CEDAR LAKE AQUATIC ECOSYSTEM RESTORATION FEASIBILITY STUDY

CEDAR LAKE, INDIANA

DRAFT FEASIBILITY REPORT & INTEGRATED ENVIRONMENTAL ASSESSMENT

U.S. Army Corps of Engineers
Chicago District

Town of Cedar Lake, Indiana

July 2016

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EXECUTIVE SUMMARY

Cedar Lake is a 781 acre glacially formed lake located within the Town of Cedar Lake in northwest Indiana. Historically, the lake supported a biologically diverse ecosystem typical of northern glacial lakes. Since the late nineteenth century, modifications to the lake and contributing watershed have resulted in adverse effects to the lake's fringe wetland habitat, littoral zone habitat, lake-bottom substrates, and the diversity and abundance of native fishes. Surrounding watershed practices have accelerated succession of the lake (i.e., lake aging process) resulting in an impaired aquatic ecosystem with shallower less diverse aquatic habitat. Initiatives such as restoration of riparian habitat along tributaries, reduction of sediment and nutrient inputs, and utilization of best management practices for stormwater management, have been taken over the past 40 years by the community. While external stressors have been addressed, impairments within the lake still need to be addressed in order to restore the ecological structure and function of Cedar Lake. This study, which seeks to restore the aquatic ecosystem of Cedar Lake, was initiated under Section 206 of the Water Resources Development Act (WRDA) of 1996. The study was then specifically authorized by Section 3065 of WRDA 2007 for the planning, design and construction of an aquatic ecosystem restoration project at Cedar Lake after the estimated project cost exceeded the Section 206 authority per project Federal funding limit of $5 million.

Due to a history of modifications to Cedar Lake's physical habitat structure and functional processes, the historic glacial lake species assemblages have become significantly reduced in both diversity and abundance. Past modifications to the Cedar Lake ecosystem include:

- Fragmentation of Cedar Lake from its tributaries
    - Founders Creek no longer flows into Cedar Lake, but instead flows into Cedar Creek, the outlet for Cedar Lake
    - Cedar Creek, outlet of Cedar Lake, contains a weir which has fragmented aquatic species movement from the creek to the lake
- Lowering of the lake level
    - Depth of lake was lowered from approximately 40 feet to 20 feet in the 1870s
- Removal of fringe wetland and littoral zone aquatic plant communities
    - Historic records and photos of Cedar Lake show significant fringe and littoral zone aquatic vegetation; however, less than 1% of the lake is now covered by aquatic vegetation (excluding Cedar Lake Marsh)
- Modification of tributary stream habitat

    - Tributary streams have been channelized and stream banks have been lined with riprap
- Modification of the native fish community
    - Past stocking events have attempted to create a sport fishery; however, the lake has been invaded by non-native species such as Common Carp (*Cyprinus carpio*) and White Perch (*Morone americana*)

Several alternative plans were developed to restore the Cedar Lake aquatic ecosystem. Specific habitat types targeted for restoration are lake fringe wetland, lake littoral zone, lake profundal zone (i.e., deep water habitat) and tributary riparian zone habitat in order to improve biodiversity within Cedar Lake. Alternative plans were derived from measures including, physical substrate restoration, chemical substrate restoration, creation of habitat islands, littoral aquatic vegetation restoration, tributary restoration, fish community management, and institutional controls. Alternative plans were evaluated for completeness, effectiveness, efficiency and acceptability.

Alternatives

Alternative Plan 0: The No Action Alternative means no Federal action will take place and is synonymous with-projected future without-project conditions. This is the alternative by which all other alternative plans are compared. The future without-project habitat conditions are not expected to change significantly without a large-scale aquatic ecosystem restoration project. While there have been significant and ongoing efforts by the Town of Cedar Lake to address watershed activities that have caused impairment of the lake's aquatic ecosystem, there has been no systematic effort to restore the aquatic habitat of Cedar Lake.

Alternative Plan 1: This alternative plan would extend the current No Wake Zone from 200 feet to 400 feet to cover approximately 35% of the lake. This extended zone would aid in reducing propeller induced wave disturbance to aquatic plants trying to establish in the littoral zone, reducing disturbance of aquatic macroinvertebrates colonizing the littoral zone and reducing forced detachment of aquatic macroinvertebrates from lake bed substrates.

Alternative Plan 2: This alternative plan builds upon Alternative Plan 1 by adding stabilization of approximately 400 acres of lake bottom with an alum dosage that would be effective to a depth of 10 cm. Long-term effectiveness would be ensured by conducting a second alum treatment after about 25 years. The chemical substrate restoration will result in a firmer, inert lake bottom that will support the reestablishment of aquatic macrophytes within the fringe wetland and littoral zone and other structural elements necessary for a healthy lake ecosystem.

Alternative Plan 3: This alternative plan builds upon Alternative Plan 1 by adding stabilization of approximately 400 acres of lake bottom with an alum dosage that would be effective to a depth of 20 cm. Due to the increased dosage of the initial alum treatment a second dose would not be required to ensure long-term effectiveness over the 50 year period of analysis. The chemical substrate restoration will result in a firmer, inert lake bottom that will support aquatic macrophyte restoration within the fringe wetland and littoral zone and other structural elements necessary for a healthy lake ecosystem.

Alternative Plan 4: This alternative plan builds upon Alternative Plan 3 by adding the rerouting of Founders Creek back to its historic connection with Cedar Lake. Rerouting Founders Creek would restore tributary riparian zone habitat and restore tributary connectivity.

Alternative Plan 5: This alternative plan builds upon Alternative Plan 4 by adding restoration of 35 acres of emergent and 95 acres of submergent aquatic macrophytes within the fringe wetland and littoral zone, reestablishment of the native glacial lake fish community, and physical removal of 1 foot of sediment across 87 acres of the lake bottom (140,000 cubic yards). The removal of non-native fish species will be carried out by the Town of Cedar Lake and the Indiana Department of Natural Resources (IDNR) through a one-time application of Rotenone, a fish piscicide. Native glacial lake fish species will then be restocked. This alternative plan is expected to restore spawning habitat for lake species; restore fringe wetland and littoral zone vegetation thereby providing increased habitat for aquatic species, shorebirds and waterfowl, and other wildlife; restore profundal zone habitat; restore a firmer inert lake bottom; improve the lake's habitat structure and function and provide a natural buffer for shoreline protection from wave erosion.

Alternative Plan 6: This alternative plan builds upon Alternative Plan 5 with additional physical substrate restoration – physical removal of 1 foot of sediment across 163 acres of the lake bottom (263,000 cubic yards). This alternative plan is expected to restore spawning habitat for lake species, restore fringe wetland and littoral zone vegetation, restore profundal zone habitat, restore a firmer inert lake bottom, improve the lake's habitat structure and function and provide a natural buffer for shoreline protection from wave erosion.

Alternative Plan 7: This alternative plan builds upon Alternative Plan 6 in addition to expanding the existing No Wake Zone to encompass the entire lake as well as restrict motorboats to engines having less than 10 HP. This alternative plan is expected to protect restored aquatic macrophytes in the fringe wetland and littoral zone, reduce disturbance of aquatic macroinvertebrates colonizing the fringe wetland and littoral zone habitats and reduce forced detachment of aquatic macroinvertebrates from bottom substrates due to propeller induced waves.

Alternative Plan 8: This alternative plan builds upon Alternative Plan 7 with additional physical substrate restoration – physical removal of 1 foot of sediment across 224 acres of the lake bottom (362,000 cubic yards).

Alternative Plan 9: This alternative plan builds upon Alternative Plan 7 with additional physical substrate restoration – physical removal of 1 foot of sediment across 444 acres of the lake bottom (717,000 cubic yards).

Recommendation

Alternative Plan 5 was identified as the National Ecosystem Restoration (NER) Plan. This plan reasonably maximizes environmental benefits and fulfills the criteria of acceptability, completeness, efficiency and effectiveness. The NER Plan would restore structural habitat for aquatic species; provide spawning, nursery and foraging habitat for fish, aquatic macroinvertebrates, amphibians, reptiles, waterfowl, shore birds and migratory birds; restore the native glacial lake fish community indicative to what historically occurred within the lake; and aid in restoring profundal zone habitat. The estimated project first cost for the NER Plan is $[redacted] with a Federal contribution of $[redacted] and a non-Federal contribution of $[redacted] including $[redacted] in cash and $[redacted] in lands, easements, rights-of-way, relocations and disposal areas (LERRDs).

The non-Federal sponsor, Town of Cedar Lake, has requested consideration of *Alternative Plan 6* for implementation as a Locally Preferred Plan (LPP). The LPP includes all the measures that are part of the NER Plan as well as an increase in the amount of physical substrate restoration to be conducted. An additional 123,000 cubic yards of substrate will be removed over an additional 76 acres of the lake. This increased physical substrate restoration will provide additional habitat benefits in the profundal zone of Cedar Lake; however, it is not as cost effective as the NER Plan. The estimated project first cost for the LPP is $[redacted] with a Federal contribution of $[redacted] and a non-Federal contribution of $[redacted] including $[redacted] in cash and $[redacted] in LERRDs.

