2014

Ft. Sheridan Ravine & Coastal Restoration

Section 506 Great Lakes Fishery & Ecosystem Restoration (GLFER)

Detailed Project Report & Integrated Environmental Assessment

Chicago District
US Army Corps of Engineers
11/07/2014

Ft. Sheridan Ravine and Coastal Restoration
Detailed Project Report & Integrated Environmental Assessment

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EXECUTIVE SUMMARY

Four non-Federal sponsors, the Lake County Forest Preserve District (LCFPD), Openlands, the Town of Ft. Sheridan, and the City of Lake Forest have requested that the Chicago District, USACE initiate a study under Section 506 Great Lakes Fishery and Ecosystem Restoration to ascertain the feasibility of restoration features to restore the ecological integrity of the combined Ft. Sheridan natural areas. This study evaluates the feasibility and environmental effects of restoring ravines, bluffs and littoral (lacustrine) areas. The scope of this study addresses the issues of altered hydrology and hydraulics, native plant community preservation, invasive species, connectivity, rare wetland communities, native species richness and encourages public education. This Feasibility Report and Integrated Environmental Assessment will assess and identify problems and opportunities, identify and evaluate measures, and recommend and design the most cost effective and feasible solution to the ecological problems and opportunities currently existing within the area of study

The study area is part of the northeastern Illinois coastline of Lake Michigan; bounded by Lake Michigan to the east and Sheridan Road to the west. The southern limits include the Schenck Ravine watershed while the northern limits include the McCormick Ravine watershed. Municipalities include the City of Lake Forest, Town of Ft. Sheridan and City of Highland Park, which may be found on the USGS Highland Park Quad Map, Illinois. The two main geologic features of the study area are Lake Michigan and the Highland Park Moraine, which posses various natural features, including eight (8) mature ravines, several small forming ravines, bluff, beach, and sand flats of Lake Michigan.

Historically, the Highland Park Moraine, which the Ft. Sheridan natural area resides, 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, urbanization pressures and fragmentation.

An iterative screening/formulation process ultimately looked at 432 combinations for ravine restoration, 96 for lacustrine restoration and 6 for bluff restoration. The habitat output / cost comparisons identified 7 plans for ravine restoration, 7 plans for lacustrine restoration and 1 plan for bluff restoration that were incrementally justified cost wise for their additions of habitat benefits. After considerations of habitat benefits, costs, risk and uncertainty and plan acceptability, completeness, efficiency, and effectiveness, the NER plan was selected. These plans consist of fully restoring 5 ravines, 40-acres of bluff and about 1.5 miles of coastal lacustrine and dune habitat. This report recommends that Ravine Plan 4, Lacustrine Plan 4, and Bluff Plan 2, which consists of establishing a diverse coastal habitat mosaic within the Ft. Sheridan natural area, are the NER/Preferred Plan. The recommended plan has a total project cost of approximately $__ (2014 price levels). This plan provides 890.6 net average annual habitat units over 200.2-acres of coastal zone. All costs, benefits and effects associated with the restoration of the Ft. Sheridan natural area ecosystem have been considered to an appropriate level of detail.

CHAPTER 1 – INTRODUCTION

1.1 – Report Organization

This Detailed Project Report (DPR) presents the results of the Ft. Sheridan Ravine and Coastal Ecosystem Restoration study. This report consists of eight (8) parts including a main report and seven appendices with figures and tables. The report is structured as follows:

Appendix A – Hydrology & Hydraulics Analysis
Appendix B – Civil Design
Appendix C – Cost Engineering (intentional excluded)
Appendix D – Geotechnical Analysis
Appendix E – Hazardous, Toxic, and Radioactive Waste (HTRW) Report
Appendix F – Real Estate Plan (intentionally excluded)
Appendix G – Coordination, 404b1, Draft FONSI
Appendix H – Monitoring Plan

*1.2 – Study Authority

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

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; and
(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; and
(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.

(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) of this section 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) of this section 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) of this section.

(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.

(g) Authorization of appropriations

(1) Development of plan- There is authorized to be appropriated for development of the plan under subsection (c)(1) of this section $300,000. Other activities- There is authorized to be appropriated to carry out paragraphs (2) and (3) of subsection (c) of this section $100,000,000.

*1.3 – Study Purpose & Background

Prior to European settlement, the Lake Michigan coastal zone was 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 much larger pre-historic lake than present Lake Michigan. These landforms and the unique coastal climate combined to host a diverse ecosystem that included densely wooded ravines and savannas, an array of herbaceous plants uniquely suited to the ravines, and bluff faces and beaches, all of which provide for a diverse suite migratory bird species. First logging, and then the establishment of Ft. Sheridan in 1887 by the US Army, removed much of this unique vegetation and also altered the landforms. Also, extensive watershed development has caused the ravine morphology to become impaired. With Fort Sheridan now in public ownership, opportunity exists to weave together remnants of this rare ecosystem.

Four non-Federal sponsors, the Lake County Forest Preserve District (LCFPD), Openlands, the Town of Ft. Sheridan, and the City of Lake Forest requested that the Chicago District, USACE initiate a study under Section 506 Great Lakes Fisheries and Ecosystem Restoration to ascertain the feasibility of restoration features to restore the ecological integrity of the combined Ft. Sheridan natural areas. This study evaluated the feasibility and environmental effects of restoring ravines, bluffs, lacustrine and littoral areas. The scope of this study addressed the issues of altered hydrology and hydraulics, native plant community preservation, invasive species, connectivity, rare wetland communities, native species richness and encourages public education. This Feasibility Report and Integrated Environmental Assessment assessed and identified problems and opportunities, identified and evaluate measures, and

recommended the most cost effective and feasible solution to the ecological problems currently existing within the area of study.

1.4 – Study Area

The study area is part of the northeastern Illinois coastline of Lake Michigan (**Figure 1**); bounded by Lake Michigan to the east and Sheridan Road to the west. The southern limits include the Schenck Ravine watershed while the northern limits include the McCormick Ravine watershed (**Figure 2 & Plate 1**). Municipalities include the City of Lake Forest, Town of Ft. Sheridan and City of Highland Park, which may be found on the USGS Highland Park Quad Map, Illinois. The two main geologic features of the study area are Lake Michigan and the Highland Park Moraine, which posses various natural features, including eight (8) mature ravines, several small forming ravines, bluff, beach, and sand flats of Lake Michigan.

Figure 1 – Fort Sheridan Study Area, Southern Lake Michigan View.

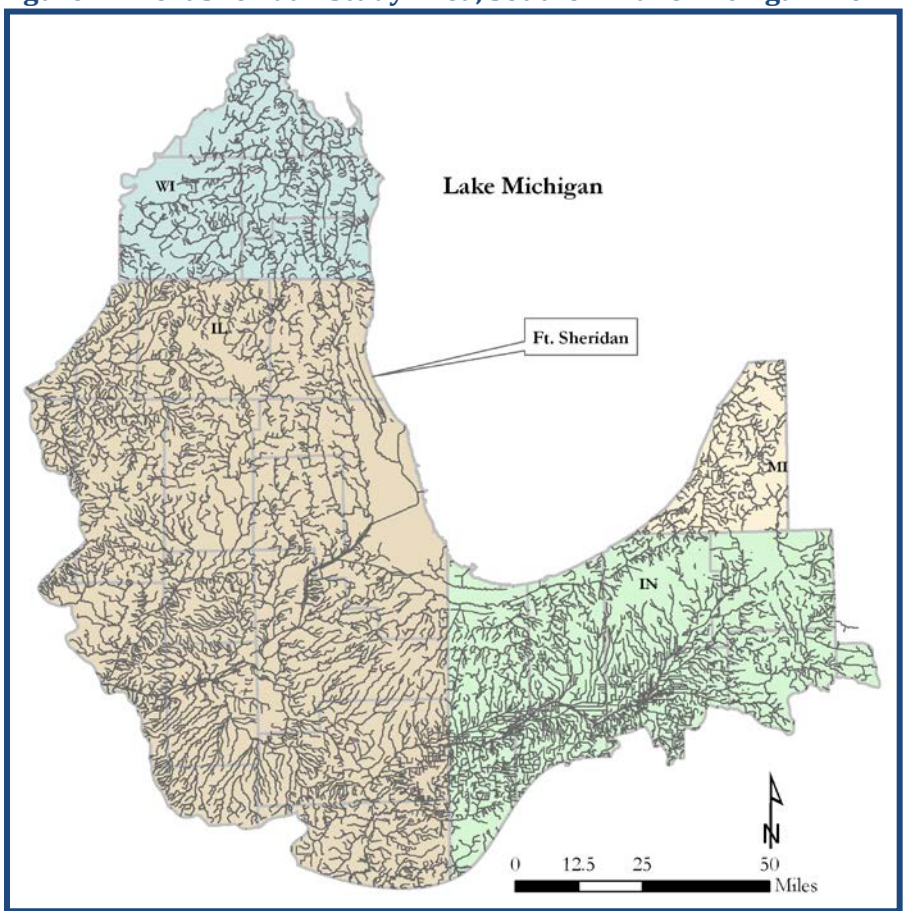
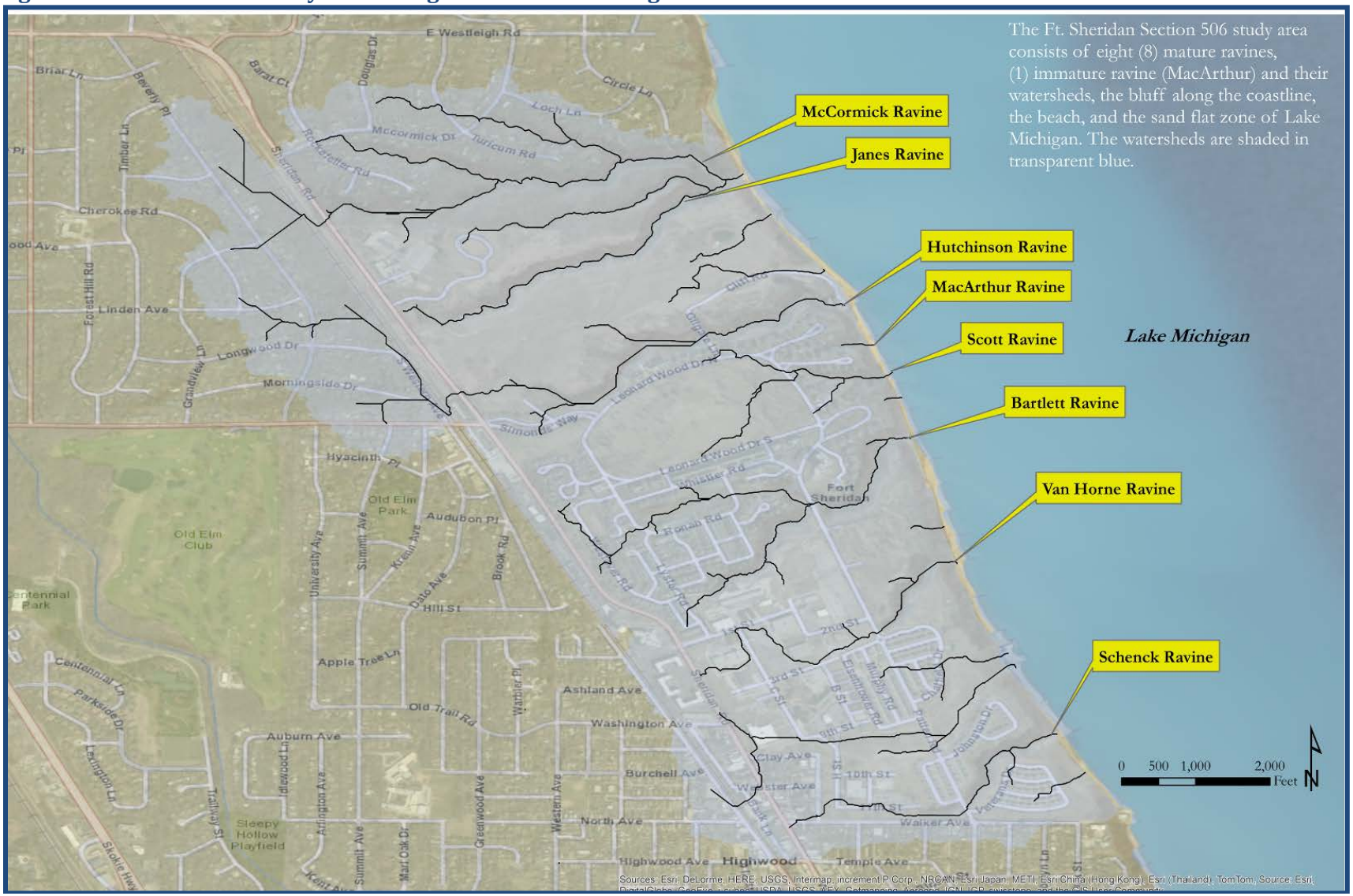


Figure 2 – Fort Sheridan Study Area along Coast of Lake Michigan.



1.5 – Pertinent Reports, Studies & Projects

Reports & Studies

- Lake County Forest Preserve. October 2003. Fort Sheridan Property Natural Resources Restoration Plan.

On February 25, 2003 the FPDLC adopted the Fort Sheridan Master Plan to guide the project. During and beyond renovation, the FPDLC is seeking to protect, enhance, and restore the substantial natural resources that remain. The rich natural resources of the site were recognized when the original Ft. Sheridan land plan was developed in the 1880's. In plant inventories conducted as part of Natural Resource Restoration Plan development, over 240 plant species (nearly 200 native) were encountered at the site, including listed species. This is a stunning array of vegetative diversity. The FPDLC has committed to the restoration of these remnant natural resources. There is no other public land like it on the lakeshore. Additionally, the site enjoys unique status as a retired military facility with a rich history and tradition. This plan describes how the FPDLC will protect and restore Fort Sheridan's natural resources.

- Openlands. October 2008. Openlands Lakeshore Preserve Existing Conditions Report.

The purpose of this report is to present the findings of an investigation of the existing conditions at the Openlands Preserve. The investigation included general information on the stormwater, ground water, and erosion with the Bartlett, Van Horne and Schenck Ravines, and the Lake Michigan bluff. A more detailed evaluation of the storm water system within Bartlett Ravine was performed. As well, a more detailed evaluation of the soils along the Lake Michigan bluff. The purpose of this investigation was to set the ground work for the restoration planning that was to follow.

- Openlands. January 2009. Bartlett Ravine Master Restoration Plan.

The purpose of this plan is to present recommendations, restoration treatments, and general specifications to support the restoration and to work towards long term sustainability of the ravine's unique physical, biological, and human landscape. Throughout the Plan, discussion of restoration activities is divided into three major project components: vegetation, stormwater and geotechnical (i.e. soil and slope stability). Recommendations of restoration treatments for each of these components as well as subsequent implementation of monitoring and management activities are intended to restore and preserve the unique ravine habitat for future generations.

- 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 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.

Pertinent Information

- Ft. Sheridan Ordinance & Anomalies Assessment
- Ft. Sheridan Flora & Planting Plans
- Ft Sheridan Remediation Plans & Specs
- Jane's Ravine Plans & Specs
- Scott Ravine Inspection Report June 09
- Greengard In Ravine Pipe Drawing and Cost Estimate July 09
- Greengard Infeasible Leonard Wood's Detention Basin Plan Dec 08
- Greengard Infeasible Ravine Detention Plan Jun 09
- Greengard Pre and Post Development Watershed Report Oct 08
- HH Holmes Boring Analysis Rpt Sec 1 of 5 July 08
- Shabica Site Inspection Rpt- Fall 08
- Scott Ravine Prop Weir Detail
- Scott Ravine Weir Plan view
- Scott Ravine Existing Weir Detail

Projects

- Section 104 Estuary Habitat Restoration Program – Ft. Sheridan Coastal Restoration Project

The responsible lead agencies for the project are the U.S. Army Corps of Engineers, Chicago District and the LCFPD. This project is currently in the monitoring phase. The Corps portion of the project established native wetland swale plant community within the stormwater bypass channel. The project was directed at restoring presettlement flows to Janes Ravine and partially to Hutchinson Ravine. Extensive ravine slope destabilization and erosion was identified and is the result of increased stormwater entering from surrounding urban development. The project removed stormwater flows from the ravine by re-routing them through a series of upland vegetated swales and ponds since space was available. Ravine streambank and slope stabilization restoration methods have been identified, which includes the placement of channel grade controls, stone, as well as regrading and filling, and the placement of erosion control matting and coir rolls. The selected plan involved:

- Re-routing runoff drainage from areas west of Janes Ravine away from the ravine and across the uplands via vegetated swales to an existing pond and then into Lake Michigan.
- Stabilize ravines by a combination of BMP techniques such as filling in erosion cuts to stabilize toes of slope; stabilize moderate and severe side slope erosion gullies using large anchored logs. These structures are made from large cut tree logs that are anchored into the side slopes and/or stream channel to stabilize eroding areas. Fill is placed behind these anchored logs then covered with special erosion control fabric matting followed by planting native species.
- Protect eroding ravine side slopes using deflection structures i.e. riffles
- Grade ravine bottoms in selected location to direct flow into historic channel to stabilize eroded areas

This study will pick up where the Estuary Habitat Restoration project left off. Removing the remaining portion of urbanized flows from the Hutchinson Ravine along with native plant community restoration within Janes and Hutchinson Ravines and the riparian space between the two ravines was the focus of this study and was not addressed by the Estuary Habitat Restoration project.

*CHAPTER 2 – AFFECTED ENVIORNMENT (INVENTORY/FORECAST)

Consideration of ecosystems within or encompassing a watershed provides a useful organizing tool to approach ecosystem-based restoration planning. Ecosystem restoration projects that are conceived as part of a watershed planning initiative or other regional resources management strategies are likely to more effectively meet ecosystem management goals than those projects and decisions developed independently. The Ft. Sheridan ravine and coastal restoration project was undertaken as a watershed based planning study for ecosystem restoration purposes, primarily to quantify the amount of water flowing through the ravines. The following chapter outlines the past, present and future without-project conditions of the seven ravine watersheds and coastal environments, both ecological and human.

2.1 – Current Conditions

2.1.1 – Physical Resources

Climate

The climate in northeastern Illinois and southeastern Wisconsin is classified as humid continental, characterized by warm summers, cold winters, and daily, monthly, and yearly fluctuations in temperature and precipitation. Average annual rainfall is usually between 30 to 40 inches per year, with greater amounts falling between April and August. Annual seasonal snowfall averages approximately 28 inches. Early spring floods occur when snow accumulations extend into a period of increasing temperatures that result in melting. If extensive melting of accumulated snow occurs when soils are already saturated, the associated runoff increases dramatically because of the large area of impervious surfaces located within the basin, which are largely a result of urban development.

Geology & Glacial Stratigraphy

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 (**Plate 02**). 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, in this case it is the face of the Highland Park Moraine.

Analysis of the till exposed in the bluffs indicate that a typical sediment size distribution is 48 percent clay, 42 percent silt, and 10 percent sand (Chrzastowski 1995). When bluff erosion occurs, only the sand-size material ultimately remains along the beaches and nearshore. The dominant clay and silt are transported offshore for eventual deposition in deep water (Colman and Foster 1994). The grayish or milky coloration that is common along the Illinois coast following times of large waves results from the suspension of the silt and clay from erosion along the bluffs or across the lake bottom.

The thickness of the till sequence above the bedrock is variable depending on the surficial landscape or lake-bottom topography compared to the subsurface bedrock topography. In general, within the Illinois coastal area, the thickest sequence of till occurs in Lake County where thickness can be 300 to 400-feet.

Highland Park Moraine – Along the coast between North Chicago and Winnetka, the lakeshore and the 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 Highland Park Moraine encompasses the entire study area. 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 some public lakeshore reaches. A discontinuous bluff face results from a series of steep-sided, V-shaped ravines that open to the lakeshore. These ravines are cut into the morainal and originate as much as one mile inland from the shore. The ravines typically have intermittent streams that discharge to Lake Michigan.

Soils

Natural soils within the Ft. Sheridan study area have been destroyed for the most part. Areas of natural soil are currently present in and along the ravines, down the bluffs, and along the sandy beaches fed by littoral currents (**Plate 03**). Natural soil may be undisturbed in some of the parkland areas, but is unlikely do to the historical uses of these sites.

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 bluffs.

Orthents – The former ravine at the naval base is classified as Orthents type soil by the NRCS. Naturally, Orthents are recently eroded material stemming from steep terrain. These soils are defined as Entisols that lack horizon development due to either steep slopes or parent materials that contain no permanent erodible minerals. Typically, Orthents are exceedingly shallow soils. They are often referred to as "skeletal soils" or Lithosols. The basic requirement for recognition of an Orthent is the lack of soil horizons and its rocky nature; this material was used to fill some of the ravines.

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. This is the predominant soil series type in the Ft. Sheridan study area although at least 75% of its extant has been converted to residential land use.

Ashkum – These soils are typically found on nearly level and gently sloping till plains of Wisconsinan Age in colluvial positions on the low lying topography and along upland swales. The soils formed in colluvial sediments consisting of eroded sediments from till and loess or shallow lacustrine materials less than 40-inches thick and in the underlying silty clay loam till. Slope gradients commonly are less than 1%and range from 0 to 3%. These soils are poorly drained and the potential for surface runoff is low. Permeability is moderately slow. Saturated hydraulic conductivity is moderately high. Where drained, an

intermittent apparent seasonal high water table is 0.5 foot above the surface to 1.0 foot below the surface at some time between January and May in normal years. Native vegetation is marsh grasses and sedges. This soils series no longer exists in the watershed due to conversion for residential uses.

Blount These soils formed on the till plains of Wisconsinan Age glacial material. Slopes commonly are 1 to 3% and range from 0 to 6%. The soils formed in silty clay loam or clay loam till. Some areas have a mantle of loess or other silty material as much as 18-inches thick. These soils are somewhat poorly drained and the potential for surface runoff is low to medium. Permeability is slow. An intermittent perched seasonal high water table is at a depth of 0.5 to 2.0 feet in most years. Native vegetation is hardwood forest. This soils series no longer exists in the watershed due to conversion for residential uses.

Landfills – These are highly modified areas where industrial or commercial wastes are buried. Soil characteristics are unpredictable and are limited for restoring native plant communities.

Fluvial Geomorphology & Topography

The Ft. Sheridan ravines 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 present ravines. Local relief is about 157-feet; a maximum elevation of 725-feet is reached along the crest of the Highland moraine, with the lowest elevation of 568-feet at the bottoms of the ravines and the Lake Michigan shoreline (**Plate 04**).

Ravine Formation – As the ravines continued to deepen and widen overtime, the depth of the stream bed toward the mouth of the ravine reached the level of Lake Michigan. As the slope of the channel flattened out upstream, the speed of water flowing through the ravine slowed. The rate of channel incision and bank slumping declined and equilibrium was then maintained from sediment/detritus influx equal to the amount of sediment discharged into Lake Michigan. The heads of the ravines continued to extend landward until they ran into non-erosive materials or lost their erosive power. In newly forming ravines, channel incision and mass wasting made it difficult for a diverse plant community to establish as the ravine widened and the slope of the banks decreased. Once the dynamic equilibrium was achieved, 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 water. This positive feedback cycle eventually resulted in the mature ravines capable of supporting a diverse community of fungi, plants, and animals. Specific details on each ravine may be found in the Alliance for the Great Lakes 2009 Report described in Section 1.5. The report is available at Great Lake.org.

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 lake from the southeast, resulting in a circulatory pattern moving along the Illinois shoreline in a counterclockwise direction. The resultant wave climate along this reach is relatively small. Beginning in late fall and continuing until spring; however, these trends reverse. Northerly winds drive waves towards the southern end of Lake Michigan generating a significantly larger wave climate. The dominant influence by northerly waves results in a net southward littoral drift along the entire Illinois coast. Waves from the southeast can influence a northward movement of beach and nearshore sediment of sand, gravel and cobble, however; the stronger northerly waves counteract this influence and produce a net southerly transport.

The Illinois coast was formerly a single continuous pathway for the southward transport of littoral sediment. This was part of a large-scale littoral transport cell that originated in Wisconsin near Sheboygan and terminated in eastern Indiana along the Indiana Dunes (Chrzastowski et al 1994). If no anthropogenic influences would have interfered with coastal erosion processes, and historical lake levels were maintained, in a thousand years the bluff coast at Ft. Sheridan would erode landward to an equilibrium position (Rovey & Borucki 1994). During this process, rates of erosion would decrease with time; however, the Illinois coast has experienced considerable reduction in the volume of littoral sediment in transport due to anthropogenic modifications. Construction of perpendicular structures such as jetties, piers and small boat harbors formed near-total barriers to littoral transport, fragmenting a continuous littoral cell into a series of cells. Coastal structures, particularly in the vicinity of Chicago have completely isolated the southern Chicago lakeshore from any littoral sediment supply from the south.

Long-term reduction in the volume of littoral sediment transport has occurred along the bluff coast. In the 1950s the USACE computed a maximum littoral transport rate along the bluff coast of 57,000-cyd/year (USACE 1953). Dredge records for sand captured at Wilmette Harbor near the south down-drift end of the bluff coast suggest that the present day bluff coast littoral transport is one third or less of what it was in the early 1950s. Only along the southern part of Illinois Beach State Park are present-day littoral transport volumes of about 80,000-cyd/year at or near what likely occurred in the natural setting. This volume of littoral transport is dependent on a sediment supply from Wisconsin sands as well as beach nourishment supplied by the State of Illinois.

The accretion of sand, gravel and cobble behind groins in the vicinity of the Fort Sheridan Ravines are consistent with transport occurring from the north to the south. Aerial photographs taken over several years do not show significant down-drift erosion, consistent with the assumption that littoral materials do bypass these structures. Without these structures, shoreline recession would occur due to natural and anthropogenic influences. Immediately north of McCormick Ravine, accretion appears to be occurring at the groin in response to shoreline recession occurring further to the north. South of Schenck Ravine, the shoreline appears to be receding. Based a quantified estimate for the equilibrium beach profile was developed and compared against the current topographical cross-sections. These comparisons suggest that some of the shoreline recession can be attributed to the littoral system seeking a stable morphology.

