. These features include, but are not limited to deep pools, undercut banks, islands, large boulders, large woody debris, aquatic vegetation, over hanging vegetation, etc. Maximum points are 20.
3. **Channel Morphology**: This metric emphasizes the quality of the stream channel that relates to the creation and stability of macrohabitat. It includes channel sinuosity, channel development, channelization, and channel stability. Maximum points are 20.
4. **Riparian Zone and Bank Erosion:** This metric emphasizes the quality of the riparian buffer zone and quality of the floodplain vegetation. This includes riparian zone width, floodplain quality, and extent of bank erosion. Each of the three components requires scoring the left and

right banks (looking downstream). The average of the left and right banks is taken to derive the component value. Maximum points are 10.

5. **Pool/Glide and Riffle-Run Quality:** This metric emphasizes the quality of the pool/glide and/or riffle/run habitats. This includes pool depth, overall diversity of current velocities (in pools and riffles), pool morphology, riffle-run depth, riffle-run substrate, and riffle-run substrate quality. Maximum points are 20.
6. **Reach Gradient**: Local or map gradient is calculated from USGS 7.5 minute topographic maps by measuring the elevation drop through the sampling area. Gradient classifications (Table V-4-3 found in Ohio EPA 2006) were assigned by stream size category after examining scatter plots of IBI vs. natural log of gradient in feet/mile (see Rankin1989). Maximum points are 10.

The principle theory underlying the QHEI model is that the integrity and structure of a riverine fish community is partially related to the physical characteristics of the habitat. The QHEI provides an indicator of habitat quality by measuring those physical factors which are known to affect fish communities. Rankin (1989) examined the relationship between the QHEI and the Index of Biotic Integrity (IBI). The analysis resulted in a significant positive relationship between QHEI and IBI scores further supporting the underlying assumptions of the model (Rankin 1989; Santucci et al 2005). The individual metrics in the model are all supported by fluvial geomorphologic principles as reported in the literature and supported by empirical evidence. **Table 2** provides the EX habitat conditions for the Ravine 10 stream. Raw data sheets may be found in **Appendix G Planning Information**.

Table 2 - Existing Condition QHEI Score for Ravine 10 Stream

Category	Attribute	Port Clinton to Moraine Park & South Fork
Substrate	Type	17
	Quality	1
	Sum (Max 20 Points)	18
In-stream Cover	Type	9
	Amount	11
	Sum (Max 20 Points)	20
Channel Morphology	Sinuosity	4
	Development	3
	Channelization	4
	Stability	2
	Sum (Max 20 Points)	13
Riparian Zone	Width	3
	Flood Plain Quality	3
	Bank Erosion	3
	Sum (Max 10 Points)	9
Pool/Glide Quality, Current Velocity	Max Depth	2
	Current Velocity	1
	Channel Width	2
	Sum (Max 12 Points)	5
Riffle/Run Quality	Riffle Depth	2
	Run Depth	1
	Substrate Stability	2
	Substrate Embedded	0
	Sum (Max 8 points)	5
Gradient	(Max 10 Points)	6
QHEI Score (EX)		**76**

* calculated using Eco-PCX certified protocol

2.7.2 – QHEI as the Habitat Suitability Index (HSI)

The Habitat Suitability Index (HSI) is the quality portion of the USACE's habitat assessment procedure to analyze measures, alternatives or plans in terms of ecosystem benefits/outputs. The QHEI has acceptable application for USACE HSI procedures in that the scoring of metrics and calculating an overall score is simple, and output interpretation is straightforward (see MEMORANDUM FOR CECW-LRD Recommendation for Regional Approval for Use of the Qualitative Habitat Evaluation Index 11 December 2014). The data required for input was gathered first hand by USACE (March 2019). Since the QHEI model output is a score between 0-100, it is easily indexed to a score between 0 to 1.0; this provides uniform and useful information across USACE ecosystem studies. Existing condition (EX) HSI score for the Ravine 10 stream is 76 out of 100, which is classified as a "good to excellent" stream habitat. The equation to normalize the QHEI score is:

- QHEI Score / 100 = HSI_{QHEI}
- 76/100 = $.76_{QHEI}$

2.7.3 – Stream Acres as Quantity Measure

USACE planning guidelines require that there be a quantity component to the habitat assessment for determining Future-Without (FWOP) and Future-With (FWP) project conditions. Since the plant community assessment utilizes acres as the quantity unit, acres were used for riverine habitat to make the analyses equivalent and avoid double counting. About 1.7 acres of channel (L 4,860-ft x W 15-ft / 43,560-ft^2) could be directly affected (study area) by this project (Figure 2). However, under the watershed approach this study takes, the ravine stream is larger and has usable fish habitat upstream of the study limits on the south branch. About 2,375-ft is fragmented by the Sheridan Road bridge, which would be an additional .82-acres. Also, the stream is fragmented at the Sheridan Road Bridge on the North Branch, which makes about 1,650-ft, or .57-acres, unusable to fishes as well. Thusly, the total acres of usable fish habitat is 2.52 –acres. The amount currently available to fishes is 1.13-acres; however, within this zone, there are many issues with intermittent fragmentation of the stream by pipes and defunct infrastructure. Based on this condition, there is actually 0-acres of habitat available in the EX condition for fishes to utilize. Past fish surveys by the non-Federal sponsor revealed no fishes currently within the Ravine 10 stream.

- Acres = 0 because this area is fragmented in too many places for use by migratory lake fishes

2.7.4 – Stream Average Annual Habitat Units (AAHUs)

In order to equally assess measures, alternatives or plans, the benefit portion of the analysis must be annualized just as the costs are. The method per USACE planning guidelines typically assigns benefits over a 50-year period of analysis. This study used 50-years as a reasonable period of analysis, noting that the benefits may actually be accrued in perpetuity. Habitat Units (HUs) were calculated by:

- HSI_{QHEI} x Stream Acres Affected = Habitat Units (HUs)
- .76 x 0.0 = 0 HU_{EX}

FWOP and FWP Average Annual HSI are calculated by:

- HSI_{n50} / 50 years = AAHSI

Average Annual Habitat Units (AAHUs) are calculated by:

- AAHSI x Stream Acres Affected = AAHUs

To ensure that existing benefits are not claimed by potential actions, only the net benefits gained are utilized. This unit is called the Net Average Annual Habitat Unit (NAAHU), which is represented as:

- FWP AAHUs – FWOP AAHUs = Net Average Annual Habitat Units ($NAAHU_{QHEI}$)

In the case of the Ravine 10 stream at Moraine Park, there are no (EX) benefits due to zero (0) acres of habitat being accessible by fishes; therefore, the EX AAHU = 0.0.

2.7.5 – Floristic Quality Assessment (FQA)

The Floristic Quality Assessment (FQA) is based on the Chicago Region's floristic coefficients of conservatism (C value) and native species richness developed by Swink and Wilhelm (1979). The C value is a numerical number between 0 and 10 that classifies a plant species as a weed (C = 0 – 3), a high quality, sensitive native plant (C = 7 – 10) and those species in between (C = 4 – 6). The C value of the FQA can be used to quantify the past, present and future effects on native plant communities. The mean C value for each plant community is calculated by:

$\bar{C}$ = Sum of the Coefficient of Conservatism / # of Native Species

Plants are exceptional indicators of short and long-term disturbance in terms of their immediate response to changes in geomorphology, soils and hydrology of an area. In turn, the change in plant community species and structure affects the animal assemblages utilizing them. Plant/animal associations for most Chicago Region plants may be found on the Illinois Wild Flower Home Page (http://www.illinoiswildflowers.info/). **Table 3** provides the (EX) habitat conditions for the study area's plant communities. FQA spread sheets may be found in **Appendix G**.

Table 3 - Existing Condition Mean C Values for the Study Area Plant Communities

	Ravine/Bluff
Total Species Richness	75
Native Species Richness	50
Mean C w/Adventives	2.65
FQI w/Adventives	22.98

2.7.6 – Mean C Value as the Habitat Suitability Index (HSI)

The quality portion of the USACE's habitat assessment procedure to analyze plant community measures, alternatives or plans in terms of ecosystem benefits/outputs. The FQA has acceptable usability for USACE HSI procedures in that the scoring of metrics and calculating an overall score is simple, and output interpretation is straightforward (http://cw-environment.usace.army.mil/model-library.cfm?CoP=Restore&Option=View&Id=318). The data required for input was gathered and quality checked by USACE botanists. Since the FQA model output (Coefficient of Conservatism) is a score between 0-10, it is easily indexed to a score between 0 to 1.0; this provides uniform and useful information across USACE ecosystem studies. Baseline floristic quality was surveyed in September 2018, which will serve as a comparison for predictions of changes to the plant community based on alternative future scenarios. Existing condition (EX) HSI scores for the study area are presented in (**Table 4**).

Table 4 - Mean C Values Conversion to Habitat Suitability Index (HSI) for Existing Conditions (EX)

Plant Community	Integrity	Mean C	EX_HSI$_{FQA}$
Ravine/Bluff	Poor	2.65	.265

The equation to normalize the Mean C Value is:

- Mean C Value / 10 = HSI$_{FQA}$

2.7.7 – Plant Community Acres as Quantity Measure

The plant community assessment utilized acres as the quantity unit. **Table 5** provides the acres per native plant community found within the study area.

Table 5 - Acres of Native Plant Community within the Study Area

Plant Community	Acres
Ravine/Bluff	23.7

2.7.8 – Plant Community Average Annual Habitat Units (AAHUs)

In order to equally assess measures, alternatives or plans, the benefit portion of the analysis must be annualized just as the costs are. The method per USACE planning guidelines typically assigns benefits over a 50-year period of analysis, or project life. This study will use 50-years as a reasonable period of analysis, noting that the benefits may actually be accrued in perpetuity. Habitat Units (HUs) are calculated by:

- HSI x Plant Community Acres Affected = Habitat Units (HUs)

Table 6 - Existing (EX) Habitat Units (HUs) per Habitat Type

Plant Community	Integrity	Mean C	EX_HSI$_{FQA}$	Acres	EX_HUs
Ravine/Bluff	Poor	2.65	.265	23.7	6.28

FWOP and FWP Average Annual HSI are calculated by:

- HSI$_{n50}$ / 50 years = AAHSI$_{FQA}$

Average Annual Habitat Units (AAHUs) are calculated by:

- AAHSI x Plant Community Acres Affected = AAHU$_{FQA}$

Even though there may be apparent benefits to be gained, there are still benefits existing in the Future-Without Project condition within the existing plant communities, as evident by the Mean C Values. To ensure that existing benefits are not claimed by potential actions, only the net benefits gained are utilized. This unit is called the Net Average Annual Habitat Unit (NAAHU), which is represented as:

- FWP AAHUs – FWOP AAHUs = Net Average Annual Habitat Units (NAAHU$_{FQA}$)

2.8 – Future Without-Project Conditions (FWOP)

The future without project condition, in general, is expected to further decline for the dune, bluff and ravine habitat within the Ravine 10 study area (**Table 7 and Figure 3**). The ravine would remain fragmented from the lake and greatly affected by excessive urban runoff. Habitat diversity in the ravine would remain low, preventing many floral and faunal species from utilizing the area while providing conditions for weedy and invasive species to remain dominant and increase in abundance as time progresses. The continuation of maintaining the ravine as a drainage conduit would prevent ecological rebound, in which case, would cause further degradation in ecologically significant patches within the study area. Overall, biological diversity would remain low within the ravine because of the lack of channel connectivity, complexity, and stability, which is caused by the altered fluvial hydraulics.

The bluff along the entire Highland Park moraine is in need of invasive species removal and native plant reestablishment. Without a Federal project, this needed activity cannot be accomplished effectively. The continuation of allowing large patches of invasive species to be present would prevent ecological rebound and in some cases would cause further degradation in ecologically significant patches along the bluff within the study area. Overall, biological diversity would remain low along the bluffs because of the lack of habitat complexity and stability that native plants would provide.