The $[redacted] increased cost of the LPP is a non-Federal responsibility. In accordance with the National Environmental Policy Act of 1969, an environmental assessment of both the NER Plan and LPP has found that both projects have no significant impacts as a result of project implementation. Public review of this draft feasibility report and integrated environmental assessment will be conducted and comments will be incorporated in the final report.

The USACE and non-Federal sponsor requested a policy waiver from the Assistant Secretary of the Army for Civil Works to recommend the LPP for implementation and approval to release the draft report for public review. The LPP policy waiver request was approved.

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ADDAMS	Automated Dredging and Disposal Alternatives Management System
AAHUs	Average Annual Habitat Units
ASA(CW)	Assistant Secretary of the Army (Civil Works)
ASP	Available Sediment Phosphorus
ASSET	Adjustable Shear Stress Erosion and Transport Flume
CAP	Continuing Authorities Program
CE/ICA	Cost Effective / Incremental Cost Analysis
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation & Liability Act
CFR	Code of Federal Regulations
CLEA	Cedar Lake Enhancement Association
CWCCIS	Civil Works Construction Cost Index System
EA	Environmental Assessment
EDC	Engineering During Construction
EFDC	Environmental Fluid Dynamics Code
EO	Executive Order
EOPs	Environmental Operating Principles
ER	Engineering Regulation
ERU	Equivalent Runoff Unit
FAA	Federal Aviation Administration
FONSI	Finding of No Significant Impact
FWCA	Fish & Wildlife Coordination Act
FWOP	Future Without-Project Condition
FY	Fiscal Year
GPS	Global Positioning System
HQ	Headquarters
HSI	Habitat Suitability Index
HTRW	Hazardous, Toxic and Radioactive Waste
HUs	Habitat Units
IDC	Interest During Construction
IDDE	Illicit Discharge Detection and Elimination
IDEM	Indiana Department of Environmental Management
IDNR	Indiana Department of Natural Resources
IDNR-DFW	Indiana Department of Natural Resources – Division of Fish and Wildlife
IDNR-DHPA	Indiana Department of Natural Resources – Division of Historic Preservation and Archaeology
IDNR-DOW	Indiana Department of Natural Resources – Division of Water
IWR	Institute for Water Resources
IWR-PLAN	Institute for Water Resources - Planning Suite Software
LARE	Indiana Lake and River Enhancement program
LERRDs	Lands, Easements, Rights-of-Way, Relocations and Disposal Areas
LPP	Locally Preferred Plan
MOA	Memorandum of Agreement
MS4	Municipal Separate Storm Sewer Systems

NAAQS	National Ambient Air Quality Standards
NEPA	National Environmental Policy Act
NED	National Economic Development
NER	National Ecosystem Restoration
NGVD29	National Geodetic Vertical Datum
NPDES	National Pollutant Discharge Elimination System
NRCS	National Resource Conservation Service
OMRR&R	Operations, Maintenance, Repair, Replacement and Rehabilitation
PED	Preconstruction Engineering and Design
PDT	Project Delivery Team
PL	Public Law
PNAs	Polynuclear aromatics
PPA	Project Partnership Agreement
RISC	Risk Integrated System of Closure
SDF	Sediment Dewatering Facility
SHPO	State Historic Preservation Officer
SNL	Sandia National Laboratories
SPEA	Indiana University School of Public and Environmental Affairs
SWPP	Storm Water Pollution Prevention
TKN	Total Kjeldahl Nitrogen
TP	Total Phosphorus
TSI	Trophic State Index
UPRR	Union Pacific Railroad
USACE	U.S. Army Corps of Engineers
USC	U.S. Congress
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
VE	Value Engineering
VHS	Viral Hemorrhagic Septicemia
WQC	Water Quality Certification
WRDA	Water Resources Development Act

CHAPTER 1 - Introduction

1.1 Report Structure

This Feasibility Study (FS) presents the results of an ecosystem restoration feasibility study for Cedar Lake. This FS presents the assessment of ecological conditions and potential alternative plans to restore important lake habitat for fish, aquatic macroinvertebrates, resident and migratory birds, and other wildlife. This report gathered historic and current site conditions, and forecasts future without and future with-project conditions for the Cedar Lake aquatic ecosystem while considering watershed attributes. This report also provides a recommended plan for restoring habitat within the study area.

This report contains the following chapters:

Chapter 1 – Introduction: introduces the project and provides a description of the study area and a summary of relevant studies and projects completed.

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

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

Chapter 4 – Plan Formulation and Evaluation: discusses how alternative plans have been formulated, presents the cost effectiveness and ecological benefits of each alternative plan, and discusses the evaluation process used to identify the National Ecosystem Restoration (NER) plan and select a recommended plan. Also includes discussion on the selection of a Locally Preferred Plan (LPP) by the non-Federal sponsor.

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

Chapter 6 – Description of Tentatively Selected Plan or the LPP: describes the measures comprising the Tentatively Selected Plan and project costs.

Chapter 7 – Plan Implementation: discusses construction sequencing, monitoring and adaptive management, project costs and cost sharing responsibilities.

Chapter 8 – Recommendation: provides the District Commander’s recommendation for implementation of an ecosystem restoration plan.

1.2 Study Authority

SEC. 206. AQUATIC ECOSYSTEM RESTORATION. Water Resources Development Act (WRDA) 1996

(a) GENERAL AUTHORITY.-The Secretary may carry out an aquatic ecosystem restoration and protection project if the Secretary determines that the project-

(1) will improve the quality of the environment and is in the public interest; and

(2) is cost-effective.

(b) COST SHARING.-Non-Federal interests shall provide 35 percent of the cost of construction of any project carried out under this section, including provision of all lands, easements, rights-of-way, and necessary relocations.

(c) AGREEMENTS.-Construction of a project under this section shall be initiated only after a non-Federal interest has entered into a binding agreement with the Secretary to pay the non-Federal share of the costs of construction required by this section and to pay 100 percent of any operation, maintenance, and replacement and rehabilitation costs with respect to the project in accordance with regulations prescribed by the Secretary.

(d) COST LIMITATION.-Not more than $5,000,000 in Federal funds may be allotted under this section for a project at any single locality.

(e) FUNDING.-There is authorized to be appropriated to carry out this section $25,000,000 for each fiscal year.

This study was initiated under Section 206 of the WRDA 1996 (as stated above). However, while developing the FS, it was realized that to appropriately restore the ecological integrity of Cedar Lake, a larger investment than the per project limit of the Section 206 authority was required. Therefore, the project was subsequently specifically authorized by Section 3065 of WRDA 2007 (as stated below).

SEC. 3065. CEDAR LAKE, INDIANA. WRDA 2007

(a) IN GENERAL.-The Secretary is authorized to plan, design, and construct an aquatic ecosystem restoration project at Cedar Lake, Indiana.

(b) COMPLETE FEASIBILITY REPORT.-In planning the project authorized by subsection (a), the Secretary shall expedite completion of the feasibility report for the project for aquatic ecosystem restoration and protection, Cedar Lake, Indiana, initiated pursuant to section 206 of the Water Resources Development Act 1996 (33 U.S.C. 2330).

(c) AUTHORIZATION.-

(1) IN GENERAL.-There is authorized to be appropriated $11,050,000 to carry out the activities authorized by this section.

(2) OTHER.-The Secretary is authorized to use funds previously appropriated for the project for aquatic ecosystem restoration and protection, Cedar Lake, Indiana, under section 206 of the Water Resources Development Act 1996 (33 U.S.C. 2330) to carry out the activities authorized by this section.

Implementation Guidance:

1. Section 3065 of WRDA 2007 authorizes the Secretary to plan, design and construct an aquatic ecosystem restoration project at Cedar Lake, Indiana. The provision further directs the Secretary to expedite completion of the feasibility report that was initiated under Section 206 of WRDA 1996, and authorizes the use of funds previously appropriated under the Section 206 program. There are currently no funds appropriated for the implementation (construction) phase. The WRDA language establishes a cap of $11,050,000 for any future appropriations of Federal funds for this project.

2. The U.S. Army Corps of Engineers (USACE) should complete the feasibility report using existing funds provided in the fiscal year (FY) 2008 Consolidated Appropriations Act (PL 110-161), and follow report guidelines for projects authorized without a report in Appendix H of Engineering Regulation (ER) 1105-2-100. The USACE will review the schedule for the project to identify all opportunities to expedite study completion.