The orientation of the Highland Park moraine (the bluff) indicates the geologic youthfulness of this coastline, which is in the early stages of reaching equilibrium with regional wave dynamics and littoral sediment supply. Conceptually, beach equilibrium is a result of balancing erosion and deposition. Since waves and water levels are dynamic in nature, the equilibrium beach morphology is dynamic as well. For this study, the typical water levels observed during non-winter months are assumed. This approach has been shown to compare well with measured beach slope and can be used as an indicator for potential shoreline erosion or accretion. For example, at the southern limit of the study area, south of Schenck Ravine, the nearshore beach slope is steeper than that of a beach slope in equilibrium. Due to the exposure of the shoreline to greater depths closer to shore, equilibrium would be reached through shoreline recession, displacing bed and bluff material lakeward to flatten the slope. Once a state of equilibrium is reached; however, the potential for further shoreline recession still exists due to wave action and surge during storm events. Although the current trends of decreasing lake levels would result in relatively lower rates of landward erosion, beaches and fore dunes would still maintain a dynamic state.

Land Use, Hydrology & Hydraulics

The study area, located within the Southwestern Lake Michigan watershed, was primarily covered by upland forests and shrub prairie prior to European settlement. Around 1670 the site of Fort Sheridan was established as a French trading post, situated on a trail connecting Green Bay, Wisconsin and the area that was early Chicago. As settlers came into the area, they used the trail between trading posts, but never

considered the site advantageous for farming due to the deep ravines, heavy forests and shoreline location. Beginning in the mid-1800's, settlements began to appear in the area, beginning with St. Johns in the 1840's and Lake Forest in 1857. The area was affected as brick making stripped the bluffs of its clay deposits and the forests were cleared from extensive logging operations. In 1886 the Commercial Club of Chicago arranged for the donation of land upon which Fort Sheridan was built. The base remained active through World War II and was ultimately closed in 1993. An Army Reserve base continues to use a portion of the original post while much of the original housing has been converted from military to residential. The remaining property is divided between residential development, Navy housing developments for personnel of the nearby Great Lakes Naval Base, a variety of ongoing commercial developments, and forest preserve. The total project area is 1475.7 acres, consisting of 28.2% residential, 1.0% commercial, 33.7% open space, 26.4% government property, and 10.7% roadways.

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 rainfall 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, such as MacArthur Ravine. The alterations to the hydrologic system due to urbanization initiated by the Federal government, however, have resulted in accelerated erosion and degradation of the ravine systems. As a result of development, the overall volume and peak discharges of rainfall runoff have increased due to an increase in impervious surfaces and the construction of rainwater collection networks. The increased volume and velocity of the discharge has resulted in the ravine floor incising and the slopes sloughing into the ravine, endangering rare native ravine habitats. Detailed descriptions of each ravine are included in Appendix A – Hydrology & Hydraulics (Chapter 3).

All of the ravines within the study area are naturally ephemeral streams except for McCormick Ravine, which is perennial. McCormick Ravine would have permanently flowing waters all year long and always have a connection with Lake Michigan; however, it is currently fragmented from Lake Michigan by a failed storm sewer system. Janes, Hutchinson and Schenck Ravines flow for the greater part of the year, but would naturally undergo some drier periods where isolated pools would remain due to groundwater exposure and hyporheic flow (flow beneath the stream bed). During late winter freshets, and spring and summer storms, these three ravine streams flow and blowout the sand plug that forms at the mouth. Scott, Van Horne and MacArthur Ravine are ephemeral and sometimes dry out completely and may or may not have isolated pools remaining. All ravine streams discharge through the bluff cut and meander freely and differently every storm over the beach section as it flows to Lake Michigan. There are no constructed channels or drainage features for the conveyance of stream flow across the beach to Lake Michigan, nor should there be.

2.1.2 – Ecological Resources

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 to paint a contextual picture that relate to the restoration alternatives investigated under this study.

Aquatic Communities

Deep Water – There are no measures presented within this study that directly address restoring habitat in the deep waters of Lake Michigan; however, species that occur there are presented to put the project into a greater context. Some of the species that primarily are found in the profundal (deep water) zone and natural reefs of Lake Michigan do utilize littoral zones as well, such as the lake chub (*Couseuis plumbeus*), the state endangered longnose sucker (*Catostomus catostomus*) and recently discovered bloater (*Coregonus hoyi*) by Dr. Phil Willink from the Shedd Aquarium, as it was collected at in the Openlands portion of the Ft. Sheridan Natural Area and the12th Street Beach of Northerly Island.

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 of Ft. Sheridan are primarily sand flats.

Littoral Zone – There are measures presented within this study that directly address providing additional structure to increase fish species richness and abundance within the littoral zone of Lake Michigan. Currently, habitat consists of extensive sand flats and minor non-conformities provided by small manmade groins. Foreign debris and manmade structures also affect study area habitat (**Photo 1**). 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 within the Immediate Ft. Sheridan Study Area 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	X	
Lota lota	burbot	X		
Myoxocephalus thompsonii	deepwater sculpin	X		

* non-native species

Photo 1 – Littoral zone with man-made infrastructure and debris

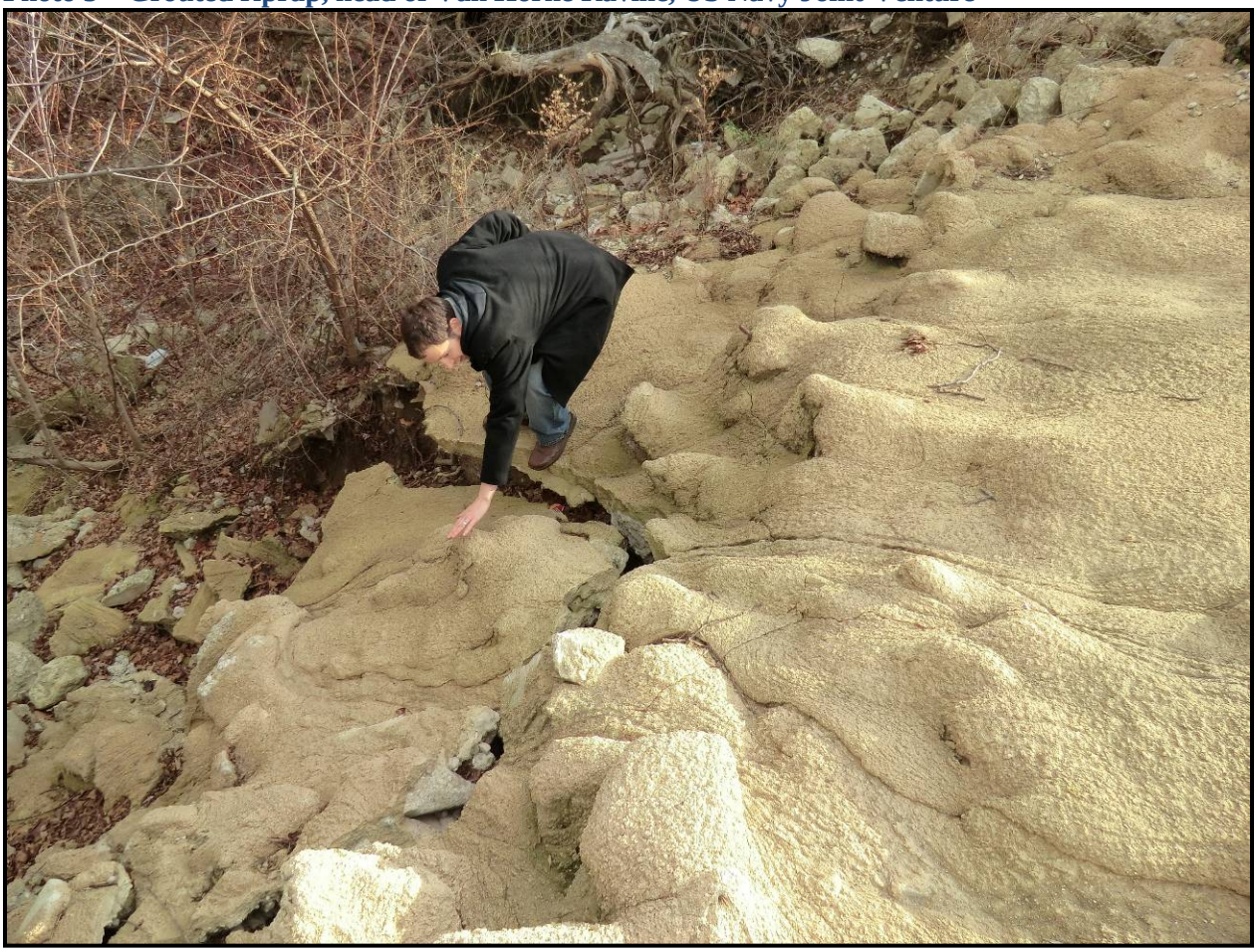
Stream - There are measures presented within this study that directly address repairing natural stream flows, channel morphology and connectivity in order to increase fish species richness and abundance within eight (8) ravines that flow into Lake Michigan. Currently, most of the ravines are fragmented from Lake Michigan by manmade structures that may include sheet pile walls, perched culverts and earthen dams (**Photo 2**). In-stream habitat and fluvial geomorphology of the ravines have been adversely impacted over the last 100-years due to watershed development. The highly erodible ravines have eroded too fast due to increase surface water flows. This in turn has greatly damaged stream habitat and has added poor quality water to the streams and eventually Lake Michigan.

Photo 2 – Hydraulic Structure at the mouth of Jane's and McCormick Ravines

Fish species that would utilize the newly connected ravines are presented in **Table 5** (Section 2.3). The most common species found within other ravines along the coast of Lake Michigan are the white sucker (*Catostomus commersonii*) and longnose dace.

Macroinvertebrates – There are measures presented within this study that directly address repairing natural stream hydraulics and channel morphology in order to increase macroinvertebrate species richness and abundance within eight (8) ravines that flow into Lake Michigan. In addition to previously mentioned impairments, base flows during low periods have been reduced due to development in uplands where rainwater can no longer recharge groundwater aquifers.

Photo 3 – Grouted riprap, head of Van Horne Ravine, US Navy Joint-Venture



The most common species found within other ravines along the coast of Lake Michigan are swimming mayflies (Ephemoptera) and midges (Diptera). Both swimming mayflies and midges have a moderate classification in terms of being tolerant to habitat and water quality degradation, which is indicative the current conditions in the ravines. Taxa collected from Millard Park Ravine, a nearby representative ravine, in 2011 included:

- ϕ Amphipoda scud
- ϕ Odonata: Anisoptera dragonfly
- ϕ Odonata: Calopterygidae broadwinged damselfly
- ϕ Ephemeroptera: Baetidae/Siphlonuridae swimming mayfly

- ϕ Trichoptera: Hydropsychidae hydropsychid caddisfly
- ϕ Trichoptera caddisfly
- ϕ Coleoptera: Elmidae/Dryopidae riffle beetle
- ϕ Diptera: Tipulidae crane fly
- ϕ Diptera: Chironomidae midge
- ϕ Diptera: Simuliidae black fly
- ϕ Gastropoda left-handed snail

Three ravines part of the Ft. Sheridan Costal restoration project were surveyed on October 4th, 2012 for woodland arthropods: McCormick Ravine, Bartlett Ravine and Schenck Ravine. Schenck and McCormick both had close canopy represented by maple (*Acer* spp.*)*, oak (*Quercus* spp) and birch (*Betula* spp.). Bartlett had an open canopy midline of the ravine caused by the paved road and drainage gutters installed in the middle of this ravine by the US Army.

Isolated arthropods where identified to their highest taxonomic unit in the field and photographed for identification confirmation in the lab. The identification level varied dependent on the diversity of the taxonomic group, with some arthropods identified to class, while others were identified down to species. Order was the highest level possible to identify (namely Opiliones and Lepidoptera); whereas other groups were identified down to the species level (Isopoda). Only presence/absence was documented; species abundance was not recorded in this survey.

A total of 73 taxonomic units were identified in this course survey, varying between Class, Order, Family, Genus, and Species. McCormick Ravine had the largest richness of taxonomic units with a total of 56 units, while Schenck had 55 units and Bartlett had 44 taxonomic units. Bartlett represented a large contrast from 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 pedestrian pathway at the base of Bartlett Ravine limits the accumulation of leaf litter and detritus, a key habitat and food source for a large detrital arthropod community.

Bartlett had the poorest taxonomic richness and was also inhabitant by the introduced Isopod *Armadillidium nasatum* who is often associated with disturbed habitats. The isopods *Haplophthalmus danicus* and *Philoscia muscorum* were found during this survey. If the identification is confirmed this represents a new state records for both terrestrial isopods in Illinois (Jass and Klausmeier 2000). This survey represents a coarse representation of the terrestrial arthropod community at the three sites. A recommendation to continue monitoring after restoration efforts would aid in determining if the terrestrial arthropod community were affected by potential restoration efforts. **Table 2** list the taxonomic groups collected.

Table 2 – Macroinvertebrates Collected from Schenck, Bartlett and McCormick Ravines

TAXONOMIC UNIT	Schenck	Bartlett	McCormick
ARACHNIDA: Class			
Araneae: Spider Families			
Araneidae	P	P	P
Clubionidae	P	P	P
Corinnidae	P		
Dictynidae	P	P	P
Hahniidae			P
Linyphiidae	P	P	P
Lycosidae	P	P	P
Salticidae	P	P	P
Tetragnathidae	P	P	P
Thomisidae	P	P	P
Xysticus sp.	P	P	P
Opiliones-Order	P		P
Pseudoscorpion-Order	P	P	P
INSECTA: Class			
Coleoptera: Beetle Families			
Carabidae	P	P	P
Chrysomelidae	P		
Diabrotica undecimpunctat		P	P
Coccinella septempuctata		P	
Harmonia axyridis		P	
Curculionidae	P	P	P
Leiodidae	P		P
Lampyridae	P		P
Scarabaeidae			P
Hydrophylidae			P
Nitidulidae	P	P	P
Staphylinidae- Sub-families			
*Aleocharinae	P		
*Steninae		P	
*Oxyporinae			
Oxyporus rufipennis			P
*Staphylininae	P	P	P
*Scaphidiinae			P
*Paederinae	P		P
*Oxytelinae			P
*Pselaphinae			P
*Tachyporinae	P		
*Ptiliidae			
Acrotrichis sp.	P		P
Blattodea-Order		P	
Dermaptera- Order		P	P
Forficula auricularia	P		
Diptera: Fly Families			
Syrphidae	P		
Hemiptera: Families			
Aphidoidea (Superfamily)	P	P	P
Reduviidae	P	P	P
Tingidae	P		P
Cicadellidae	P		P
Miridae	P	P	
Pentatomidae	P	P	P
Gerridae			P

TAXONOMIC UNIT	Schenck	Bartlett	McCormick
Hymenoptera: Families			
Apidae	P	P	P
Vespidae			
Vespula pensylvanica	P		P
Formicidae-Ant genera			
Amblyopone sp.			P
Myrmecina sp.	P		
Myrmica sp.	P		P
Prenolepis sp.	P	P	P
Tetramorium sp.	P	P	P
Lepidoptera- Order	P	P	P
Mantodea -Order			
Tenodera aridifolia	P		
Orthroptera- Order			
Melanoplus differentialis	P	P	P
Thysanoptera- Order	P	P	P
MIRIOPODA -Class			
Diplopoda: Millipede Families			
Paradoxosomatidae	P	P	P
Polycenidae			
Polyxenus sp.		P	
Parajulidae	P	P	
Polyzoniidae			P
Chilopoda: Centipede Orders			
Geophilomorpha	P	P	P
Lithobiomorpha	P	P	P
ENTOGNATHA -Class			
Collembola: Families			
Entomobryidae	P	P	P
Isotomidae	P	P	P
Tomoceridae	P		P
Hypogastruridae	P	P	P
Diplura -Order	P	P	P
MALOCOSTRACA Class			
Isopoda: Species			
Armadillidium nasatum		P	
Haplophthalmus danicus?**	P		P
Hyloniscus riparius	P	P	P
Philoscia muscorum?**	P	P	
Tracheoniscus rathkei	P	P	P
Trichoniscus pygmaeus	P	P	P
TOTAL TAXONOMIC UNITS:	**55**	**44**	**56**

The letter (P) represents a presence of that taxonomic unit at the each site. The (*) represent sub-family level identification. The (**) represents new state record.

Resident & Migratory Birds

The Ft. Sheridan 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 route of the Mississippi Flyway, which is an important migration route for many songbirds and waterfowl. 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 Ft. Sheridan area during lakefront bird surveys at various points of the year (**Table 3**). Of these species, Bald Eagle (*Haliaeetus leucocephalus*), Brewer's blackbird (*Euphagus cyanocephalus*), Broad-winged Hawk (*Buteo platypterus*), Golden Eagle (*Aquila chrysaetos*), Grasshopper Sparrow (*Ammodramus savannarum*), Gyrfalcon (*Falco rusticolus*), Long-Tailed Duck (*Clangula hyemalis*), Mississippi Kite (*Ictinia mississippiensis*), Red Headed Woodpecker (*Melanerpes erythrocephalus*), and Smith's Longspurs (*Calcarius pictus*) are listed as species of concern by the National Audubon Society.

Table 3 – Birds Observed Along the Coast and Ravines of the Ft. Sheridan Area

Common Name	Resident	Migratory	Rare/Concern		Common Name	Resident	Migratory	Rare/Concern
American Crow		X			Indigo Bunting		X	
American Goldfinch		X			Lesser Scaup		X	
American Kestrel		X			Long-Tailed Duck		X	X
Bald Eagle		X	X		Louisiana Waterthrush		X	
Baltimore Oriole		X			Merlin		X	
Barn Swallows		X			Mississippi Kite		X	X
Bay-breasted Warbler		X			Northern Flicker		X	
Black Scoter		X			Northern Goshawk		X	
Blackburnian Warbler		X			Northern Harrier		X	
Blue Jay		X			Northern Mockingbird		X	
Blue-winged Teal		X			Orchard Oriole		X	
Brewer's Blackbirds		X	X		Osprey		X	
Broad-winged Hawk		X	X		Peregrine Falcon		X	
Brown Creeper		X			Prairie Falcon		X	
Brown Thrasher		X			Purple Finch		X	
Bufflehead		X			Red Bellied Woodpecker		X	
Caspian Terns		X			Red Knot		X	
Common Goldeneye		X			Red-Headed Woodpecker		X	X
Common Night Hawks		X			Red-shouldered Hawk		X	
Common Tern			X		Red-tailed Hawk		X	
Connecticut Warbler		X			Ring-bill Gulls	X		
Cooper's Hawk		X			Rough-legged Hawk		X	
Cormorant		X			Sharp-shinned Hawk		X	
Eastern Kingbird		X			Short-eared Owl		X	
Eastern Phoebe		X			Smith's Longspurs		X	X
Eastern Towhee		X			Snowy Bunting		X	
Eastern Wood Peewee		X			Snowy Owls		X	
Ferruginous Hawk		X			Solitary Sandpiper		X	
Forester's Tern			X		Spotted Towhee		X	
Golden Eagle		X	X		Swainson's Hawk		X	
Grasshopper Sparrow		X	X		Tree Swallow		X	
Great Blue Heron		X			Turkey Vulture		X	
Great Crested Flycatcher		X			Warbling Vireo		X	
Green Teal		X			Willow Flycatcher		X	
Gyrfalcon		X	X		Winter Wren		X	
Horned Grebes		X			Yellow-breasted Chat		X	
Horned Lark		X			Yellow-throated Warbler		X	

Mammalian Community

The Ft. Sheridan natural 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*).

Plant Communities

Ravine – The evolution of the study area's ravines has shaped a unique environment with impressive flora. A multitude of factors contribute to the high diversity of plant species found within the ravines of which include the underlying glacial substrate, close proximity to Lake Michigan, varying slope inclinations and natural instabilities (dune and beach shifting), and presence of groundwater seeps.

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 have been significantly reduced because of increased storm water 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*), tall fescue (*Festuca elatior*), black locust (*Robinia pseudoacacia*), 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 (**Photo 4**). 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 a diverse shrub strata consists of witch hazel (*Hamamelis virginiana*), dwarf honeysuckle (*Diervilla lonicera*), 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 such as common buckthorn (*Rhamnus cathartica*), glossy buckthorn (*Frangula alnus*), black locust (*Robinia pseudoacacia*), Norway maple (*Acer platanoides*), white mulberry (*Morus alba*), green ash (*Fraxinus lanceolata*), cottonwood (*Populus deltoides*), and basswood (*Tilia americana*).

Photo 4 – McCormick Ravine with current vegetation cover

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*). Soil erosion, fire suppression, and an increase in invasive species have also significantly impacted populations of spring ephemerals.

Bluff – The unique climate and erosive-prone clay bluff within the study area welcomes an interesting suite of native plants that have evolved to withstand its harsh conditions (**Photo 5**). Rare northern boreal (forest) 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*).

A few extant shrub prairies occur on the bluff where stands of buffalo berry (*Shepherdia canadensis)* and common juniper (*Juniperus communis*) occur along with the following species: veiny pea (*Lathyrus venosus*), false toadflax (*Comandra umbellata*), ivory sedge (*Carex eburnea*), golden sedge (*Carex aurea*), prairie brome (*Bromus kalmii*), spreading dogbane (*Apocynum androsaemifolium*), smooth blue aster (*Aster laevis*), and stiff gentian (*Gentiana quinquefolia occidentalis*).

Just as the ravines have become heavily shaded, the bluffs too have degraded from fire suppression, in turn degrading the rich herbaceous understory which has increased rates of soil erosion. Invasive species such as crown vetch (*Securigera varia*), reed canary grass (*Phalaris arundinacea*), black locust (*Robinia*

pseudoacacia), common reed (*Phragmites australis*), and buckthorn (*Rhamnus* spp.) have established on the bluffs and along with increased rates of soil erosion have decimated remnant bluff communities.

Photo 5 – Bluff habitat, which is the lake ward slope of the Highland Park Moraine

Beach – Much of 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 (**Photo 6**). 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*). Since the study area currently contains narrow strips of beach impacted by heavy foot traffic and invasive species such as lyme grass (*Elymus arenarius*) (**Photo 6**), sweet clover (*Melilotus* spp.), and crown vetch (*Securigera varia*) -- less conservative plants are found growing elsewhere on the beach, among them being common milkweed (*Asclepias syriaca*), common evening primrose (*Oenothera biennis*), early goldenrod (*Solidago juncea*), riverbank grape (*Vitis riparia*) and a multitude of non-native species.

Photo 6 – Small dunes form along the bluff toe; critical habitat for small migratory birds

Threatened & Endangered Species

The County Distribution of Federally-listed Threatened, Endangered, Proposed and Candidate Species was reviewed for Lake County by the Chicago District. The following federally listed species and their critical habitats are identified by the USFWS as occurring within Lake County:

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

- Eastern massasauga (*Sistrurus catenatus*) – Candidate – 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

- 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

Habitats that will be restored through this project include stream, ravine, bluff, foredune and lake. Recent surveys done by the USACE Chicago District 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 Ft. Sheridan Section 506 Restoration Project will have "no effect" on listed species or proposed or designated critical habitat.

Ten (10) plant, 2 fish and 1 bird species that are state listed (**Table 4**) have been recorded in the study area. The marram grass, sea rocket, common juniper and seaside spurge are specific to foredune and beach landforms. The golden sedge, pale vetchling, weak bluegrass, downy Solomon's seal, buffalo berry and star flower are specific to ravine and bluff landforms. The longnose sucker and lake herring are specific to deep water and littoral zone of Lake Michigan; however, it is possible that longnose sucker would utilize the ravines as spawning habitat. The common tern is specific to the littoral zone for foraging and it appears there is not suitable breeding habitat currently within the study area for this species.

Table 4 – Illinois Threatened & Endangered Species Recorded from Study Area.

Species	Common Name	Status
Ammophila breviligulata	marram grass	SE
Cakile edentula	sea rocket	ST
Carix aurea	golden sedge	ST
Chamaesyce polygonifloia	seaside spurge	SE
Juniperus communis	common juniper	ST
Lathyrus ochroleucus	pale vetchling	ST
Poa languida	weak bluegrass	SE
Polygonatum pubescens	downy Solomon's seal	SE
Shepherdia canadensis	buffalo berry	SE
Trientalis borealis	star flower	SE
Viola conspersa	dog violet	ST
Catostomus catostomus	longnose sucker	ST
Coregonus artedii	lake herring	ST
Sterna hirundo	common tern	ST

2.1.3 – Cultural Resources

Archaeological & Historical Properties

Ft. Sheridan is listed on the National Register of Historic Properties. A total of ninety four buildings on an area of 110-acres make up the Ft. Sheridan Historic District (listed 1980). Sixty four of the buildings were designed by Holabird & Roche of Chicago. The Ft. Sheridan Historic District was declared a National Historic Landmark in 1984. The surrounding communities of Highland Park, Highwood, and Lake Forest each contains a large number of structures listed on the National Register of Historic Places, either as individual structures or as historic districts. None of these properties are located in the general vicinity of Ft. Sheridan.

Land Use History

By passed during the early settlement of Lake County because of its high bluffs and deep ravines, the area of Ft. Sheridan was undeveloped woodland until 1886 when its 632 acres was purchased by the

Commercial Club of Chicago and donated to the United States government for use as a military installation. Initially named Camp Highwood, the installation was renamed Ft. Sheridan in 1888 after U. S. General Phillip Sheridan. The primary purpose of Ft. Sheridan was to protect business interests in Chicago during an era of labor unrest. Troops from Ft. Sheridan were instrumental in putting down the Pullman strike of 1894. Use of the fort shifted during the Spanish American war when it was transformed into a regional Army recruitment center, a function that continued until the fort was closed in 1993. Ninety acres were retained as an Army Reserve center, and the remaining property was sold to private developers. The area of Ft. Sheridan is now divided between the surrounding communities of Highland Park, Highwood, Lake Forest, with the Historic District maintained as unincorporated county land. Ft. Sheridan is also the location of the Ft. Sheridan National Cemetery, now within the City of Lake Forest. It is noted that the Schenck Ravine watershed was developed by the US Navy and is responsible for discharging storm water directly into this ravine.