Table 7 - Future Without-Project Conditions for the Three Habitat Zones

Description	Habitat Types	Acres	ExHSI	AAHSI	ExHUs	FWOP AAHUs
Ex Condition	Stream	0.0	0.76		0.0	
	Ravine/Bluff	23.7	0.256		6.28	
No Action /	Stream	0.0		0.76		0.0
FWOP	Ravine/Bluff	23.7		0.19		4.5

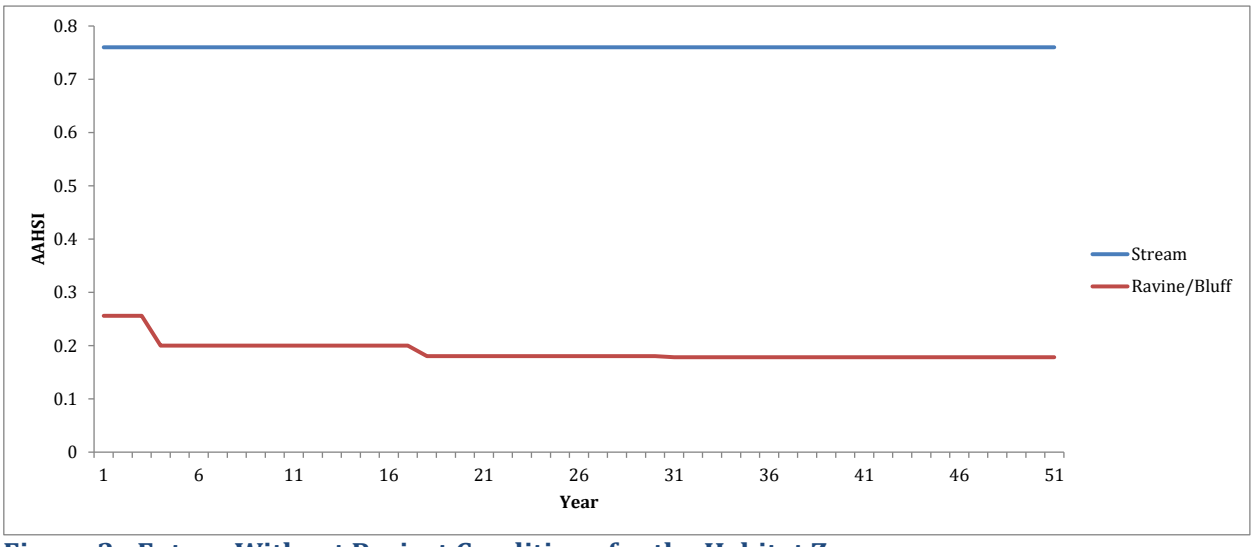


Figure 3 - Future Without Project Conditions for the Habitat Zones

2.9 – Goals, Objectives & Constraints

The primary goal of this Feasibility Study is to determine a cost effective restoration plan that meets the goal and objectives.

2.9.1 – Goal

The primary goal of a resulting project would be to restore coastal Lake Michigan habitat which include the stream, ravine, and bluff habitats within the study area for flora, fish and wildlife.

2.9.2 – Objectives

Planning objectives are statements that describe the desired results of the planning process by solving the problems and taking advantage of the opportunities identified. The planning objectives must be directly related to the problems and opportunities identified for the study and will be used for the formulation and evaluation of plans. Objectives must be clearly defined and provide information on the effect desired, the subject of the objective (what will be changed by accomplishing the objective), the location where the expected result will occur, the timing of the effect (when would the effect occur) and the duration of the effect.

Federal Objective

The Federal objective of water and related land resources planning is to contribute to the protection, restoration, and conservation and management of environmental resources in accordance with numerous 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 considered more of a National goal. Water and related land resources project 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. Contributions to the Federal objective include increases in the net value of those goods, services and ecosystems that are or are not marketable.

Protection of the Nation's environment is achieved when damage to the environment is 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 protection. 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:

- 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)
- Endangered Species Act of 1973, as amended (16 USC 1531 et seq.)
- Fish and Wildlife Coordination Act, as amended (16 USC 661)
- Migratory Bird Treaty Act of 1918, as amended (16 USC 703 et seq.)
- Responsibilities of Federal Agencies to Protect Migratory Birds (E.O. 13186)
- Clean Water Act of 1977, as amended (33 USC. 1251 et seq.)
- Safe Drinking Water Act of 1986 as amended (42 USC 201)

- National Environmental Policy Act of 1969 (42 U.S.C. 4321 et seq.)
- Resource Conservation and Recovery Act of 1976, as amended (42 USC 6901, et seq.)
- Protection and Restoration of the Great Lakes (E.O. 13340)
- Protection and Enhancement of Environmental Quality (E.O. 11514)
- Floodplain Management (E.O. 11988)
- Protection of Wetlands (E.O. 11990)
- Wild and Scenic Rivers Act of 1968 (16 USC 1271-1287 Public Law 90-542 82 Stat. 906)

Study Objectives

The non-federal sponsor has general goals for ecosystem restoration. These are to improve and increase viable habitats and improve ecological functions along the coast of Lake Michigan to support sustainable populations of diverse and valuable plant and animal species. Specifically, the sponsor aims to protect, enhance, naturalize and restore coastal ecosystems. The following objectives are those that will be directly measured for alternative analysis within this feasibility study:

Naturalize Ravine Hydraulics – Currently, Ravine 10 within the study area is impaired by a formerly subsurface sewer pipe that is impairing fluvial geomorphic processes and connectivity for fishes. Due to the natural direction of the ravine to be further incising and widening, there is no natural recovery mechanism to repair connectivity. These impairments are specific to impeding riverine hydraulics, sediment transport, substrate sorting, resulting in a loss of structural habitat heterogeneity (geomorphology). The effects desired by meeting this objective are to provide riverine functions and/or structure to restore, connect and sustain habitats. The targeted location of these affects would be throughout the Ravine 10 stream channel. These affects would be sustained over the life of the project and optimistically in perpetuity. This objective seeks to reestablish natural fluvialgeomorphic parameters (hydraulics, substrates) and structures to support riverine and riparian habitats within the study area. Improvement is measured via the predicted increase in quality of riverine habitat (FWP HSI (QHEI) and FWP HSI (FQA)).

Reduce / Eliminate Invasive Plants – This objective seeks to remove or ease the adverse effects of non-native and invasive species, particularly plant species for this study. Typically, invasive species gain a foot hold and eventually dominate a site due to soil disturbance at the site, particularly to hydrologic, soils, or bio-chemical parameters. In this case, once the ravine's hydrology and geomorphic impairments are remedied, invasive plant species may be addressed quite effectively. The objective would be to achieve a target overall Conservatism Coefficient (Mean C) of ~5 for the ravine, bluff and dune plant communities as described in Section 2.3 Habitat Assessment Methodology, Floristic Quality Assessment; and to reduce the targeted invasive species plant population to <1% of aerial coverage.

Increase Native Plant Species Richness & Coverage – This objective seeks to increase number of native plant species and their abundance over the entire project footprint. Plants are the secondary driver to providing critical habitats for both micro and macro organisms. Ultimately, there is no habitat restored without a native and diverse plant community mosaic. This object would be measured by the coefficient of conservatism for the ravine, bluff and dune plant communities.

2.9.3 – 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 solutions. The establishment of planning constraints is done in concert with the entire study team and in cooperation with stakeholders. A list of planning constraints for the NER purpose follows.

Any measures/alternatives implemented should:

- Avoid adverse impacts to the hydrology, hydraulics and erosion processes of the ravines
- Avoid adverse impacts to the littoral drift of Lake Michigan
- Avoid adverse impacts to the state listed species present on site

CHAPTER 3 – PLAN FORMULATION AND EVALUATION*

The formulation, evaluation, and comparison of alternative plans comprise the third, fourth, and fifth steps of the Corps' planning process. These steps are often referred to collectively as plan formulation. Plan formulation is an iterative process that involves cycling through these steps to develop a reasonable range of alternatives, and then narrow those plans down to a final plan, which is feasible for implementation.

Plan formulation for ecosystem restoration (ER) presents a challenge because alternatives have non-monetary benefits. To facilitate the plan formulation process, the methodology outlined in the Corps' Engineering Circular 1105-2-404, "Planning Civil Work Projects under the Environmental Operating Principles," 1 May 2003 was used. The steps in the methodology are summarized below:

1. Identify a primary project purpose. For this portion of the study, ecosystem restoration (ER) is identified as the primary purpose. Alleviating local drainage issues is not a purpose of this project.
2. Formulate management measures to achieve planning objectives and avoid planning constraints, where measures are the building blocks of alternative plans.
3. Identify and select those sites/patches most beneficial for ecological restoration.
4. Formulate, evaluate, and compare an array of alternatives to achieve the primary purpose (ER) and identify cost effective plans.
5. Perform an incremental cost assessment on the cost effective plans to determine the NER plan.

3.1 – Measure Identification

In general, there are two types of activities investigated for this project – stream habitat sustainability and native plant community reestablishment. These two types are not dependent upon each other for this study/project, but can be combined. Measures assessed for this study/project may be viewed on **Figure 2**.

3.1.1 – (SMC) Stream Morphology & Connectivity

This measure seeks to naturalize sediment transport and provide a connected stream within the study area. Small boulder/cobble riffles, J-hooks and other small stone structures would be placed at strategic points in the ravine stream channel as the primary method to address problems (**Photo 6**). These small stone structures would slow down channel down-cutting by backing up alluvial materials of silt, sand, gravel and small cobble; i.e. cover up pipes with natural alluvium. These structures are not intended to halt bank erosion, which is currently in a natural state and beneficial to stream habitat and substrate sequestration. At the same time, these stone structures would also provide stream connectivity in terms of flowing water and fish passage. To also naturalize sediment transport and restore stream habitat, foreign debris would be removed under this measure; foreign debris includes broken clay pipe and concrete, wire mesh from broken gabions, riprap from broken gabions and failed erosion measures, filter fabric and large pieces of plastic and construction material. Specific line items for this measure includes:

- Remove foreign debris and trash
- Install boulder/cobble structures
    - Riffles, J-hook, cross-vane, etc.
    - Glacial/fluvial stone, rounded to sub-angular

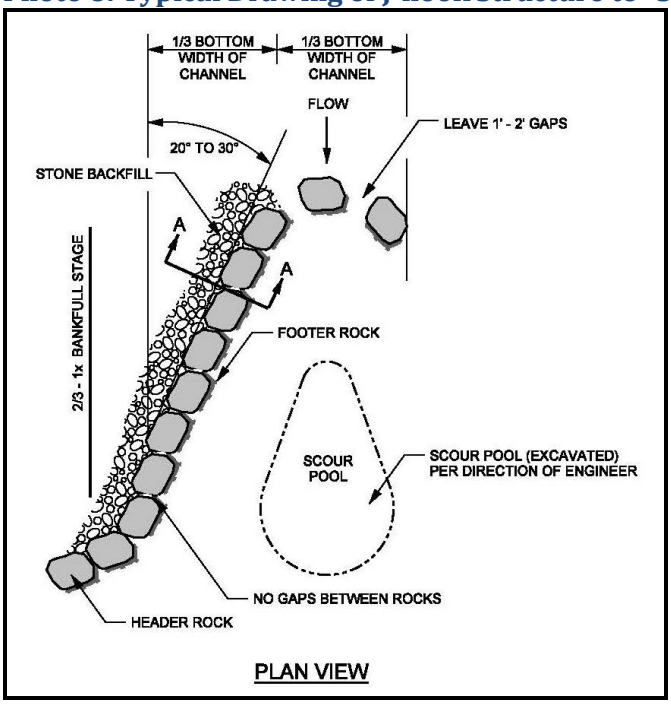
Photo 6: Example Location for Boulder Riffle to Create Fish Passage & Induce Alluviation

3.1.2 – (BR) Bank Restoration

This measure seeks to restore ravine banks and floodplain terraces where impacted by large manmade infrastructure and failed erosion measures. These include removing steel sheet pile, metal retaining walls, concrete slabs, concrete boxes, gabion baskets and angular riprap (**Photo 7**). Once removed, these structures would be replaced with stone structures (**Photo 8**) on the stream floor and planted with native plant species adapted to the lower banks. Steep areas supporting infrastructure could be protected with glacial/fluvial stone or limestone flags if necessary.

Photo 7: Retaining Wall & Riprap Removal Area

Photo 8: Typical Drawing of J-hook Structure to "Stabilize" Restored Bank



3.1.3 – (RB) Ravine & Bluff Plant Community

This measure seeks to selectively remove invasive and opportunistic woody vegetation shading the ravine and bluff's understory. Selective shrub and tree clearance includes, but is not limited to, Common Buckthorn (*Rhamnus cathartica*), Glossy Buckthorn (*Frangula alnus*), European Highbush Cranberry (*Viburnum opulus*), Black Locust (*Robinia pseudoacacia*), Norway maple (*Acer platanoides*), White Mulberry (*Morus alba*), Green Ash (*Fraxinus lanceolata*), and European Privet (*Ligustrum vulgare*). This measure also includes the removal of invasive herbaceous species by spot application of herbicide as well as the incorporation of a prescribed burn. This measure would plant native species of local genotype that are known to inhabit lakeshore ravine and bluff communities; species harder to establish from seed will be introduced as plugs. Given the unique climate of lakeshore ravines and bluffs and the suite of rare flora that inhabit them, genetic preservation of species, including rare and state listed species, will be maintained by contract growth of certain species that currently reside in low numbers and/or which are not available commercially. Use of contract grown species from sources within the site and nearby areas not only preserves the unique genetics of the area, but also maximizes the success of establishment as local genotypes within or near the study area are more likely adapted to the harsh conditions presented by lakeshore bluffs.