3. Following completion of a feasibility report containing a positive recommendation, and using the balance of the available funds, the USACE may enter into a Preconstruction Engineering and Design (PED) agreement and initiate PED activities. The design agreement will include a provision to recoup the non-Federal share of the FS cost. Upon approval by the Secretary, the project may be considered for implementation in accordance with existing budgetary policies and procedures. However, no project construction may be initiated until funds are specifically appropriated to accomplish the work. Any additional funds provided by Congress will be utilized in accordance with current Civil Works program execution guidance.

In addition to the implementation guidance, a coordinated legal opinion determined that the $11,050,000 authorized by Section 3065 does not include amounts previously appropriated under Section 206 of WRDA 1996. Prior to the specific authorization, $683,900 had been expended while Cedar Lake was still a Section 206 project. Therefore, the total Federal costs (i.e., not including non-Federal costs) that may be expended for the planning, design, and construction of a feasible project at Cedar Lake are $11,734,000.

1.3 Study Purpose*

This report documents whether or not a project is warranted for Federal participation based on feasibility level assessment of potential benefits, estimated costs, and possible environmental impacts of various alternatives, all of which follow the USACE planning and policy guidelines. The main purpose of the FS is to recommend a plan, including consideration of the No Action Plan, for ecosystem restoration of Cedar Lake. By restoring lake and connecting habitats, this project could provide essential life history requisites for resident and migratory fish and wildlife.

This ecosystem restoration study was initiated under Section 206 of WRDA 1996. Section 206 projects are funded by the USACE and a non-Federal sponsor and provide authority for the USACE to support restoration projects in aquatic environments such as rivers, lakes and wetlands. The study was initiated by request of the Cedar Lake Enhancement Association

(CLEA); however, while developing the FS, it was realized that to appropriately restore the ecological integrity of Cedar Lake, a larger investment than the per project limit of the Section 206 authority was required. At the time the decision was made, the Section 206 authority per project Federal limit was $5 million. Additionally, due to the level of investment required, the Town of Cedar Lake replaced CLEA as the prospective non-Federal sponsor for this project.

The U.S. Environmental Protection Agency (USEPA), U.S. Fish and Wildlife Service (USFWS), Indiana Department of Environmental Management (IDEM), Indiana Department of Natural Resources (IDNR), and the CLEA are all critical and involved stakeholders.

1.4 Study Background*

Historically, Cedar Lake supported a biologically diverse ecosystem with native flora and fauna characteristic of northern glacial lakes. Since the late nineteenth century, alterations to Cedar Lake have caused major adverse effects to its natural hydrology, littoral zone habitat, fringe wetland, profundal zone (i.e. deep aquatic) habitat and littoral processes. In the past 100 years, these changes have accelerated lake succession. Lake succession refers to the aging process of a lake. In general, lakes are created and over time they age by filling in with sediment and becoming semi-marshes and eventually full marshes when they become entirely filled in. The time it takes for a lake to proceed through the aging process varies based on numerous factors (e.g., size of lake, rate of filling in, etc.). Lake succession, or the aging process, of Cedar Lake has been accelerated by human activities that have increased the rate of sedimentation (i.e., filling in with sediment) within the lake, resulting in a shallower less diverse aquatic ecosystem. Currently, the lake does not possess the ecosystem functions it historically did, and restoration efforts are needed to improve and restore native species diversity and abundance. These improvements would allow the lake to support a healthy sustainable aquatic community of native organisms.

1.5 General Study Area*

Cedar Lake is a 781 acre, glacially formed lake located in the Town of Cedar Lake in Lake County, Indiana. The study area is located in west central Lake County, T34N, R9W, Sections 22, 23, 26, 27, 34 and 35. It lies 4.5-miles southwest of Crown Point and forty miles southeast of Chicago. US Route 41 (Wicker Street), Lake Shore Drive, Parrish Avenue, Lauerman Street, 133rd Avenue, 141st Avenue and Morse Street are the main streets surrounding the lake. A general location map is shown in ***Figure 1***.

The Cedar Lake watershed is located atop the Valparaiso Moraine and is characterized by distinct glacial topography. Since the 1800s, Cedar Lake has been described in numerous accounts, including reports of early surveyors, settlers and explorers of natural resources (Large 1897, Indiana Academy of Science 1896, Blatchey 1900). Early accounts indicate that Cedar Lake was formed when the melt-water of retreating glaciers collected on clay deposits in a narrow valley. Processes that formed the lake created a relatively small and limited watershed covering about 7.6 square miles (4,864 acres), with all but the southern portions of the lake confined by steep slopes. One significant exception to the steep slopes of the surrounding basin is the 400 acre Cedar Lake Marsh on the south end of the lake. Nearly half of the entire Cedar Lake watershed drains into this marsh before reaching the lake (SPEA 1984). In addition to the marsh, two small riparian wetlands are associated with intermittent tributaries on the north end of the lake.

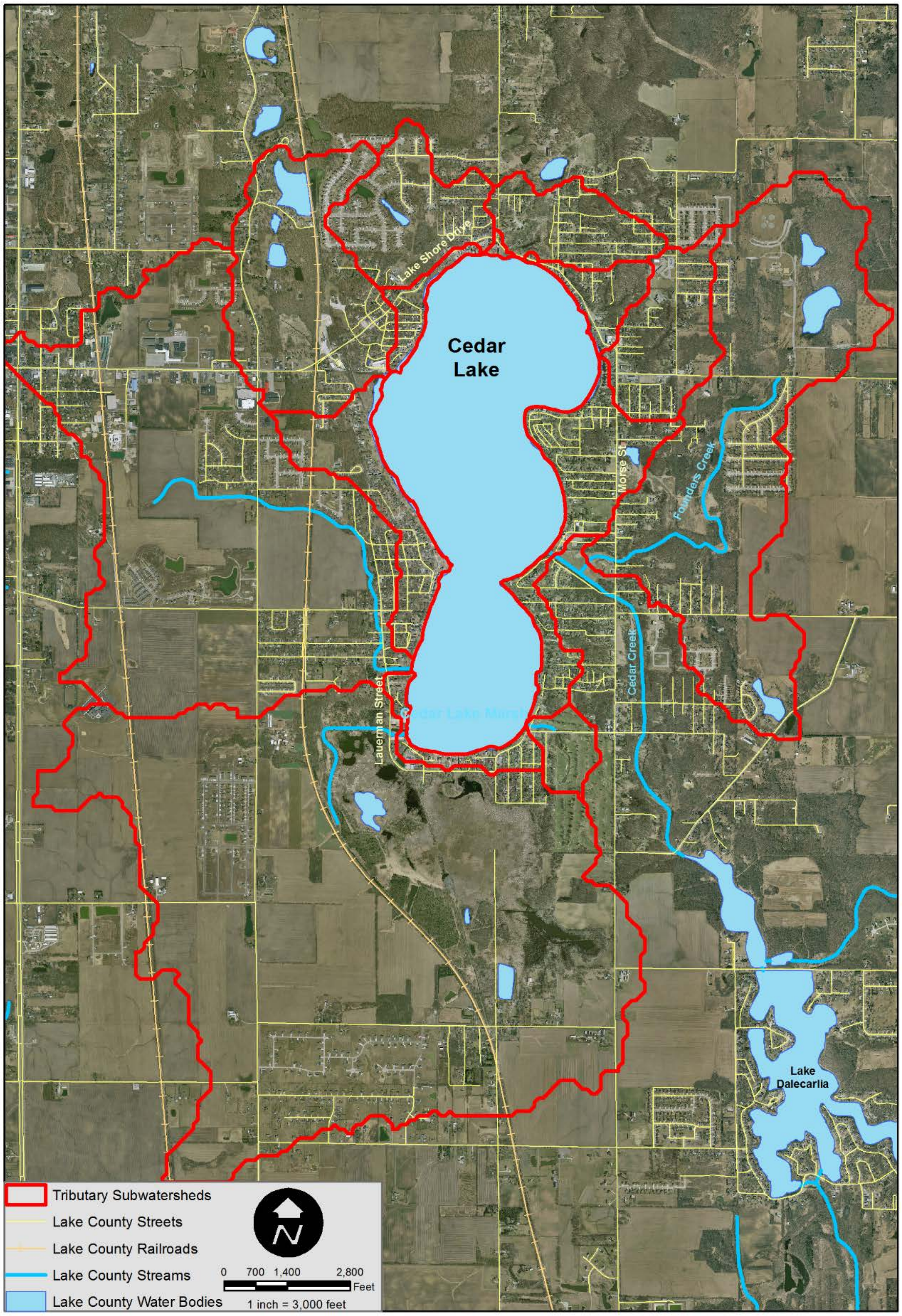

Figure 1: General Location Map

1.6 Prior Studies and Reports

Beginning in the late 1970s through the early 1990s, the following studies were conducted by the Indiana University School of Public and Environmental Affairs (SPEA):