Social Properties

Ft. Sheridan is located in Lake County, Northeastern Illinois on the shore of Lake Michigan. Approximately 635 acres in size Ft. Sheridan is divided politically between the three surrounding municipalities and Lake County. The area has an ethnically diverse population of 1,077 (2009). Medium household income is $64,130 (2009), and medium home value is $1,094,200 (2009).

Recreational Activities

The northern third of Ft. Sheridan is Lake County Forest Preserve District land and open space. This area includes hiking trails and bluff overlooks and is popular for picnicking and bird watching. Parks in the surrounding communities provide soccer and baseball facilities. A number of public golf courses and private country clubs are present in the general area. Public beaches are available in both Highland Park and Lake Forest.

Hazardous, Toxic & Radioactive Waste (HTRW) Analysis

This investigation was performed to determine if the selected measures for Ft Sheridan Restoration project will have an impact on any Recognized Environmental Conditions (RECs) that may exist in the surrounding areas, and if RECs will have an impact on the implementation of the project. According to ER 1165-2-132, non-HTRW issues that do not comply with federal, state, and local regulations should be discussed in the HTRW evaluation along with HTRW issues. The complete HTRW report and Parcel Maps can be found in Appendix E.

Existing information available for review documenting the BRAC site study and cleanup prior to property transfer was very extensive. All potential RECs onsite appear to have been adequately addressed. No work will occur on the landfill 7 area as a part of this project. All USTs at active gasoline stations are distanced from project work areas and are unlikely to affect the project. No other data presented in the EDR Database Report indicated any surrounding sites that are likely to pose REC concerns to the project resulting from federal or state regulated facilities within the ASTM established search distances. Results of this investigation suggest that it is unlikely that Recognized Environmental Conditions remain on the project site. However, additional awareness needs to be paid to the northeast corner of the site, the location of a former range.

Any activities including landscaping occurring on Parcel G/landfill 2 will require coordination with Louisville District or a USACE MM Design Center. Activities in this area are limited to a depth of one foot.

Activities on Parcels F and G require construction support because of the potential for encounters with unexploded ordnance. A clearance activity on these areas, and the beach associated with them, was completed in 2004. Construction support may no longer be required. If the final project measures will occur in these areas, construction support needs to be reviewed by USACE MM Design Center Omaha. However, although it is highly unlikely that ordnance will be encountered; no clearance activity can wholly eliminate the uncertainty. Additionally, although the beach area was cleared to a depth of four feet, it is the nature of the beach and littoral zone to have shifting sand. The project team as a precaution decided to engage in a limited level of construction support for activities north of Hutchinson Ravine occurring not only on Parcel F and G, but also for the beach and littoral zones in these areas; all formulated plans would be limited to surficial activities less than 1-foot in depth.

No investigation can wholly eliminate uncertainty regarding the potential for encountering a REC associated with a project area. Performance of this investigation is intended to reduce, but not eliminate, uncertainty regarding the potential for encountering a REC in connection with a project area. Any activities including landscaping occurring on Parcel G/landfill 2 will require coordination with Louisville District or a USACE MM Design Center. Activities in this area are limited to a depth of one foot due to former military activities and the possible presence of unexploded ordnance or other RECs. All activites for these areas would have no earth disturbing measures and be limited to herbicide application to remove invasive weed species and replanting native species via seeding and plugs.

2.2 – Problems and Opportunities

The overall problem within the study area is the holistic decrease in biodiversity. Biodiversity is a term that is used to describe all aspects of biological variety including species richness, ecosystem complexity and genetic variation. Biodiversity is decreased as a response to the loss of hydrogeomorphic function, fluvialgeomorphic function, littoral processes and land use change; collectively a reduction in abiotic complexity.

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, 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, 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

generally displays a negative relationship to the amount of human disturbance to natural areas in direct or indirect ways.

Lacustrine, Beach, Dune & Bluff – Recreation, industrialization and urban 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. Any influence by anthropomorphic features along the shoreline upon wave patterns will be limited to within the immediate vicinity of the structures. While localized current patterns will obviously be impacted by coastal features, regional trends will largely remain unaffected. 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. The impact of shoreline hardening should also be considered. Even when the cells contained by up-drift structures have completely filled and are bypassing, the system still feels the effects of reduced overall littoral drift (i.e. there is a net loss of material). Near shore, beach, dune and bluffs are 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. Specific problems with primary ecosystem drivers include:

- Altered hydraulics and littoral drift from manmade infrastructure
- Altered coastal geomorphology from manmade infrastructure and land use
- Altered coastal geomorphology from non-native plant species colonization (buckthorn, lyme grass)

Based on these problems with the ecosystem drivers above, the following are specific resulting ecological problems for the Ft. Sheridan study limits:

- Reduced acres (quantity) of the native coastal communities and habitat
    - Dune/beach loss of about 20-acres
- Reduced richness and abundance (quality) of the native species per community type
    - Lacustrine loss of about 29 species of fishes
    - Dune/Beach loss of over 20 species
    - Bluff loss of over 50 species
- Reduced richness and abundance of higher level organisms including insects, amphibians, reptiles, birds and mammals

Opportunities to remedy these issues and return some stability in terms of littoral processes exist within the study area. Methods can be employed to temporarily trap sand once again along the Lake Michigan coast and compensate for the interrupted littoral sources. Once the littoral sands come into more of a dynamic equilibrium along the Ft. Sheridan coastline, invasive species can be removed and native bluff and dune vegetation reestablished into sustainable ecosystems. Opportunity exists in terms of creating fish habitat if the littoral structures can be installed to bring the system into equilibrium. Aside from the rock structures themselves, add-ons of cobble pockets and woody debris would create foraging and spawning habitat for species such as rockbass (*Ambloplites rupestris*), smallmouth bass (*Micropterus dolomieu*) and transient redhorse (*Moxostoma* spp.) and longnose suckers (*Catostomus catastomus*). Based on the problems within the Ft. Sheridan study limits, the following opportunities exist to improve ecological diversity within the lacustrine, beach, dune and bluff communities:

- Manipulation of manmade structures to increase acres of beach and dune habitat
- Manipulation of manmade structures to increase quality of lacustrine, dune and bluff habitat

- Address invasive plant species issues to increase quality of dune and bluff habitat
- Increase quantity and improve quality of habitat for 100+ species of migratory and resident bird

Ravine – The colonization and subsequent development of the land surrounding the ravines has greatly accelerated the pace of the geologic 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 where native trees and plants once grew has greatly increased the flow of rainwater runoff via laminar flow and prevents groundwater recharge. The result is an increase in the rate of channel incision through the ravine.

The greater the quantity of water, the level of downward stream cutting increases, making the lower portion of the ravine slopes adjacent to the stream much steeper and increases the frequency of slumping. The slumping in particular has a devastating effect on the ability of plants and trees to grow on the banks. It is noted that the Schenck Ravine watershed was developed by the US Navy. The USN's stormwater plan includes direct discharge of storm water into this ravine. Bartlett Ravine was converted into an access road by the US Army. The US Army is also responsible using an unnamed ravine for a hazardous landfill.

In a sense, the ravines are becoming younger instead of maturing due to the constant increase in runoff. Predictably, over time the slope of the stream bed will level off even further, the steepness of the banks will decline as the ravine further widens, and plants and trees will again be able to survive on the slopes rather than topple over in mudslides. Given enough time, the ravines might adapt to the increased volume of water, although most species of native vegetation specific to the ravines will vanish in the process and won't return because the ravines have lost their morphology and functions that supported such a plant community. In the short term, however, the accelerated rate of erosion spells disaster for the trees, herbaceous growth, stream channel and the fish and wildlife that utilizes them. Specific problems with primary ecosystem drivers include:

- Altered stream hydraulics from increased rainwater runoff
- Altered fluvialgeomorphic processes from urbanized watershed
    - Channel widening & incision
    - Bank mass wasting
- Altered hydrology, hydraulics and geomorphology from manmade dams at mouths of ravines
- Altered geomorphology from invasive plant and tree species
    - Large amounts of unnatural woody debris
    - Channel destabilizing buckthorn and honeysuckles

Based on these problems with the ecosystem drivers above, the following are specific resulting ecological problems for the Ft. Sheridan study limit ravines:

- Reduced length (quantity) of accessible stream and riparian habitat (fragmentation)
    - Schenck Ravine 1,520-feet
    - Van Horne Ravine 1,110-feet
    - Bartlett Ravine 4,290-feet
    - Scott Ravine 1,170-feet
    - MacArthur Ravine 520-feet
    - Hutchinson Ravine 5,240-feet
    - Jane Ravine 6,640-feet
    - McCormick 8,840-feet
- Reduced acres of riparian oak woodland of about 1,200-acres
- Reduced richness and abundance (quality) of the native species per community type

    - Ravine (stream) loss of about 29 species of fishes
    - Ravine (ravine slopes) loss of over 100+ species
    - Oak woodland loss of over 100+ species
- Reduced richness and abundance of higher level organisms including insects, amphibians, reptiles, birds and mammals

Opportunities to remedy these issues and return stability in terms of ravine habitat exist. Methods can be employed to detain, retain, or reroute large volumes of stormwater runoff. Once the water issue is remedied, physical repairs may be made to address erosion points and channel incision, invasive species removed, and native ravine vegetation reestablished. Opportunity also exists in terms of creating or providing fish stream habitat through removing the fragmenting structures at the mouths of the ravines and connecting them back to Lake Michigan. Small riffle and woody debris structures would be designed and built to create foraging and spawning habitat for species such as longnose dace (*Rhinichthys cataractae*), sand shiners (*Notropis stramineus*), and white suckers (*Catostomus commersonii*). Based on the problems for the Ft. Sheridan 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/removal of manmade structures to reduce excess rainwater flows within ravines
- Address acute problems caused by chronic hydraulic issues within the ravines
    - Bank erosion and wasting
    - Attenuate channel incision to natural rate
- Address invasive plant species issues to increase quality of ravine habitat
- Increase quantity and improve quality of habitat for hundreds of migratory and resident birds

2.3 – Habitat Assessment Methodology

Many methods are available to measure current ecosystem resource conditions and to predict future conditions of those resources. Habitat assessment methods developed for individual species may have limitations when used to assess ecosystem restoration problems and objectives. They do not consider communities of organisms and typically consider habitat in isolation from its ecosystem context. The assessment methodology selected for this study is community based and governed by how well the technique meets the needs of the study goals, objectives, and level of detail. The assessment methodology, or Habitat Suitability Index (HSI), focuses on native species richness and function of plant and fish communities. This HSI was developed to assess the ecological value of the proposed future without-project condition and any proposed management measures. This index is based on how native species of plants and fish will respond to a given condition and quantified through use of the Floristic Quality Assessment (FQA) and native fish species richness (R). There was no weighting per community type since each part of the coastal ecosystem is just as important as the other. All three of these habitat evaluation methods are currently under review for model certification, but are at various stages.

Floristic Quality Assessment

The Floristic Quality Assessment (FQA) is based on the Chicago Region's floristic coefficients of conservatism developed by Swink and Wilhelm (1979) and was approved for regional use by the USACE Ecosystem Planning Center of Expertise (ECO-PCX). The FQA will capture the effects of various future scenarios on the quality of the plant community. Regarding the FQA, the determination of "quality" with respect to plant assemblages has been the subject of much discussion and development in Illinois since the mid 1970's and more recently, throughout the U.S. and Canada. Quality, as used in this study, is essentially an assessment of the degree to which native plant species to a region are present within a defined area of land. Vegetation, which can be a mix of native and non-native species, reflects long-term

natural area stability and/or complexity and this pattern is the basis for the integration of the concept of floristic quality indicating overall system quality. Plants are exceptional indicators of short and long-term disturbance in terms of changes to the geomorphology, soils and/or hydrology of an area. Out of the approximately 2,500 plant species known to occur in the Chicago Region, around one-third were not present before European colonization. Non-native species did not evolve within the same environmental conditions as native species, although their persistence indicates a certain degree of naturalization to the area. Numerically describing the quality of an area using vegetation reflects the level of disturbance to the biological integrity of the site. In the Chicago Region, there is one commonly used approach that attempts to describe plant community quality with a simple numerical metric, which is the Floristic Quality Assessment.

The FQA method specifically excludes the use of "indicator" species, instead assessing the sensitivity of individual plant species that inhabit an area. Species "conservatism" is used as its basis for assessment; conservatism being known as a level of tolerance each plant species exhibits to disturbance type, amplitude, and frequency, as well as fidelity to specific habitat types. As an area's equilibrium is disturbed, the habitat's capacity to absorb disturbance is weakened and the first plants lost will come from the high end of the conservatism spectrum. Therefore, what is being measured is the extent to which an area supports conservative native plants.

Based on species inventory, the FQA generates two essential metrics: the Mean C, which is the average coefficient of conservatism for a site, and the FQI, which is derived by multiplying Mean C by the square root of the number of native species inventoried,

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$$FQI = \overline{C}\sqrt{N}$$

where C is the coefficient of conservatism and N is the species richness. The FQI, therefore, is a function of both conservatism (function) and species richness (structure). Typically, larger sites have a greater number of habitat types and likely will have greater species richness. Generally, both mean C and FQI values are considered in the evaluation of an area or landscape unit. Based on statistical analysis of previous studies, the FQI shows a significant positive relationship to species richness (Ervin et al. 2006) and as such the Mean C value represents the more comparable and accurate metric.

Each native species has been assigned a coefficient of conservatism (C), ranging from 0 to 10. C values were assigned to species within a predefined geographic area by Swink and Wilhelm (1979). A 0 is assigned to species that are highly tolerant to disturbance and are considered general in their habitat distribution and a 10 is assigned to species with a very low tolerance to disturbance which display very specific relationships to certain habitat types. The following descriptions of categories were used to assign coefficients of conservatism to native plant species:

- 0-3 Wide range of ecological tolerance and found in a variety of conditions
- 4-6 Mid range of ecological tolerance and a smaller variety of conditions
- 7-8 Low range of ecological tolerance and associated with advanced succession
- 9-10 Very low range of ecological tolerance and niche specific

It has been demonstrated that sites with mean C and Floristic Quality Index (FQI) values less than 2.8 and 20 respectfully, as surveyed during the growing season, are degraded or derelict plant communities. Sites with mean C values that approach 3.2 are considered to be moderately disturbed. When site inventories yield mean C values greater than 3.4 or higher, one can be confident that there is sufficient native

character present for the area to be at least regionally noteworthy - such landscapes are essentially irreplaceable in terms of their unique composition of remnant biodiversity. Sites with mean C and FQI values greater than 4.0 and 50, respectively, are rare and indicate highly significant natural areas of statewide importance.

With an active land management plan and time, the mean C and FQI values will reflect the extent to which conservative species are being recruited and the floristic quality is improving. In this way, the FQA method can be used to assess restoration management decisions, as well as to document floristic changes (positive or negative) in the landscape over time.

Fish Species Richness & Abundance

This portion of the assessment uses fish species richness (R), which is the total number of native fish species. An assessment was done utilizing the Fishes of the Chicago Region database, which is primarily comprised of fish collection vouchers stowed at the Field Museum on Natural History and the Illinois Natural History Survey from 1895 – 2007. One hundred and fifty six (156) fish collections were queried from the whole coast line of Lake County, IL and from two similar streams just north of the study in Kenosha County, WI (**Table 5**).

Table 5 – Projected Fish Species Richness for Ravine and Lacustrine Habitat Restoration

Species	Ravine R	Lacustrine R		Species	Ravine R	Lacustrine R
Acipenser fulvescens		1		*Luxilus cornutus*	1	
Ambloplites rupestris	1	1		*Micropterus dolomieu*	1	1
Ameiurus melas	1			*Micropterus salmoides*	1	1
Ameiurus natalis	1			*Moxostoma erythrurum*	1	
Ameiurus nebulosus				*Moxostoma anisurum*		1
Anguilla rostrata				*Moxostoma macrolepidotum*		1
Catostomus catostomus	1	1		*Myoxocephalus thompsonii*		1
Catostomus commersonii	1	1		*Notemigonus crysoleucas*	1	
Coregonus artedi		1		*Notropis atherinoides*	1	1
Coregonus clupeaformis		1		*Notropis dorsalis*	1	
Coregonus hoyi		1		*Notropis heterodon*		
Cottus bairdii	1	1		*Notropis heterolepis*		
Cottus cognatus		1		*Notropis hudsonius*	1	1
Couesius plumbeus	1	1		*Notropis stramineus*	1	1
Culaea inconstans	1	1		*Noturus gyrinus*		
Dorosoma cepedianum		1		*Perca flavescens*		1
Erimyzon sucetta				*Percopsis omiscomaycus*		1
Esox americanus	1			*Phoxinus erythrogaster*		
Esox lucius		1		*Pimephales notatus*	1	1
Etheostoma exile				*Pimephales promelas*	1	1
Etheostoma microperca				*Pomoxis annularis*		1
Etheostoma nigrum	1			*Prosopium cylindraceum*		1
Fundulus diaphanus	1	1		*Pungitius pungitius*	1	1
Gasterosteus aculeatus	1	1		*Rhinichthys cataractae*	1	1
Lepomis cyanellus	1	1		*Rhinichthys obtusus*	1	
Lepomis gibbosus	1	1		*Salvelinus namaycush*		1
Lepomis macrochirus	1	1		*Semotilus atromaculatus*	1	
Lota lota	1	1		*Umbra limi*	1	
				Total Species Richness, R	**32**	**36**

It was determined from these historic collections that about 32 native species have in the past utilize ravine stream habitat and about 36 native species could potentially use restored lacustrine habitat. Several species were listed but not counted (blank cells in **Table 5**), such as blacknose shiner (*Notropis heterodon*), since the chance of recolonization is unlikely.

Habitat Suitability Index

Habitat outputs for the future without and future with project condition were estimated over a 50 year period of analysis. In order to restore the ecosystem within the project site, both ecosystem function and structure were addressed through the two methods described above. These predicted benefits are resultant of the measures described in Section 3.1. The following were used for the HSI:

- Littoral HSI = $(R_L/3.6 + C)/2$
- Bluff HSI = (C)
- Ravine HSI = $(R_R/3.2 + C)/2$

where R_L = lacustrine species richness, R_R = ravine species richness, and C = coefficient of native plant conservatism. To make the lacustrine and ravine species richness equivalent to the coefficient of conservatism, species were divided into bins of ten (10); so an increase in the plant mean C of 1 point is equivalent to an increase of 3.2 species for ravine or 3.6 species for lacustrine. Total habitat outputs, in terms of habitat units (HUs) were calculated by multiplying the affected area times the habitat suitability index:

$$HUs = A(HSI)$$

where A is the affected habitat area expressed in acres.

*2.4 – Future Without-Project Conditions (FWOP/No Action)

The future without project condition or No Action is expected to further decline for lacustrine, bluff and ravine habitat within the Ft. Sheridan study area (**Table 6 & Figure 1**). The LCFPD and Openlands will likely engage in small vegetation management and plantings; however, the ability to systematically remedy the coastal and ravine hydraulic impairments and extensive invasive species issues is unlikely.

The lake, beach and dunes, which are grouped under lacustrine, will continue to experience impairments caused by recreational, residential and industrial development, which has had a major influence on the physical structure of coastal habitat and the littoral 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. The non-Federal sponsors do not have the ability to provide features that would naturalize the littoral drift that is currently being sequestered by manmade structures up-drift. Habitat structure and function along the coast would remain unstable, preventing many floral and faunal species from utilizing the area, which provides conditions for weedy and invasive species to remain dominant and further increase in abundance as time progresses. The reliance on ineffective groins will 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 lake and dunes because of the lack of sand accretion, lack physical habitat structure, and the instability of the littoral drift.

The bluff along the entire Ft. Sheridan coast is in need of an overarching invasive species removal plan and native plant reestablishment. Without a Federal project, this needed activity cannot be accomplished

effectively across the two mile stretch of various landowners and municipalities. Small patches are being restored by Openlands, but across the several parcels the non-Federal sponsors own, their ability to perform a comprehensive bluff restoration is not possible due to funding constraints and work force ability. 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 remnants 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.

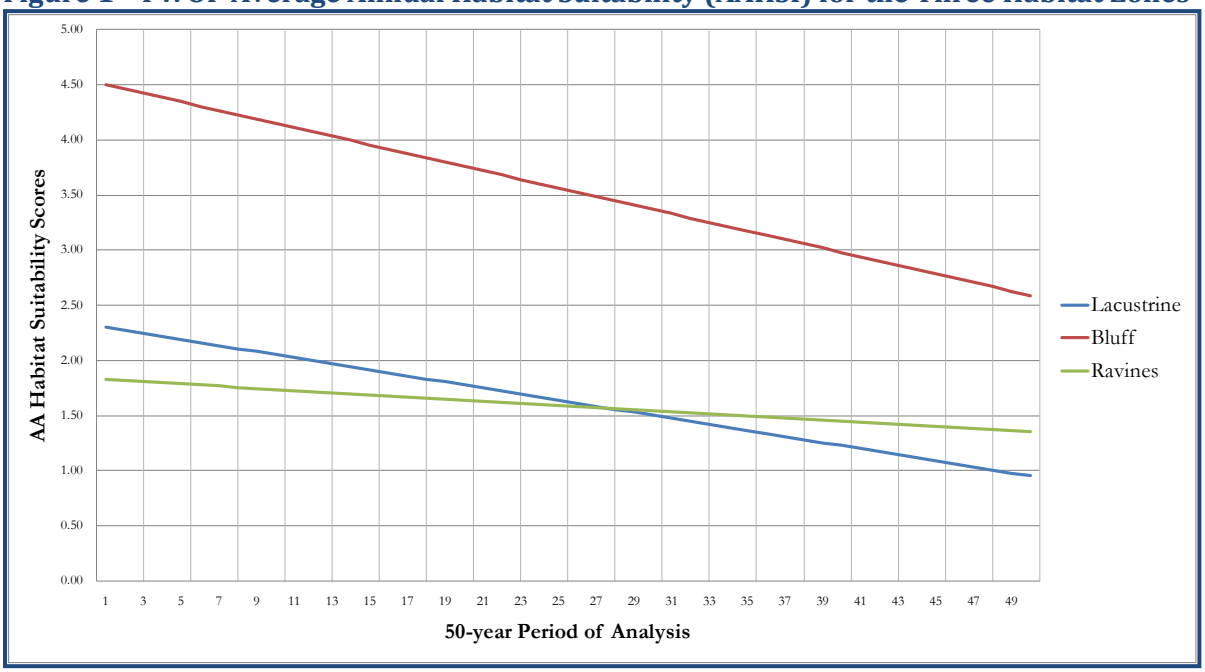
The ravines will remain fragmented from the lake and greatly affected by excessive urban rainwater runoff. Habitat diversity in the ravines will remain low, preventing many floral and faunal species from utilizing the area and providing conditions for weedy and invasive species to remain dominant and increase in abundance as time progresses. The continuation of maintaining the ravines as drainage conduits will 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 ravines because of the lack of channel habitat complexity and stability, which is caused by impaired hydraulic function.

Table 6 – Future Without-Project Conditions for the Three Habitat Zones

Description	R	Mean C	AAHSI	Acres*	AAHUs
Lacustrine			1.63	8.0	**13.0**
Dune		1.35		4.0	
Lake	1.9			4.0	
Bluff		3.5	3.5	41.0	**141.8**
Ravine/Oak Woodland			1.6	162.1	**280.6**
Bartlett Ravine		3.6	1.8	18.8	33.8
Hutchinson Ravine		3.4	1.7	19.7	33.6
Janes Ravine		3.5	1.8	43.4	76.0
McCormick Ravine		3.5	1.8	62.2	109.0
Schenck Ravine		3.2	1.6	7.9	12.8
Scott Ravine		2.2	1.1	2.1	2.3
Van Horne Ravine		3.3	1.7	7.0	11.7
MacArthur		2.6	1.3	1.0	1.3

*acres in FWOP will not be the same as acres FWP since parcel availability and lacustrine habitat will change acres.

Figure 1 – FWOP Average Annual Habitat Suitability (AAHSI) for the Three Habitat Zones



2.5 – Goals, Objectives & Constraints

The primary goal of this Feasibility Study is to determine a cost effective restoration plan, whether it be the No Action Plan or a plan with recommended restoration activities. Since the site is rather diverse in geomorphic features, the plan must account for how the system functions as a whole.

National Ecosystem Restoration (NER) Goal

The primary goal of this project is to restore critical habitat patches within the Ft. Sheridan natural area for native flora and native and migratory faunal communities within the coastal zone of Lake Michigan.

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 were 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.

<u>Federal Objective</u>

The Federal objective of water and related land resources planning is to contribute to national economic and/or ecosystem development in accordance with national environmental statutes, applicable executive orders, and other Federal planning requirements and policies. The use of the term “Federal objective” should be distinguished from planning/study objectives, which are more specific in terms of expected or desired outputs whereas the Federal objective is 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 a 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.)
- **Stewardship of the Ocean, Our Coasts, and the Great Lakes (EO 13547)**
- **Protection and Restoration of the Great Lakes (EO 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)
- Federal Water Project Recreation Act, as amended (16 USC 460 (L),(12))

Study Objectives

The study non-Federal sponsors, including the Lake County Forest Preserve District (LCFPD), City of Lake Forest, Openlands, and the Town of Ft. Sheridan, have 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, this study aims to protect, enhance, naturalize and restore coastal ecosystems. The following objectives are those that were directly measured for alternative analysis within this feasibility study:

Promote Littoral Processes – This objective seeks to naturalize coastal processes and dynamic equilibrium, and provide littoral habitat for native lacustrine fishes. The engineered shore protection structures along the coastline have greatly impaired the littoral drift, which naturally sustains and creates coastal habitat features such as lake bottom, beach, dune. The study area lies within a zone of erosion. If humans did not colonize the coastal zone in this area, the shoreline would naturally erode over the next several hundred years another 1,500 to 3,000-feet. Now that humans have sandwiched natural habitat between development and the lake, natural area managers typically need to implement small coastal features in order to preserve what coastal habitat remains. This objective is measured by the projected

increase in native fish species richness (R), and the increase in acreage and mean C of dune plant communities. The area this objective addresses is the lake, beach, dune for a 50-year period of analysis.