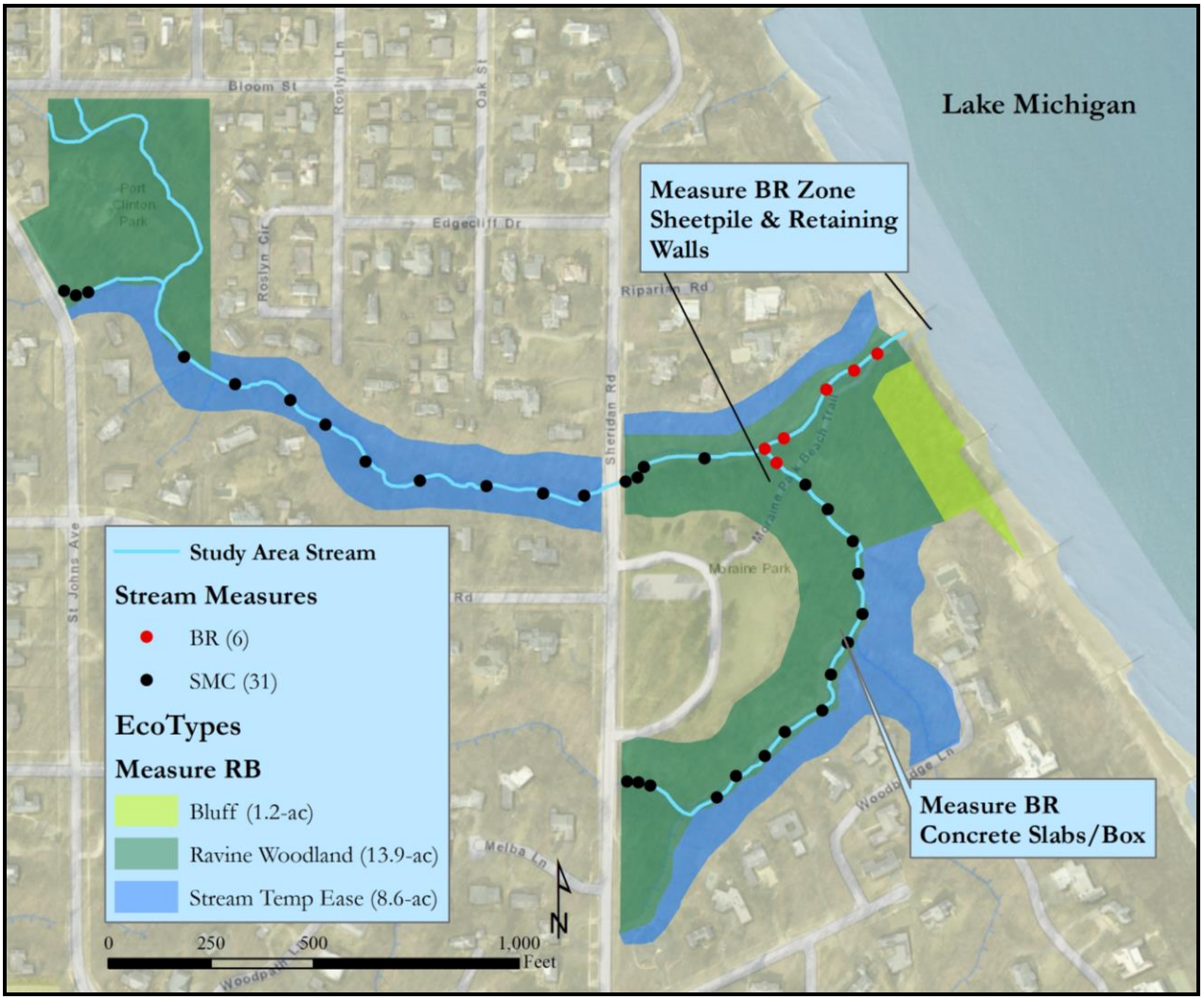


Figure 4 - Spatial Distribution & Location of Restoration Measures

3.2 – Measure Costs & Assumptions

Detailed discussion on planning level feature costs is presented in Appendix B – Cost Engineering. Conceptual, planning level cost estimates were prepared for measures/features that were identified by the study team in conjunction with the non-federal sponsors (**Table 7**). These cost estimates do not represent complete project construction cost estimates, but rather individual measures of work or components of the entire project. The measures were used to provide an economic basis for the development of project alternatives. Once the project alternatives have gone through the plan formulation process, and additional design information was developed for the recommended plan, a more detailed and reliable cost estimate was performed (**Appendix B**). Estimates were developed using cost information from previous studies, lump sum and unit prices, and for plant, labor, and material methods. Planning level unit costs were placed into a matrix to utilize the different costs for each measure of work.

Cost Annualization: Annualizing costs is a method where the project costs are discounted to a base year then amortized over the period of analysis. The base year for this project was determined to be the year in which the first phase of the project is to be completed (calendar year 2020). Costs that occur prior to this year need to be compounded to the base year, while those occurring after the base year need to be discounted to the base year. The period of analysis for the Section 506 project is 50 years. Discounting to the base year and summing values gives net present value. Costs are compounded or converted to present value for the base year then the amortization of the NPV yields average annual equivalent value. Discount rate was determined by the appropriate Economic Guidance Memorandum 19-01, Federal Interest Rates for Corps of Engineers Projects, which is currently 2.875%. The method shown in the above table does this for each measure. The individual measures of the project have the construction period spread out over 1 to 5-years, depending on magnitude or redundancy. Each year of every measure is either compounded or discounted to the base year. Calculation of the measures Average Annual Cost (AA Cost) is completed by multiplying the present value to the 50-year amortization factor.

Real Estate: An Initial Value Estimate (IVE) of the lands necessary to implement measures for this ecosystem restoration project was included in the Average Annual costs per measure on an acre basis. The IVE of ~$285,000 provided by the real estate section determined various preliminary numbers to accomplish plan formulation. This number is preliminary and does not constitute the gross appraisal, which would be completed for the NER Plan.

Table 8 - Planning Level Total & Average Annual Costs per Measure, FY 2019 PL

Code	Measure	Measure Cost*	IVE LERRD	Adpt. Mgm.	Monitoring†	Total Measure	AA O&M	AA Cost
SMC	Stream Morphology & Connectivity	$297,329	$11,200	$21,463	$7,500	$337,492	$0	$12,961
BR	Bank Restoration	$2,601,577	$1,750	$10,000	$2,500	$2,615,827	$500	$102,437
RB	Ravine and Bluff Restoration	$1,960,985	$130,400	$10,000	$8,000	$2,109,385	$1,650	$80,500

3.3 – Measure Benefits

The evaluation of habitat benefits is a comparison of the with-project and without-project conditions for each measure. Environmental outputs are the desired or anticipated measurable products or results of restoration measures and plans. The term “outputs” is often used interchangeably with “benefits” or “habitat units (HUs).” Ecosystem restoration proposals 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 reasonable 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, will actually have beneficial effects to the affected area’s dune, bluff, ravine, and stream ecosystem. The measures for this study were evaluated with the HSI methodology

described in Section 2.3 and were prescribed benefits in which the derivations of are depicted on **Figure 4**.

Table 9 - Average Annual Habitat Units per Measure

Description	Habitat Types	Acres	AAHSI	AAHUs	NAAHUs
No Action / FWOP	SMC	*0.0*	*0.76*	*0.00*	
	BR	*0.5*	*0.76*	*0.38*	
	Ravine/Bluff	23.7	0.256	*6.07*	
Action / FWP	SMC	*3.2*	*0.86*	*2.75*	*2.75*
	BR	*0.5*	*0.86*	*0.43*	*0.05*
	Ravine/Bluff	*23.7*	*0.456*	*10.80*	*4.73*

Through the implementation of hydraulic repair measures for the purpose of stream habitat and riparian restoration, hydraulic conditions would be able to provide life history requisites for a given assemblage of fishes. The main structures providing fish and macroinvertebrate habitat for this potential project are stone riffles (woody debris and rootwads would naturally accumulate overtime). It is well known that the force of water over and through these riffle structures create prime conditions for lotic fishes and macroinvertebrates to colonize, and in turn attract those fish that do not need faster flowing water but do like to feed on those invertebrates and fishes in the riffles, such as rock bass and smallmouth bass. These structures when constructed properly will provide habitat in itself and induce other habitat features such as point bar formation, scour pools, and diverse substrate patches. In turn, these new formations can provide critical hydraulic conditions such as critical and helical flows, all of which would attract lotic macroinvertebrates and fishes.

3.4 – Cost Effectiveness / Incremental Cost Analysis

Cost effectiveness and incremental cost analysis (CE/ICA) are two distinct analyses that must be conducted to evaluate the effects of alternative plans according to USACE policy. First, it must be shown through cost effectiveness analysis that a restoration plan's output cannot be produced more cost effectively by another alternative. *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, through incremental cost analysis, a variety of alternatives and various-sized alternatives are evaluated to arrive at a "best" level of output within the limits of both the sponsor's and the USACE's capabilities.

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." As a group of measures, 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 will increase as well. The incremental analysis by itself will 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 help the study team select and recommend a particular plan.

Eight (8) plans were generated (**Table 10**) from the 3 measures input into the IWR-Planning software. The software identified that 1 plan was cost effective, which means that no one plan provided the same benefits as another plan that was less costly. Four (4) plans were revealed as "best buys" (**Figure 5**), which are deemed the most cost efficient of the 8 plans generated.

Table 10 - All Plans (8) Generated, FY 2019 PL

Alt Plan #	Generated Plan	Cost ($10)	Output Value	Cost Effective
1	BR	$102,437	0.05	Non-Cost Effective
2	SMC & BR	$115,398	2.8	Non-Cost Effective
3	BR & RB	$182,937	4.78	Non-Cost Effective
4	RB	$80,500	4.73	Cost Effective
5	No Action Plan	$0	0	Best Buy
6	SMC	$12,961	2.75	Best Buy
7	SMC & RB	$93,461	7.48	Best Buy
8	SMC & BR & RB	$195,898	7.53	Best Buy

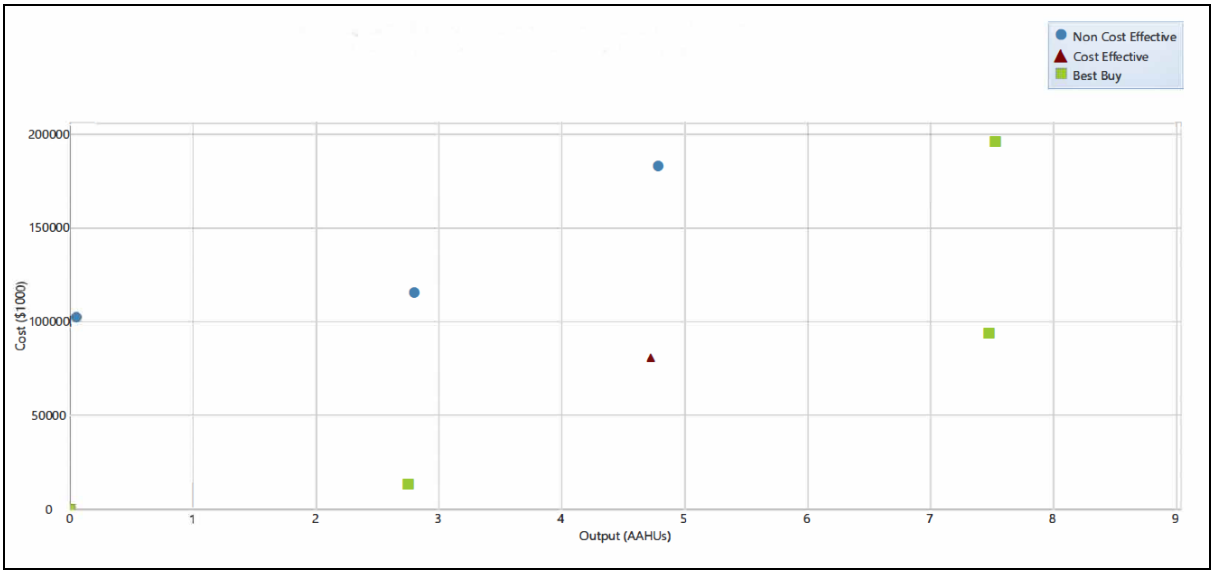


Figure 5 - Cost Effective Analysis on All (8) Plan Combinations, FY 2019 PL

Table 11 - Incremental Analysis of Best Buy Plans for Ravine Restoration, FY 2019 PL

Alt Plan #	Plan Name	Incremental Cost Per Unit	Output	Average Annual Cost	Cost Effective
5	No Action Plan	$0	0	$0	Best Buy
6	SMC	$4,713	2.75	$4,713	Best Buy
7	SMC & RB	$17,019	7.48	$12,495	Best Buy
8	SMC & BR & RB	$2,048,740	7.53	$26,016	Best Buy