- Cedar Lake Restoration FS (SPEA 1979)
- Cedar Lake Restoration FS – Final Report (SPEA 1984)
- Cedar Lake Enhancement Study – Final Report (SPEA 1991)

More recently, private consultants have conducted additional studies for the Cedar Lake Enhancement Association, Inc. The following restoration and feasibility studies have been completed to characterize the physical conditions of the lake and present ideas for improving water quality, recreation potential and land values:

- Cedar Lake Engineering FS (Prepared by Harza for CLEA, 1999)
- Cedar Lake Dredging FS (Prepared by Harza for CLEA, 1998b)
- Comprehensive Plan for Restoration of Cedar Lake (Prepared by Harza for CLEA, 1998c)
- Cedar Lake Diagnostic FS (Prepared by Harza for CLEA, 2001)
- Cedar Lake Engineering FS (Prepared by EnviroForensics for CLEA, 2004)
- Aquatic Ecosystem Restoration Goals & Opportunities Report (Prepared by Tetra Tech for CLEA, 2005)

In addition, over the past 40 years, the Town of Cedar Lake and CLEA have completed several projects to address sediment loading, stormwater discharge, combined sewer overflows, and shoreline erosion within the lake's watershed. These combined efforts have addressed ecosystem impairments and habitat degradation within the Cedar Lake watershed. For a detailed list of improved land management practices and projects completed by the Town of Cedar Lake and CLEA please refer to *Appendix M – Local Existing Conditions Report*.

CHAPTER 2 – Study Area Inventory and Forecasting

The purpose of this step of the planning process is to develop an inventory and forecast of critical resources (physical, environmental, social, etc.) relevant to the problems and opportunities under consideration. This information is used to define and characterize the problems and opportunities. A quantitative and qualitative description of these resources is made for both current and future conditions, and is used to define existing and future without-project conditions. Existing conditions are those at the time the study is conducted. The forecast of the future without-project condition reflects the conditions expected during the period of analysis (i.e., 50 years). The future without-project condition provides the basis from which alternative plans are formulated and impacts are assessed. Since impact assessment is the basis for plan evaluation, comparison and selection, clear definition and full documentation of the without-project condition are essential. Gathering information about historic and existing conditions requires an inventory. Gathering information about potential future conditions requires forecasts, which should be made for selected years over the period of analysis to indicate how changes and other conditions are likely to have an impact on problems and opportunities. Information gathering and forecasts will continue throughout the planning process. As such, Chapter 2 contains the following:

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

2.1 Current Conditions

2.1.1 Physical Resources*

<u>Climate:</u>

The climate of the Cedar Lake area is temperate continental; marked by cold winters, warm humid summers and the lack of a pronounced dry season. The climate of the northern half of the Kankakee River Basin, of which Cedar Lake is a part of, is influenced by its proximity to Lake Michigan. Lake effect climatic conditions include warmer autumns, cooler springs, higher humidity, increased winter cloud cover, and greater amounts of snow than in areas of comparable latitude. In general, Lake Michigan produces a marine effect moderating the continental climate of northern Indiana and Illinois. Average annual precipitation was approximately 35 inches per year from 1980 to 2015 (NOAA 2016). The annual temperature (1980 to 2015) averages 50^{o}F. Minimum average January temperatures were around 23^{o}F and the maximum average temperatures in July were 73^{o}F.

Also of some concern are the potential future effects of climate change on the land and water resources of the Great Lakes region. Current science-based predictions indicate that climate changes in this region will likely include higher mean temperatures in summer and winter (Pryor et al. 2014). Additionally, more intense rainfall events that lead to greater precipitation across the entire region are expected. Heavy downpours are anticipated to occur primarily in winter and spring months while summer months are expected to become drier. This could lead to higher lake levels during the winter and spring months as intensive rainfall events increase overland and tributary runoff into the lake (Pryor et al. 2014). Conversely, higher temperatures during the summer months, combined with less precipitation, could generate greater rates of evaporation from the Cedar Lake watershed, and potentially mean less overland and tributary flow into the lake. This would tend to lead to lower lake levels and potentially higher water temperatures during the summer months, which may impact lake species.

Decreases in overall winter and summer precipitation could also endanger general aquatic ecosystems and reduce groundwater inflow to Cedar Lake. Ongoing research is supporting the observed trend toward more regionally-intense storm and rainfall events, primarily during seasonal transition periods in the fall and spring.

Geology, Topography, and Soils:

Cedar Lake lies atop the Valparaiso Moraine, a complex system of rolling hills extending in an arc from northeastern Illinois, through northwestern Indiana and into southwestern Michigan. The main crest of the moraine passes along a ridge about a quarter mile north of Cedar Lake. The Valparaiso Moraine and Cedar Lake were formed about 14,000 years ago. The upper layer of glacial deposit consists of clay/loam material with intermittent deposits of sand and gravel, and ranges from about 15-50 feet thick. Beneath this deposit is a layer of glacio-fluvial sands, which the bottom of Cedar Lake does not reach.

The Valparaiso till plain of the Cedar Lake area is rather irregular and narrow with numerous divides and many steep slopes. Topography of the watershed ranges from the surface water elevation of Cedar Lake at 692 feet referenced to National Geodetic Vertical Datum of 1929 (NGVD29) to 780 feet as shown in ***Figure 2***. Most of the relief occurs just north of Cedar Lake at the top of the Valparaiso Moraine. The watershed is predominantly depressional and does not possess outlets for water, thus this area is covered with dark, poorly drained soils. Primary soil types include Carlisle muck, Blount silt loam, Elliot silt loam, Milford silt loam, Morley silt loam, Pewamo silty clay loam, and urban lands. The combination of low permeability and high water table levels cause serious restrictions in the use of soils.

Cedar Lake is one of the many lakes formed from ice-block depressions called kettle holes. Cedar Lake has a maximum length of 2.1 miles and a maximum width of 0.9 miles. Physical characteristics include a total volume of 6,170 acre-feet, an average depth of 7.9 feet, a maximum depth of 13.9 feet and a total shoreline length of 5.9 miles.

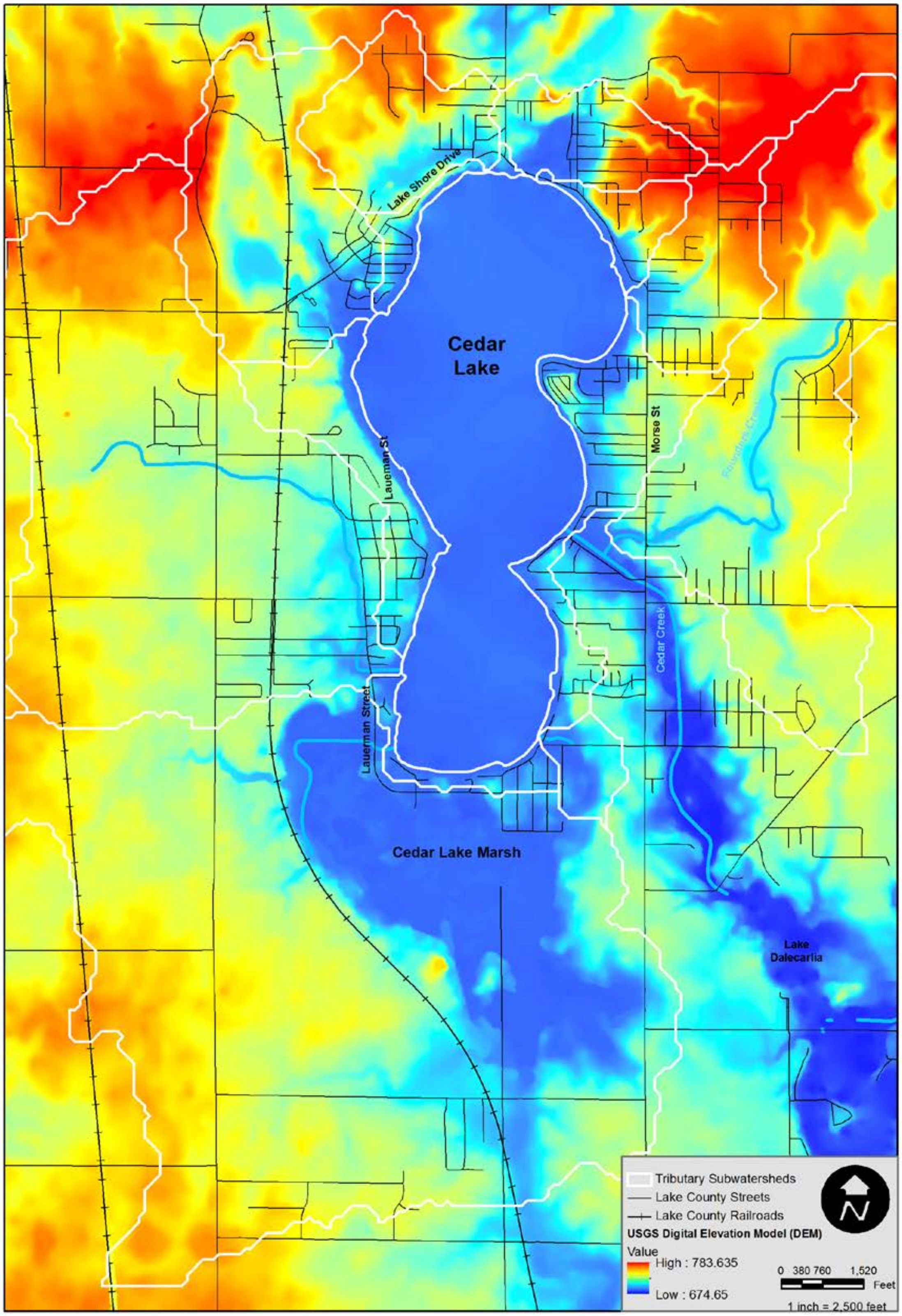

Figure 2: Topography Map

Land Use:

Existing land use mapping was recently completed as part of the Cedar Lake Comprehensive Plan (Cedar 2007). Classes of land use were determined in the following percentages: agriculture 36%, residential 28%, grassland 15%, woodland 14%, wetland 4%, and commercial 3% as shown in ***Figure 3***. The immediate shoreline of Cedar Lake is heavily developed with residences as well as a few businesses including two marinas. Publicly owned properties include three parcels on the north and east shorelines. Two wetland areas of significance are also present in the watershed. One 14 acre wetland lies at the northern edge of the lake and the 400 acre Cedar Lake Marsh on the south side of the lake. The watershed is rapidly urbanizing and according to the Cedar Lake Comprehensive Plan, most of the existing agricultural lands will be converted to residential and commercial uses. With stormwater quality ordinances in effect for new developments and re-developments within the Cedar Lake watershed (e.g., Ordinance No. 1218, Stormwater Management Ordinance of Cedar Lake, Indiana), as well as the use of Best Management Practices (BMPs), this conversion of agriculture lands to residential and commercial uses may benefit Cedar Lake by reducing the amount of fertilizer-sourced nutrients entering tributaries from agricultural runoff.

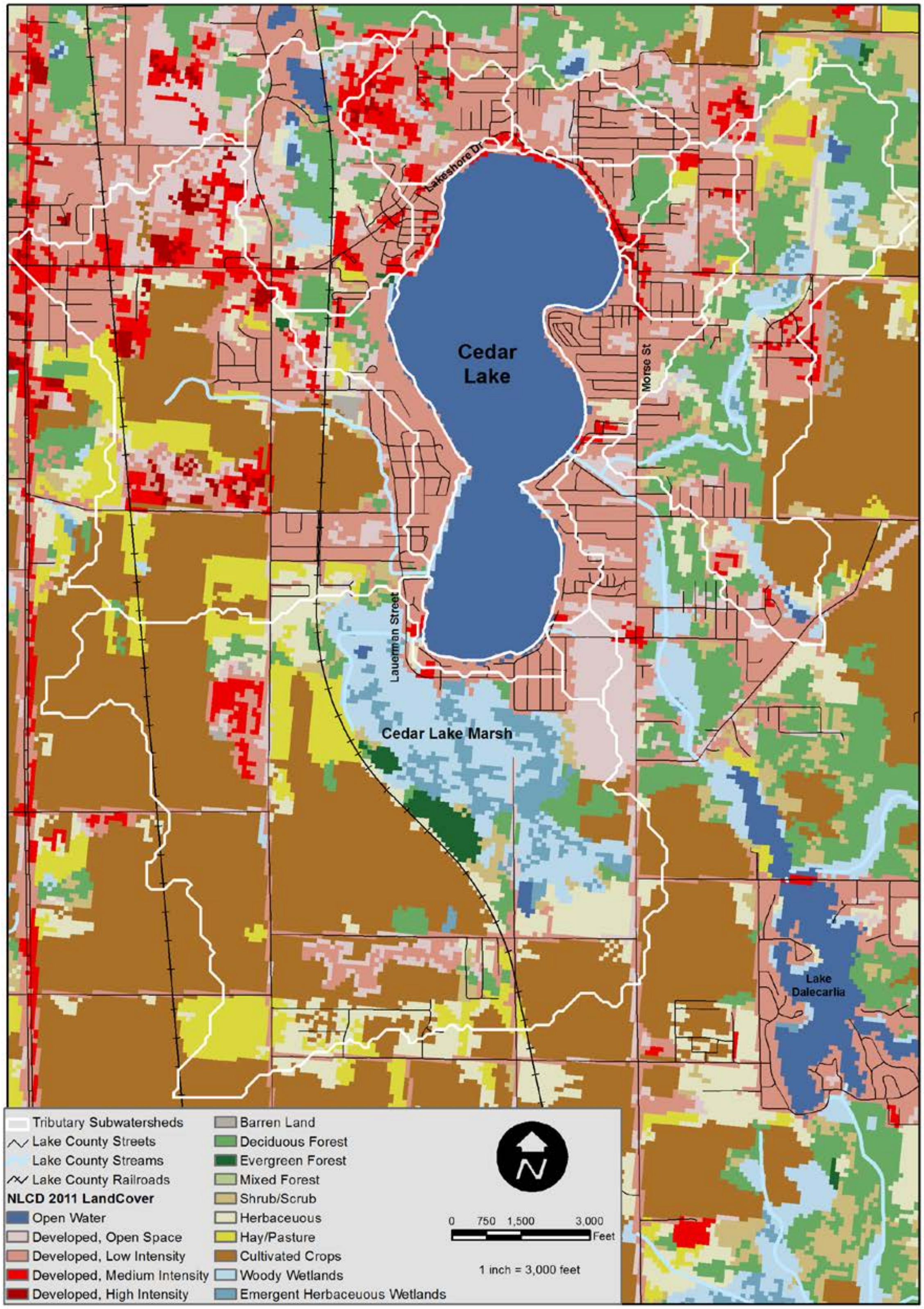

Figure 3: Existing Landuse Map

<u>Surface Waters:</u>

As shown in ***Figure 4*** and **Table 1,** the 4,864 acre Cedar Lake watershed is drained by six intermittent tributaries that feed the lake. Four of the six intermittent tributaries flow into the north basin of the lake, while the remaining two flow into the south basin of the lake (***Figure 4***). These intermittent tributaries for the most part have been channelized and lined with riprap: Unnamed Tributary/Pickerel Creek, Sleepy Hollow Ditch, North Point Marina Tributary, Condo Tributary, Chamber Tributary, and Old Bank Building Tributary.

A seventh tributary, Founders Creek, has been fragmented from its historic connection with Cedar Lake. Historically, Founders Creek drained an area northeast of Cedar Lake directly into the lake. Portions of the creek were channelized and cleared of all viable habitats for small stream fishes and aquatic organisms. In the late 1800s, this tributary was rerouted to bypass the lake and enter Cedar Creek yards downstream of the overflow weir from Cedar Lake.

Cedar Creek is the outlet for Cedar Lake. Upstream passage of fish species from Cedar Creek to Cedar Lake was fragmented by the construction of a broad-crested weir overflow structure set at an elevation of 692.90 feet NGVD29. The overflow structure was built at the lake outlet to stabilize seasonal fluctuations in water levels, and was later modified to provide a fish barrier designed to prevent Common Carp (*Cyprinus carpio*) and other fish species from migrating upstream into Cedar Lake. The overflow structure maintains a current lake surface area of approximately 781 acres, compared to a surface area of about 749 acres in 1900 (Blatchley 1900).

In the 1870s, a channel was cut through the glacial ridges that impounded Cedar Lake on the east side. The channel allowed the lake level to lower 8 to 12 feet in order to reclaim about 200 acres of wetland habitat at the south end of Cedar Lake.

Lowering of the lake level reduced the maximum depth of Cedar Lake from approximately 40 feet to less than 20 feet (Blatchley 1900), and destroyed the natural riparian and lake habitat features that existed during pre-settlement times including intermittent, seasonal, and permanently flooded wetlands, fringe wetland and littoral habitat, and diverse aquatic communities. Lowering of the lake level also created the approximately 400 acre Cedar Lake Marsh, which lies at the southern end of Cedar Lake. The Unnamed Tributary/Pickerel Creek drain Cedar Lake Marsh.

A bathymetric survey of Cedar Lake was conducted by the USACE in June 2005. During the survey, the maximum depth was measured at 13.9 ft in the center of the northern lobe of the lake. Average depth during the survey was calculated to be 7.9 ft. The survey was compared to the previous bathymetry completed by the IDNR in 1954, and over the approximately fifty years between surveys, the average depth reduced by 0.9 ft and maximum depth reduced by 2.1 ft.