Naturalize Ravine Hydraulics – This objective seeks to stabilize channel geomorphology and naturalize flow characteristics. As the small ravine watersheds became developed and land use changed from forest, savanna and grassland to impervious surfaces, all of the ravines within the study area became utilized as discharge points for stormwater, however, Janes Ravine was since restored via the Estuary Habitat Restoration 104 Project. Any hydraulic repair measures for the purpose of stream habitat and riparian restoration would need to target hydraulic conditions that would be able to provide life history requisites for a given assemblage of fishes. It is well known that the force of water over and through in-stream structure creates requisites for lotic (moving water) fishes and macroinvertebrates to colonize. In turn, this also attracts those fish that do not need faster flowing water but feed on those invertebrates and fishes in the riffles, such as rockbass and smallmouth bass. Therefore, under this objective measures would be assessed in terms of how they affect in stream structure to compensate for abnormally high velocities associated with the larger urban flows or how the measure reduces the quantity of urban flow to the naturalized targets provided in **Table 7**. Ultimately, this objective translates the naturalized flows or flow conditions to a projected increase in native fish species richness and the mean C of ravine plant communities in response to restored hydraulic regimes.

Simulations for targeted flows were performed using the pre-development models to determine which duration would yield the largest peak flow for the 2-year rainfall event (**Appendix A**). Once the critical events had been determined using HEC-HMS, the peak discharges for the pre-development condition at the locations corresponding to the existing outfalls were identified. **Table 7** depicts the restoration target flows in cubic feet per second of the critical duration analysis, as observed at the mouth of the ravines along Lake Michigan.

Table 7 – Objective pre-development flows (cfs) for ravine hydraulics restoration

Durations	Mc/Janes	MacArthur	Scotts	Bartlett	Van Horne	Schenck
2-year Event						
6-hr	41.4	0.4	9.2	23.1	9.3	8.8
12-hr	46.3	0.4	10.2	25.4	10.3	9.7
24-hr	43.8	0.4	9.5	23.7	9.7	9.0
48-hr	29.9	0.3	6.5	16.2	6.7	6.2
72-hr	22.9	0.2	5.0	12.4	5.1	4.7
100-year Event						
6-hr	300.3	2.7	63.5	164.4	55.9	61.3
12-hr	259.4	2.3	55.9	140.7	56.8	53.1
24-hr	190.1	1.6	41.3	103.2	42.1	39.0
48-hr	113.0	1.0	24.6	61.0	25.2	23.2
72-hr	84.3	0.7	18.4	45.6	18.8	15.6

Promote Bluff Stability – This objective seeks to reduce erosion and promote healthy bluff hydrology. Any point in landscape topography where there is a sharp break in elevation, such as the edge of a bluff, the potential for erosion is great, especially when the underlying soils and glacial deposition are of highly erodible materials. Also, the Highland Park Moraine bluff face exhibits sloped-wetlands, which is driven by groundwater discharge slowly through the bluff face. Thusly, the target for bluff restoration would be to remove damaging surficial flows and recharge ground waters to sustain sloped wetlands. This objective is measured by the projected increase in acres and the mean C of native bluff plant communities.

Reduce / Eliminate Invasive Plants – This objective seeks to remove or ease the adverse affects/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 previous impairments placed on the site, particularly to hydrologic, soils, or chemical parameters. Once a sites hydrology and geomorphic impairments are remedied, invasive plant species may be addressed quite effectively. It is not uncommon to keep invasive plant species to a minimum or less than 1% of the site's spatial coverage. Measures, alternatives or plants should at minimum keep invasive plant species to less than 5% of the spatial coverage.

NER 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.

Opportunities are limited by:

- Highly impaired littoral drift processes
- Unnatural discharge of urban runoff from watershed development with impervious surfaces
- Parcel availability and acceptability for water storage and restoration features. The study area is very diverse in parceled out lands and ownerships. This constraint was identified in order to ensure that the real estate would be available and acceptable for USACE ecosystem restoration activities as coordinated with Real Estate and Environmental sections. For example, one of the main parcel constraints is the Historic Parade Ground, which the IL SHPO recommended no modifications to the grounds via a Federal project.

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 typically have non-monetary benefits. To facilitate the plan formulation process, in addition to The Smart Guide and ER 1105-2-100, the methodology outlined in the Corps' Engineering Circular 1105-2-404, "Planning Civil Work Projects under the Environmental Operating Principles," 1 May 2003 will be 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.
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 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 – physical repair and biological reestablishment. The biological reestablishment measures are dependent upon fixing the current conditions of the physical environment. For example, if one were to remove invasive species and replant native species along the ravine slopes without first repairing the hydraulics of the ravine's stream, the biological measures would fail overtime. With that being said, there was an initial assessment on the cost effectiveness of the physical repair measures. Once the most cost effective way to repair physical damage to stream hydraulics, littoral drift and bluff erosion was discerned, a second step displayed the paired measures of physical repair and biological reestablishment in an incremental fashion to guide decisions in selecting the most significantly beneficial plan that has an associated reasonable cost.

3.1.1 – Measures for Ravine Stream Hydraulics Repair

The following measures for the repair of stream hydraulics within the ravines are various and custom tailored to the ravine, and the ravine's current needs to be restored. These range from moving water around the ravine in pipes, detaining/retaining water, placing instream features to alleviate localized hydraulic issues, and reconnecting the stream to be confluent with Lake Michigan once again. All features that are situated in a position to provide habitat will be constructed of natural materials and stone similar to those that currently exist within the ravines. **Table 8** summarizes the physical repairs assessed for all ravines. The measures highlighted in red have been screened out for cultural resource purposes. Preliminary coordination with the Illinois State Historic Preservation Office indicated that modification of the Ft. Sheridan historic parade ground was not acceptable. Other measures were crafted to replace the function of these screened out measures.

Table 8 – Measures Summary for Ravine Stream Hydraulics Repair*

				Combinibility	
Ravine	**Code**	**Description**	**Plate #**	**Never**	**Always**
Bartlett	BRA	Ravine Head Option #1	6		BRB
	BRB	Ravine Head Option #2	6		BRA
	BRC	Tributary Restoration	6		
	BRD	Storm Sewer Near Head Option #1 - Armor Slope	6	BRE	
	BRE	Storm Sewer Near Head Option #2 - In-Ravine pipe	6	BRD	
Hutchinson	HRA	Scotts/Hutchinson Option #1 - Reroute Sewer to Det. Strg.	7	HRB, HRC, HRD	SRF, SRG
	HRB	Scotts/Hutchinson Option #2 - Reroute Sewer to Rvn Head	7	HRA, HRC, HRD	SRD, SRE
	HRC	Scotts/Hutchinson Option #3 - Above Ground Detention	7	HRA, HRB, HRD	
	HRD	Scotts/Hutchinson Option #4 - Below Ground Detention	7	HRA, HRB, HRC	
MacArthur	MRA	Ravine Head Option #1 - Storm Sewer Rerouting	8	MRB, MRC	
	MRB	Ravine Head Option #2 - In-Ravine Pipe	8	MRA, MRC	
	MRC	Ravine Head Option #3 - Riffle Series	8	MRA, MRB	
McCormick	MJRA	Ravine Mouth Option #1 - Steep Cobble Gradient	9	MJRB	MJRC
/Janes	MJRB	Ravine Mouth Option #2 - Riffles	9	MJRA	MJRC
	MJRC	Ravine Mouth Option #3 - Toe Reinforcement	9		
Schenck	SRA	Ravine Head Option #1 - Under Grd. Storage on Openlands Property	10	SRB, SRC	SRD, SRK
	SRB	Ravine Head Option #2 - Deep Cistern	10	SRA, SRC	SRD, SRK
	SRC	Ravine Head Option #3 - In-Ravine Pipe	10	SRA, SRB	SRD, SRK
	SRD	Ravine Mouth - 23 Grade Control Riffles	10		SRA, SRB, SRC
	SRE	Ravine Mouth Storm Sewer #1 - To Ravine	10	SRF	
	SRF	Ravine Mouth Storm Sewer #2 - To Ravine w/ Cistern	10	SRE	
	SRK	Ravine Riffles	10		
Scotts	SRA	Ravine Head Option #1 - Detention Basin to Trib w/ Drill Pipe	11	SRB, SRC, SRF, SRG	
	SRB	Ravine Head Option #2 - Detention Basin to Trib wo/ Drill Pipe	11	SRA, SRC, SRF, SRG	
	SRC	Ravine Head Option #3 - Under Grd. Storageto Trib wo/ Drill Pipe	11	SRA, SRB, SRF, SRG	
	SRD	Ravine Head Option #4 - In-Ravine Pipe w/ Drilled Pipe	11	SRE, SRF, SRG	
	SRE	Ravine Head Option #5 - Open Channel	11	SRD, SRF, SRG	
	SRF	Ravine Head Option #6 - Detention Basin to Head wo/ Drill Pipe	11	SRD, SRE, SRG	
	SRG	Ravine Head Option #7 - Under Grd. Storage w/o Drilled Pipe	11	SRD, SRE, SRF	
	SRH	Ravine MouthOption #1 - Check Dam Removal	11		
Van Horne	VRA	Ravine Head Option #1 - Detention Basin	12	VRB, VRC	
	VRB	Ravine Head Option #2 - Under Grd. Storage	12	VRA, VRC	
	VRC	Ravine Head Option #3 - In-Ravine Pipe	12	VRA, VRB	
	VRD	Ravine Mouth Option #1 - Culvert Inlet Stabilization	12	VRC, VRE-VRH	
	VRE	Ravine Mouth Option #2 - Culvert Inlet Stabilization	12	VRC, VRD-VRH	
	VRF	Ravine Mouth Option #3 - Culvert Inlet Stabilization	12	VRD-VRH	
	VRG	Ravine Mouth Option #4 - Earthen Dam Removal & Chute	12	VRD-VRH	
	VRH	Ravine Mouth Option #5 - Earthen Dam Tunnel & Chute	12	VRD-VRH	
	VRI	Ravine Riffles	12		VRA, VRB

-measures highlighted in red were screened out due to SHPO compliance issues
* see Plate 20 for measures crosswalk

Bartlett Ravine (Plate 06)

Ravine Head Option #1 (BRA) – This measure seeks to alleviate damage caused by storm water discharging from the pond at the head of Bartlett Ravine's tributary. Two elevated culverts serve as the outlets for the pond. Because the discharge drops several feet scouring of the channel is a significant problem. This measure is not combinable with measure BRB. An 8-foot long concrete drop structure with baffle blocks would be installed under the discharge culverts to dissipate the energy in the discharge from the culverts. A stone apron would be provided at the downstream end of the drop structure to prevent scour from occurring at the transition between the drop structure and the channel bottom.

Ravine Head Option #2 (BRB) – This measure seeks to alleviate damage caused by storm water discharging from the pond at the head of Bartlett Ravine's tributary. . Two elevated culverts serve as the outlets for the pond. Because the discharge drops several feet scouring of the channel is a significant

problem. This measure is not combinable with measure BRA. The channel downstream of the outfall would be stabilized using a combination of (21) twenty-one 6" and 12" riffles of varying spacing, effectively reducing the overall channel slope while accommodating the same elevation drop across the hardened points. The existing grade control structure located near the confluence will be removed and replaced with a single 18" high riffle.

Tributary Remediation (BRC) – This measure seeks to alleviate damage caused by storm water discharging from the outfall located along the tributary to Bartlett Ravine by removing the existing rubble headwall and advancing it approximately seventy feet towards the confluence with the tributary. The outfall at the base of the existing headwall will be removed and relocated such that it discharges directly to the ravine. A plunge pool will be installed immediately downstream of the outlet at the spur to prevent erosion. Fill would be placed behind the proposed headwall to the existing grade.

Storm Sewer Near Head Option #1 (BRD) – This measure seeks to alleviate the channel incision caused by the storm water discharging from the sewer outfall located near the top of a small tributary of the main ravine. This measure is not combinable measure BRE. This measure calls for armoring the tributary channel with 6" stone to a thickness of 12" from the outfall to the base of the concrete chute located near the base of the ravine.

Storm Sewer Near Head Option #2 (BRE) – This measure seeks to alleviate the channel incision caused by the storm water discharging from the sewer outfall located near the top of a small tributary of the ravine by the installation of an in-ravine pipe to discharge the water directly to the base of the ravine. A new structure would be installed at the current outfall and an additional 180' of 18" pipe placed along the existing channel. The pipe would be covered with 12" of stone and 12" of clean backfill. This measure is not combinable with measure BRD.

Hutchinson Ravine (Plate 07)

Scotts / Hutchinson Option #3 (HRC) – This measure seeks to attenuate the storm sewer discharge entering Hutchinson Ravine discharge for large return period events. This would be accomplished by diverting flows through a detention basin prior to discharging them to the ravine. This measure is not combinable with measures HRA, HRB, or HRD. The existing storm sewer network is characterized by a significant difference in elevation between its upstream structures and outlet within a relatively dense configuration, thereby limiting the opportunities for the incorporation of offline storage. The existing storm sewer network would be intercepted to divert flows to the proposed detention basin. Preliminary sizing calls for a facility 6 feet deep with an average surface area of approximately 36,500 ft^2. The outlet of the detention basin would reconnect to the existing storm sewer network a short distance prior to its outlet into the ravine. Segments of the original storm sewer network superfluous after the introduction of the detention basin would be abandoned.

Scotts / Hutchinson Option #4 (HRD) – This measure seeks to attenuate the storm sewer discharge entering Hutchinson Ravine discharge for large return period events. This would be accomplished by diverting flows through underground storage prior to discharging them to the ravine. This measure is not combinable with measures HRA, HRB, or HRC. This measure is equivalent to measure HRC except that flow attenuation is achieved using underground storage instead of a detention area.

MacArthur Ravine (Plate 08)

Ravine Head Option #1 (MRA) – This measure seeks to restore more natural flow conditions to the MacArthur Ravine via redirecting the storm intercept sewers. The easternmost structures in the cul-de-sac – an inlet and its downstream manhole - would be replaced, allowing for a reversal of the direction of

flow. The original pipe would be blocked where the storm sewer legs originally merge between homes and a new 18” diameter, 90’ long pipe would be installed. An additional pipe would then be run to the bluff and connect to a directionally-drilled pipe that would descend down to the beach. A structure would be placed at the toe of the bluff to intercept the flow, diverting the storm water runoff away from the homeowner located at the mouth of Hutchinson Ravine. The water would finally be discharged onto a stone apron located on the beach to prevent scouring at the outfall.

Ravine Head Option #2 (MRB) – This measure seeks to mitigate the damages caused by unnatural flows due to urban development adjacent to the MacArthur Ravine via redirecting all inflows through an in-ravine pipe directly connected to the existing outlet. The pipe would be buried beneath the ravine floor and covered with 12” of stone and 12” of alluvial material. Water from the pipe would discharge directly onto the beach, which would be protected with a cobble apron.

Ravine Head Option #3 (MRC) – This measure seeks to restore more natural flow conditions to the MacArthur Ravine via armoring the floor of the ravine with construction of (79) seventy-nine small riffles constructed with a median stone size of twelve inches. The water would finally flow onto a stone apron to prevent scouring of the beach.

McCormick & Jane’s Ravines (Plate 09)

Ravine Mouth Option #1 (MJRA) – This measure seeks to remove the poorly maintained storm sewer structures located at the confluence of McCormick and Jane’s Ravines and replace them with a mild boulder/cobble slope that would extend a small distance upstream and downstream. This structure will inhibit further down cutting and permit connectivity with the rest of the ravine. The existing monolithic slabs, failed structures and broken pipe will be removed and replaced with boulder and cobbles approximately 2 feet in diameter laid at a slope of 10%. The armoring will extend upstream and downstream of the apron 10’ to protect from undercutting and scour. This measure is not compatible with MJRB.

Ravine Mouth Option #2 (MJRB) – This measure seeks to remove the poorly maintained storm sewer structures located at the confluence of McCormick and Jane’s Ravines and replace them with mildly sloped riffles that would dissipate the severe elevation difference over a longer length of the ravine. These structures will inhibit further down cutting and will permit connectivity with the rest of the ravine. The existing monolithic slabs and failed structures will be removed and ravine floor graded from the confluence of Janes and McCormick Ravine back to the limits of construction. The remaining pipe in McCormick Ravine will be relocated or pulverized and buried for approximately 600 feet upstream of the confluence. In Janes Ravine, a series of (11) eleven 12” riffles using a median stone size of 6 inches will be placed throughout the ravine. In McCormick Ravine, a series of (6) six 12” riffles using a median stone size of 16 inches will be placed throughout the ravine. The currently eroded banks will be cut back to a stable slope. The channel behind the riffles will be prefilled using spoil from the regrading of the channel banks. A plunge pool will be placed at the confluence of the two ravines. A cutoff wall should be provided at the downstream end of the plunge pool. This measure is not compatible with MJRA.

Ravine Mouth Option #3 (MJRC) – This measure seeks to stabilize and provide habitat at the mouth of the ravine and provide connectivity to the lake. The existing toe of the southern bluff exhibits signs of undercutting and sloughing. Tree trunks, root wads, boulders and native plants would be embedded in/along the toe of the bluff to resist flows due to design storm events. Through these features, the ravine mouth and adjoining bluffs would no longer be unstable.

Schenck Ravine (Plate 10)

Ravine Head Option #1 (SRA) – This measure is not combinable with SRB or SRC. This measure calls for an underground storage area to attenuate urban discharge into the Schenck Ravine. This underground storage would be installed in-line with the existing sewer line south of the residential development. A stone apron would be placed at the storm sewer's existing outlet into the ravine and a cobble riffle placed at the immediate downstream end of the apron.

Ravine Head Option #3 (SRC) – This measure is not combinable with SRA or SRB. This measure calls for bypassing urban flows using an in-ravine pipe placed beneath the ravine floor. A stone blanket consisting of 18" diameter stones on top of a gravel base would be placed along the first 100' of ravine. At the end of the stone channel, a junction box would be utilized to transfer the water into the pipe. The in-ravine pipe would be buried below 12" of stone and 12" of suitable alluvial materials. The water from the pipe would then discharge directly onto the beach, which could be protected with a cobble apron if necessary.

Ravine Mouth (SRD) – This measure seeks to repair the Scheck Ravine mouth, which became unraveled due to urban runoff and unsuccessful repair attempts. A total of 23 cobble riffles would be utilized to prevent further head-cutting and to minimize flow velocities. This stream reach would visually resemble a high gradient Appalachian mountain stream during storm events, but with the channel slope experiencing minor settling over time.

Ravine Mouth Storm Sewer #1 (SRE) – This measure is not compatible with SRF. This measure seeks to prevent and restore the area damaged at the northern slope of the ravine mouth. A new structure would intercept the storm water and safely transport down to the lake, where the outlet would be located at the toe of the slope, allowing the water to fall approximately four feet before discharging to the ravine. Unless integrated into SRC, a stone apron would need to be placed at the storm sewer outfall to prevent scouring.

Ravine Mouth Storm Sewer #2 (SRF) – This measure is not compatible with SRE. This measure seeks to repair the failed storm sewer pipe that has caused damage to the northern slope of the ravine mouth. The existing outlet line and upstream structure would be replaced by three (3) 8'x10' box culverts 75' long. Each of the storage underground storages would be positioned side by side and interconnected to each other. A manhole, set to a depth of 25', would be installed directly outside the structure, to which a 6" primary outlet and a 12" overflow outlet would be connected. A 150' long, 12" directionally-drilled pipe would be installed, discharging water to the head of the ravine. The outlet would be located in a structure installed in the toe of the slope, allowing the water to fall approximately four feet before discharging to the ravine. Unless integrated into SRC, a stone apron would need to be placed at the storm sewer outfall to prevent scouring.

Ravine Riffles (SRK) – This measure would install (9) nine 12" riffles along the ravine floor in order to repair former channel incision, to provide habitat for macroinvertebrates and fishes and to reduce channel velocity during extreme rainfall events by decreasing the floor's slope.

Scotts Ravine (Plate 11)

Ravine Head Option #4 (SRD) – This measure seeks to remove the unnatural flows caused by urban development to the Scotts Ravine via an in-ravine pipe placed on the ravine floor and buried below two feet of fill, causing the flow to effectively bypass the ravine. This measure assumes the pipe would discharge directly to the beach where it would be armored with a plunge pool and stone apron. A plunge pool would be constructed at the head of the ravine to catch the discharge of water from existing storm

sewers. An inlet structure would be installed to divert the storm water into the subsurface pipe. Roughly half way down the ravine, an additional manhole would be installed to intercept the sewer outfall on the north slope of the ravine. This measure is not combinable with SRE, SRF or SRG. This measure would need to provide (12) twelve 12" riffles downstream to reduce velocity and to prevent further channel incision from surface runoff down the ravine.

Ravine Head Option #5 (SRE) – This measure is not combinable with SRD. This measure seeks to augment the existing natural ravine floor with engineered structures to allow excess storm water to be conveyed to the mouth of the ravine without further detrimental impacts to the ravine floor or adjacent slopes. This measure does not provide for a directionally-drilled pipe that would reroute storm sewer flow from the tributary directly to the beach. A plunge pool would be provided at the head of the ravine to catch the discharge of water from the sewer lines.

Ravine Mouth Option #1 (SRH) – This measure seeks to naturalize the mouth of Scotts Ravine by removing the existing check dam that currently prevents natural connectivity to Lake Michigan. The earth fill would be completely removed and the slope of the floor of the ravine reduced by increasing the extent of the excavation to the spur. This measure would provide twelve (12) 12" stone riffles spaced every 18.5 feet to ensure stability of the ravine mouth to beach transition while providing spawning habitat for lake fishes.

Van Horne Ravine (Plate 12)

Ravine Head Option #1 (VRA) – This measure seeks to remove the unnatural flows caused by urban development to the Van Horne Ravine via a detention basin at the head of the ravine. A 1.5-acre detention basin would be excavated between 2nd Street, 3rd Street and Patten Road. All storm sewer networks currently discharging to the head of the ravine would be rerouted so that storm water first enters the detention basin for attenuation purposes prior to discharging back to the ravine.

Ravine Head Option #2 (VRB) – This measure is the same as VRA except that attenuation is achieved using underground storage instead of a detention facility.

Ravine Head Option #3 (VRC) – This measure seeks to remove the unnatural flows caused by urban development to the Van Horne Ravine via an in-ravine pipe buried in the ravine floor below 12" of stone and 12" of alluvial material. The water from the pipe would discharge directly onto the beach, which would be protected with a cobble apron.

Ravine Mouth Option #1 (VRD) –This measure seeks to restore flow from the ravine to the beach by stabilizing the culvert inlet that allows storm flows to pass under the earthen dam at the mouth of the ravine. The culvert would be excavated – an estimated depth of 5 to 6 feet – and an approach sloped at 2% provided. A pair of riffles will be placed upstream of the culvert outlet to prevent sedimentation of the culvert. The sides of the excavation will be set back to a stable slope to prevent sedimentation of the culvert. This measure does not provide fish passage.

Ravine Mouth Option #2 (VRE) –This measure seeks to restore flow from the ravine to the beach by stabilizing the culvert inlet that allows storm flows to pass under the earthen dam at the mouth of the ravine. The culvert would be excavated – an estimated depth of 5 to 6 feet – and an approach sloped at 20% provided. The slope would be armored with a blanket of 9" stone. A headwall and wingwalls would reinforce the sides of the excavation. This measure does not provide fish passage.

Ravine Mouth Option #3 (VRF) – This measure seeks to restore flow from the ravine to the beach by stabilizing the culvert inlet that allows storm flows to pass under the earthen dam at the mouth of the

ravine. A rectangular manhole of sufficient size would be installed at the mouth of the ravine to provide connectivity between the proposed in-ravine pipe and the existing culvert. A beehive grate would be provided to facilitate drainage of the natural storm flows from the ravine. This measure does not provide fish passage.

Ravine Mouth Option #4 (VRG) – This measure seeks to naturalize the mouth of Van Horne Ravine by removing the existing earthen structure that currently prevents natural connectivity to Lake Michigan. A channel would be cut from the inland side of the existing earthen structure until it intersects with the bluff. A cobble chute would be constructed using appropriately sized stones. This measure provides fish passage.

Ravine Mouth Option #5 (VRH) – This measure seeks to naturalize the mouth of Van Horne Ravine by constructing a tunnel through the existing earthen structure that currently prevents natural connectivity to Lake Michigan. The tunnel would be constructed from the inland side of the existing dam and would exit at the toe of the bluff. The interior of the chute would be lined with appropriately sized stones. A stone apron will be installed at the mouth of the outfall structure. This measure may facilitate fish passage.

Ravine Riffles (VRI) – This measure would install (14) fourteen 18" riffles along the ravine floor in order to repair former channel incision, to provide habitat for macroinvertebrates and fishes, and to reduce channel velocity during extreme rainfall events by decreasing the ravine floor's slope. All riffles would be constructed of natural cobble and boulder materials.

3.1.2 – Measures for Littoral Drift Repair

The following measures for naturalizing littoral drift functions focus on sand aggradations to increase the size of fore dune habitat and to provide physical habitat for fishes via sand bar formation and the rock structures themselves. These structures would be small rock structures that would be prefilled with sand to start off at equilibrium. These features would be constructed of natural materials and stone similar to those cobbles and boulders found along the beach. There are various pockets of quarried stone along the beach and bluff toe currently that may be reused under some of these features as well. **Table 9** summarizes the physical repairs assessed for littoral drift and may be viewed on **Plate 13**. Although Plate 13 currently shows the small rock reef systems as straight line features, these will be designed for habitat optimization and to be aesthetically pleasing.