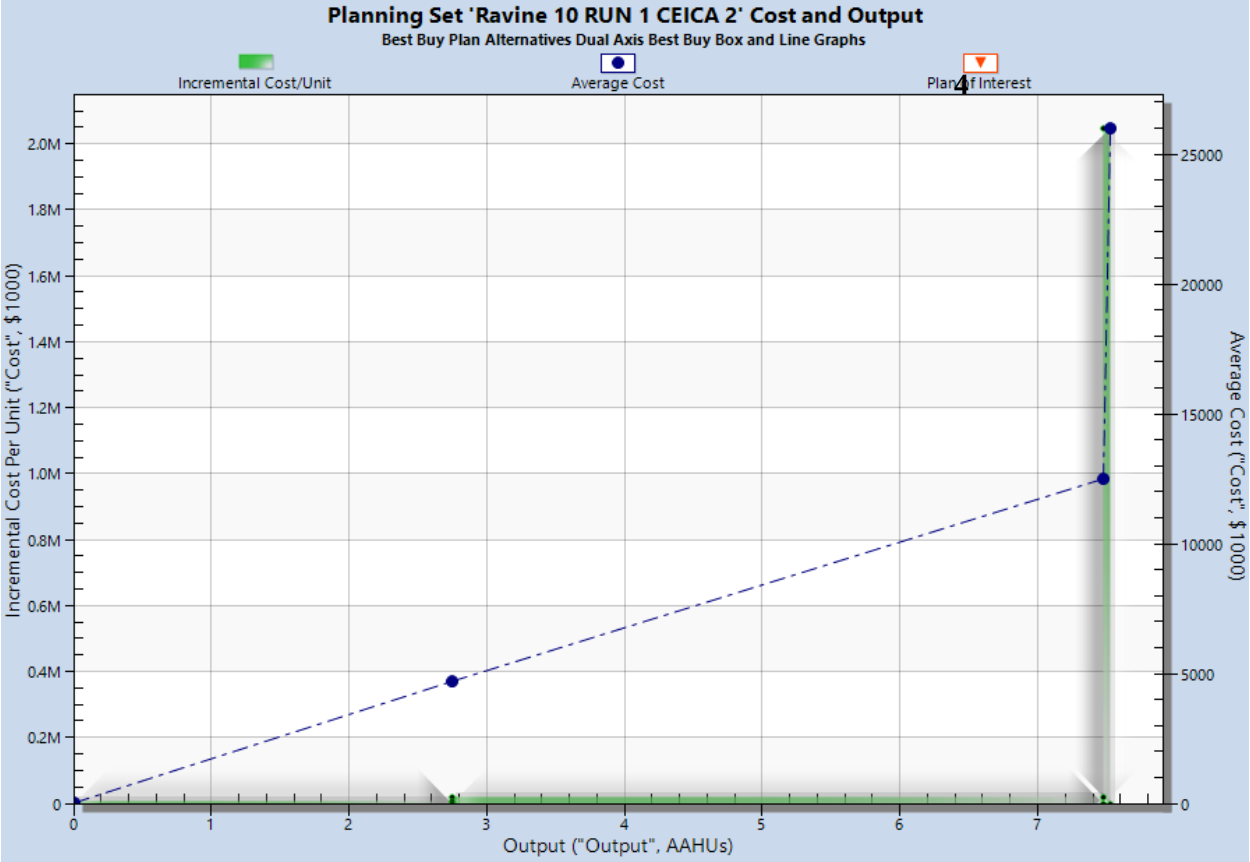


Figure 6 - Graphical Representation of Incremental Costs vs. Benefits, FY 2019 PL

3.5 –Plan Trade-Off Analysis

Alternative plans that qualified for further consideration, best buy plans, will be compared against each other in order to identify the selected sites and their associated alternatives to be recommended for implementation. A comparison of the effects of various plans must be made and tradeoffs among the differences observed and documented to support the final recommendation. The effects include a measure of how well the plans do with respect to planning objectives including NER benefits and costs. Effects required by law or policy and those important to the stakeholders and public are to be considered. Previously in the evaluation process, the effects of each plan were considered individually and compared to the without-project condition. In this step, plans are compared against each other, with emphasis on the important effects or those that influence the decision-making process. The comparison step concludes with a ranking of plans.

3.5.1 – Acceptability, Completeness, Effectiveness and Efficiency

Acceptability, completeness, effectiveness, and efficiency are the four evaluation criteria the USACE uses in the screening of alternative plans. These criteria are evaluated in Table 11a. Alternatives considered in any planning study, not just ecosystem restoration studies, should meet minimum subjective standards of these criteria in order to qualify for further consideration and comparison with other plans. The following discussion addresses the tentative plan, which is Alternative Plan 7 (SMC & RB).

Table 12a – Qualitative Analysis of Acceptability, Completeness, Effectiveness, and Efficiency for Best Buy Plans for Ravine Restoration

Alt Plan #	Acceptability	Completeness	Effectiveness	Efficiency	Notes
5	++	-	-	-	No action or outputs.
6	++	++	+	++	Less effective than tentative plan, fewer ecosystem outputs
7	++	++	++	++	Tentative plan
8	++	++	++	+	Less efficient than tentative plan, more ecosystem outputs but at a far higher cost per output

++: Strongly favorable
+: Favorable
-: Unfavorable

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. A recommended plan must be acceptable to the non- Federal cost-sharing partner. However, this does not mean that the recommended plan must be the locally preferred plan.

All plans would be acceptable to state and Federal resources based on the nature of the project and the outputs. Ecological restoration with incidental benefits of water quality improvements are in congruence with the goals and objectives the US Fish & Wildlife Service, US Environmental Protection Agency, the Illinois Dept. of Natural Resources, Illinois EPA, the Lake County Stormwater Management Commission and the Lake County Forest Preserve. All measures, alternatives and resulting plans were formulated through various iterations under the close guidance and review of the non-Federal sponsors. The plans were tailored to meet the needs and integrity of the non-Federal sponsor's ecosystem holdings.

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 sponsorship factors must be considered. Where there is uncertainty concerning the functioning of certain restoration features and an adaptive management plan has been proposed it must be accounted for in the plan.

The tentative plan, Plan 7, is complete unto itself, which means the plan can be implemented without any supporting projects or contributions from other entities. The tentative plan would restore about 27 acres of ravine, bluff and dune within the natural open space of the study area. The tentative plan is in congruence with the Alliance for the Great Lakes' 2009 publication that identifies restoration of the north shore ravines and coastal habitats. Currently, there are no recommended restoration features under the tentative plan that has a significant degree of uncertainty concerning functionality or structure.

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 tentative plan makes significant contributions to addressing the problems identified in Section 2.2. Based on planning level assessments, this plan would restore important habitat along the coast of Lake Michigan in terms of ravine hydrology and hydraulics, geomorphic repairs and the establishment of viable and diverse native plant communities. A potential of about 27 acres of restoration was assessed under this Feasibility Study, with the tentative plan recommending 27 acres as high priority under the Corps Ecosystem mission.

Efficiency

An ecosystem restoration plan must represent a cost-effective means of addressing the restoration problem or opportunity. It must be determined that the plan's restoration outputs cannot be produced more cost effectively by another agency or institution.

The selected alternative maximizes efficiency by selecting the highest ecosystem outputs for the lowest unit cost.

The tentative plan provides outputs that cannot be produced more cost effectively by the Corps or other agencies/institutions. All components of the tentative plan have passed tests of redundancy, habitat output significance, cost effectiveness and Corps expertise. The USACE sets criteria for selecting projects based on Corps expertise.

3.5.2 –Tentatively Selected Plan

Alternative Plan 7 "Best Buy" was selected as the tentative plan based on cost effectiveness, ecological outputs, significance and meeting the goals and objective of the study.

3.5.3 – Significance of Ecosystem Outputs

Because of the challenge of dealing with non-monetized 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 will help determine whether the proposed environmental investment is worth its cost and whether a particular alternative should be recommended. Statements of significance provide qualitative information to help decision makers evaluate whether the value of the resources of any given restoration alternative are worth the costs incurred to produce them. The significance of the Ravine 10 ecosystem restoration outputs are herein recognized in terms of institutional, public, and/or technical importance.

Institutional Recognition

Significance based on 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. The following are exemplary instances:

Clean Water Act, 33 U.S.C. § 1251 – Restore the chemical and biological integrity of the Nation's waters. Restoration of native plant communities as well as stream hydraulics and hydrology will not only improve habitat diversity, but also biogeochemical processes important in the filtering of precipitation and runoff. This in turn will mean the return of higher quality water to Lake Michigan and prevent the ravine from adding waste into Lake Michigan.

Endangered Species Act of 1973, 16 U.S.C. § 1531 – 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. Although no Federal listed species have been recorded from the project site, project features would be beneficial to Federally endangered and/or threatened species that may colonize the area in the future. Additionally, restored site conditions could support colonization or continued habitation of state rare, threatened, and endangered species such as the following species: common tern (*Sterna hirundo*), Forster's tern (*Sterna forsteri*), marram grass (*Ammophila breviligulata*), sea rocket (*Cakile edentula*), seaside spurge (*Chamaesyce polygonifloia*), common juniper (*Juniperus communis*), downy Solomon's seal (*Polygonatum pubuescens*), longnose sucker (*Catostomus catostomus*), and lake herring (*Coregonus artedii*).

Fish and Wildlife Conservation Act of 1980, 16 U.S.C. § 2901 – All Federal departments and agencies to the extent practicable and consistent with the agencies authorities should conserve and promote conservation of non-game fish and wildlife, and their habitats. Restoring the vegetative structure and increasing the native plant growth of the bluff, ravine, and dune habitats will enhance the habitat diversity of the ravine system. The restored site would have increased native species richness and fewer invasive and non-native species. In addition, removal of manmade structures that are impediments to aquatic species dispersal would increase availability of high quality habitat. All habitat improvements will benefit plants, invertebrates, fish, birds, amphibians, reptiles, and other wildlife.

EO 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. Improving the quality of Ravine 10 would help to restore the unique Bluff-Lake Michigan interface, an area that once had many environmental treasures.

EO 13186 Responsibilities of Federal Agencies to Protect Migratory Birds – 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 will restore native plant diversity and thus provide better forage and shelter to numerous migratory bird species as discussed in Section 2.3.3, Resident and Migratory Birds.

Executive Order 13340 - Identified the Great Lakes as a national treasure and defined a Federal policy to support local and regional efforts to restore and protect the Great Lakes ecosystem through the establishment of regional collaboration. A number of activities have been accomplished by Federal agencies working in partnership with state, tribal and local governments in response to the Executive Order. The USACE has been a major participant in these activities. The Executive Order established the Great Lakes Interagency Task Force. The Task Force worked with the governors of the eight Great Lakes states, mayors, and tribal leaders to establish the Great Lakes Regional Collaboration. The initial goal of the Collaboration was to develop a "strategy for the protection and restoration of the Great Lakes" within 1 year. The Collaboration developed the strategy by using teams consisting of 1,500 stakeholders for the following eight priority issues identified by the Great Lakes governors and mayors with items in bold relative to this project:

1. Toxic contaminants
2. **Non-point source pollution**
3. **Coastal health**
4. **Habitat/species**
5. Contaminated sediments/AOCs
6. **Indicators/information**
7. **Sustainable development**
8. **Invasive species**

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.

Alliance for the Great Lakes. October 2009. Stresses and Opportunities in Illinois Lake Michigan Watersheds Strategic Sub-Watershed Identification Process (SSIP) Report for the Lake Michigan Watershed Ecosystem Partnership.

This report is organized around three aspects of the Lake Michigan land and water ecology: the water quality of Lake Michigan and the streams and rivers feeding into it, the level of erosion in ravines along the coast of the lake, and the range and quality of habitat in the region. Water quality and habitat were analyzed in terms of sub-watershed boundaries, whereas ravine erosion was analyzed ravine-by-ravine. Ravine 10 was the highest ranked ravine for erosion potential out of 47 ravines. The immediate goals of the study are to 1) prioritize sub-watersheds based on their potential to negatively impact water quality or 2) the quality and extent of habitat within their boundaries; and 3) to rank ravines based on their potential for erosion. The larger goal of the study is to serve as a tool for LMWEP, municipalities and other interested groups, such as private landowners, to make informed decisions about where to focus restoration efforts and resources in order to improve the ecology of the Lake Michigan region.

Technical Recognition

Technical recognition means that the resource qualifies as significant based on its "technical" merits, which are based on scientific knowledge or judgment of critical resource characteristics. Whether a resource is determined to be significant may of course 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.

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.

Scarcity is represented at Ravine 10 by the presence of significant and unusual topographic features including beach, foredune, bluff, and ravine habitat. Ravine 10 lies within the Illinois Beach Resource Rich Area (RRA) which has the second highest percentage of urban/built-up acreage (63%). Only 24% of the RRA contains natural habitats such as forest, wetland, and grassland. This narrow band of habitats is comprised of beaches, sand dunes, swales, marshes, sand prairies, savannas, and oak forests that occur

along the coast of Illinois as a result of the gradual lowering of Lake Michigan. The Illinois Beach RRA is one of the most biologically diverse areas in the state with more than 650 species of plants having been identified from this area.

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. Although the study area has been highly disturbed from anthropogenic activities, the Ravine 10 natural area is representative of a southwestern Lake Michigan ravine-lake interface. This project would restore connectivity between the ravine and lake, upstream aquatic species dispersal, and a diverse array of rare and conservative plant species. This project would repair the ravine-lake interface to a representative form, and to once again provide habitat for ravine species as well as refuge for lacustrine species.

Status and Trends of the Ravine 10 natural area describe a once highly functional lacustrine habitat that has become degraded primarily due to effects of urbanization from the ever expanding Chicago metropolitan area. However, it is part of the Illinois Beach RRA which is one of the most ecologically rich and unique areas in Illinois. This RRA is comprised of a diverse array of habitats that were created because of its proximity to the shores of Lake Michigan. Ravine 10 contains many of these unique habitats, one of which is the notable bluff habitat. With implementation of the proposed project, distinctive habitats may be restored to their former excellence and provide beneficial outputs to terrestrial and aquatic wildlife.