Table 1: Cedar Lake Inlet Drainage Areas

Tributary/Watershed	Area (acres)	% of Total
Chamber Tributary	123	3%
Condo Tributary	179	4%
Golf Course Tributary	47	1%
North Point Marina Tributary	371	8%
Old Bank Building Tributary	161	3%
Sleepy Hollow Ditch	1,209	25%
Unnamed Inlet/Pickerel Creek	2,096	43%
Direct Drainage	651	10%
Total Drainage Area	4,837	-
Founders Creek (currently bypasses)	795	-

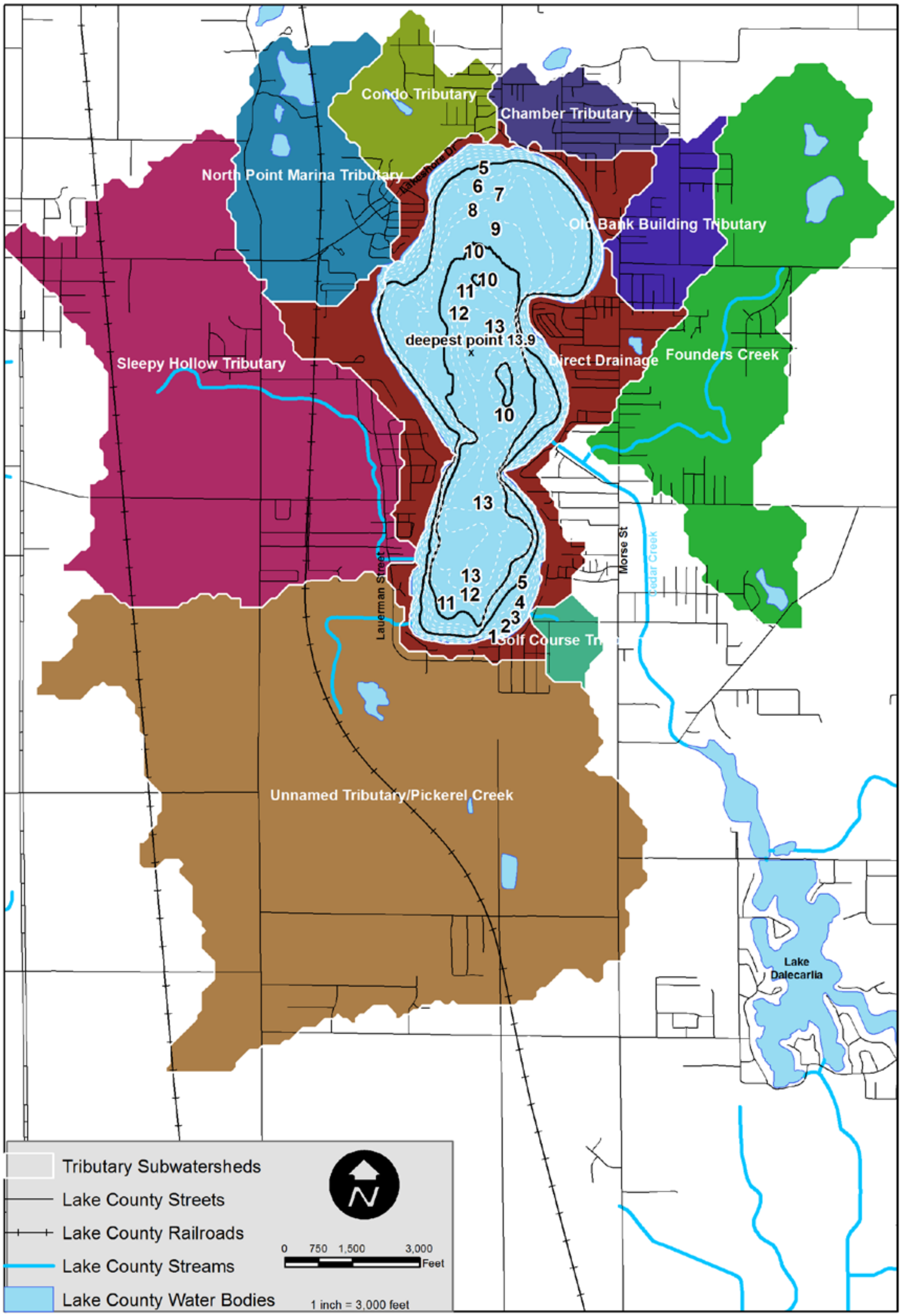

Figure 4: Watershed and Bathymetry Map

Sediment Quality:

Cedar Lake sediments (i.e., substrates) were sampled in 2007 and 2008 and compared to the State of Indiana Risk Integrated System of Closure (RISC) Soil Default Closure Levels for Residential and Industrial Land Use Applications to determine if the sediment has any recognized environmental conditions (RECs). When compared to the RISC residential default closure value, the most restrictive risk-based concentrations developed under the RISC voluntary remediation program, all of the estimated concentrations of organics detected in the sediments collected in 2007 were below the RISC residential default closure values. The sediment sampling data confirmed elevated levels of total organic carbon, ammonia-nitrogen, phosphorous, and metals in the sediment. The 2008 sediment samples confirmed elevated concentrations of arsenic and lead. Arsenic concentrations within Cedar Lake sediments are similar to concentrations of arsenic found in background soils in the watershed, and lead and arsenic do not leach at concentrations that would affect the groundwater.

Overall, the sediments within Cedar Lake have been impaired due to past cultural eutrophication (i.e., acceleration of lake succession as a result of human activities). Extremely high phosphorus and nutrient loading from legacy combined sewer overflows, and non-point source pollution mainly from agricultural lands, have enriched the sediments with nutrients. Inland glacial lakes like Cedar Lake typically contain natural sand and gravel substrates; however, Cedar Lake contains several feet of fine silts and clays that have accumulated from years of surface and agricultural runoff discharged to the lake from tributaries and storm water inflows.

Water Quality:

Water quality data for Cedar Lake collected in 2005 (June, July, August, September and November) and 2006 (March and May) (most recent dates for which data is available) suggests that the water quality meets the General Use water quality standards for the State of Indiana. Results suggest fluctuations in nutrient concentrations in the lake depending on the season and water temperature, with elevated concentrations of total phosphorous found in the spring and fall. Elevated concentrations of total suspended solids could be due to any number of variables including an abundance of algal growth, shoreline erosion, tributary loading from stormwater runoff, recirculation of bottom sediments, or plant decomposition. In addition, elevated dissolved oxygen concentrations suggest that the water is supersaturated with oxygen; a characteristic indicative of excessive algal growth. In addition to air-water exchange, photosynthetic-active species (e.g., plants and algae) are common sources of dissolved oxygen in an aquatic system. These organisms produce pure oxygen during photosynthesis (i.e., conversion of light energy into chemical energy), and thus have the ability to be the dominant factor in determining the dissolved oxygen content. Water sampling results for sampling conducted in 2005 and 2006 are summarized in ***Table 2***.

A qualitative water quality survey was performed for Founders Creek, near its confluence with Cedar Creek, in August 2005. The qualitative survey indicated that flows within the creek were of good water quality indicative of groundwater flow. In 2007, a 20 acre forested tract at the confluence of Founders Creek with Cedar Creek, was clear cut to make way for residential development. The water quality entering Cedar Creek was subsequently observed to be markedly reduced as a result of the clear-cutting. In August 2007, the temperature was no longer cool in the creek and the banks were noticeably eroded and sediment deposits were observed at the confluence with Cedar Creek. By the fall of 2009, 1,075 linear feet of forested riparian adjacent to Founders Creek had been restored as part of mitigation for the 2007 clear cut. The restoration included enhancing in-stream structure within Founders Creek and planting approximately 2.5 acres of forested riparian area adjacent to the stream channel. Qualitative evaluation of the restored site's habitat in 2011 showed an increase in habitat value from the pre-impact evaluation; therefore, it is likely that water quality within the stream has also improved since 2007.

Table 2: Cedar Lake Monthly Water Quality.