Table 9 - Measures Summary for Littoral Drift Repair

				Combinability	
Coastal Zone	**Code**	**Description**	**Plate #**	**Never**	**Always**
McCormick/Janes	DC	Rock Reef System Option #1	13	DO,DN,DM	
McCormick/Janes	DD	Rock Reef System Option #2	13		
Bartlett	DE	Rock Reef System Option #3	13	DL, DK, DP	
Schenck	DF	Rock Reef System Option #4	13		
Schenck	DG	Dune Restoration Option #1 - Existing	13		
Schenck	DH	Dune Restoration Option #2 - Proposed	13		
Bartlett	DI	Dune Restoration Option #3 - Proposed	13		
Bartlett	DJ	Dune Restoration Option #4 - Existing	13		
Bartlett	DK	Dune Restoration Option #5 - Proposed	13	DE	
Bartlett	DL	Dune Restoration Option #6 - Existing	13	DE	
McCormick/Janes	DM	Dune Restoration Option #7 - Existing	13	DC	
McCormick/Janes	DN	Dune Restoration Option #8 - Proposed	13	DC	
McCormick/Janes	DO	Dune Restoration Option #9 - Proposed	13	DC	
Bartlett	DP	Rock Reef System Option #5	13	DL, DK, DE	

Rock Reef System Option #1 (DC) – This measure seeks to provide shallow, near shore lacustrine, beach and dune habitats. This would be achieved via engaging the long shore sediment transport by constructing a series of nearshore and headland rock reefs adjacent to McCormick Ravine. These would be placed north of the Section 104 Estuary Project's detention pond outfall and south of the project boundary. Optimization of the reefs would be conducted during design, which includes various in lengths, heights and geometric configurations in order to maximize habitat diversity within the affected zone. The cells produced by these reef structures would be prefilled with 120% of the estimated stable volume upon construction to minimize affects to the current littoral drift conditions.

Rock Reef System Option #2 (DD) – This measure seeks to provide shallow, nearshore lacustrine, beach and dune habitats. This would be achieved via engaging the long shore sediment transport by constructing a series of nearshore and headland rock reefs adjacent to Hutchinson Ravine. These would be placed south of the Section 104 Estuary Project's detention pond outfall and north of Hutchinson Ravine. Optimization of the reefs would be conducted during design, which includes various in lengths, heights and geometric configurations in order to maximize habitat diversity within the affected zone. The cells produced by these reef structures would be prefilled with 120% of the estimated stable volume upon construction to minimize affects to the current littoral drift conditions.

Rock Reef System Option #3 (DE) – This measure seeks to provide shallow, nearshore lacustrine, beach and dune habitats. This would be achieved via engaging the long shore sediment transport by constructing a series of nearshore and headland rock reefs in front of Bartlett Ravine. Optimization of the reefs would be conducted during design, which includes various in lengths, heights and geometric configurations in order to maximize habitat diversity within the affected zone. The cells produced by these reef structures would be prefilled with 120% of the estimated stable volume upon construction to minimize affects to the current littoral drift conditions. This measure is not combinable with DP.

Rock Reef System Option #4 (DF) – This measure seeks to provide shallow, nearshore lacustrine, beach and dune habitats. This would be achieved via engaging the long shore sediment transport by constructing a series of nearshore and headland rock reefs in front of and to the south of Schecnk Ravine. Optimization of the reefs would be conducted during design, which includes various in lengths, heights and geometric configurations in order to maximize habitat diversity within the affected zone. The cells produced by these reef structures would be prefilled with 120% of the estimated stable volume upon construction to minimize affects to the current littoral drift conditions.

Dune Restoration Option #1 (DG) – This measure seeks to increase dune acres and stability along a 540 foot length of shoreline north of Schenck Ravine. The existing stone revetment along the bluff toe would simply be covered with a layer of sand, allowing for the planting of native dune grasses, flowers, shrubs and cacti.

Dune Restoration Option #2 (DH) – This measure seeks to increase dune acres and stability along a 480 foot length of shoreline north of Schenck Ravine. There is no existing stone revetment along the bluff toe in this reach, therefore, to provide a base for dune formation, large woody debris and/or boulders would be placed and simply covered with a layer of sand, allowing for the planting of native dune grasses, flowers, shrubs and cacti.

Dune Restoration Option #3 (DI) – This measure seeks to increase dune acres and stability along a 1,200 foot length of shoreline north of the existing crescent beach. There is no existing stone revetment along the bluff toe in this reach, therefore, to provide a base for dune formation, large woody debris and/or boulders would be placed and simply covered with a layer of sand, allowing for the planting of native dune grasses, flowers, shrubs and cacti.

Dune Restoration Option #4 (DJ) – This measure seeks to increase dune acres and stability along a 1,050 foot length of shoreline north of Van Horne Ravine. The existing stone revetment along the bluff toe would simply be covered with a layer of sand, allowing for the planting of native dune grasses, flowers, shrubs and cacti.

Dune Restoration Option #5 (DK) – This measure seeks to increase dune acres and stability along a 470 foot length of shoreline north of the Navy's sewer lift station. There is no existing stone revetment along the bluff toe in this reach, therefore, to provide a base for dune formation, large woody debris and/or boulders would be placed and simply covered with a layer of sand, allowing for the planting of native dune grasses, flowers, shrubs and cacti.

Dune Restoration Option #6 (DL) – This measure seeks to increase dune acres and stability along a 480 foot length of shoreline north of Bartlett Ravine. There is no existing stone revetment along the bluff toe in this reach, therefore, to provide a base for dune formation, large woody debris and/or boulders would be placed and simply covered with a layer of sand, allowing for the planting of native dune grasses, flowers, shrubs and cacti.

Dune Restoration Option #7 (DM) – This measure seeks to increase dune acres and stability along a 220 foot length of shoreline adjacent to the Section 104 Estuary Project's detention pond. The existing stone revetment along the bluff toe would simply be covered with a layer of sand, allowing for the planting of native dune grasses, flowers, shrubs and cacti.

Dune Restoration Option #8 (DN) – This measure seeks to increase dune acres and stability along a 440 foot length of shoreline south of McCormick Ravine. There is no existing stone revetment along the bluff toe in this reach, therefore, to provide a base for dune formation, large woody debris and/or boulders would be placed and simply covered with a layer of sand, allowing for the planting of native dune grasses, flowers, shrubs and cacti.

Dune Restoration Option #9 (DO) – This measure seeks to increase dune stability along a 500 foot length of shoreline north of McCormick Ravine. There is no existing stone revetment along the bluff toe in this reach, therefore, to provide a base for dune formation, large woody debris and/or boulders would be placed and simply covered with a layer of sand, allowing for the planting of native dune grasses, flowers, shrubs and cacti.

Rock Reef System Option #5 (DP) – This measure seeks to provide shallow, nearshore lacustrine, beach and dune habitats. This would be achieved via engaging the long shore sediment transport by constructing a series of nearshore and headland rock reefs in front of Bartlett Ravine, but situated on just north of the ravine mouth. Optimization of the reefs would be conducted during design, which includes various in lengths, heights and geometric configurations in order to maximize habitat diversity within the affected zone. The cells produced by these reef structures would be prefilled with 120% of the estimated stable volume upon construction to minimize affects to the current littoral drift conditions. This measure is not combinable with DE.

3.1.3 – Measures for Bluff Erosion Repair

The following measures for the repair of physical disturbance to the bluff focus on preventing further damage from water erosion, and repairing small gullies and rills (**Table 10**). The measures for bluff erosion repair may be viewed on **Plate 14**.

Table 10 - Measures Summary for Bluff Erosion Repair

				Combinability	
Area Name	**Code**	**Description**	**Plate #**	**Never**	**Always**
Bluff	BC	Abandoned Storm Sewer Outfall Option #1	14	BD	
Bluff	BD	Abandoned Storm Sewer Outfall Option #2	14	BC	
Bluff	BE	Grading for Purposes of Plantings	14		
Bluff	BE	Grading for Purposes of Plantings	14		
Schenck Ravine Bluff	SRG	Eroded Bluff Face Option #1 - Multiple Drop Structures	14	SRH, SRI	
Schenck Ravine Bluff	SRH	Eroded Bluff Face Option #2 - Baffled Chute	14	SRG, SRI	
Schenck Ravine Bluff	SRI	Eroded Bluff Face Option #3 - Single Drop Structure	14	SRG, SRH	
Schenck Ravine Bluff	SRJ	Eroded Bluff Face Option #4 - Swale Modification	14		
Bartlett Ravine Bluff	BRF	Eroded Bluff Face Option #5 - Bartlett Mouth	14		

Abandoned Storm Sewer Outfall Option #1(BC) – This measure seeks to address the outfall currently discharging at the top of the bluff. The existing manhole at the top of the bluff will be replaced by a structure with a depth of approximately 6'. An 18" diameter pipe will be installed from the structure to the toe of the bluff at the beach. A stone apron will be provided at the outlet to prevent erosion.

Abandoned Storm Sewer Outfall Option #2(BD) – This measure seeks to address the outfall currently discharging at the top of the bluff. While the outfall still collects water from the storm sewer network to which it is connected, the neighborhood the network previously served has been razed and the area left vacant. The storm sewer pipe leading to the outfall will be cut approximately 10' from the property line and mechanically plugged. Concrete will be placed around the plug and backfilled upon curing. The gully will be restored.

Gully and Rill Repair (BE) – This measure seeks to perform minor grading and filling of small gullies and rills on the bluff faces in the two areas depicted on Plate 14. This measure needs to be accomplished in order to establish native bluff plant communities in these areas.

Eroded Bluff Face Option #1 (SRG) – This measure seeks to repair the eroding bluff face to the south of the Schenck Ravine mouth. This measure is not combinable with measure SRH or SRI. Surface runoff currently discharged from the pair of outfalls down the bluff would instead be routed directly to the beach via a 12" diameter,100'long pipe laid at a 4% slope'. The urban flows would then discharge to a 120' long 12" diameter pipe that would discharge directly to the beach. A stone apron for the storm sewer outfall would be placed on the beach to prevent scouring.

Eroded Bluff Face Option #2 (SRH) – This measure seeks to repair the eroding bluff face to the south of the Schenck Ravine mouth. This measure is not combinable with measure SRG or SRI. Surface runoff currently discharged from the pair of outfalls directly down the bluff would instead be routed through a baffled chute drop structure. The existing outfall structures would be intercepted by a 2' wide cast-in-place rectangular concrete chute that would run for approximately 10' at a slope of 0.01. At the end of this approach, the baffled chute would run parallel to the bluff face to the beach. The baffled chute would be 2.4' deep and include rows of baffles spaced every 2 to 2.5'. Typical sizing of baffles would be 9" long, 10" high and 14.5" wide. Rows of baffles would alternate between a single baffle centered in the chute and two partial baffles projecting 6" from the walls of the chute. A stone apron would be placed at the base of the baffled chute to prevent scouring.

Eroded Bluff Face Option #3 (SRI) - This measure seeks to repair the eroding bluff face to the south of the Schenck Ravine mouth. This measure is not combinable with SRG or SRH. Surface runoff currently discharged from the pair of outfalls directly down the bluff would instead be routed directly to the beach.

The existing outfall structures would be replaced with a manhole that would intercept the storm sewer discharge. The structure would have an approximate rim elevation of 642 and invert elevation of 617. It would discharge to a 12" diameter pipe directionally-drilled at an 18% slope with its outlet located at the beach. A stone apron would be provided for the outfall on the beach.

Eroded Bluff Face Option #4 (SRJ) - This measure seeks to repair the eroding bluff face to the south of the Schenck Ravine mouth. The storage volume available in the existing "detention feature" will be increased by removing the intermediate inlet structures from the swale. A series of cobble check dams will be installed along the northern swale, creating four basins. Flow will primarily occur through the interstitial spaces, but the crest elevation will be set to an elevation of 1 to 1.5 feet above the thalweg allowing for overtopping if necessary. A swale will be provided at the downstream end that would convey any discharge due to overtopping back into the storm sewer outlet pipe.

Eroded Bluff Face Option #5 (BRF) – This measure seeks to redirect existing urban laminar discharge that is eroding bluff face near old mouth of Bartlett Ravine, which has resulted from a previous US Army project that turned Bartlett Ravine into a road without functional drainage features. A vertical-faced curb will be installed along the northern edge of the bluff, tying into the existing curb and extending to the edge of the existing pavement. The end of the road would slightly be regarded to achieve appropriate pitch to properly channel the rushing storm water. A grate spanning the roadway from curb-to-curb over a trench 6' deep and 3' wide will intercept the flow to safely convey the storm water to the beach and prevent it from careening over the bluff and continue causing damage to important geologic and biological resources. A stone plunge pool will be provided at the outlet to prevent the beach from scouring. Damage to the bluff would be repaired through grading and planting heavily with native bluff plant species.

3.1.4 – Measures for Biological Establishment

The following measures for the establishment of native dune, bluff and ravine plant communities consist of clearing and herbicide application to remove invasive species, collecting and sowing of native seed per community type, and collecting seed of the purpose of growing plug material to be planted (Table 11). The measures for bluff erosion repair may be viewed on **Plate 15**.

Table 11 - Measures Summary for Biological Establishment

				Combinibility	
Area Name	**Code**	**Description**	**Plate #**	**Never**	**Always**
Bartlett Ravine	BRG	Invasive Species Removal	15		BRH
Bartlett Ravine	BRH	Native Plant Establishment	15		BRG
Dune	DA	Invasive Species Removal	15		DB
Dune	DB	Native Plant Establishment	15		DA
Bluff	BA	Invasive Species Removal	15		BB
Bluff	BB	Native Plant Establishment	15		BA
Hutchinson Ravine	HRE	Invasive Species Removal	15		HRD
Hutchinson Ravine	HRF	Native Plant Establishment	15		HRC
MacArthur Ravine	MRD	Invasive Species Removal	15		MRE
MacArthur Ravine	MRE	Native Plant Establishment	15		MRD
McCormick Ravine	MJRD	Invasive Species Removal	15		MJRE
McCormick Ravine	MJRE	Native Plant Establishment	15		MJRD
Schenck Ravine	SRL	Invasive Species Removal	15		SRM
Schenck Ravine	SRM	Native Plant Establishment	15		SRL
Scotts Ravine	SRP	Invasive Species Removal	15		SRH
Scotts Ravine	SRQ	Native Plant Establishment	15		SRG
Van Horne Ravine	VRJ	Invasive Species Removal	15		VRK
Van Horne Ravine	VRK	Native Plant Establishment	15		VRJ

Bartlett Ravine

Invasive Species Removal (BRG) – This measure seeks to selectively remove invasive and opportunistic woody vegetation shading the ravine's understory. Invasive species removal would cover about 20.8-acres.

Native Plant Establishment (BRH) – This measure seeks to plant 20.8-acres of native ravine species of local genotype; species harder to establish from seed will be introduced as plugs. Given the unique climate and suite of rare species within the ravine's topology, genetic preservation of rare or state listed species will be maintained by contract growth of certain species that currently reside in low numbers within the ravine and/or which are not available commercially. Use of contract grown species from sources within or near the site not only preserve the unique genetics of the area, but also maximize the success of establishment as local genotypes within the study area are more likely adapted to the harsh conditions presented by ravines. Species to be planted are included in Appendix B.

Beach & Dune

Invasive Species Removal (DA) – This measure seeks to remove all woody and herbaceous invasive species within about 10-acres of dune area by hand pulling and/or spot herbicide application. This measure is cost out on the per acre basis and will fluctuate per the measure.

Native Plant Establishment (DB) – Native plant establishment of about 10-acres of dune will be achieved primarily though the installation of sand stabilizing marram grass (*Ammophila breviligulata*) as well as other species of local genotype that regularly inhabit beach and foredune areas. In order to replicate the genetic diversity and local genotypes found within native stands of marram grass in Illinois, only rhizome transplants of marram grass from existing stands within Fort Sheridan as well as Illinois Beach State Park, with permission from IDNR, will be used within the project area. Current available commercial sources of marram grass do not match the genetic constitution or genetic diversity of local native populations of marram grass and thus may negatively impact long term establishment and success of restored populations as well as potentially threaten the sustainability of nearby native stands of this state endangered species (Fant 2008). Species to be planted are included in Appendix B.

Bluff

Invasive Species Removal (BA)

This measure seeks to selectively remove about 40-acres of invasive and opportunistic woody vegetation shading the 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*), staghorn sumac (*Rhus typhina*), Norway maple (*Acer platanoides*), gray dogwood (*Cornus racemosa*), white mulberry (*Morus alba*), green ash (*Fraxinus lanceolata*), cottonwood (*Populus deltoides*), and basswood (*Tilia americana*). This measure also includes the removal of invasive herbaceous species by spot application of herbicide as well as the incorporation of a prescribed burn.

Native Plant Establishment (BB)

This measure seeks to plant about 40-acres of native species of local genotype that are known to inhabit lakeshore bluff communities; species harder to establish from seed will be introduced as plugs. Given the unique climate of lakeshore 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. Species to be planted are included in Appendix B.

Hutchinson Ravine

Invasive Species Removal (HRE) – This measure seeks to selectively remove invasive and opportunistic woody vegetation shading the ravine's understory. Invasive species removal would cover about 23.2-acres. 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*), Japanese barberry (*Berberis thunbergii*), Norway maple (*Acer platanoides*), gray dogwood (*Cornus racemosa*), white mulberry (*Morus alba*), green ash (*Fraxinus lanceolata*), cottonwood (*Populus deltoides*), and basswood (*Tilia americana*). Following selective clearance, all stumps will be swabbed with herbicide. This measure also includes the removal of invasive herbaceous species by spot application of herbicide as well as the incorporation of a prescribed burn.

Native Plant Establishment (HRF) – This measure seeks to plant 23.2-acre of native ravine species of local genotype; species harder to establish from seed will be introduced as plugs. Given the unique climate and suite of rare species within the ravine's topology, genetic preservation of rare or state listed species will be maintained by contract growth of certain species that currently reside in low numbers within the ravine and/or which are not available commercially. Use of contract grown species from sources within or near the site not only preserve the unique genetics of the area, but also maximize the success of establishment as local genotypes within the study area are more likely adapted to the harsh conditions presented by ravines. Species to be planted are included in Appendix B.

MacArthur Ravine

Invasive Species Removal (MRD) – This measure seeks to selectively remove invasive and opportunistic woody vegetation shading the ravine's understory. Invasive species removal would cover about 1-acres. 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*), Japanese barberry (*Berberis thunbergii*), Norway maple (*Acer platanoides*), gray dogwood (*Cornus racemosa*), white mulberry (*Morus alba*), green ash (*Fraxinus lanceolata*), cottonwood (*Populus deltoides*), and basswood (*Tilia americana*). Following selective clearance, all stumps will be swabbed with herbicide. This measure also includes the removal of invasive herbaceous species by spot application of herbicide as well as the incorporation of a prescribed burn.

Native Plant Establishment (MRE) – This measure seeks to plant 1-acre of native ravine species of local genotype; species harder to establish from seed will be introduced as plugs. Given the unique climate and suite of rare species within the ravine's topology, genetic preservation of rare or state listed species will be maintained by contract growth of certain species that currently reside in low numbers within the ravine and/or which are not available commercially. Use of contract grown species from sources within or near the site not only preserve the unique genetics of the area, but also maximize the success of establishment as local genotypes within the study area are more likely adapted to the harsh conditions presented by ravines. Species to be planted are included in Appendix B.

McCormick & Jane's Ravine

Invasive Species Removal (MJRD) – This measure seeks to selectively remove about 108-acres of invasive and opportunistic woody vegetation shading the ravine's understory. Invasive species removal would cover about 108-acres. 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*), Japanese barberry (*Berberis thunbergii*), Norway maple (*Acer platanoides*), gray dogwood (*Cornus racemosa*), white mulberry (*Morus alba*), green ash (*Fraxinus lanceolata*), cottonwood (*Populus deltoides*), and basswood (*Tilia americana*). Following selective clearance, all stumps will be swabbed with herbicide. This measure also includes the removal of invasive herbaceous species by spot application of herbicide as well as the incorporation of a prescribed burn.

Native Plant Establishment (MJRE) – This measure seeks to plant 108-acres of native ravine and mesic woodland species of local genotype; species harder to establish from seed will be introduced as plugs. Given the unique climate and suite of rare species within the ravine's topology, genetic preservation of rare or state listed species will be maintained by contract growth of certain species that currently reside in low numbers within the ravine and/or which are not available commercially. Use of contract grown species from sources within or near the site not only preserve the unique genetics of the area, but also maximize the success of establishment as local genotypes within the study area are more likely adapted to the harsh conditions presented by ravines. Species to be planted are included in Appendix B.

Schenck Ravine

Invasive Species Removal (SRL) – This measure seeks to selectively remove about 10-acres of invasive and opportunistic woody vegetation shading the ravine's understory. Invasive species removal would cover about 10-acres. 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*), Japanese barberry (*Berberis thunbergii*), Norway maple (*Acer platanoides*), gray dogwood (*Cornus racemosa*), white mulberry (*Morus alba*), green ash (*Fraxinus lanceolata*), cottonwood (*Populus deltoides*), and basswood (*Tilia americana*). Following selective clearance, all stumps will be swabbed with herbicide. This measure also includes the removal of invasive herbaceous species by spot application of herbicide as well as the incorporation of a prescribed burn.

Native Plant Establishment (SRM) – This measure seeks to plant about 10-acres of native ravine species of local genotype; species harder to establish from seed will be introduced as plugs. Given the unique climate and suite of rare species within the ravine's topology, genetic preservation of rare or state listed species will be maintained by contract growth of certain species that currently reside in low numbers within the ravine and/or which are not available commercially. Use of contract grown species from sources within or near the site not only preserve the unique genetics of the area, but also maximize the success of establishment as local genotypes within the study area are more likely adapted to the harsh conditions presented by ravines. Species to be planted are included in Appendix B.

Scotts Ravine

Invasive Species Removal (SRP) – This measure seeks to selectively remove invasive and opportunistic woody vegetation shading the ravine's understory. Invasive species removal would cover about 2.5-acres. 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*), Japanese barberry (*Berberis thunbergii*), Norway maple (*Acer platanoides*), gray dogwood (*Cornus racemosa*), white mulberry (*Morus alba*), green ash (*Fraxinus lanceolata*), cottonwood (*Populus deltoides*), and basswood (*Tilia americana*). Following selective clearance, all stumps will be swabbed with herbicide. This measure also includes the removal of invasive herbaceous species by spot application of herbicide as well as the incorporation of a prescribed burn.

Native Plant Establishment (SRQ) – This measure seeks to plant 2.5-acres of native ravine species of local genotype; species harder to establish from seed will be introduced as plugs. Given the unique climate and suite of rare species within the ravine's topology, genetic preservation of rare or state listed species will be maintained by contract growth of certain species that currently reside in low numbers within the ravine and/or which are not available commercially. Use of contract grown species from sources within or near the site not only preserve the unique genetics of the area, but also maximize the success of establishment as local genotypes within the study area are more likely adapted to the harsh conditions presented by ravines. Species to be planted are included in Appendix B.

Van Horne Ravine

Invasive Species Removal (VRJ) – This measure seeks to selectively remove invasive and opportunistic woody vegetation shading the ravine's understory. Invasive species removal would cover about 7-acres. 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*), Japanese barberry (*Berberis thunbergii*), Norway maple (*Acer platanoides*), gray dogwood (*Cornus racemosa*), white mulberry (*Morus alba*), green ash (*Fraxinus lanceolata*), cottonwood (*Populus deltoides*), and basswood (*Tilia americana*). Following selective clearance, all stumps will be swabbed with herbicide. This measure also includes the removal of invasive herbaceous species by spot application of herbicide as well as the incorporation of a prescribed burn.

Native Plant Establishment (VRK) – This measure seeks to plant native ravine species of local genotype; species harder to establish from seed will be introduced as plugs. Given the unique climate and suite of rare species within the ravine's topology, genetic preservation of rare or state listed species will be maintained by contract growth of certain species that currently reside in low numbers within the ravine and/or which are not available commercially. Use of contract grown species from sources within or near the site not only preserve the unique genetics of the area, but also maximize the success of establishment as local genotypes within the study area are more likely adapted to the harsh conditions presented by ravines. Species to be planted are included in Appendix B.

3.2 – Measure Costs & Assumptions

Detailed discussion on planning level feature costs is presented in Appendix C – Cost Engineering. Conceptual, planning level cost estimates prepared for measures/features identified by the study team in conjunction with the non-Federal sponsors are presented in Tables 12 – 15. 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 C). 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 whereby 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 2015). 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 is the present value method. Costs are compounded or converted to present value for the base year then amortized over the 50-year period of analysis to give the annual cost. Discount rate was determined by the appropriate Economic Guidance Memorandum 08-01, Federal Interest Rates for Corps of Engineers Projects, which is 3.5%. 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. The IVE provided by the real estate section determined a various preliminary numbers to accomplish plan formulation. This number is preliminary and does not constitute the gross appraisal.

Table 12 – Planning Level Costs & NAAHUs per Ravine Repair Measures

Area Name	Code	Measure Cost	AA Cost	NAAHUs	Area Name	Code	Measure Cost	AA Cost	NAAHUs
Bartlett Ravine	BRA	$ 29,138	$ 1,744	0	Scotts Ravine	SRD	$ 225,184	$ 13,474	0
Bartlett Ravine	BRB	$ 80,160	$ 4,797	0	Scotts Ravine	SRE	$ 219,101	$ 13,110	0
Bartlett Ravine	BRC	$ 37,413	$ 2,239	0	Scotts Ravine	SRH	$ 56,167	$ 3,361	0
Bartlett Ravine	BRD	$ 9,925	$ 594	0	Van Horne Ravine	VRA	$ 139,782	$ 8,364	0
Bartlett Ravine	BRE	$ 13,327	$ 797	0	Van Horne Ravine	VRB	$ 749,522	$ 44,850	0
Hutchinson Ravine	HRC	$ 248,008	$ 14,840	0	Van Horne Ravine	VRC	$ 154,413	$ 9,240	0
Hutchinson Ravine	HRD	$ 1,114,219	$ 66,672	0	Van Horne Ravine	VRD	$ 15,323	$ 917	17.2
MacArthur Ravine	MRA	$ 88,422	$ 5,291	0	Van Horne Ravine	VRE	$ 31,151	$ 1,864	17.2
MacArthur Ravine	MRB	$ 47,532	$ 2,844	0	Van Horne Ravine	VRF	$ 2,917	$ 175	17.2
MacArthur Ravine	MRC	$ 67,649	$ 4,048	0	Van Horne Ravine	VRG	$ 427,346	$ 25,571	30.5
McCormick Ravine	MJRA	$ 99,392	$ 5,947	0	Van Horne Ravine	VRH	$ 337,237	$ 20,179	27.4
McCormick Ravine	MJRB	$ 198,674	$ 11,888	0	Van Horne Ravine	VRI	$ 39,775	$ 2,380	0
McCormick Ravine	MJRC	$ 36,361	$ 2,176	0					
Schenck Ravine	SRA	$ 318,100	$ 19,034	0					
Schenck Ravine	SRC	$ 240,602	$ 14,397	0					
Schenck Ravine	SRD	$ 5,833	$ 349	0					
Schenck Ravine	SRE	$ 49,278	$ 2,949	0					
Schenck Ravine	SRF	$ 277,927	$ 16,630	0					
Schenck Ravine	SRK	$ 11,411	$ 683	0					

*NAAHUs with 0 are either dependent on another measure to accrue benefits or are required for subsequent measures to accrue benefits.