Connectivity of Ravine 10 to other natural areas and Lake Michigan is crucial for fish species as well as migratory birds. Ravine 10 is one of several areas along the Lake County lakeshore to be undergoing restoration or proposed restoration. Additional areas where bluff and ravine restoration has been proposed to occur within the next decade are Ft. Sheridan, Central Park, Millard Park, and Rosewood Park. Extensive restoration of this coastline will provide connected high quality habitat for wildlife, especially migrant birds which follow the Lake Michigan Flyway during spring and fall migration. In addition, Ravine 10 is located within the Illinois Beach RRA which encompasses 49,172 acres stretching from Cook County to Lake County, Illinois. Included within the Illinois Beach RRA is Illinois Beach State Park, North Dunes, and Spring Bluff; three nature preserves that provide critical habitat to wildlife and form a habitat corridor with the aforementioned parks.

Limiting Habitat exists at Ravine 10. Although no Federal listed species have been recorded from the project site, numerous state species have been found in the area. Once restored, site conditions could support colonization or continued habitation of state rare, threatened, and endangered species such as the following species: common tern (*Sterna hirundo*), Forster's tern (*Sterna forsteri*), marram grass (*Ammophila breviligulata*), sea rocket (*Cakile edentula*), seaside spurge (*Chamaesyce polygonifloia*), common juniper (*Juniperus communis*), downy Solomon's seal (*Polygonatum pubuescens*), longnose sucker (*Catostomus catostomus*), and lake herring (*Coregonus artedii*).

Biodiversity within the Chicago Region is in decline due to the replacement of a number of high quality species that have links throughout the food web and ecosystem, with species that have few or no users in the system. As more species are lost, a cascade effect results in the loss of the species that are dependent on the ones immediately affected by the problem. Through the restoration of ravine hydraulics and hydrology, ravine-lake connectivity, native plant community richness, water quality, and nutrient cycling; species diversity would increase logarithmically along with existing populations of fish, amphibians, and other species.

3.6 – Selection of the National Ecosystem Restoration Plan

When selecting a single alternative plan for recommendation from those that have been considered, the criteria used to select the 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. Additional factors to consider include the following items.

3.6.1 – Partnership Context

This restoration project was planned in cooperation with the City of Highland Park. This restoration project makes a significant contribution to regional, national, and international programs that include the North American Waterfowl Management Plan, Lake-wide Management Plans, the ILDNR Coastal Zone Management Plan and the Alliance for the Great Lakes' plan to restore north shore ravines. The USFWS service has also indicated the importance of ravine restoration along the north shore of Lake Michigan.

3.6.2 – Reasonableness of Costs

All costs associated with a plan were considered and tests of cost effectiveness and incremental cost analysis have been satisfied for the alternatives analyzed. The cost estimate was reviewed by the Walla Walla District, which is the USACE's Civil Works Cost Engineering and Agency Technical Review Mandatory Center of Expertise (MCX). A risk analysis was also performed to establish the level of confidence associated with the estimated costs.

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 the Great Lakes in terms of habitat, and human uses has been documented through numerous sources. The importance of the Great Lakes to the nation was established through Executive Order 13340. As previously noted, the Great Lakes is one of the world's largest bodies of freshwater, providing drinking water, food, recreation, and aesthetics for about 32 million people.

In terms of non-monetary values, the ecosystem of the Ravine 10 natural area and its importance to the region is emphasized by the institutional significance of this area as identified by the Chicago Wilderness and the Alliance for the Great Lakes. Numerous studies by these groups identified resource impacts and subsequent restoration needs for the Great Lakes ecosystem. The conclusion is that restoration projects such as proposed can address the significant impairments to the aquatic ecosystem, which includes macroinvertebrates, fish, reptiles, aquatic dependent wildlife including waterfowl and piscivorous mammals.

3.6.3 – Risk and Uncertainty

When the costs and outputs of alternative restoration plans are uncertain and/or there are substantive risks that outcomes will not be achieved, which may often be the case, the selection of a recommended alternative becomes more complex. It is essential to document the assumptions made and uncertainties encountered during the course of 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. Other activities may have higher associated risks such as restoration of coastal marsh in an area subject to hurricanes. When identifying the NER/recommended plan, the associated risk and uncertainty of achieving the proposed 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 dropped from further consideration. However, it might be possible that, due to uncertainties beyond the control or knowledge of the planning team, the slightly more expensive plan will 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.

Native plantings have an associated risk of not establishing due to a variety of unforeseen events. Predation from herbivorous animals and insects is a possibility and can be reasonably estimated based on baseline surveys of the existing flora and fauna. However, weather also plays a large role in the establishment success of new plantings. Periods of drought or early frost may alter the survival percentage of plantings. Although historical records can help to predict the best possible location and timing of new plantings, single unforeseen events may lead to failure. To mitigate these risks, planting over several years, overplanting and/or adaptive management and monitoring may be incorporated into the overall plan. In addition, climate change in the years to come may play a role in impacting the project outcome. Increased temperatures or rainfall may lead to changes in the ecosystem of the project area; however, Lake Michigan primarily drives the weather in the Chicagoland area and may partly mitigate climate change concerns.

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, increasingly so when native species have not yet established. Changes in nutrient cycling processes and soil chemistry (due to impaired hydrology and prolonged invasive species establishment) further increases uncertainty with the eradication of invasive species. Measures that prevent further degradation to soils and measures that alleviate impaired hydrology, will help reduce the invasion on non-native species into the ecosystem which should lessen the risk and uncertainty associated with invasive species removal.

3.6.4 – The NER Plan

The plan that reasonably maximizes net national ecosystem restoration benefits, consistent with the Federal objective and USACE Policy, is identified as the national ecosystem restoration (NER) plan. Thus, the plan that maximizes net NER benefits and has shown great merit in the trade-off analysis will be a number of selected sites with their associated best buy alternative plans. The NER and recommended plan is Alternative Plan 7, which consists of stream morphology and connectivity improvements as well as ravine and bluff plant community restoration.

The NER plan would first perform minor grading and debris removal to prepare the new stream channel and banks for riffle placement. No piping or water diversion structures would be used to divert higher flows. The riffles are designed to specifically handle the larger urban derived flood pulses. Once the stream channel is in place, opportunistic trees and invasive species would be removed by the USACE, all areas will be planted with native species, and establishment activities would commence.

Repairs to an existing trail would be performed as a recreational feature. A discussion and preliminary design for trail repairs are found in Appendix A.

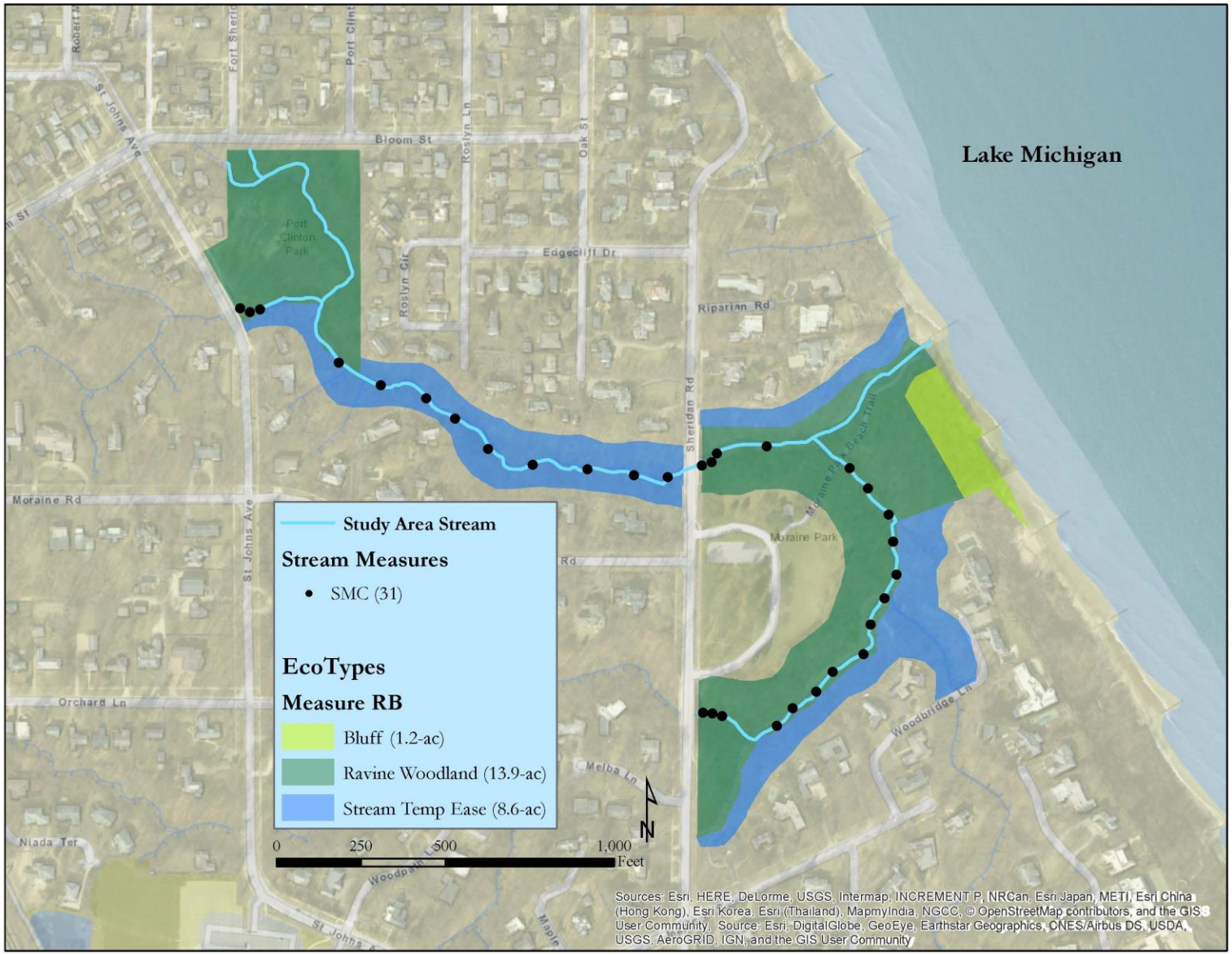


Figure 7 - The NER Plan

CHAPTER 4 – ENVIRONMENTAL ASSESSMENT*

This chapter involves identification of direct environmental effects to current conditions stemming from any of the proposed alternatives if they were to be implemented. An asterisk in the table of contents notes sections that are required for NEPA compliance.

4.1 – Need & Purpose

Historically, the Highland Park moraine was dominated by several naturally occurring communities including wetlands, forests, savannas and prairies. By the late 1800s, much of these communities, particularly prairies, savannas and wetlands, were converted to agricultural, urban or industrial use. Subsequently, there was a significant loss of biodiversity and adverse physical effects such as an increase in flooding events and a decrease in water quality. Furthermore, the remnant parcels of natural community types are under pressure from continued human activities. Human induced disturbances to the remaining natural areas include fire suppression, altered hydrology and hydraulics, increase colonization of invasive species and fragmentation. Specific problems that need to be addressed are detailed in Section 2.6.

Dune & Bluff – Recreation and residential development has had a major influence on the physical structure of coastal habitat and the processes that created and sustained these habitats. This has allowed invasive nonnative species to colonize these altered areas that no longer provide suitable life requisites for native species. Lacustrine process of littoral drift and wave/current patterns have been altered from their natural state through shoreline development; the construction of harbors, break walls, jetties, piers, etc. Coastal habitat can no longer rely on the natural replenishment and movement of sand down the coast since these structure now intercept a great deal of the material. Sand flats are located far enough from the shore as to not be effected by this; however, near shore, beach, dune and bluffs are dramatically affected by these altered conditions. It is apparent that littoral drift sands accumulate where humans have built structures and erode away from natural areas where there are no effective structures.

Ravine – The colonization and subsequent development of the land surrounding the north shore ravines has greatly accelerated the pace of the natural forces which first created them. The primary force responsible for the ravines' continued degradation is the increased volume of water flowing into and through them. The proliferation of impervious surfaces and turf grass within the subwatersheds has greatly increased the flow of rainwater runoff. The result is an increase in the quantity and velocity of water flowing through the ravine, which increases the rate of erosion. This condition combined with foreign debris within the channel bottom from previous failed stabilization structures has ultimately caused the ravine stream and bank habitats to become severely degraded to a point where the ravine currently does not provide fish with any habitat and minimal habitat for riparian macroinvertebrates and migratory birds.