		Concentration			
Parameter	**Units**	**Min**	**Max**	**Mean**	**Standard**
Temperature	°C	4.6	28.5	18.7	NS **/1**
pH	std. Unit	8.3	9.2	8.7	6 – 9
Dissolved Oxygen	(mg/L)	7.2	17.4	11.0	> 4
Ammonia-Nitrogen (NH_3-N)	(mg/L)	0.2	0.8	0.4	0.25 – 0.8
Nitrate (NO_3-N)	(mg/L)	< 0.10	0.7	0.5	10 (Nitrate + Nitrite)
Nitrite (NO_2-N)	(mg/L)	0.011	0.028	0.03	1.0
Total Kjedahl Nitrogen (TKN)	(mg/L)	1.3	2.5	1.9	NS
Total Phosphorous	(mg/L)	0.043	0.170	0.1	NS
Ortho-Phosphorous (reactive)	(mg/L)	0.006	0.084	0.07	NS
Total Dissolved Solids	(mg/L)	230	430	266	NS
Total Suspended Solids	(mg/L)	16	57	37	NS

(1) Reference Indiana Administrative Code Title 327 Article 2
/1 No Standard

Air Quality:

The IDEM lists nonattainment area designations for counties in Indiana that do not meet the National Ambient Air Quality Standards (NAAQS). Nonattainment areas are regions within the country where the concentration of one or more criteria pollutants exceeds the level set as the Federal air quality standards. Lake County, Indiana, is listed as nonattainment for 8-hour ozone. A redesignation petition for ozone and maintenance plan for Lake County was submitted to USEPA on December 5, 2012. On December 10, 2014, USEPA denied the redesignation petition and maintenance plan.

Hazardous, Toxic and Radioactive Wastes:

USACE conducted a Phase I Environmental Site Assessment (ESA) in accordance with ASTM E-1527-13. According to ER 1165-2-132, non-HTRW environmental issues that do not comply with Federal, State, and Local regulations should be discussed in the HTRW evaluation along with HTRW issues. The HTRW Phase I ESA included in Appendix F was completed using existing information, historical aerial photograph review, telephone interviews, database research, and a site visit. No HTRW or recognized environmental conditions were identified and two non-HTRW issues were identified in the investigation: 1) onsite soils reuse and 2) proper disposal of all debris. Soils excavated from the SDF site should be reused to the maximum extent possible and construction plans should require the proper disposal of all debris removed from the SDF site in accordance with Local, State, and Federal laws and regulations. There are no indications that site soils have been impacted by any RECs. A Phase II ESA is not recommended.

2.1.2 Ecological Resources*

Algae:

A number of factors influence algae populations in glacial lakes including biological factors such depth, turbidity, and substrate composition. The algae of Cedar Lake exhibit an expected pattern of seasonal population growth and species composition for a shallow hypereutrophic lake (i.e., very nutrient-rich lake characterized by frequent and severe nuisance algal blooms and low transparency), where they should reflect an oligotrophic (i.e., lake with low primary productivity, the result of low nutrient content) or mesotrophic (i.e., lake with an intermediate level of primary productivity) population composition. The algae population of Cedar Lake is dominated by blue-green algae, *Mycrocystis* sp., for most of the growing season. Algae productivity is high, but is limited to the surface waters since turbidity prevents light penetration; however, the turbidity provides algae the required nutrients for growth. These summer algae blooms are identified as a problem stemming from excess nutrients stored in the bottom sediments of Cedar Lake. Streams flowing into Cedar Lake do not exhibit large or nuisance populations of algae.

Aquatic Macrophytes:

From field observations, less than 1% of Cedar Lake contains aquatic macrophytes (i.e., aquatic plants). Historical records and photographs show significant fringe wetland and aquatic plants throughout Cedar Lake (***Figure 5***). Lake level modifications, high turbidity, high nutrient content, motorized boating and shoreline development have all contributed to the depletion of native submergent and emergent vegetation. Spatterdock (*Numphar advena*) is the only species of emergent macrophyte that occurs at two locations in Cedar Lake. Coontail (*Ceratophyllum demersum*), a submergent aquatic macrophyte, was documented in the 1970s, but was not observed during this study. Cedar Lake Marsh contains a diverse assemblage of both emergent and submergent macrophytes.

Figure 5: Historical photographs of Cedar Lake showing abundance of aquatic macrophytes.

Additionally, the majority of the 5.9 mile Cedar Lake shoreline has been modified, excluding Cedar Lake Marsh. The shoreline is comprised mainly of riprap and/or turf grass. The turf grass is typically mowed up to the surface water's edge, which does not allow for the establishment of a vegetated buffer zone to effectively filter nutrients from surrounding area runoff.

<u>Macroinvertebrates:</u>

Sampling for aquatic macroinvertebrates (i.e., aquatic insects) in Cedar Lake has not been performed; however, during the 2005 fish survey conducted by the USACE, crayfish were observed within the lake. Stomach contents of five White Perch (*Morone americana*), benthic feeders, were also examined for the presence of aquatic macroinvertebrates; however, only zooplankton (i.e., drifting aquatic organisms) were present. Based on the lack of littoral zone aquatic macrophytes and unsuitable substrates, it is assumed that the macroinvertebrate population is comprised of mainly pollution tolerant species and is not very abundant.

<u>Fishes:</u>

The glacial lake fish community of Cedar Lake has been for the most part eradicated. Historically, over 30 species inhabited the lake; however, in the past 40-years only 14 native glacial lake species have been collected. The fish community is now dominated by two non-native, invasive species, the White Perch and Common Carp. The impact of these two non-native species is largely attributed to their benthic feeding behavior (Welcomme 1984). These species increase phosphorus concentrations (Breukelaar et al. 1994, Havens 1991, Brabrand et al. 1990, Lamarra 1975, Vanni and Findlay 1990), increase phytoplankton (i.e., microscopic plants) biomass, increase turbidity (Schefer 1998) and reduce the abundance of aquatic macrophytes (Crivellis 1983, Skubinna et al. 1995).

In May 2005, USACE conducted a fish community survey to determine the health of Cedar Lake. The following native species were found to still inhabit the lake, but did not occur in any significant abundance: Bowfin (*Amia calva*), Brown Bullhead (*Amieurus nebulosus*), Northern Pike (*Esox lucius*), Pumpkinseed (*Lepomis gibbosus*), and Yellow Perch (*Perca flavescens*). The survey confirmed the poor condition of the Cedar Lake fish community in terms of native lake species diversity and abundance. Conditions that have resulted in modification of the fish community include: lack of aquatic macrophytes, past management measures, lake level modification, exotic species introduction, and shoreline development. ***Table 3*** shows the summary of the fish community surveys conducted by the State of Indiana between 1976 and 2004 and the 2005 USACE survey.

Table 3: Summary of Fish Surveys performed at Cedar Lake

		Number of Fish Collected					
Common Name	**Scientific Name**	**1976**	**1979**	**1987**	**2001**	**2004**	**2005**
Bowfin	*Amia calva*	2		2	1	3	1
Gizzard Shad	*Dorosoma cepedianum*	1415		21	490	4	3
Northern Pike	*Esox lucius*	3	4	3			1
Common Carp	*Cyprinus carpio^*	303	155	345	44	82	13
Goldfish	*Carassius auratus^*	178	2	37	1	2	2
White Sucker	*Catostomus commersonii*			1	5	2	1
Channel Catfish	*Ictalurus punctatus*	41	38	32	118	213	15
Black Bullhead	*Ameiurus melas*	2	2				
Brown Bullhead	*Ameiurus nebulosus*	10		1	3		8
White Perch	*Morone americana^*				5197	574	613
Hybrid Bass	*Morone saxatilis x M. chrysops^*				7	23	
Black Crappie	*Pomoxis nigromaculatus*	143	170	168	2	16	
White Crappie	*Pomoxis annularis*			6	4		
Largemouth Bass	*Micropterus salmoides*	23	3	3	1	17	3
Smallmouth Bass	*Micropterus dolomieu*				8	3	
Bluegill	*Lepomis macrochirus*	149	21	120	5	16	1
Green Sunfish	*Lepomis cyanellus*	8		15	1	7	
Longear Sunfish	*Lepomis megalotis*	7					
Pumpkinseed	*Lepomis gibbosus*	3		45		3	5
Orangespotted Sunfish	*Lepomis humilis*		4				
Walleye	*Sander vitreus*	1			3	3	
Yellow Perch	*Perca flavescens*			516	9	33	11
	Total	2288	399	1315	5899	1001	677
	# of Native Species	13	7	13	13	12	10

^non-native species

USACE did not sample the tributaries to Cedar Lake; however, Cedar Creek, the outlet of Cedar Lake, has been sampled by IDNR. Fish from Cedar Creek can move upstsream into Founders Creek, which was a former tributary to Cedar Lake before it was rerouted into Cedar Creek in the late 1800s. Therefore, it is likely that the fish population found in Cedar Creek is similar to that which would be in Founders Creek. Species collected in Cedar Creek by IDNR include the following: Central Mudminnow (*Umbra limi*), Creek Chub (*Semotilus atromaculatus*), Hornyhead Chub (*Nocomis biguttatus*), Bluntnose Minnow (*Pimephales notatus*), White Sucker (*Catostomus commersonii*), Yellow Bullhead (*Ameiurus natalis*), Green Sunfish (*Lepomis cyanellus*), and Johnny Darter (*Etheostoma nigrum*).