Table 13 – Planning Level Costs & NAAHUs per Littoral Repair Measures

Coastal Zone	Code	Measure Cost	AA Cost	NAAHUs	Coastal Zone	Code	Measure Cost	AA Cost	NAAHUs
McCormick/Janes	DC	$ 1,460,027	$ 87,365	22	Bartlett	DK	$ 84,018	$ 5,027	0.2
McCormick/Janes	DD	$ 2,420,434	$ 144,833	26.8	Bartlett	DL	$ 85,804	$ 5,134	0.1
Bartlett	DE	$ 2,094,476	$ 125,329	21.4	McCormick/Janes	DM	$ 39,294	$ 2,351	0.1
Schenck	DF	$ 2,359,642	$ 141,195	22.3	McCormick/Janes	DN	$ 78,676	$ 4,708	0.2
Schenck	DG	$ 96,550	$ 5,777	0.2	McCormick/Janes	DO	$ 89,386	$ 5,349	0.3
Schenck	DH	$ 66,144	$ 3,958	0.2	Bartlett Nearshore	DP	$ 177,286	$ 10,608	10.7
Bartlett	DI	$ 214,521	$ 12,836	0.4					
Bartlett	DJ	$ 187,697	$ 11,231	0.5					

Table 14 – Planning Level Costs & NAAHUs per Bluff Repair Measures

Area Name	Code	Measure Cost	AA Cost	NAAHUs
Bluff	BC	$ 28,441	$ 1,702	0.0
Bluff	BD	$ 2,171	$ 130	0.0
Bluff	BE	$ 18,808	$ 1,125	0.0
Schenck Ravine	SRG	$ 18,546	$ 1,110	0.0
Schenck Ravine	SRH	$ 15,939	$ 954	0.0
Schenck Ravine	SRI	$ 14,784	$ 885	0.0
Schenck Ravine	SRJ	$ 20,482	$ 1,226	0.0
Bartlett Ravine	BRF	$ 163,309	$ 9,772	0.0

*NAAHUs with 0 are either dependent on another measure to accrue benefits or are required for subsequent measures to accrue benefits

Table 15 – Planning Level Costs & NAAHUs per Biological Establishment

Area Name	Code	Measure Cost	AA Cost	NAAHUs
Bartlett Ravine	BRG	$ 165,455	$ 9,864	0
Bartlett Ravine	BRH	$ 247,444	$ 14,752	53.2
Beach & Dune	DA	$ 23,544	$ 1,404	0
Beach & Dune	DB	$ 10,861	$ 648	**
Bluff	BA	$ 318,183	$ 18,970	0
Bluff	BB	$ 170,238	$ 10,149	54.2
Hutchinson Ravine	HRE	$ 184,546	$ 11,002	0
Hutchinson Ravine	HRF	$ 98,738	$ 5,887	95.5
MacArthur Ravine	MRD	$ 7,955	$ 474	0
MacArthur Ravine	MRE	$ 11,868	$ 708	3.7
McCormick Ravine	MJRD	$ 859,095	$ 51,218	0
McCormick Ravine	MJRE	$ 1,281,781	$ 76,418	262.4
Schenck Ravine	SRL	$ 79,546	$ 4,742	0
Schenck Ravine	SRM	$ 118,963	$ 7,092	42.9
Scotts Ravine	SRP	$ 19,886	$ 1,186	0
Scotts Ravine	SRQ	$ 29,741	$ 1,773	9.3
Van Horne Ravine	VRJ	$ 55,682	$ 3,320	0
Van Horne Ravine	VRK	$ 83,274	$ 4,965	17.2

** nested with the Lacustrine measures

3.3 – Physical Repair Measures Cost Effectiveness Screening

As stated at the introduction of Section 3.1, there was an initial assessment on the cost effectiveness of the physical repair measures. Once the most cost effective way to repair physical damage to stream hydraulics and littoral drift was discerned, then the CE/ICA coupled the measures of physical repair and biological reestablishment in an incremental fashion to guide decisions in selecting the most significantly beneficial plan that has an associated reasonable cost.

The following measures for the repair of stream hydraulics within the ravines are grouped based on redundancy; this means each measure performs the same function and has the same outcome, but in a different manner. **Table 16** shows the measures that were retained based on cost effectiveness (in blue).

Table 16 – Cost Effectiveness Screening of Redundant Ravine Hydraulic Repair Measures

Area Name	Code	Measure Cost	AA Cost	Cannot Combine	Retain / Remove
Bartlett Ravine	BRD	$ 9,925	$ 594	BRE	retain
Bartlett Ravine	BRE	$ 13,327	$ 797	BRD	remove
Hutchinson Ravine	HRC	$ 248,008	$ 14,840	HRD	retain
Hutchinson Ravine	HRD	$ 1,114,219	$ 66,672	HRC	remove
MacArthur Ravine	MRA	$ 88,422	$ 5,291	MRB, MRC	remove
MacArthur Ravine	MRB	$ 47,532	$ 2,844	MRA, MRC	retain
MacArthur Ravine	MRC	$ 67,649	$ 4,048	MRA, MRB	remove
Schenck Ravine	SRA	$ 318,100	$ 19,034	SRB, SRC	remove
Schenck Ravine	SRB	$ 396,110	$ 23,702	SRA, SRC	remove
Schenck Ravine	SRC	$ 240,602	$ 14,397	SRA, SRB	retain
Schenck Ravine	SRE	$ 49,278	$ 2,949	SRF	retain
Schenck Ravine	SRF	$ 277,927	$ 16,630	SRE	remove
Scotts Ravine	SRF	$ 447,788	$ 26,795	SRG	retain
Scotts Ravine	SRG	$ 3,674,327	$ 219,863	SRF	remove
Scotts Ravine	SRD	$ 225,184	$ 13,474	SRE	remove
Scotts Ravine	SRE	$ 219,101	$ 13,110	SRD	retain
Van Horne Ravine	VRA	$ 139,782	$ 8,364	VRB, VRC	retain
Van Horne Ravine	VRB	$ 749,522	$ 44,850	VRA, VRC	remove
Van Horne Ravine	VRC	$ 154,413	$ 9,240	VRA, VRB	remove

3.4 – Alternative Development & Analysis

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 lacustrine, riverine and riparian ecosystem. The measures for this study were evaluated with the HSI methodology described in Section 2.3 and calculations presented on Plates 16, 17 and 18. The three sets of alternatives (Ravine, Lacustrine, Bluff) were developed by the study team via drawing from the first set of cost effective measures presented above. Since the IWR Planning Suite software is capable of handling a limited number of iterations, the Alternatives were loaded into the Solutions & Scales interface by combining both the costs (AA Cost) and benefits (FWP NAAHUs) of the measures that make up that particular alternative. Dependencies and combinabilities were accounted for by both loading alternatives

into the Solution & Scales interface as well as setting them in the Relationships interface of the software. Ultimately, 432 Plans were electronically generated for the Ravines, 96 for Lacustrine, and 6 for the Bluff. The following sections discuss each set of alternatives for each habitat type, including dependencies, combinabilities, plan generation, cost effective plans and best buy plans.

Ravine Alternatives

There are 12 alternatives for ravine restoration presented in **Table 17** that shows which measures comprise the alternative and what the associated costs and benefits are. These alternatives, plus the no action plan, were processed through the IWR-Planning Suite software to determine cost effective and best buy plans in the following sections. Alternative HR-A is dependent on the implementation of alternative ScR-A to function as intended, however, ScR-A is not dependent on HR-A. Alternatives MJR-A and MJR-B are not combinable because they are different options that accomplish the same outputs and occupy the same physical space; redundant measures. The Van Horne Ravine mouth repair alternatives VR-A through VR-E are not combinable with each other since they assess different methods of reconnecting the ravine stream with Lake Michigan.

Table 17 – Ravine Alternatives with Associated Average Annual Costs and Benefits

Alts	Ravine Name	Measures	FWOP AAHUs	FWP AAHUs	FWP NAAHUs	AA Cost
BR-A	Bartlett	BRA, BRB, BRC, BRD, BRG, BRH	33.8	53.2	19.4	$ 33,989
HR-A	Hutchinson	HRC, HRE, HRF	33.6	95.5	61.9	$ 31,729
MJR-A	McCormick/Jane's	MJRA, MJRC, MJRD, MJRE	109.0	468.9	359.9	$ 135,759
MJR-B	McCormick/Jane's	MJRB, MJRC, MJRD, MJRE	109.0	520.5	411.5	$ 141,699
ShR-A	Schenck	SRC, SRD, SRE, SRK, SRL, SRM	12.8	42.9	30.1	$ 30,212
ScR-A	Scott	SRE, SRH, SRP, SRQ	2.3	9.3	7.0	$ 19,430
VR-A	Van Horne	VRA, VRD, VRJ, VRK, VRI	11.7	17.2	5.5	$ 19,945
VR-B	Van Horne	VRA, VRE, VRJ, VRK, VRI	11.7	17.2	5.5	$ 20,893
VR-C	Van Horne	VRA, VRF, VRJ, VRK, VRI	11.7	17.2	5.5	$ 19,203
VR-D	Van Horne	VRA, VRG, VRJ, VRK, VRI	11.7	30.5	18.9	$ 44,600
VR-E	Van Horne	VRA, VRH, VRJ, VRK, VRI	11.7	27.4	15.7	$ 39,208
McR-A	MacArthur	MRB, MRD, MRE	1.3	3.7	2.4	$ 4,026

Lacustrine Alternatives

There are 8 alternatives for lacustrine restoration presented in **Table 18**, which shows which measures comprise the alternative and what the associated costs and benefits are. These alternatives, plus the no action plan, were processed through the IWR-Planning Suite software to determine cost effective and best buy plans in the following sections. Alternatives MJL-A and MJL-C are not combinable, and alternatives BL-A, BL-B and BL-C are not combinable. These measures select between small rock reef systems or small stone piles in the fore dune zone covered with sand in the same areas. All other alternatives are deemed combinable.

Table 18 – Lacustrine Alternatives with Associated Average Annual Costs and Benefits

Alts	Coastal Zone	Measures	FWOP AAHUs	FWP AAHUs	FWP NAAHUs	AA Cost
MJL-A	McCormick/Janes	DC, DA, DB	11.7	37.1	25.3	$ 89,416
MJL-B	McCormick/Janes	DD, DA, DB	14.3	45.3	31.0	$146,884
MJL-C	McCormick/Janes	DO, DN, DM, DA, DB	0.7	1.2	0.6	$ 14,459
BL-A	Bartlett	DE, DJ, DI, DA, DB	12.9	38.8	25.9	$151,447
BL-B	Bartlett	DP, DJ, DI, DA, DB	12.9	20.7	7.9	$ 36,727
BL-C	Bartlett	DL, DK, DJ, DI, DA, DB	2.0	3.7	1.7	$ 36,281
SL-A	Schenck	DF, DA, DB	11.9	37.6	25.7	$143,247
SL-B	Schenck	DH, DG, DA, DB	0.7	1.2	0.6	$ 11,786

Bluff Alternatives

There are 6 alternatives for bluff restoration presented in **Table 19** that shows which measures comprise the alternative and what the associated costs and benefits are. These alternatives, plus the no action plan, were processed through the IWR-Planning Suite software to determine cost effective and best buy plans in the following sections. These alternatives consider combinations between two sets of alternatives (i.e. BC vs. BD and SRG vs. SRH vs. SRI). As the measures available in each address the same issue, they are not combinable. It follows, then, that all alternatives are not combinable.

Table 19 – Bluff Alternatives with Associated Average Annual Costs and Benefits

Alts	Measures	FWOP AAHUs	FWP AAHUs	FWP NAAHUs	AA Cost
BLF-A	BC, SRG, SRJ, BE, BRF, BA, BB	141.8	196	54.2	$ 44,054
BLF-B	BC, SRH, SRJ, BE, BRF, BA, BB	141.8	196	54.2	$ 43,898
BLF-C	BC, SRI, SRJ, BE, BRF, BA, BB	141.8	196	54.2	$ 43,828
BLF-D	BD, SRG, SRJ, BE, BRF, BA, BB	141.8	196	54.2	$ 42,482
BLF-E	BD, SRH, SRJ, BE, BRF, BA, BB	141.8	196	54.2	$ 42,326
BLF-F	BD, SRI, SRJ, BE, BRF, BA, BB	141.8	196	54.2	$ 42,257

3.5 – 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.

Ravine Restoration CE / ICA

Four hundred and thirty two (432) plans were generated from the 12 alternatives input into the IWR-Planning software. The software identified that 47 plans were cost effective (**Figure 2**), which means that no one plan provided the same benefits as another plan that was less costly. Seven (7) plans were revealed as "best buys" (**Table 20**), which are deemed the most cost efficient of the 47 plans generated. **Figure 3** shows one significant break point going from Plan 4 to 5. The break point is going from a plan that includes Hutchinson, Scott, McCormick/Jane and Schenck Ravine, whereas plan 5 adds MacArthur Ravine, plan 6 adds Bartlett Ravine and plan 7 adds Van Horne Ravine.

Figure 2 – Cost Effective Analysis on 432 Ravine Restoration Plan Combinations

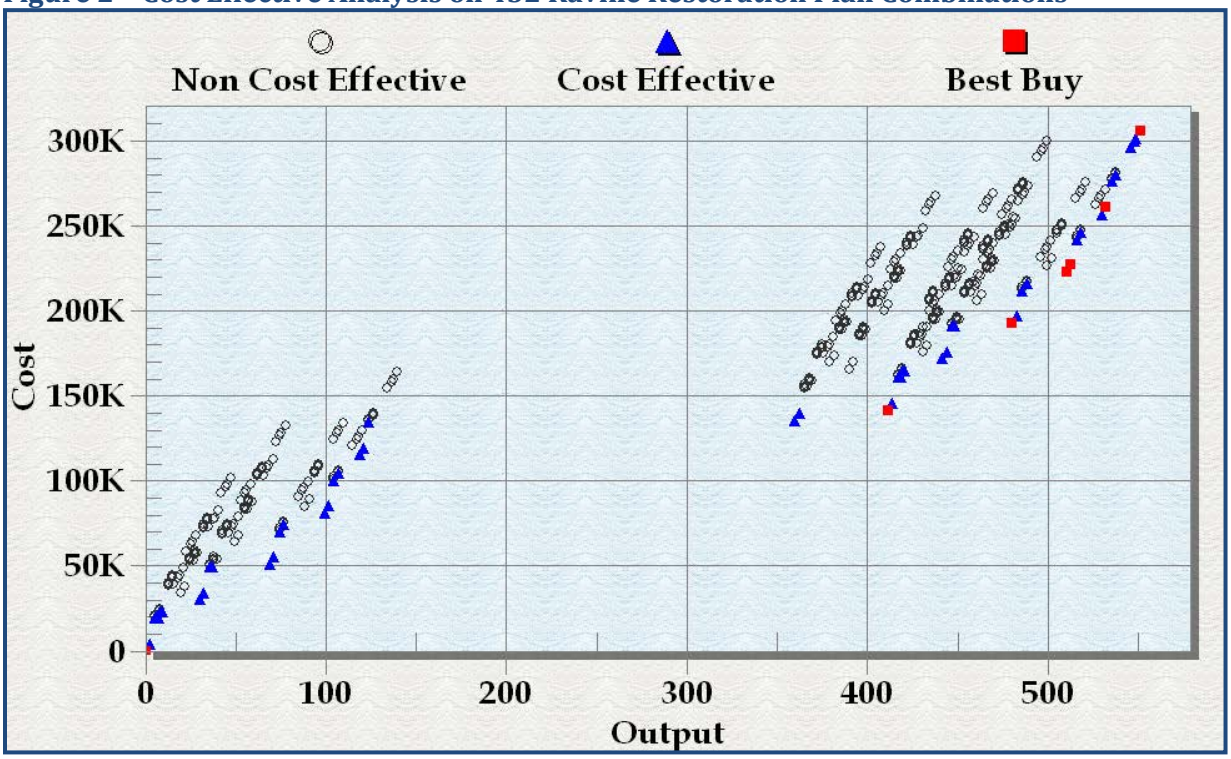
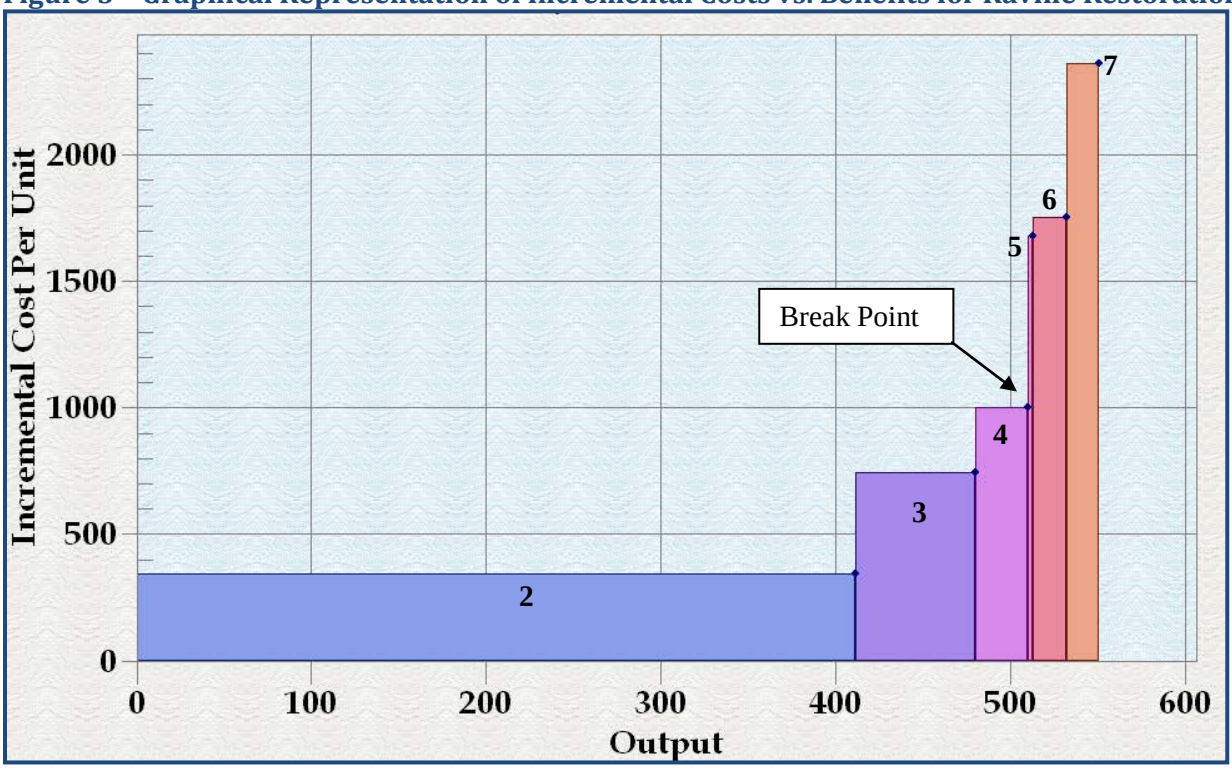


Table 20 – Incremental Analysis of 7 Best Buy Plans for Ravine Restoration

#	Plan	HU	AA Cost	AA Cost / HU	Inc. Cost	Inc. HU	Inc. Cost / HU
1	No Action Plan	0	$ -				
2	MJR-B	411.5	$ 141,699	$ 344	$ 141,699	411.5	$ 344
3	HR-A & SCR-A & MJR-B	480.4	$ 192,858	$ 401	$ 51,159	68.9	$ 743
4	HR-A & SHR-A & SCR-A & MJR-B	510.5	$ 223,070	$ 437	$ 30,212	30.1	$ 1,004
5	HR-A & MCR-A & SHR-A & SCR-A & MJR-B	512.9	$ 227,096	$ 443	$ 4,026	2.4	$ 1,678
6	BR-A & HR-A & MCR-A & SHR-A & SCR-A & MJR-B	532.3	$ 261,085	$ 490	$ 33,989	19.4	$ 1,752
7	BR-A & HR-A & MCR-A & SHR-A & SCR-A & VR-D & MJR-B	551.2	$ 305,685	$ 545	$ 44,600	18.9	$ 2,360

Figure 3 – Graphical Representation of Incremental Costs vs. Benefits for Ravine Restoration



Lacustrine Restoration CE/ICA

Ninety six (96) plans were generated from the 8 alternatives input into the IWR-Planning software. Preliminary cost effectiveness screening was not performed for lacustrine measures since there were no redundant measures with identical benefits. Cost effectiveness was provided via analysis through the IWR Planning software as presented in (**Figure 4**); in which 32 plans were deemed cost effective. Seven (7) plans were revealed as "best buys" (**Table 21**), which are deemed the most cost efficient of the 32 cost effective plans. **Figure 5** shows a significant break point going from Plan 6 to plan 7, which are the additions of bluff toe options, which provide little, if any habitat benefits just north of the Schenck Ravine mouth. The difference between Plans 4 and 5 is the addition of SL-A and between 5 and 6 is that BL-A replaces BL-B, which consists of measure DE replacing DP. Measure DE is a larger version of DP, which is more expensive and has minimal benefits to be gained over DP.

Figure 4 – Cost Effective Analysis on 96 Lacustrine Restoration Plan Combinations

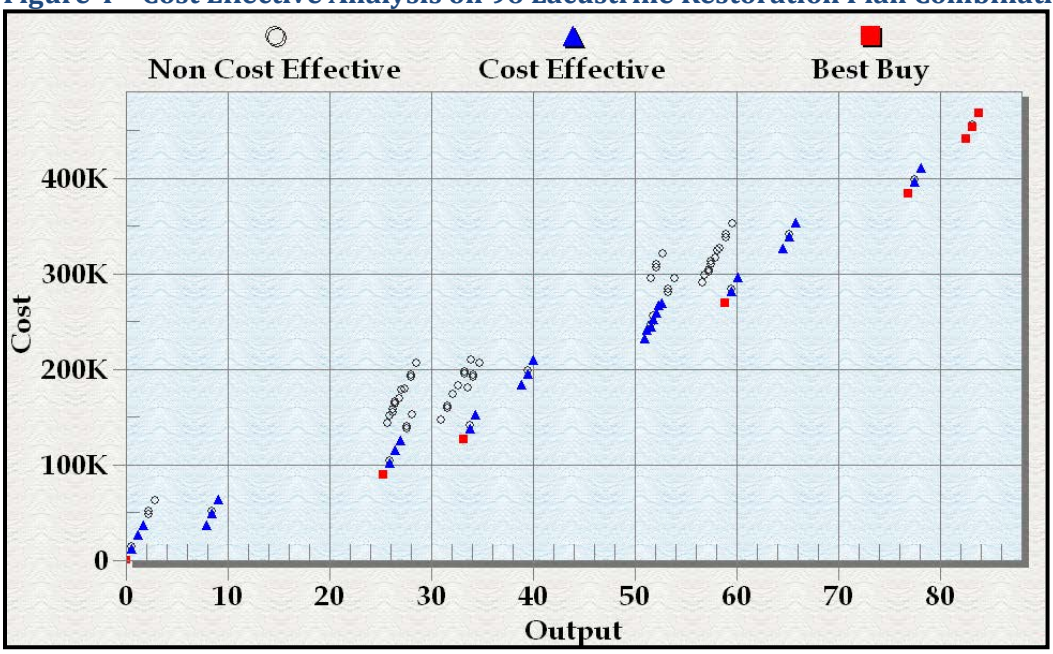
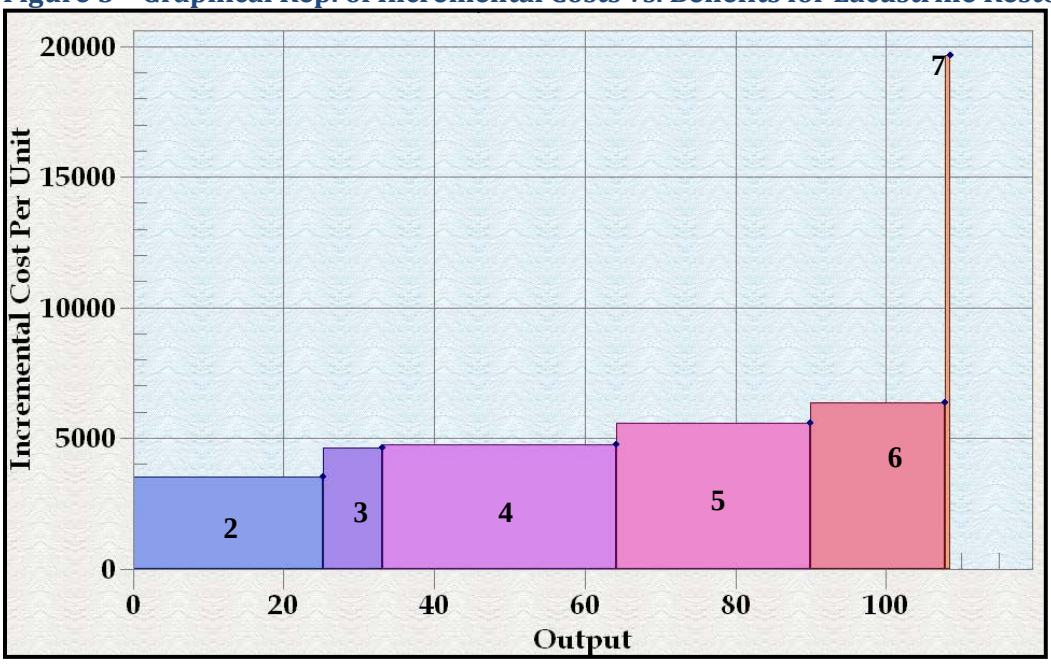


Table 21 – Incremental Analysis of 7 Best Buy Plans for Lacustrine Restoration

#	Plan	HU	AA Cost	AA Cost / HU	Inc. Cost	Inc. HU	Inc. Cost / HU
1	No Action Plan	0.0	$ -				
2	**MJL-A**	25.3	$ 89,416	$ 3,534	$ 89,416	25.3	$ 3,534
3	MJL-A & **BL-B**	33.2	$ 126,143	$ 3,799	$ 36,727	7.9	$ 4,649
4	MJL-A & **MJL-B** & BL-B	64.2	$ 273,027	$ 4,253	$ 146,884	31.0	$ 4,738
5	MJL-A & MJL-B & BL-B & **SL-A**	89.9	$ 416,274	$ 4,630	$ 143,247	25.7	$ 5,574
6	MJL-A & MJL-B & **BL-A** & SL-A	107.9	$ 530,994	$ 4,921	$ 114,720	18.0	$ 6,373
7	MJL-A & MJL-B & BL-A SL-A & **SL-B**	108.5	$ 542,780	$ 5,003	$ 11,786	0.6	$ 19,643

Figure 5 – Graphical Rep. of Incremental Costs vs. Benefits for Lacustrine Restoration



Bluff Restoration CE/ICA

Six (6) plans derived from the bluff measures (**Table 19**) were input into the IWR-Planning software. The cost effectiveness analysis (**Figure 6**) identified only one cost effective and one best buy plan, which is plan BLF-F (**Figure 7**).