4.2 – Alternatives Considered

Chapter 3 details the plan formulation process and how the NER plan was selected. An iterative screening process ultimately looked at 8 combinations for ravine restoration. The habitat output / cost comparisons identified several plans for ravine restoration that were incrementally justified cost wise for their additions of habitat benefits. After taking into considerations of habitat benefits, costs, USACE policy, risk and uncertainty and plan acceptability, completeness, efficiency, and effectiveness, the NER plan was selected. This plan consists of naturalizing stream velocities within the ravine, restoring connectivity to Lake Michigan, restoring the stream channel with alluvial material and riffles, removing invasive plant species and reestablishing native ravine and bluff plant species. The NER plan is depicted in **Figure 7.**

4.3 – The Affected Environment

The affected environment is described in detail in Chapter 2 – Inventory & Forecasting. In general, the ravine, dune and bluff habitats under consideration for ecological restoration activities outlined by this report are degraded. The ravine was originally formed by the erosive forces of stormwater interacting with the bluff (Highland Moraine), but became a conduit for stormwater as the watershed was developed. This has led to an increase in the volume of stormwater discharged into the ravine systems and has resulted in their prompt habitat degradation. The source of the unnatural water stems from impervious surfaces within Ravine 10 watershed. The watershed's collection system ends up at a discharge pipe at the head of Ravine 10. The water is discharged openly into the ravine where it flows until it reaches the beach and then into Lake Michigan. Ravine, bluff and dune plant communities have become degraded due to the presence of disturbed habitat. This has led to the reduction in richness and abundance of native plants over the entire site.

4.4 – Direct & Indirect Effects of the Preferred Plan

4.4.1 – Physical Resources

Climate

The minor scale of the proposed project would not be able to affect the regional climate. The increase in acreage of natural plant communities would increase evapotranspiration in a minor way, but still not great enough to affect weather patterns or rainfall within the region. No significant adverse effects are expected as a result of implementing the proposed project.

Geology & Glacial Stratigraphy

The proposed project would not adversely affect geology or glacial stratigraphy. All of the proposed features under the proposed project are too small in scale to affect the local geology and glacial stratigraphy.

Soils

The proposed project would result only in beneficial effects to natural soils. Currently at the study site, natural soils for the most part have already been destroyed. Only those soils along the ravines, upland edges and down the bluffs, and along the beaches are considered intact with the exception of disruption to their A horizons due to years of tilling, fertilization, carbon stripping, and overwatering. Through the reestablishment of natural flow regimes, return of native plant communities, and return of mycorrihizzal fungi/bacterial interactions, overtime the A horizons of these soils would heal, thusly feeding back to diversify the native plant and animal assemblages of those restored soils. Since the proposed project would be implemented in a fashion as to facilitate the return of natural soils structure, no significant adverse affects resultant from implementation of the project are expected.

Fluvial Geomorphology & Topography

Implementation of the proposed project would result in beneficial effects to fluvial geomorphology and natural topography within the project area limits. Restoration of the stream channel morphology will aid in the restoration of sediment transport and critical hydraulic parameters within the ravines. Fluvialgeomorphic processes would be further restored by removing invasive plant species that cause

stream banks to unravel and unnaturally erode. No adverse effects to fluvial geomorphology and topography are expected resulting from implementation of the preferred plan.

Littoral Processes

Implementation of the proposed project would not affect littoral processes since there are no measures planned for Lake Michigan under this study. No adverse effects to the littoral process, coastal geomorphology and topography are expected resulting from implementation of the preferred plan.

Hydrology, Hydraulics & Land Use

Hydrology: Implementation of the proposed project would result in minor changes to the current hydrology of the ravine that would promote a more healthier and diverse ecosystem. The natural hydrology of the ravine and bluff was impaired due to watershed development. The increased rainfall-runoff from the subwatersheds discharged into the ravine has greatly impaired the stability of the plant communities of these features. The proposed plan would be designed to work with the existing hydrologic regime of the ravine and bluff by installing cobble riffles and step pools. The project would not negatively or positively affect ground water in any manner since the land use cover types that are impairing groundwater are not being addressed under this project.

Hydraulics: Implementation of the proposed project would result in changes to the current hydraulics of the ravine to promote a more healthy and diverse ecosystem. The natural hydraulics of the ravines and coast were impaired due to watershed development. Increased rainfall-runoff from the tributary areas impaired the stability of the ravine side slopes and bed. The proposed plan would naturalize stream hydraulics of the ravine. The ravine hydraulics would be restored by removing manmade structures and riprap while increasing riffle/run complexes within the system. The project would not adversely affect fluvial or coastal hydraulics.

Land Use: Implementation of the proposed project would result in no changes to the current land uses since open space areas are conducive for restoring back to natural plant community cover types. Open space areas that would change typically consist of degraded natural plant communities or mowed turf grass. The proposed project would be implemented in a fashion as to restore land use instead of converting it; therefore, no significant adverse effects are expected.

Water Quality

The water quality of the storm water would be the same at the Lake Michigan discharge point with or without project conditions. The rate at which these storm water pulses flow through the open ravine allows no attenuation time for nutrients to be taken up by the vegetation or sediments to settle out, and in fact, the pulses pick up more sediment and organic matter (leaf litter) from the ravine and wash them into the lake. The sediment in the creek is clean so it does not affect water quality.

4.4.2 – Ecological Resources

Lacustrine Communities

The proposed project would ultimately improve native aquatic species richness and abundance. Restored stream connectivity to the lake would provide increased foraging and spawning habitat for littoral zone species (e.g. sand shiners and longnose dace) as well as some deep water species (e.g. lake chub and longnose sucker). There are no significant adverse effects expected to the Lacustrine Communities.

Beach Communities

Implementation of the proposed project would ultimately improve native floristic species richness and abundance within the beach and dune habitats by removing invasive species. There are no significant adverse effects expected to the Beach Communities.

Ravine Communities

Implementation of the proposed project would ultimately improve native floristic species richness and abundance within the ravines by repairing fluvial hydraulics, removing invasive species and seeding areas with native vegetation exhibiting local genotypes. There are no significant adverse effects expected to the Ravine Communities.

Bluff Communities

Implementation of the proposed project would ultimately improve native floristic species richness and abundance along the bluff by reducing overland stormwater flows, removing invasive species, and seeding areas with native vegetation exhibiting local genotypes. There are no significant adverse effects expected Bluff Communities.

Threatened & Endangered Species

Implementation of the proposed project would benefit endangered and threatened species if they were to colonize the project site. Currently, no Federal listed endangered or threatened species or their critical habitats have been recorded from the project site; however, numerous state listed species have been recorded. Restoration features would directly increase the quality of the habitat present at Ravine 10; hence potentially encouraging colonization or continued habitation of the area by state listed species such as the common tern (*Sterna hirundo*), longnose sucker (*Catostomus catostomus*), marram grass (*Ammophila breviligulata*), common juniper (*Juniperus communis*), downy Solomon's seal (*Polygonatum pubescens*), seaside spurge (*Chamaesyce polygonifloia*), and sea rocket (*Cakile edentula*).

Given the highly mobile nature of the long-eared bat, a restriction on tree removal between June 1 and July 31 will be imposed to reduce any potential for harm to maternal roosts.

Coordination with the USFWS and the Illinois Department of Natural Resources (IDNR) was commenced on April 04, 2019 with a project scoping letter. The USACE has concluded in this report that the project is not likely to adversely affect federal or state listed species, which precludes the need for further consultation for this project. It is expected that the USFWS will provide a letter of "No Objection" in response to the public/agency release of the NEPA document.

4.4.3 – Cultural Resources

Cultural & Social Properties

There are 43 properties and four historic districts listed on the National Register of Historic Places located within Highland Park. Only two properties, the Granville-Mott House (listed in 1982) and the Mary W. Adams House (listed in 1982) are located near the project area on the north side of Ravine 10. The proposed NER plan would have no adverse effects on either of these properties since they will be unaffected by implementation.

Archaeological & Historical Properties

The proposed project would have no adverse impact on archaeological or historic properties.

Areas of planned ecological restoration have been heavily modified. Channeled rainwater and drain runoff has heavily eroded the existing ravines. In the event cultural resources are discovered during this project, work in that area will stop and the Illinois State Historic Preservation Agency will be notified.

National Historic Preservation Act of 1966, 54 U.S.C. § 306108 – The proposed construction would have no adverse impact on archaeological or historic properties. The Illinois Historic Preservation Agency has been contacted in a letter dated April 04, 2019 and responded in a letter dated April 24, 2019 with their concurrence with a no adverse impact determination.

Native American groups having an historic cultural interest in northeast Illinois have been consulted.

In the event that cultural remains are discovered during the project, the Chicago District will be notified immediately and work will cease to allow for consultations with the Illinois State Historic Preservation Agency to take place.

Land Use History

The proposed project would result in beneficial effects to land use within the watershed. The proposed project would be implemented to restore an open space parcel to a more natural condition. Significant adverse effects as a result of implementing the proposed project are not expected to occur.

Social Properties

During construction, increased traffic congestion would be localized and intermittent. Employment could increase slightly during construction, and the region's labor force should be sufficient to provide the necessary workers. Noise levels would be increased during construction activities and increased truck traffic. Any aesthetic impacts would be negligible and temporary. The proposed project would have no significant adverse effect on human health or welfare, municipal or private water supplies, recreational or commercial fisheries, property values or aesthetic values.

Recreational Activities

The proposed project would not have any long-term adverse effects to recreation. Implementation of the plan could include compatible recreation opportunities (e.g. Walking Trails). Any impacts to adjacent recreational opportunities from construction of the proposed project would be short term and temporary in nature.

Environmental Justice

All of the proposed alternative plans would not cause adverse human health effects or adverse environmental effects on minority populations or low-income populations. 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 EPA EJView mapping tool revealed that within the portion of Highland Park containing the Ravine 10 project site, 0-20% of the population is considered below the poverty line and 0-30% of the population is considered a minority. Since the overall project is considered ecosystem restoration and will only benefit the surrounding environment and communities, no adverse effects to any low income populations and/or minority populations are expected.

4.4.4 – Hazardous, Toxic & Radioactive Waste (HTRW) Analysis

No HTRW, or recognized environmental conditions (RECs), were identified in the HTRW Phase I Environmental Site Assessment (ESA). The NER Plan would not result in the release of or influence to HTRW materials. Any debris removed from the ravine during implementation of the project, including stone, bricks, concrete, or drainage materials will be disposed as clean construction demolition debris (CCDD) in accordance with Federal, State, and local laws and regulations. Disturbed soils will be reused and stabilized on-site post-construction.

4.4.5 – 17 Points of Environmental Quality

The 17 points are defined by Section 122 of Rivers, Harbors & Flood Control Act of 1970 (P.L. 91-611). Effects to these points are discussed as follows:

Noise: Any of the alternative plans would cause minor and temporary increase in noise levels beyond the current conditions. The minor noise effects would stem from machinery utilized for grading banks, placing cobble riffles, removing manmade structures from the ravines and lake, and removal of trees and brush. Long term, significant effects in terms of noise is not expected.

Displacement of People: None of the alternative plans would displace local residents within the township of the study area since only open space parcels are proposed for restoration.

Aesthetic Values: None of the alternative plans would permanently reduce the aesthetic values of the study area. Temporary deteriorations in aesthetics would occur from herbicide application to stands of invasive species, temporary storage of debris piles, and graded areas of stream banks before native vegetation has established. These effects on aesthetics are minor and temporary as native plant species would sufficiently cover the ground after establishment. The removed foreign debris, removed invasive species, and restored plant communities would provide an increase in aesthetic values. This would be visually evident by a diverse mix of native wildflowers and grasses that would also attract new fish and wildlife species that would otherwise not be present without this restoration project.

Community Cohesion: None of the alternative plans would disrupt community cohesion. A constructed project would provide restored open space for community activities.

Desirable Community Growth: None of the alternative plans would adversely effect community growth and would potentially attract people to a more aesthetically pleasing area based on project restoration measures.

Desirable Regional Growth: None of the alternative plans would adversely effect regional growth.

Tax Revenues: None of the alternative plans would adversely or beneficially affect tax revenues.

Property Values: None of the alternative plans would have adverse effects on property values. A constructed project would have the potential to increase surrounding land values.

Public Facilities: None of the alternative plans would adversely effect Highland Park public facilities, but would provide a more natural and healthy open space.

Public Services: None of the alternative plans would adversely affect public services.

Employment: None of the alternative plans would adversely affect employment, but would temporarily increase employment during construction activities.

Business and Industrial Activity: None of the alternative plans would adversely or beneficially effect local commerce.

Displacement of Farms: None of the alternative plans would 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 effect man-made resources.

Natural Resources: The No Action Alternative allows for the continued degradation of native species, rare communities, and significant habitats. The proposed project would not adversely affect natural resources, but improve them greatly.

Air: Any of the alternative plans would have a similar *de minimis* impact on the area, due to construction equipment emissions. These emissions would be fully compliant with federal law, and would not rise to a level of significance under the Clean Air Act.

Water: None of the alternative plans would adversely affect water quality; however, ravine and in-stream features are expected to improve dissolved oxygen, sediment transport, and provide substrate for denitrifying bacteria.

4.5 – Cumulative Effects

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) have and will affect the same resources. In assessing cumulative effects, the key determinant of importance or significance is whether the incremental effect of the proposed action will 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 Council on Environmental Quality (CEQ) and 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.

The overall cumulative impact of the proposed Ravine 10 restoration project is considered to be beneficial environmentally, socially, and economically. The restoration ravine and bluff habitats will contribute to

the overall restoration and preservation of coastal habitat along the Highland Park Moraine and Zion Beach-Ridge Plain.

4.5.1 – 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 has been broadened to consider effects beyond the footprint of Ravine 10. The spatial boundary being considered is normally in the general area of the proposed ecological restoration; however, this area may be expanded on a case-by-case basis if some particular resource condition necessitates broadening the boundary.

Three temporal boundaries were considered:

- Past –1830s because this is the approximate time that the landscape was in its natural state, which included forested ravines, wet mesic/mesic forest and oak savanna.
- Present – 2020 when the decision is being made on the most beneficial ecological restoration
- Future – 2070, 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.

- Stable growth in both population and water consumption near the study area
- Sowing of native plants to return plant communities across the landscape
- Continued increase in tourism/recreation in the open spaces of the region
- Continued, but slowed urban development near the study area
- Continued application of environmental requirements such as those under the Clean Water Act
- Implementation of various programs and projects to deal with runoff and waste water pollution and to restore degraded environments
- Community will increasingly value not only the open space but the biodiversity as well
- Improvement to nearby natural areas such as Ravinia Bluff and Rosewood Park

4.5.2 – Cumulative Effects on Resources

Physical Resources

The topography, soils, hydrology, hydraulics and geomorphology of this area was significantly disturbed by past actions of vegetation stripping, draining, ditching, tilling, dumping, impervious surface creation and poorly functioning water use infrastructure. Cumulative effects of past practices and infrastructure have damaged in some way, shape or form the physical properties that are primary drivers to ecosystem diversity. Remedying the physical resource impairments would in some ways push the area back to a more naturalistic landscape. Naturalizing the hydraulics and native plant community of the ravine would produce a setting more representative of historical natural conditions of the area. Future actions such as

infrastructure upgrading may have damaging or beneficial effects in the future, and should thusly be part of the non-Federal sponsors operations and maintenance responsibilities to safeguard the future. Cumulative impacts of the proposed and combined future actions to the physical resources would be beneficial to the human environment, water resources and ecosystem sustainability.

Biological Resources

The project area lies upon the Highland Moraine geologic feature. Forested ravines, wet mesic/mesic forest and oak savanna typically dominated this area. Along with all of the Physical Resource impairments (primary drivers), the plant communities (secondary drivers), were all but completely eradicated for agriculture and urban space. These plant communities supported an enormous diversity of aquatic plants and animals that also aided in regulating hydrology and hydraulics. Cumulative effects of the past have decimated plant communities for thousands of species and reduced them to isolated patches scattered throughout the area. After naturalizing the past physical impairments, biological resource impairments would be reestablished as well, which in this case are the plants. This would set the stage for higher organism recolonization. Reestablishing the ravine, bluff and dune plant communities would produce spatial structure, food source and reproductive habitat for many native species. Future actions such as infrastructure upgrading may have damaging or beneficial effects and should be part of the non-federal sponsors' operations and maintenance responsibilities to safeguard the project's future. Cumulative impacts of the proposed and combined future actions to the biological resources would be beneficial to the human environment, water resources and ecosystem sustainability.

Cultural Resources

Adverse cumulative impacts to archaeological and cultural resources were inflicted by agriculture, construction of infrastructure, and residential development, which began in the 1800s. The landscape changed from a mosaic of ravine, forest, dune, and beach to an urbanized area. Although these probably increased the comfort of human life, it probably adversely affected archaeological and cultural resources strewn about the landscape. Proposed project features and foreseeable land use restoration would not adversely affect cultural resources because these parcels were already disturbed from their natural conditions and all of the work is surficial in nature. The quality of human life would not be adversely affected, but may see some improvement with the procurement of natural open spaces to escape the hardened urban landscape. The project would restore the current degraded nature of the ravine, bluff and dune plant communities. This will include removing non-native species and reestablishing vegetation. Reestablishing native vegetation and removing antiquated structures would only increase the aesthetic value of the project site. Cumulative impacts of the proposed and combined future actions to the cultural resources would be beneficial to the human environment, water resources and ecosystem sustainability.

4.5.3 – Cumulative Effects Summary

The overall cumulative effects of the Ravine 10 habitat restoration project are considered to be beneficial environmentally, socially and economically. The irreversible and irretrievable commitment of resources was not identified to be the result from implementation of the proposed action; NEPA 1502.16 (102(2)(C)(v)). Relationships between local short-term uses of man's environment and maintenance and enhancement of long term productivity would be swayed towards ecological recovery of Ravine 10; NEPA 1502.16 (102(2)(C)(iv)). No adverse environmental effects which cannot be avoided were identified should the proposal be implemented; NEPA 1502.16 (102(2)(C)(ii)).

The restoration of degraded ravine and bluff habitats, which were once part of a vast Lake Michigan coastal ecosystem, would contribute to increased acreage of viable open space and habitat within the

Great Lakes basin, while improving water quality, visual aesthetics and migratory bird habitat within the Lake Michigan portion of the Mississippi Flyway.

4.6 – Discussion of Environmental Compliance

The NER /Preferred Plan presented is in compliance with appropriate statutes and executive orders including the Endangered Species Act of 1973 as amended, 33 U.S.C. §§ 1251-1388; the Fish and Wildlife Coordination Act of 1934 as amended, 16 U.S.C. §§ 661-667g-2; Executive Order 12898 (Environmental Justice); Executive Order 11990 (Protection of Wetlands); Executive Order 11988 (Floodplain Management); and the Rivers and Harbors Act of 1899 as amended, 33 U.S.C. § 403; the Clean Air Act, as amended, 42 U.S.C. §§ 4701-7671q, and the National Environmental Policy Act of 1969, 42 U.S.C. §§ 4321-4347, as amended.

Environmental Justice EO 12898

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 shall 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. The preferred plan would not have any adverse effects to any populations including minority and low-income populations.

Clean Air Act

The local air quality in Lake County is considered 'non-attainment' under the Clean Air Act as amended, 42 U.S.C. §§ 4701-7671q, for ozone. The project is within the non-attainment zone. Due to the small scale and short duration of this project, the main sources of emissions would be vehicle emissions and dust associated with the construction activities. The project does not include any stationary sources of air emissions, and a General Conformity Analysis was not completed. The temporary mobile source emissions from this project, for any alternative, are *de minimis* in terms of the National Ambient Air Quality Standards and the State Implementation Plan. All construction vehicles will comply with federal vehicle emission standards. USACE and its Contractors comply with all Federal vehicle emissions requirements. USACE follows EM 385-1-1 for worker health and safety, and requires all construction activities to be completed in compliance with Federal health and safety requirements. The project is not expected to be a significant source of Green House Gas emissions.

Section 401 & 404 of the Clean Water Act

A Section 404 analysis was completed for the preferred plan. Features addressed by the 404 include the fill materials for stream restoration where cobble, gravel, sand and clean clays would be placed to mimic natural substrates. No adverse effects to water quality or aquatic habitat were determined.

Section 401 Water Quality Certification is granted under the U.S. Army Corps of Engineers, Chicago District Regulatory Branch Regional Permit 5, Wetland & Stream Restoration and Enhancement. All aspects and project features fall within the guidelines of this Regional Permit. All applicable information and analyses required to receive 401 Water Quality Certification were included as part of the study document. No adverse effects to water quality or aquatic habitat were determined.

USFWS Coordination

Coordination with the USFWS commenced with a project scoping letter dated 04 April 2019. The recommended plan was determined to have “no effects” on Federally listed threatened or endangered species or their habitats, which precluded Section 7. The USFWS provided an email on 25 April 2019 stating that they not aware particular issues that should be addressed and will be reviewing the NEPA documents once they are complete.

State of Illinois Historic Preservation Act

Pursuant to Section 106 of the National Historic Preservation Act (54 U.S.C. § 306108) and 36 C.F.R. Part 800, the staff of the Illinois State Historic Preservation Officer (Illinois SHPO) has conducted an analysis of the materials dated 04 April 2019. Based upon the documentation available, the staff of the Illinois SHPO has not identified any historic buildings, structures, districts, or objects listed in or eligible for inclusion in the National Register of Historic Places within the probable area of potential effects. Therefore the SHPO has no objection to the project. All areas affected by ground disturbance under this project have already been previously disturbed; therefore an archaeological survey is unnecessary and is consistent with the SHPO letter dated 24 April 2019.

Highland Park Steep Slope Ordinance

This project is in compliance with the Highland Park’s Steep Slope Ordinance (Ord. 38-01, J.27, p. 146-167, passed 6/25/01; Ord. 26-08, J. 34, p. 050-068, passed 4/14/08), which was passed to protect the natural conditions of these rare natural ravine landforms. Regulating the intensity of development according to the natural characteristics of steep slope terrain, such as degree of sloping, significant vegetation, and soil stability and existing drainage patterns, will allow for suitable development while minimizing the physical impact of such development on sensitive ravine and bluff steep slope areas. This project would restore and maintain natural ravine features, which is in support of this ordinance.

Coastal Zone Management Act

Coordination with the Illinois Coastal Management Program commenced with a project scoping letter dated 04 April 2019. A federal consistency application was initiated with a letter dated 31 July 2019. The proposed activities comply with Illinois’ approved coastal management program and will be conducted in a manner consistent with such policies.

Public Interest

An Environmental Assessment (EA) was prepared for the project and sent to Federal, State and local agencies along with the general public for review. A 30-day Public Review period was held from _____ to _____for the Environmental Assessment.

Conclusion

In accordance with the National Environmental Policy Act of 1969, 42 U.S.C. § 4332, and Section 122 of the River and Harbor Act of 1970, Pub. L. No. 91-611, 84 Stat. 1818, 1823, the U.S. Army Corps of Engineers has assessed the environmental impacts associated with this project. The purpose of this EA is to evaluate the impacts that would be associated with the restoration of about 27 acres at Ravine 10. The proposed project has been determined to be in full compliance with the appropriate statutes, executive orders and USACE regulations.

The assessment process indicates that this project would not cause significant effects on the quality of the human environment. The assessment process indicates that this project would have only beneficial impacts upon the ecological, biological, social, or physical resources of this area, and would provide environmental benefits to the Lake Michigan coastal zone and the Great Lakes as a whole. The findings indicate that that the proposed action is not a major Federal action significantly affecting the quality of the human environment.

CHAPTER 5 – DESCRIPTION OF THE NER PLAN*

5.1 – Plan Components

The National Ecosystem Restoration (NER) Plan is the recommended plan, which is Alternative Plan 7. All of the identified community types would have been represented within the pre-settlement coastal zone within the Chicago Region. The implementation of these features is generally described as follows and according to the measure descriptions in Section 3.1. A detailed set of plans & specifications would be created if approval of this Detailed Project Report (DPR) is granted.

Site Preparation – The first task would be to install safety fencing, signage and other safety features in order for public safety. Staging areas and access roads would be demarcated. All defunct surficial infrastructures would need to be removed and discarded or stockpiled and saved depending on the non-federal sponsor's needs.

SMC – Stream Morphology & Connectivity – This measure seeks to naturalize sediment transport and provide a connected stream within the study area. Small boulder/cobble riffles, J-hooks and other small stone structures would be placed at strategic points in the ravine stream channel as the primary method to address problems. These small stone structures would slow down channel down-cutting by backing up alluvial materials of silt, sand, gravel and small cobble; i.e. cover up pipes with natural alluvium. These structures are not intended to halt bank erosion, which is currently in a natural state and beneficial to stream habitat and substrate sequestration. At the same time, these stone structures would also provide stream connectivity in terms of flowing water and fish passage. To also naturalize sediment transport and restore stream habitat, foreign debris would be removed under this measure; foreign debris includes broken clay pipe and concrete, wire mesh from broken gabions, riprap from broken gabions and failed erosion measures, filter fabric and large pieces of plastic and construction material. Specific line items for this measure includes:

- Remove foreign debris and trash
- Install boulder/cobble structures
    - Riffles, J-hook, cross-vane, etc.
    - Glacial/fluvial stone, rounded to sub-angular

(RB) Ravine & Bluff Plant Community – This measure seeks to selectively remove invasive and opportunistic woody vegetation shading the ravine and bluff's understory. Selective shrub and tree clearance includes, but is not limited to, Common Buckthorn (*Rhamnus cathartica*), Glossy Buckthorn (*Frangula alnus*), European Highbush Cranberry (*Viburnum opulus*), Black Locust (*Robinia pseudoacacia*), Norway maple (*Acer platanoides*), White Mulberry (*Morus alba*), Green Ash (*Fraxinus lanceolata*), and European Privet (*Ligustrum vulgare*). This measure also includes the removal of invasive herbaceous species by spot application of herbicide as well as the incorporation of a prescribed burn. This measure would plant native species of local genotype that are known to inhabit lakeshore ravine and bluff communities; species harder to establish from seed will be introduced as plugs. Given the unique climate of lakeshore ravines and bluffs and the suite of rare flora that inhabit them, genetic preservation of species, including rare and state listed species, will be maintained by contract growth of certain species that currently reside in low numbers and/or which are not available commercially. Use of contract grown species from sources within the site and nearby areas not only preserves the unique genetics of the area, but also maximizes the success of establishment as local genotypes within or near the study area are more likely adapted to the harsh conditions presented by lakeshore bluffs.

Recreational Features – A trail would be restored and protected under this project. The trail provides incidental recreational benefits.