Figure 6 – Cost Effective Analysis on 6 Bluff Restoration Plan Combinations.

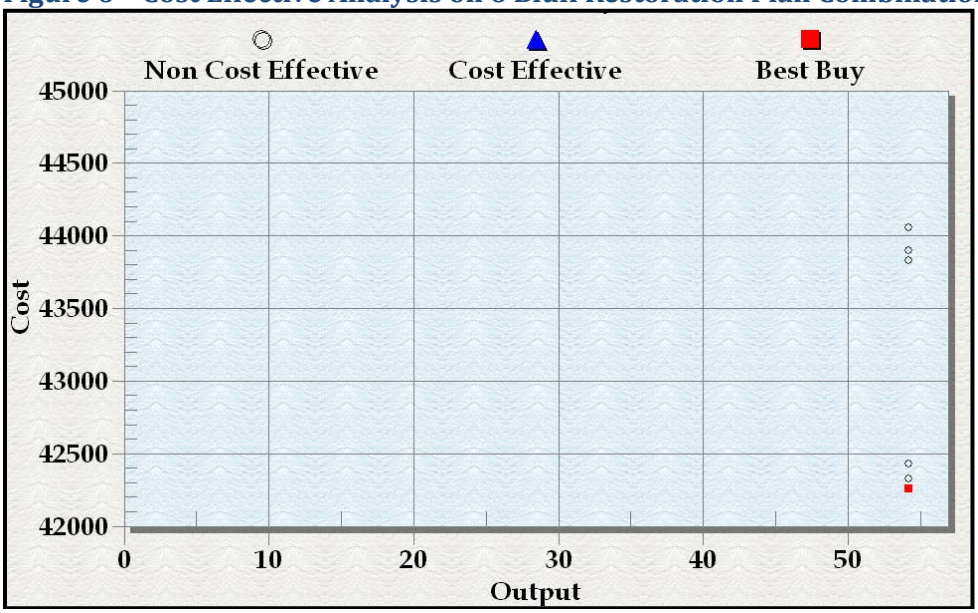
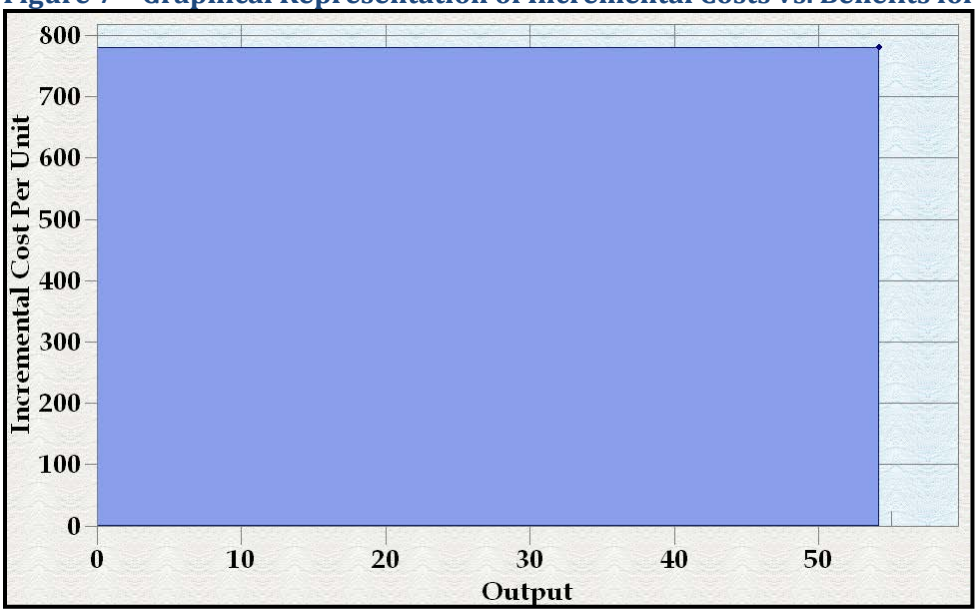


Table 22 – Incremental Analysis of 2 Best Buy Plans for Bluff Restoration.

#	Plan	HU	AA Cost	AA Cost / HU	Inc. Cost	Inc. HU	Inc. Cost / HU
1	No Action Plan	0.0	$ -				
2	**BLF-F**	54.2	$ 42,257	$ 779	$ 42,257	54.2	$ 779

Figure 7 – Graphical Representation of Incremental Costs vs. Benefits for Bluff Restoration.



3.6 –Plan Trade-Off Analysis

Alternative plans that qualified for further consideration were 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.

3.6.1 – Federal Investment and Ecological Benefits

Ravines

The CE/IC Analysis results for ravine restoration show that benefits are reasonable for the amount expended up to and including Plan 4 (**Figure 3**). This plan includes naturalizing instream hydraulics, repairing geomorphic damage, removing habitat fragmentation, removing invasive plant species and reestablishing the native ravine plant communities in McCormick, Jane, Hutchinson, Scott and Schenck Ravines. The additions of MacArthur, Bartlett and Van Horne Ravines start to increase the cost expended per habitat unit significantly, which is due to the highly impaired physical nature of Bartlett and Van Horne, while small size is the driving factor at MacArthur Ravine.

Plan 5 – MacArthur Ravine is very small (~1-acre) and in turn the cost of repairing the hydraulics for such a small amount of physical viable habitat is relatively high. It is the Federal opinion that this ravine could be managed more efficiently through local partnerships and best management practices. Based on this, there is no Federal interest in restoring this ravine as part of the NER Plan.

Plan 6 – Bartlett Ravine currently has a paved road where the stream used to be. Investment into restoring the hydraulics and hydrology of this ravine is not warranted unless the road could be removed and replaced with a stream once again, which this option was not in the local interest. The ravine banks could be restored vegetatively, but then again, there is no stream to restore a meaningful riparian zone. Based on this, there is no Federal interest in restoring this ravine as part of the NER Plan.

Plan 7 – Van Horne Ravine is a significantly impaired ravine that is fragmented from Lake Michigan by a large earthen dam, has unnatural hydrology and hydraulics due to surrounding land uses and the dam, and is highly degraded from a vegetation and habitat structure standpoint. Due to the great degree of hydraulic and ecological damage, it is quite expensive to remedy. This ravine is in the Federal interest to restore if the ravine was able to be reconnected to Lake Michigan for aquatic passage, but the current land use priority for this ravine does not support this measure, thusly eliminating Federal interest in the restoration of this ravine. The high costs of fully restoring this ravine would be worth the Federal investment due to the critical habitat it would provide migratory birds, as defined by various Acts and Executive Orders; however, based on being unable to restore connectivity, there is no Federal interest in restoring this ravine as part of the NER Plan.

Lacustrine

The CE/IC Analysis results for ravine restoration show that benefits are reasonable for the amount expended up to and including Plan 4 (**Figure 5**). This plan includes diversifying habitat structure along the sandy shoreline, providing structure and refugia for coastal fishes, offsetting the coastal wave climate to regain dune habitat, removing invasive plant species and reestablishing the native ravine plant communities on all of the existing and newly formed dunes. Plan 5, 6 and 7, which is the addition of measures DG & DH, are far too costly for the minimal amount of habitat benefits gained to be within the Federal interest for implementation.

Bluff

The CE/IC Analysis results for ravine restoration show that benefits are reasonable for the amount expended for Plan 2 only (**Figure 7**). This plan includes restoring the entire 40^{+}acres of bluff within the entire Ft. Sheridan natural area. This plan would curtail minor bluff erosion and rilling, remove invasive plant species and reestablish the native bluff plant community.

3.6.2 – Acceptability, Completeness, Effectiveness and Efficiency

Acceptability, completeness, effectiveness, and efficiency are the four evaluation criteria specified the USACE uses in the screening of alternative plans. 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 combination of Ravine Plan 4, Lacustrine Plan 4 and Bluff Plan 2 as the tentative plan.

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 is complete unto itself, which means the plan can be implemented without any supporting projects or contributions from other entities. The NER plan would completely restore 5 ravines

and 2-miles of continuous bluff, dune and lake habitats, totaling about 218-acres of habitat. The NER 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 recommend restoration features under the NER 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 significant portions of the Ft. Sheridan natural area in terms of ravine and coastal hydrology and hydraulics, geomorphic repairs and the establishment of viable and diverse native plant communities. A potential 251-acres of restoration was assessed under this Feasibility Study, with the NER plan recommending 218-acres as high priority under the Corps Ecosystem mission. The NER plan effective would restore %87 of the Ft. Sheridan natural, while the remaining 13% is recommended to be restored by locals or through other programs that are more suitable for dealing with open space projects as opposed to strictly ecosystem restoration.

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 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 Authority expertise. The USACE sets criteria for selecting projects based on Corps expertise. The implementation of the NER plan is reflected under the following criteria and numerical scores according to the requirements identified in the Corps Budget guidance (EC 11-2-194):

- Habitat Scarcity – Score of 25/25
- Connectivity – Score of 25/25
- Special Status Species – Score of 5/10
- Hydrologic Character – Score of 20/20
- Geomorphic Character – Score of 20/20
- Plan Recognition – Score of 10/10
- Self Sustaining – Score of 10/20
- Nationally Significant – No
- Regionally Significant – Yes

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 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.

3.6.4 – 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 Fort Sheridan Ravine and Coastal 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. Sources of institutional recognition include public laws, executive orders, rules and regulations, treaties, and other policy statements of the Federal Government; plans, laws, resolutions, and other policy statements of states with jurisdiction in the planning area; laws, plans, codes, ordinances, and other policy statements of regional and local public entities with jurisdiction in the planning area; and charters, bylaws, and other policy statements of private groups.

Clean Water Act – 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.

Endangered Species Act of 1973 – All Federal departments and agencies shall seek to conserve endangered species and threatened species. The purpose of the act is to provide a means whereby the ecosystems upon which endangered and threatened species depend may be conserved and to provide a

program for the conservation of such endangered and threatened species. 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. In addition, 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 – 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, dune, and beach habitats will enhance the habitat diversity of the Fort Sheridan ravine system. Removal of unnatural habitats would reduce the abundance ratio of exotic to 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 Rosewood Park will help to restore the unique Fort Sheridan Bluff-Lake Michigan interface, an area that once had many environmental treasures.

Migratory Bird Treaty Act (1918)

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

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

The Mississippi Flyway

There are 4 principal North American flyways, the Atlantic, Mississippi, Central and Pacific. Except along the coasts, such as Lake Michigan, the flyway boundaries are not always sharply defined. Its eastern boundary runs along western Lake Erie and the western boundary is ambiguous, as the Mississippi Flyway merges unnoticeably into the Central Flyway. The longest migration route in the Western Hemisphere lies in the Mississippi Flyway; from the Arctic coast of Alaska to Patagonia, spring migration of some shorebird species fly this nearly 3,000 mile route twice. Parts of all four flyways merge together over Panama.

The route which includes Ft. Sheridan is ideal for migratory waterfowl because it is uninterrupted by mountains, dotted with tens of thousands of lakes, wetlands, ponds, streams and rivers, and is well timbered in certain reaches. Chicago is located in the Mississippi Flyway and about 300 species of birds pass along Lake Michigan's shoreline annually. The Chicago reach is also one of America's most important migration routes for songbirds, with more than ~5 million individuals passing through during

the migration season. Illinois and Indiana farmland consists of corn and soybean fields, which do not provide the type and variety of food and shelter required by nearly all migrating birds. In comparison, Lake Michigan's shoreline provides a variety of plant life and habitat for resting and refueling. Chicago's parks and even residential backyards are particularly important, because of they are the only patches of habitat left within a concrete watershed. The preservation of parkland along water bodies is critical to the survival of millions of birds that migrate through Chicago every spring and fall. The Jackson Park restoration project has great potential to provide critical migratory bird habitat.

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 lake, ravine stream, ravine woodland, ravine savanna, open woodland, thus providing forage and shelter for numerous migratory bird species. This project lies within a significant portion of the Mississippi Flyway along the coast of Lake Michigan that particularly favors both ecological and economically valuable waterfowl species. Outputs of this project would fulfill the DOD role and responsibility by utilizing its Ecosystem Restoration Mission, authority and supporting polices to restore past damages to diverse habitats for Migratory Waterfowl and fishes that support these bird species.

EO 13547 Stewardship of the Ocean, Our Coasts, and the Great Lakes – This order establishes a national policy to ensure the protection, maintenance, and restoration of the health of ocean, coastal, and Great Lakes ecosystems and resources, enhance the sustainability of ocean and coastal economies, preserve our maritime heritage, support sustainable uses and access, provide for adaptive management to enhance our understanding of and capacity to respond to climate change and ocean acidification, and coordinate with our national security and foreign policy interests.

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. 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 Fort Sheridan by the presence of significant and unusual topographic features including beach, foredune, bluff, and ravine habitat. Fort Sheridan 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 Ft. Sheridan 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 Ft. Sheridan 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, Ft. Sheridan 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. Ft. Sheridan contains many of these unique habitats one of which is the notable bluff habitat. With implementation of the proposed project, Ft. Sheridan's distinctive habitats may be restored to their former excellence and provide beneficial outputs to terrestrial and aquatic wildlife.

Connectivity of Fort Sheridan to other natural areas and bluff/ravine habitats is crucial for fish species as well as migratory birds. Fort Sheridan 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 Moraine Park, 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, Fort Sheridan 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 Fort Sheridan. 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, lacustrine habitat, native plant community richness, water quality, and nutrient cycling; species diversity would increase logarithmically along with existing populations of fish, amphibians, and other species.

3.7 – 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.

Partnership Context

This restoration project was planned in cooperation with the Lake County Forest Preserve District, City of Lake Forest, Town of Ft. Sheridan, Openlands, the City of Highland Park, the Highland Park District and the Lake County Stormwater Management Commission. 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 Coastal Zone Management Plan and the Alliance for the Great Lakes' plan to restore north shore ravines.

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 center of expertise for cost estimating. 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 Ft. Sheridan 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.

The NER Plan

The plan that reasonably maximizes net national ecosystem restoration benefits, consistent with the Federal objective, is identified as the NER plan. Thus, the plan that maximizes net NER benefits and has shown great merit in the trade-off analysis are a number of selected sites with their associated best buy alternative plans. Each plan per site includes a combination of restoration measures as described in the proceeding narrative. It is determined that the NER plan consists of the combined Ravine Plan 4, Lacustrine Plan 4 and Bluff Plan 2 (**Table 23 & Figure 8**).

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 poorly maintained storm sewer infrastructures would need to be removed and discarded or stockpiled and saved depending on the non-Federal sponsors needs.

Ravine Plan 4 – McCormick, Janes, Scott, and Schenck Ravines were identified under the NER for restoration measures.

McCormick and Jane Ravine would have their confluence with each other and to the lake reconstructed. Non-functional and outdated storm sewer infrastructure would be removed and the geomorphology of the mouth sculpted to that of a natural stream once again. A series of riffles and pools would be fashioned to withstand present and future flows within the ravine and provide enough habitat stability and passage for lake fishes. This work would effectively return native fishes to the McCormick Ravine stream once again, in which they currently do not occur. Invasive and non-native plant species would be cleared from the riparian zone and native ravine and oak woodland communities would be reestablished via sowing of seed and planting of live plugs. This component of the NER plan would restore about 49 acres of ravine plant community, 59.4 acres of riparian oak woodland, and about 700-feet of perennial stream; however, by

removing the fish passage barrier at the mouth, about 3,000-feet of stream habitat would become available.

Table 23 – NER Plan Components

Habitat Zone/Alt.	Measures	Description
Ravines		
Bartlett (BR-A)	Not Selected	
Hutchinson (HR-A)	HRC	Attenuate unnatural flow with detention basin
	HRE	Remove invasive plant species
	HRF	Reestablish native plant species
McCormick/Janes (MJR-B)	MJRB	Repairs and naturalizes the mouth of the ravines
	MJRC	Repairs and naturalizes the mouth of the ravines
	MJRD	Remove invasive plant species
	MJRE	Reestablish native plant species
Schenck (ShR-A)	SRD	Repair channel at mouth with riffles
	SRK	Reduce power of flows with large riffles, no pipe
	SRL	Remove invasive plant species
	SRM	Reestablish native plant species
Scott (ScR-A)	SRE	Reduce power of flows with large riffles
	SRH	Restore connectivity to Lake Michigan
	SRP	Remove invasive plant species
	SRQ	Reestablish native plant species
Van Horne	Not Selected	
MacArthur	Not Selected	
Lacustrine		
MJL-A	DC	McCormick breakwater for fish & dune habitat
	DA	Remove invasive plant species
	DB	Reestablish native plant species
MJL-B	DD	Hutchinson breakwater for fish & dune habitat
	DA	Remove invasive plant species
	DB	Reestablish native plant species
BL-B	DP	Bartlett breakwater for fish, dune & bluff habitat
	DJ	Dune restoration via placing stone and sand
	DI	Dune restoration via placing stone and sand
	DA	Remove invasive plant species
	DB	Reestablish native plant species
Bluff		
BLF	BD	Repair gully on bluff near Barlett Ravine mouth
	BE	General gully repairs
	SRI	Repair gully on bluff south of Schenck Ravine
	SRJ	Repair eroding bluff face south of Schenck Ravine
	BRF	Redirect existing urban laminar flows that is causing erosion
	BA	Remove invasive plant species
	BB	Reestablish native plant species

Hutchinson Ravine would have a detention basin constructed at the head of the ravine to attenuate urban flows enough to mimic flows if the land cover of the watershed were natural. A detention pond about 1 acre in size would be excavated and designed to look like a natural wetland pond. A set of inflow and outflow pipes would be utilized in conjunction with the pond to detain and attenuate urban runoff flows back to the ravine stream. The pipes are only being used to send the water into and out of the detention basin and the water will ultimately travel the full length of the ravine in the open stream channel. Invasive and non-native plant species would be cleared from the riparian zone and native ravine communities would be reestablished via sowing of seed and planting of live plugs. This component of the NER plan would restore about 23 acres of ravine plant community and about 3,500-feet of stream habitat.

Scott Ravine would have the check dam currently present at the mouth of the ravine removed to permit connectivity with the lake. Urban induced flows would be dealt with by installing large boulder riffles in order to provide stable instream habitat. A naturalized channel would be constructed to withstand post-project flows. Invasive and non-native plant species would be cleared from the riparian zone and native ravine communities would be reestablished via sowing of seed and planting of live plugs. This component of the NER plan would restore about 2.5 acres of ravine plant community and allow fish passage to about 500-feet of stream habitat.

Schenck Ravine would have the urban induced flows managed through the installation of large cobble riffles, in lieu of the subsurface pipe removing unnatural stormwaters. The riffles described in measure SRK would be sized to handle the future with project condition flows. Cobble would be installed along the first 100 feet of the ravine from the head for stability. The series of riffles and pools would permit connectivity to the lake along the slope of the bluff, while protecting the upstream restoration measures from further head cutting. Invasive and non-native plant species would be cleared from the riparian zone and native ravine communities would be reestablished via sowing of seed and planting of live plugs. This component of the NER plan would restore about 8.3 acres of ravine plant community and allow fish passage and access to about 1,300-feet of stream habitat.

Lacustrine Plan 4 – Lacustrine and dune habitat restoration would be accomplished under the NER Plan via the construction of small rock reefs that would induce larger beaches and submerged sand bars to form, but also allow for dynamic coastal interactions. These sand bars, beaches and dunes would be prefilled with sand to 120% capacity to ensure the littoral drift is not impacted per State of Illinois permitting requirements. The rock reef structures are not intended for storm damage reduction along the coast, but to increase the heterogeneity, size and stability of lacustrine, dune and bluff habitat, but still allow for littoral dynamics. The NER Plan identified three rock reef systems to be implemented; MJL-A, MJL-B, and BL-B as depicted on **Plate 19**. Once the rock reefs are constructed and the cells and dunes filled with sand, native plant communities would be established on the dunes and bluff via invasive species removal, seeding sowing and live plugging. This component of the NER Plan would restore about 12.8 acres of dune/beach habitat and about 12.0 acres of lacustrine structural and hydraulic habitat for fishes.

Bluff Plan 2 – Bluff restoration would be accomplished via alleviating surface water flows down the bluff face, minor grading in areas that were previously affected by these surface waters, invasive plant species removal and establishment of native bluff plant species. The largest problem is at the former mouth of Bartlett Ravine. Since the ravine was turned into a vehicle roadway by the US Army, the water rushing down the road was allowed to careen over the bluff and down onto the beach, which has in turn destroyed previously existing habitat and prevents new habitat from becoming stable enough to support native species. Measure BRF will allow the surface flows over the bluff safe passage to the beach, and further prevent habitat destruction and erosion. About 40-acres of native bluff habitat would be restored. Due to the potential of the USACE not being able to conduct invasive species removal and native seeding in Environmentally Restricted Parcels F and G, an option to exclude these parcels from the project is a

possibility. Removal of the bluff habitat restoration within parcels F & G would reduce habitat benefits by 5.7AAHUs and would insignificantly affect project costs.

Native Plant Community Establishment – The most effective measure for establishing biological diversity is the establishment of appropriate native plant communities; the establishment of native vegetation is directly related to the abundance and diversity of soil fungi and other microorganisms, insects, birds, and other organisms among various trophic levels. The project would ensure the establishment of native ravine, bluff and dune plant communities over the remainder of the construction period. Species would be located according to new hydrogeomorphology, soils and substrates established by the previous steps. Once the physical work is complete and all invasive species removed native seed and plugs would be planted. Years 2 – 5 of the project would manage and establish the native plant communities. This work includes spot herbicide application for invasive species regrowth and replanting small areas if necessary.

No unique methods are proposed beyond the physical repairs described within other sections of the report that would help keep plants in place on slopes. Standard practice for establishing plants on slopes will include the placement of erosion control blankets where seed and plugs will be planted. "Placement of erosion control blankets" will be added to each Native Plant Establishment measure within the Measures for Biological Establishment.

The removal of invasive plants and opportunistic woody vegetation will also keep plants in place by allowing adequate amounts of light to reach the ravine's understory. The native plants being introduced that were lost to physical damage and dense shade will restore soil aggregate stability and cohesion with root structures that supply soil organic matter which relates to improved soil structure that increases soil permeability and water holding capacity. This then translates into lower soil bulk density that makes it harder for rainwater to flow over a ravine's slope causing soil erosion which circles back to physical damage that decreases biological diversity.

Prescribed burns would be conducted by a burn crew that is highly trained and experienced in fire management and the prescribed burning of natural areas. The burn crew will be under the direct control of a qualified burn coordinator having completed at least the minimum amount of training, including S-230 (Single Resource Boss), required to provide controlled burning services in a safe and responsible manner. Primary fire breaks will be installed around the boundary of the site and additional fire breaks will be mowed at least 15 feet around any private parcels within the area of the prescribed burn. The resulting smoke from the burn will be minimized by burning during the daytime when transport winds and mixing heights are such that smoke can be lifted and dispersed safely away from roads and residences unless adequate safeguards have been taken such as appropriate notifications and traffic control. Burns will only take place under acceptable weather parameters (air temperature, humidity, etc) and once all required burn permits are obtained.

Recreational Features – Components of recreation are not proposed under this project.

Figure 8 – The NER / Preferred Ft. Sheridan Restoration 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. All sections denoted with an asterisk are pertinent to the Environmental Assessment.

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 2.2.

Lacustrine, Beach, Dune & Bluff – Recreation and residential and industrial 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 ravines has greatly accelerated the pace of the geologic 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 and along the upper perimeter of ravines where native trees and plants once grew has greatly increased the flow of rainwater runoff via laminar flow down the surface of their slopes. The result is an increase in the rate of surface erosion across the slopes, and in the quantity and velocity of water flowing through the ravine. The greater the quantity of water, the level of downward stream cutting increases, making the lower portion of the ravine slopes adjacent to the stream much steeper and increases the frequency of slumping. The slumping in particular has a devastating effect on the ability of plants and trees to grow on the banks. The ravines are secondarily impacted by the numerous storm sewer outlets which drain stormwater from the surrounding streets into the ravines. These outlets, some of which are several feet in diameter, cause massive destruction to the banks where they discharge and dramatically increase the quantity and velocity of water in the ravines. In a sense, the ravines are becoming younger instead of maturing due to the constant increase in urban runoff. Predictably, over time the slope of the stream bed will level off even further, the steepness of the banks will decline as the ravine further widens, and plants and trees will again be able to survive on the slopes rather than topple over in mudslides. Given enough time, the ravines might adapt to the increased volume of water, although most species of native vegetation specific to the ravines will vanish in the process and won't return because the ravines have lost their morphology and function. In the short term, however, the accelerated rate of erosion spells disaster for the trees and

herbaceous growth. It also should give landowners along the tops of the ravines reason to implement proper techniques for dealing with surface water, since it ultimately means their homes may eventually fall into the ever adjusting ravines.