5.2 – Plans & Specifications

During the design phase, a detailed set of plans and specifications will be developed in order to solicit and award a construction contract. Also, prior to finalization of the plans and specifications, assurance will be made that all areas to be prepared by the non-federal sponsor shall be in compliance with ER 1165-2-132, Federal, State, and local regulations. A schedule, quality control plan, and labor estimate was fashioned along the FS QCP for the plans and specifications phase; if approval is granted to this project, the QCP would continue to be followed.

5.3 – Real Estate

The current non-federal LERRDs credit is detailed within the Real Estate Plan, Appendix C, and totals $405,000.

5.4 – Operation, Repair, Replacement and Rehabilitation

The OMRR&R costs of the project are estimated to total an annual cost of $49,000. The total cost of OMRR&R is calculated for 10 years and included into the total project cost. Slope maintenance includes the addition of stone or soil in certain areas that experienced minor erosion. Natural plant community maintenance includes the prevention of non-native and exotic species colonization and the addition of native species overtime. A detailed O&M Manual containing all the upkeep requirements will be provided to the non-federal sponsor after construction is closed out.

5.5 – Monitoring Plan

Section 2039 of WRDA 2007, 33 U.S.C. § 2330a, 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 can include a plan for monitoring the success of the ecosystem restoration for a period of up to ten years from completion of construction of an ecosystem restoration project This monitoring shall be a cost-shared.

A five year monitoring plan will be implemented for this project (**Appendix F**). The USACE, Chicago District would conduct monitoring in conjunction with the non-federal sponsors to determine the success of the project. The primary goal of this project is restore ravine, dune and bluff coastal communities in support of Great Lakes fishes, amphibians, reptiles, and migratory bird species. Baseline data for current conditions on Ravine 10 are detailed in this DPR. The following specific monitoring objectives were established to determine the effectiveness of this project:

- Restore ravine stream and riparian corridor habitat as measured by the presence of naturalized stream hydrology and hydraulics
- Improve native plant species richness and assemblage structure as measured by coefficient of conservatism of the Chicago Region Floristic Quality Index: Target Overall Mean C Score $\geq$ **5**
- Reestablish natural fluvialgeomorphic parameters (hydraulics, substrates) and structures to support riverine and riparian habitats within the study area. Improvement is measured via the predicted increase in quality of riverine habitat (QHEI)
- Eradicate/reduce the presence of non-native and invasive species: Target Invasive Species Eradication Percentage **<1% Areal Coverage**

5.6 – Division of Responsibilities

As established in Section 506 of WRDA 2000, as amended, 42 U.S.C. § 1962d-22, project costs are shared with the non-Federal sponsor in accordance with project outputs. The City of Highland Park and the Park District of Highland Park has agreed to serve as the local cost-sharing sponsor for the Ravine 10 506 Great Lakes Fishery & Ecosystem Restoration project. The cost-sharing requirements and provisions will be formalized with the signing of the Project Partnership Agreement (PPA) between the local sponsor and USACE prior to initiation of contract award activities. In this agreement, the local sponsor will agree to cost sharing requirements. Based on the cost sharing requirements, the total project cost (2019 price levels) and pertinent cost-sharing information for the restoration project are summarized in **Tables 12** and **13**.

Table 13 - Total Project Cost, FY 2019 PL

Item	**Cost**	
Feasibility Cost	$	308,000
Plans & Specifications	$	470,000
Implementation Ecosystem [1]	$	4,033,000
Implementation Recreation	$	1,395,000
OMRR&R	$	49,000
LERRDs	$	405,000
Total Project Cost	**$**	**6,660,000**
Cost Sharing (Ecosystem)		
65% Federal	$	3,222,050
35% non-Federal	$	1,734,950
Total Ecosystem Cost	**$**	**4,957,000**
Cost Sharing (Recreation)		
50% Federal Cost [2]	$	322,205
50% non-Federal Cost [2]	$	1,072,795
Total Recreation Cost	**$**	**1,395,000**

Notes:
[1] Includes Construction Management and Relocation costs
[2] Per Section 1140 of WRDA 2016, Pub. L. No. 114-322, 130 Stat. 1628, 1658, the Federal costs of recreation features may not exceed 10 % of the Federal ecosystem restoration cost of the project. All recreation costs in excess of 10% of the federal ecosystem restoration costs are 100% non-Federal responsibility.

Table 14 – Total Project Cost FY Breakout, FY 2019 PL

	FY19	FY20	FY21-26	Total Project Cost Share
Feasibility Phase				
Detailed Project Report[1]	$308,000			$308,000
Design and Implementation				
100% P&S		$470,000		$470,000
Restoration Features			$4,033,000	$4,033,000
Recreation Features[2]			$1,395,000	$1,395,000
OMRR&R			$49,000	$49,000
LERRDs			$405,000	$405,000
Total Project Cost	$308,000	$470,000	$5,882,000	**$6,660,000**
Fed/ non-Fed Breakdown				
Federal share	$235,200	$305,500	$3,238,755	$3,779,455
non-Federal	$72,800	$164,500	$2,643,245	$2,880,545
non-Federal cash/WIK				$2,475,545
100% non-Federal LERRD				$405,000

Notes:
[1] First $100,000 of the Feasibility Study is a 100% Federal Cost
[2] Per Section 506 of WRDA 2000, The Federal costs of recreation features may not exceed 10 % of the Federal ecosystem restoration cost of the project. All recreation costs in excess of 10% of the federal ecosystem restoration costs are non-Federal responsibility.

Responsibilities

Federal - The estimated Federal cost share for implementation of the project is about $3,779,455. The USACE would accomplish the plans and specifications phase, which includes additional design studies and plans and specifications, contract for construction, overall supervision during construction, prepare an operation and maintenance manual, and participate in a portion of the post construction monitoring.

Non-Federal Responsibilities - Prior to initiation of the design phase, the Federal Government and the non-Federal sponsors will execute a PPA. The LERRDs and OMRR&R of the project will be the responsibility of the non-Federal sponsors for the proposed project. The estimated non-Federal cost share for implementation of the project is about $2,880,545 and will be covered by LERRDs credit of $405,000 and a cash contribution of $2,475,545. The non-Federal sponsors shall, prior to implementation, agree to perform the following items of local cooperation:

1. Provide 35 percent of the separable project costs allocated to environmental restoration as further specified below
   a) Provide the non-Federal share of all complete planning and design work upon execution of the PCA
   b) Provide all lands, easements, and rights-of-way, including suitable borrow and dredged or excavated material disposal areas, and perform or ensure the performance of all relocations determined by the government to be necessary for the construction and O&M of the project
   c) Provide or pay to the government the cost of providing all features required for the construction of the project

d) Provide, during construction, any additional costs as necessary to make its total contribution equal to 35 percent of the separable project costs allocated to environmental restoration

2. Provide all recreation costs in excess of 10 percent of the federal ecosystem restoration costs.
3. Contribute all project costs in excess of the USACE implementation guidance limitation of $10,000,000
4. For so long as the project remains authorized, operate, maintain, repair, replace, and rehabilitate the completed project or the functional portion of the project at no cost to the government in accordance with applicable federal and state laws and any specific directions prescribed by the government
5. Give the government a right to enter, at reasonable times and in a reasonable manner, upon land that the local sponsor owns or controls for access to the project for the purpose of inspection and, if necessary, for the purpose of completing, operating, maintaining, repairing, replacing, or rehabilitating the project
6. Assume responsibility for operation, maintenance, repair, replacement, and rehabilitation (OMRR&R) of the project or completed functional portions of the project, including mitigation features, without cost to the government in a manner compatible with the project's authorized purpose and in accordance with applicable federal and state laws and specific directions prescribed by the government in the OMRR&R manual and any subsequent amendments thereto
7. Comply with Section 221 of Public Law (P.L.) 91-611, Flood Control Act of 1970, as amended, and Section 103 of the WRDA of 1986, as amended, 33 U.S.C. § 2213, which provides that the Secretary of the Army shall not commence the construction of any water resource project or separable element thereof until the nonfederal sponsor has entered into a written agreement to furnish its required cooperation for the project or separable element
8. Hold and save the United States free from damages due to construction of or subsequent maintenance of the project except those damages due to the fault or negligence of the United States or its contractors
9. Keep and maintain books, records, documents, and other evidence pertaining to costs and expenses incurred pursuant to the project to the extent and in such detail as will properly reflect total project costs
10. Perform or cause to be performed such investigations for hazardous substances that are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), 42 *U.S. Code* 9601 through 9675, that may exist in, on, or under lands, easements, or rights-of-way necessary for the construction, and O&M of the project, except that the nonfederal sponsor shall not perform investigations of lands, easements, or rights-of-way that the government determines to be subject to navigation servitude without prior written direction by the government
11. Assume complete financial responsibility for all necessary cleanup and response costs for CERCLA-regulated material located in, on, or under lands, easements, or rights-of-way that the government determines necessary for the construction and O&M of the project
12. To the maximum extent practicable, conduct OMRR&R of the project in a manner that will not cause liability to arise under CERCLA
13. Prevent future encroachment or modifications that might interfere with proper functioning of the project
14. Comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, P.L. 91-646, as amended in Title IV of the Surface Transportation and Uniform Relocation Assistance Act of 1987, P.L. 100-17, and the uniform regulation contained in Part 24 of Title 49, *Code of Federal Regulations* (CFR), in acquiring lands, easements, and rights-of-way for construction and subsequent O&M of the project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said acts
15. Comply with all applicable federal and state laws and regulations, including Section 601 of Title VI of the Civil Rights Act of 1964, P.L. 88-352, and Department of Defense Directive 5500.11 issued pursuant thereto and published in 32 CFR, Part 300, as well as Army Regulation 600-7 entitled "Non-Discrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army"
16. Provide 35 percent of that portion of the total cultural resource preservation, mitigation, and data recovery costs attributable to environmental restoration that are in excess of
    1 percent of the total amount authorized to be appropriated for environmental restoration
17. Do not use federal funds to meet the nonfederal sponsor's share of total project costs unless the federal granting agency verifies in writing that the expenditure of such funds is expressly authorized by statute

Financial Capability of 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.

CHAPTER 6 – RECOMMENDATION*

I have considered all significant aspects of the problems and opportunities as they relate to the project resource problems of the Ravine 10 natural area. Those aspects include environmental, social, and economic effects, as well as engineering feasibility.

I recommend Alternative Plan 7, the NER /Preferred Plan, which consists of establishing a diverse ravine stream and riparian habitat. The recommended plan has a total project cost of approximately $6,660,000 (2019 price levels). This plan provides 7.48 net average annual habitat units over about 27 acres of coastal zone. All costs associated with the restoration of Ravine 10 natural area ecosystem have been considered.

_____

Aaron W. Reisinger
Colonel, U.S. Army
District Commander

CHAPTER 7 – BIBLIOGRAPHY AND ACRONYMS*

Chotkowski, M.A. and J.E. Mardsen. 1995. Reproductive Success of Stocked Lake Trout in Southwestern Lake Michigan. Illinois Natural History Survey. Aquatic Ecology Technical Report 95/12.

Chrzastowski, M. J. and C. B. Trask, 1995, Nearshore geology and geologic processes along the Illinois shore of Lake Michigan from Waukegan Harbor to Wilmette Harbor: Illinois State Geological Survey, Open File Series 1995-19, Champaign, IL, 93 p.

Chrzastowski, M. J. and C. B. Trask, 1995, Nearshore geology and geologic processes along the Illinois shore of Lake Michigan from Waukegan Harbor to Wilmette Harbor: Illinois State Geological Survey, Open File Series 1995-19, Champaign, IL.

Colman, S. M. and D. S. Foster, 1994, A sediment budget for southern Lake Michigan: source and sink models for different time intervals: Journal of Great Lakes Research, v. 20, no. 1, pp. 215-228.

Fant, Jeremie A., R.M. Holmstrom, E. Sirkin, J.R. Etterson, and S. Masi. "Genetic Structure of Threatened Native Populations and Propagules Used for Restoration in a Clonal Species, American Beachgrass (Ammophila breviligulata Fern.)." Restoration Ecology 16 (1998): 594-603.

Horns, W.H. 1991. Site Specific Substrate Mapping of Julian's Reef. Illinois Natural History Survey. Aquatic Ecology Technical Report 91/7.

Jass, J., and B. Klausmeier. 2000. Endemics and Immigrants: North American Terrestrial Isopods (Isopoda, Oniscidea) North of Mexico. Crustaceana 73:771-799.

Rovey, C.W. and M.K. Borucki. 1994. Bluff evolution and long-term recession rates, southwestern Lake Michigan: Environmental Geology, v.23, pp. 256-263.

Willman, H. B., 1971, Summary of the geology of the Chicago area: Circular 460, Illinois State Geological Survey, Urbana, IL.

U.S. Army Corps of Engineers. 1953, Illinois shore of Lake Michigan beach erosion control study: 83rd U.S. Congress, 1st Session, House Doc. 28, 137 p. plus 5 appendices.

U.S. Army Corps of Engineers. Recent US Climate Change and Hydrology Literature Applicable to US Army Corps of Engineers Missions – Great Lakes Region 04. Civil Works Technical Report, CWTS-2015-07, USACE, Washington, DC, April 2015.