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 432 combinations for ravine restoration, 96 for lacustrine restoration and 6 for bluff restoration. This assessment includes the No Action alternative as well, which is synonymous with the Future Without Project Condition (FWOP). The habitat output / cost comparisons identified 7 plans for ravine restoration, 7 plans for lacustrine restoration and 1 plan for bluff restoration that were incrementally justified cost wise for their additions of habitat benefits. After taking into considerations of habitat benefits, costs, risk and uncertainty and plan acceptability, completeness, efficiency, and effectiveness, the NER plan was selected. This plan consists of fully restoring 5 ravines, 40-acres of bluff and about 1.5 miles of coastal lake and dune habitat. The NER plan is depicted on **Figure 8** & **Plate 19** and outlined in **Table 23** above. Due to the potential of the USACE not being able to conduct invasive species removal and native seeding in Environmentally Restricted Parcels F and G, an option to exclude these parcels from the project is under consideration. Removal of the bluff habitat restoration within parcels F & G would reduce habitat benefits by 5.7AAHUs and would insignificantly affect project costs or other effects assessment.

4.3 – The Affected Environment

The affected environment is described in detail in Chapter 2 – Inventory & Forecasting. In general, the lacustrine, stream, ravine, and bluff habitats under consideration for ecological restoration activities outlined by this report are degraded. Ravines within the project area were originally formed by the erosive forces of stormwater interacting with the bluffs. Ravines became the natural conduits for stormwater runoff reaching Lake Michigan; however, rapid urbanization in the area has led to an increase in the volume of stormwater discharged into the ravine systems and has resulted in their prompt degradation. Increased urbanization has also led to the presence of shoreline structures along the coast to prevent beach and bluff erosion. Some of these poorly designed structures have inhibited littoral drift while providing limited habitat for aquatic species. In regards to vegetation communities, there are limited high quality pockets of functioning habitats within the boundaries of the project. Overall, vegetative communities within the beach, dune, riparian, and bluff habitats have become degraded due to the presence of disturbed habitat. This has led to the reduction in richness and abundance of native plants species within these habitats.

4.4 – Direct & Indirect Effects of the Preferred Plan

Affects for the Future Without Project Condition or No Action are provided in Section 2.4.

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 within the watershed. 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. The removal of unnatural, urban flows to the ravines would effectively return the presettlement hydraulics to the ravine streams, whether they are ephemeral or perennial. Removal of ineffective manmade structures would 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 affects to fluvial geomorphology and topography are expected resulting from implementation of the preferred plan.

Littoral Processes

Implementation of the proposed project would result in beneficial effects to the littoral habitats and natural geomorphology within the project area limits. Removal of ineffective manmade structures (steel groins) would aid in the restoration of littoral transport and critical hydraulic forces along the beach and surf zone. The proposed rock reefs to replace nonfunctional and outdated infrastructure are fashioned to not trap littoral sands, but pass them through the system, while effectively maintain beach, dune and bluff habitats that would otherwise be eroded by current lake and infrastructure conditions. These new rock reef structures would also increase the acreage of beach and dune from the current condition. No adverse affects 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 ravines, Lake Michigan and other isolated wetland pockets that would promote a more healthy and diverse ecosystem. The natural hydrology of the ravines and bluff were impaired due to watershed development. The denial of water to be absorbed into the ground by impervious surfaces, and then discharged all at once through the ravines has greatly impaired the stability of the plant communities of these features. The proposed plan would manage storm water entering the ravines to minimize negative affects to the ecosystem and to facilitate restoration of habitat. Because the expected flow volumes exceed what would have been managed by the ravines prior to urbanization, re-establishment of natural

flow regimes is not always achievable. The project would not negatively or positively affect ground water in a significant 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 ravines and coastal waves that would promote a healthier and more diverse ecosystem. The natural hydraulics of the ravines and coast were impaired due to watershed development. Increased runoff, which results from the addition of impervious surfaces, triggers higher and more rapid flows from watershed and into receiving streams. For the ravines, this change in runoff conditions has resulted in impairments to the stability of the ravine walls and bed. The proposed plan would be implemented to stabilize the ravines and attenuate flood pulses. The ravines would be restored by the construction of in-stream features to repair legacy damage from increased runoff. Detention and controlled release of storm water will also support the restoration of the ravines by reducing flood flows and velocities. The coastal hydraulics would be manipulated to establish an equilibrium condition that would stabilize beach and dune habitats. 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.

4.4.2 – Ecological Resources

Lacustrine Communities

The proposed project would ultimately improve native aquatic species richness and abundance. Debris and antiquated shoreline protection structures would be removed and replaced with more naturalistic stabilization features composed of cobbles and woody debris, which 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.

Beach Communities

Implementation of the proposed project would ultimately improve native floristic species richness and abundance within the beach and dune habitats by naturalizing coastal hydraulics, removing invasive species and seeding areas with native vegetation exhibiting local genotypes. There are no significant adverse effects expected.

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.

Bluff Communities

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

Riparian Plateau Communities

Implementation of the proposed project would ultimately improve native floristic species richness and abundance along the plateau by removing invasive species and seeding areas with native vegetation exhibiting local genotypes. There are no significant adverse effects expected.

Threatened & Endangered Species

Implementation of the proposed project would only benefit endangered or threatened species if they colonize the project site. Currently, no Federal listed endangered or threatened species have been recorded from the project site; however, numerous state listed species have been recorded (**Table 4**). Restoration features would directly increase the quality of the habitat present at Fort Sheridan; hence potentially encouraging colonization or continued habitation of the area by state listed species such as the common tern (*Sterna hirundo*), Forster's tern (*Sterna forsteri*), longnose sucker (*Catostomus catostomus*), lake herring (*Coregonus artedii*), marram grass (*Ammophila breviligulata*), common juniper (*Juniperus communis*), downy Solomon's seal (*Polygonatum pubescens*), seaside spurge(*Chamaesyce polygonifloia*), and sea rocket (*Cakile edentula*). The USACE has determined that there would be no adverse affects, temporary or minor, to threatened and endangered species. Remnant patches of high quality vegetation containing listed species would be flagged and avoided during construction.

Coordination with the U.S. FWS and the Illinois Department of Natural Resources (IDNR) was commenced on 15 February 2010 with a project scoping letter. Upon review of this document, the U.S. FWS concluded that the project is not likely to adversely affect federal or state listed species, and their letter dated 15 March 2010, precluded the need for further consultation on the Fort Sheridan ravine and coastal restoration project as required under Section 7 of the Endangered Species Act of 1973, as amended.

4.4.3 – Cultural Resources

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 by earlier military activity, including the use of tracked vehicles and live ordinance. 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-The proposed project would have no adverse impact on archaeological or historic properties. Areas of planned ecological restoration have been heavily modified by earlier military activity. Channeled rainwater and drain runoff has heavily eroded the existing ravines. Unexploded ordinance is present on the bluff face and beach areas. The Illinois Historic Preservation Agency will be contacted and is expected to concur with this determination.

Land Use History

The proposed project would result in beneficial effects to land use within the watershed. The proposed project would be implemented in such a fashion as to restore open space parcels 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 provide the necessary workers. Noise levels would be increased during construction as a result of passing trucks. 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 would be planned so as to minimize interference between recreational opportunities and construction activities related to the project. Any impacts to recreational opportunities from construction of the proposed project would be temporary in nature.

Hazardous, Toxic & Radioactive Waste (HTRW) Analysis

The HTRW investigation was performed to determine if the proposed project will have an impact on any Recognized Environmental Conditions (RECs) that may exist in the surrounding areas, and if RECs will have an impact on implementation of the project. According to ER 1165-2-132, non-HTRW issues that do not comply with federal, state, and local regulations should be discussed in the HTRW evaluation along with HTRW issues. The complete HTRW report and Parcel Maps can be found in Appendix E.

Existing information available for review documenting the BRAC site study and cleanup prior to property transfer was very extensive. All potential RECs onsite appear to have been adequately addressed. No work will occur on the landfill 7 area as a part of this project. All USTs at active gasoline stations are distanced from project work areas and are unlikely to affect the project. No other data presented in the EDR Database Report indicated any surrounding sites that are likely to pose REC concerns to the project resulting from federal or state regulated facilities within the ASTM established search distances. Results of this investigation suggest that it is unlikely that Recognized Environmental Conditions remain on the project site. However, additional awareness needs to be paid to the northeast corner of the site, the location of a former range.

Activities including landscaping occurring on Parcel G/landfill 2 are in coordination with Louisville District or a USACE MM Design Center. Activities in this area are limited to a depth of one foot.

Activities on Parcels F and G require construction support because of the potential for encounters with unexploded ordnance. A clearance activity on these areas, and the beach associated with them, was completed in 2004. Construction support may no longer be required. If the final project measures will occur in these areas, construction support needs to be reviewed by USACE MM Design Center Omaha. However, although it is highly unlikely that ordnance will be encountered; no clearance activity can wholly eliminate the uncertainty. Additionally, although the beach area was cleared to a depth of four feet, it is the nature of the beach and littoral zone to have shifting sand. The project team as a precaution may decide to engage a limited level of construction support for activities north of Hutchinson Ravine occurring not only on Parcel F and G, but also for the beach and littoral zones in these areas.

Due to the potential of the USACE not being able to conduct invasive species removal and native seeding in Environmentally Restricted Parcels F and G, an option to exclude these parcels from the project is a possibility. Removal of the bluff habitat restoration within parcels F & G would reduce habitat benefits by 5.7AAHUs and would insignificantly affect project costs.

No investigation can wholly eliminate uncertainty regarding the potential for encountering a REC associated with a project area. Performance of this investigation is intended to reduce, but not eliminate, uncertainty regarding the potential for encountering a REC in connection with a project area.

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 (Accessed 31 May 2012), revealed that within the portion of Highland Park containing the Fort Sheridan ravine and coastal restoration 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 – 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) from (ER 1105-2-240 of 13 July 1978). Effects to these points are discussed as follows:

Noise: Any of the alternative plans would cause minor and temporary 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: Any of the alternative plans would not displace local residents within the township of the study area since only open space parcels are proposed for restoration.

Aesthetic Values: Any of the alternative plans would not 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 affects on aesthetics are minor and temporary as native plant species would sufficiently cover the ground after the first growing season. 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: Any of the alternative plans would not disrupt community cohesion, but provide restored open space for community activities.

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

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

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

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

Public Facilities: Any of the alternative plans would not adversely affect public facilities of Fort Sheridan, but would provide a more natural and healthy open space for future public amenities such as nature trails.

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

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

Business and Industrial Activity: Any of the alternative plans would not adversely or beneficially affect local commerce.

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

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

Natural Resources: The No Action Alternative allows for the 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 not adversely affect air quality since machinery for construction activities would be unnoticeable compared to current traffic and activities of the immediate project area.

Water: Any of the alternative plans would not adversely affect water quality; however, ravine and lacustrine 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 Fort Sheridan ravine and coastal restoration project is considered to be beneficial environmentally, socially, and economically. The restoration of about 218-acres of ravine, bluff, lacustrine, beach and dune, and riparian woodland habitat will contribute to the overall preservation of habitat within Fort Sheridan and to a larger degree, the Great Lakes.

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 Fort Sheridan. 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, a vast prairie/wetland/woodland mosaic.
- Present – 2012 when the decision is being made on the most beneficial ecological restoration
- Future – 2062, 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 of the ravines and manipulating the coastal wave hydraulics 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, the plant communities, which are 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 repairing the past physical impairments, biological resource impairments would be repaired 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 form many native species. Future actions such as infrastructure upgrading may have damaging or beneficial effects 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 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, creation 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 degraded current degraded nature of the ravine, bluff and dune plant communities. This will include removing non-native species and reestablishing vegetation. Reestablishing native vegetation (including wildflowers) and removing antiquated structures (sewer drains) would only increase the aesthetic value of the project site. Ft. Sheridan is currently unused to its full potential for passive recreation. The ecosystem restoration project would maximize the public's use of the site for viewing and enjoying wildlife. 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 Ft. Sheridan habitat restoration project are considered to be beneficial environmentally, socially and economically. The restoration of about 218-acres of degraded 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 Central Flyway.

Section 4.6 – Public Review

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 07 November 2014 to 07 December 2014 for the Environmental Assessment. Significant comments from the Federal, State or local agencies or the public were addressed and are attached to this FONSI. All comments and correspondence are attached to this FONSI. Appendix G lists agencies and public entities that were provided opportunity to comment; however, the NEPA was placed on the Chicago District USACE's internet for widest distribution possible.

Section 4.7 – General Compliance

The NER /Preferred Plan presented is in compliance with appropriate statutes and executive orders including the Endangered Species Act of 1973 as amended; the Fish and Wildlife Coordination Act of 1934 as amended; 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; the Clean Air Act of 1970 as amended and the National Environmental Policy Act of 1969 as amended.

Environmental Justice EO12898

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

Due to the small scale, short duration and relatively unpolluted nature of the restoration project, it is assumed that the project is below the de minimis level of PM 100 tons per year. As a reference, other USACE projects that are much grander in scale and earthwork have General Conformity Act emissions well below the PM 100 tons per year.

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 would be applied for should the NER plan be approved for implementation. The Illinois EPA accepts nothing less than final designs for 401 Permitting. It is anticipated this project would receive 401 Water Quality Certification based on the incidental water quality improvements to the ravines and ultimately Lake Michigan.

USFWS Coordination

Coordination with the U.S. FWS and the Illinois Department of Natural Resources (IDNR) was commenced on 15 February 2010 with a project scoping letter. Upon review of this document, the U.S. FWS concluded that the project is not likely to adversely affect federal or state listed species, and their letter dated 15 March 2010, precluded the need for further consultation on the Fort Sheridan ravine and coastal restoration project as required under Section 7 of the Endangered Species Act of 1973, as amended.

State of Illinois Historic Preservation Act

Pursuant to Section 106 of the National Historic Preservation Act (16 U.S.C. § 4701) 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 22 February 2012. Based upon the documentation available, the staff of the Illinois SHPO has identified that any modification to Historic Parade ground constitutes an effect as defined by 36 C.F.R. Part 800. Subsequently, the plan formulation took this into account and developed alternate measures to completely avoid the Historic Parade Ground. All other areas affected by ground disturbance under this project have already been previously disturbed; therefore an archaeological survey is unnecessary and is consistent with the recommendations of the SHPO. Coordination will be finalized during the 30-day NEPA Review Period.

CHAPTER 5 – NER PLAN COMPONENTS

5.1 – Plan Benefits

The National Ecosystem Restoration (NER) Plan is the recommended/preferred plan described in Section 3.7, which is a combination of Ravine Plan 4, Lacustrine Plan 4 and Bluff Plan 6 Alternative (**Plate 19**). This combined plan consists of alternatives and measures identified in **Table 23**. The three habitat zones or community types would have been represented within the pre-settlement coastal zone of Illinois. **Table 24** shows the improvement made to these historic habitat types within the coastal zone, which include a marked increase in acreage of lacustrine habitat and increased quality of all habitats. The FWOP acres are greater than the FWP NER Plan acres due to Van Horne Ravine and private parcels along various ravines not being recommended, and the difference between increasing acres of viable lacustrine habitat.

Table 24 – Plan Component Output Summary

	FWOP			FWP NER			
Habitat Type	**Acres**	**AAHSI**	**AAHUS**	**Acres**	**AAHSI**	**AAHUS**	**AA Net Benefits**
Lacustrine	4.0	1.9	7.6	24.8	5.1	125.2	117.6
Bluff	41.0	3.5	141.5	41.0	4.9	200.9	59.5
Ravine/Oak Woodland	162.1	1.6	257.7	134.4	4.2	564.5	306.7
Totals	207.1		406.8	200.2		890.6	483.8

Due to the potential of the USACE not being able to conduct invasive species removal and native seeding in Environmentally Restricted Parcels F and G, the following scenario shows the difference in benefits on the Bluff Habitat. Coordination with cost engineer indicated that the reduction of 2.1-acres had no affect on the overall cost of the measure due economy of scale and contingency parameters. Removal of the bluff habitat restoration within parcels F & G would reduce habitat benefits by 5.7AAHUs.

Table 25 – Plan Component Output Summary without Bluff Habitat Parcels F & G

	FWOP			FWP NER			
Habitat Type	**Acres**	**AAHSI**	**AAHUS**	**Acres**	**AAHSI**	**AAHUS**	**AA Net Benefits**
Lacustrine	4.0	1.9	7.6	24.8	5.1	125.2	117.6
Bluff	40.0	3.5	141.8	39.9	4.9	195.5	53.7
Ravine/Oak Woodland	162.1	1.6	257.7	134.4	4.2	564.5	306.7
Totals	206.1		407.1	199.1		885.2	478.1

5.2 – Plans & Specifications

During the design phase, a detailed set of plans and specifications will be fashioned 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 estimated based on the gross appraisal in Appendix F, Real Estate, which is $426,000.

5.4 – Operation and Maintenance

The O&M costs of the project are estimated to total an annual cost of $15,000 with a 4.875% interest rate over 50 years. 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. Pipes, inlet, outlets and other structures for rerouting of stormwater would also need to be maintained, especially kept free from leaf litter and debris. A detailed O&M Manual containing all the duties will be provided to the non-Federal sponsor after construction is closed out.

5.5 – Monitoring Plan

Section 2039 of WRDA 2007 directs the Secretary to ensure that when conducting a feasibility study for a project (or a component of a project) for ecosystem restoration that the recommended project includes a plan for monitoring the success of the ecosystem restoration. Within a period of ten years from completion of construction of an ecosystem restoration project, monitoring shall be a cost-shared project cost.

A five year monitoring plan following completion of construction will be implemented for this project (Appendix H). 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 lacustrine, stream, and native coastal plant communities in support of Great Lakes fishes, amphibians, reptiles, and migratory bird species. Baseline data for current conditions on the Ft. Sheridan natural area are detailed in this DPR. The following specific objectives were established for monitoring the effectiveness of this project:

- Improve native fish species richness, evenness, and diversity. Shannon- Wiener Index will be used to determine diversity and evenness.
    - Target richness= **≥15**
    - Target evenness= **≥ 0.7**
    - Target diversity= **≥ 1.9**
- Improve macroinvertebrate species richness, evenness, and diversity. Target values are hard to determine since no baseline data is available. Instead we will track the progression of these indices through time.
- 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 = **≥5.**
- 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 PL99-662, as amended, project costs are shared with the non-Federal sponsor in accordance with project outputs. The Lake County Forest Preserve District, Openlands, the Township of Ft. Sheridan and the City of Lake Forest have agreed to serve as the non-Federal cost-sharing sponsors for the Ft. Sheridan 506 Great Lakes Fishery & Ecosystem Restoration project. The cost-sharing

requirements and provisions will be formalized with the signing of four (4) separate Project Partnership Agreements (PPA) between the non-Federal sponsors and USACE prior to initiation of contract award activities. In these agreements, the local sponsors will agree to pay 35 percent of the total project costs per sponsor plan. The NER Plan is separable into four (4) plans that can be implemented by each non-Federal sponsor under their specific PPA. **Plate 20** and **Table 25** show that the NER Plan features or habitat zones were separated by the non-Federal sponsors landholdings, thus there would be no delays or losses should construction schedules be staggered or of different productivities. **Plate 20** also shows that the previous USACE partnership with the LCFPD does not overlap with the NER/Preferred Plan under this study.

Table 26 – Non-Federal Sponsor NER Plan Component Breakout

Sponsor Plan	Habitat Zone	Acres	Measures	Description
City of Lake Forest	McCormick Ravine	20.3	MJRB, MJRC, MJRD, MJRD	Reestablishes connectivity of ravine to Lake Michigan for all fishes. Repairs geomorphic damage caused by defunct infrastructure and stabilizes mouth of ravine with minor grading and riffle placement. Restores native ravine woodland by removing invasive tree and shrub species and reestablishing oak/hickory canopy with a diverse understory of native shrubs and herbaceous plants.
	McCormick Woodland	33.2	MJRD, MJRD	Restores native oak woodland riparian zone to McCormick and Janes Ravines by removing invasive tree and shrub species and reestablishing oak/hickory canopy with a diverse understory of native shrubs and herbaceous plants.
	Bluff	1.5	BLF	Restores native bluff plant communities by preventing future erosion, repairing old erosion points, removing invasive species and reestablishing native bluff plant species.
	Lacustrine	9	DC	Provides reef habitat for fishes and induces dynamic sand bar, beach and fore dune formation.
Lake County FPD	Janes Ravine	20.4	MJRB, MJRC, MJRD, MJRD	Reestablishes connectivity of ravine to Lake Michigan for spring spawing fishes. Repairs geomorphic damage caused by defunct infrastructure and stabilizes mouth of ravine with minor grading and riffle placement. Restores native ravine woodland by removing invasive tree and shrub species and reestablishing oak/hickory canopy with a diverse understory of native shrubs and herbaceous plants.
	Hutchinson Ravine	23.2	HRC, HRE, HRF	Attenuates the last half of urban induced flows via a detention basin. Restores native ravine woodland by removing invasive tree and shrub species and reestablishing oak/hickory canopy with a diverse understory of native shrubs and herbaceous plants.
	Scott Ravine	0.5	SRH	Reestablishes connectivity of ravine to Lake Michigan for spring spawning fishes.
	McCormick Woodland	20.3	MJRD, MJRD	Restores native oak woodland riparian zone to McCormick and Janes Ravines by removing invasive tree and shrub species and reestablishing oak/hickory canopy with a diverse understory of native shrubs and herbaceous plants.
	Bluff	14.1	BLF	Restores native bluff plant communities by preventing future erosion, repairing old erosion points, removing invasive species and reestablishing native bluff plant species.
	Lacustrine	18.5	DD	Provides reef habitat for fishes and induces dynamic sand bar, beach and fore dune formation.
Openlands	Schenck Ravine	8.3	SRD, SRK, SRL, SRM	Reestablishes connectivity of ravine to Lake Michigan for spring spawning fishes. Designed to withstand urban flows induced by US Navy subdivision. Repairs geomorphic damage caused by defunct infrastructure and stabilizes mouth of ravine with minor grading and riffle placement. Restores native ravine woodland by removing invasive tree and shrub species and reestablishing oak/hickory canopy with a diverse understory of native shrubs and herbaceous plants.
	BLF	25.4	BLF	Repairs and prevents further bluff damage caused by surficial flows along the Bartlet Ravine road constructed by the US Army. Restores native bluff plant communities by preventing future erosion, repairing old erosion points, removing invasive species and reestablishing native bluff plant species
	Lacustrine	5.3	DP, DI, DJ	Provides reef habitat for fishes and induces dynamic sand bar, beach and fore dune formation.
TWP of Ft. Sheridan	Scott Ravine	2	SRE, SRP, SRQ	Reduces power of urban induced flows with large boulder riffles, remove invasive plant species and reestablish native ravine plant community on slopes.

Based on the cost sharing requirements, the total project cost and pertinent cost-sharing information for the restoration project are summarized in **Tables 26** thru **30**.

Table 27 – TPC & Cost Sharing Breakout in 1000's*

INTENTIONALLY EXCLUDED

*All costs input from the Certified TPC by the Walla Walla Cost MXC on 06 February 2014 except LERRDs which were derived from the Real Estate Plan Appendix D; includes 24% contingency

Table 28 – City of Lake Forest Cost Sharing

INTENTIONALLY EXCLUDED

Table 29 – Lake County Forest Preserve Cost Sharing

INTENTIONALLY EXCLUDED

Table 30 – Openlands Cost Sharing

INTENTIONALLY EXCLUDED

Table 31 – Township of Ft. Sheridan Cost Sharing

INTENTIONALLY EXCLUDED

Responsibilities

Federal - The estimated Federal cost share of the project is about $ $__. 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 4 separate PPAs. The LERRDs and OMRR&R of the project will be the responsibility of the non-Federal sponsors for the proposed project. The estimated total non-Federal share of the total first cost of the project is about $__ and will be covered by LERRDs credit of $__ and a cash/WIK contribution of $ $__. In addition to the total first cost, the feasibility level operations and maintenance costs of the project are estimated to total an annual cost of $__. 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 PPA
   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. Contribute all project costs in excess of the USACE implementation guidance limitation of $10,000,000

3. 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
4. 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
5. 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
6. 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, 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
7. 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
8. 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
9. 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
10. 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
11. To the maximum extent practicable, conduct OMRR&R of the project in a manner that will not cause liability to arise under CERCLA
12. Prevent future encroachment or modifications that might interfere with proper functioning of the project
13. 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
14. 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"
15. 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
16. 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 funds are authorized to be used to carry out the Project.

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 greater Ft. Sheridan Ravine and Coastal area. Those aspects include environmental, social, and economic effects, as well as engineering feasibility.

I recommend combined plans of Ravine Plan 4, Lacustrine Plan 6, and Bluff Plan 2, which consists of establishing the diverse coastal habitat mosaic within the Ft. Sheridan natural area. The recommended plan has a total project cost of approximately $ $__ (2014 price levels). This plan provides 890.6 average annual habitat units over 200.2-acres of coastal zone. All costs associated with the restoration of the Ft. Sheridan natural area ecosystem have been considered.

_____

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

CHAPTER 7 – BIBLIOGRAPHY AND ACRONYMS

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ACRONYMS AND ABBREVIATIONS

FQI	Floristic Quality Index
HEP	Habitat Evaluation Procedure
HGM	Hydrogeomorphic Assessment
IBI	Index of Biotic Integrity
NER	National Ecosystem Restoration
QHEI	Qualitative Habitat Evaluation Index