<u>Amphibians & Reptiles:</u>

No specific records for amphibians and reptiles or surveys from Cedar Lake exist. Due to the highly degraded lake and shoreline habitat, and the quality of Cedar Lake Marsh, species are thought to mostly occupy the marsh. Cedar Lake probably supports tolerant species such as Snapping Turtle (*Chelydra serpentina*) and Softshell Turtle (*Apalone mutica*). Species that likely occur within the marsh and may venture out into the lake include Musk Turtle (*Sternotherus oderatus*), Redear Slider (*Trachemys scripta*), and Northern Water Snake (*Nerodia sipedon*).

<u>Birds:</u>

More than 325 bird species follow the Mississippi Flyway each year from their breeding grounds in Canada and the northern United States to their overwintering grounds along the Gulf of Mexico and in Central and South America. Cedar Lake's proximity to Lake Michigan is of great importance for migratory birds along the Lake Michigan flyway, not only providing a stopover refuge, but a source of breeding habitat, which is very rare within the Chicago metropolitan area. According to the Chicago Region Audubon Society (letter dated October 13, 2015, *Appendix O – Coordination*):

> "Migratory stopover sites such as Cedar Lake play a critical role in these birds' most perilous life stage. Their survival is highly dependent on the availability of food at locations where they stop to rest between flights and on the availability of necessary cover to avoid predators and elements of nature."

Bird data for Cedar Lake was provided by the Chicago Region Audubon Society. The observational data spanned from 2003 to 2008 and included Cedar Lake and the nearby Lemon Lakes. During that time period a total of 67 species were observed. An additional six species were observed by the Bird Conservation Network between 2011 and 2013 at Cedar Lake. These species were: Chipping Sparrow (*Spizella passerina*), Dark-eyed Junco (*Junco hyemalis*), House Finch (*Carpodacus mexicanus*), Osprey (*Pandion haliaetus*), Tufted Titmouse (*Baeolophus bicolor*), and Whooping Crane (*Grus americana*).Of those 73 species, 28 were residents, 5 were migratory, 39 were breeding (summer residents), and 1 was non-breeding (winter resident) (***Table 4***).

The Whooping Crane is listed as endangered by the International Union for Conservation of Nature, and is also a Federally endangered species within its current range (i.e., Canada to Texas). However, the individual observed at Cedar Lake was likely from a population of Whooping Cranes reintroduced outside of their current range but within their historic range (i.e., Wisconsin to Florida). They are labeled as "non-essential" per Section 10 of the Endangered

Species Act because they were reintroduced. The reintroduced Whooping Cranes are the same genus and species as the population listed as Federally endangered and are afforded protection under the Endangered Species Act through the prohibitions of Section 9 and the requirements of section 7.

From the species observed at Cedar Lake, the State of Indiana recognizes the Marsh Wren (*Cistothorus palustris*), Osprey, and Sedge Wren (*Cistothorus platensis*) as endangered, and the Great Egret (*Ardea alba*) and Sandhill Crane (*Grus canadensis*) as a Species of Concern. Three species (i.e., Bobolink (*Dolichonyx oryzivorus*), Sandhill Crane, and Wood Thrush (*Hylocichla mustelina*)) are Audubon Priority bird species – birds of significant conservation need (Audubon 2016). Two species (i.e., Common Grackle (*Quiscalus quiscula*) and Field Sparrow (*Spizella pusilla*)) are on the Audubon Common Birds in Decline List (Audubon 2007). Other species that have been observed at Cedar Lake and are protected by the Federal Migratory Bird Act include the following: Ring-necked Duck (*Aythya collaris*), Wood Duck (*Aix sponsa*), American Coot (*Fulica americana*), Great Blue Heron (*Ardea herodias*), Great Egret, Red-tailed Hawk (*Buteo jamaicensis*), and the American Avocet (*Recurvirostra americana*) (Keller 1986).

Table 4: Bird species observed at Cedar Lake between 2003 and 2008 by the Chicago Region Audubon Society and from 2011 to 2013 by the Bird Conservation Network

Scientific Name	Common Name	Resident	Migratory	Summer (Breeding)	Winter (Non-Breeding)
Recurvirostra americana	American Avocet		X		
Fulica americana	American Coot			X	
Corvus brachyrhynchos	American Crow	X			
Spinus tristis	American Goldfinch	X			
Falco sparverius	American Kestrel	X			
Turdus migratorius	American Robin	X			
Icterus galbula	Baltimore Oriole			X	
Hirundo rustica	Barn Swallow			X	
Poecile atricapillus	Black-capped Chickadee	X			
Polioptila caerulea	Blue-gray Gnatcatcher			X	
Cayanocitta cristata	Blue Jay	X			
Anas discors	Blue-winged Teal			X	
Dolichonyx oryzivorus	Bobolink			X	
Molothrus ater	Brown-headed Cowbird	X			
Toxostoma rufum	Brown Thrasher			X	
Branta canadensis	Canada Goose	X			
Bombycilla cedrorum	Cedar Waxwing	X			
Spizella passerina	Chipping Sparrow			X	
Quiscalus quiscula	Common Grackle	X			

Scientific Name	Common Name	Resident	Migratory	Summer (Breeding)	Winter (Non-Breeding)
Geothylpis trichas	Common Yellowthroat			X	
Accipiter cooperii	Cooper's Hawk	X			
Junco hyemalis	Dark-eyed Junco				X
Picoides pubescens	Downy Woodpecker	X			
Tyrannus tyrannus	Eastern Kingbird			X	
Sayornis phoebe	Eastern Phoebe			X	
Contopus virens	Eastern Wood-Pewee			X	
Spizella pusilla	Field Sparrow	X			
Anas strepera	Gadwall		X		
Dumetella carolinensis	Gray Catbird			X	
Ardea herodias	Great Blue Heron	X			
Myiarchus crinitus	Great Crested Flycatcher			X	
Ardea alba	Great Egret			X	
Bubo virginianus	Great Horned Owl	X			
Butorides virescens	Green Heron			X	
Carpodacus mexicanus	House Finch	X			
Passer domesticus	House Sparrow	X			
Trgolodytes aedon	House Wren			X	
Passerina cyanea	Indigo Bunting			X	
Anas platyrhynchos	Mallard	X			
Cistothorus palustris	Marsh Wren			X	
Zenaida macroura	Mourning Dove	X			
Cardinalis cardinalis	Northern Cardinal	X			
Colaptes auratus	Northern Flicker			X	
Fandion haliaetus	Osprey		X		
Podilymbus podiceps	Pied-billed Grebe			X	
Melanerpes carolinus	Red-bellied Woodpecker	X			
Vireo olivaceus	Red-eyed Vireo			X	
Melanerpes erythrocephalus	Red-headed Woodpecker			X	
Buteo jamaicensus	Red-tailed Hawk	X			
Agelaius phoeniceus	Red-winged Blackbird	X			
Larus delawarensis	Ring-billed Gull		X		
Aythya collaris	Ring-necked Duck			X	
Phasianus colchicus	Ring-necked Pheasant	X			
Pheucticus ludovicianus	Rose-breasted Grosbeak			X	
Archilochus colubris	Ruby-throated Hummingbird			X	

Scientific Name	Common Name	Resident	Migratory	Summer (Breeding)	Winter (Non-Breeding)
Grus canadensis	Sandhill Crane			X	
Cistothorus platensis	Sedge Wren			X	
Accipiter striatus	Sharp-shinned Hawk	X			
Melospiza melodia	Song Sparrow	X			
Porzana carolina	Sora			X	
Baeolophus bicolor	Tufted Titmouse	X			
Tachycineta bicolor	Tree Swallow			X	
Cathartes aura	Turkey Vulture			X	
Vireo gilvus	Warbling Vireo			X	
Sitta carolinensis	White-breasted Nuthatch	X			
Vireo griseus	White-eyed Vireo			X	
Grus americana	Whooping Crane		X		
Empidonax traillii	Willow Flycatcher			X	
Aix sponsa	Wood Duck			X	
Hylocichla mustelina	Wood Thrush			X	
Coccyzus americanus	Yellow-billed Cuckoo			X	
Icteria virens	Yellow-breasted Chat			X	
Setophaga petechia	Yellow Warbler			X	

Threatened & Endangered Species:

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

- Mead's Milkweed (*Asclepias meadii*) – Threatened – Tall-grass prairie, thin soil glades and barrens
- Pitcher's Thistle (*Cirsium pitcheri*) – Threatened – near-shore plant communities and non-forested dune systems
- Karner Blue Butterfly (*Lycaeides melissa samuelis*) – Endangered – Savanna and barren habitat typified by dry sandy soils and remnants of these habitats, dependent on wild lupine
- Indiana Bat (*Myotis sodalis*) – Endangered – Roost in dead trees along riparian zones, bottomland and floodplain habitats, wooded wetlands, and upland communities; also utilize caves and mines in winter
- Northern Long-eared Bat (*Myotis septentrionalis*) – Threatened – Roost in live and dead trees as well as cooler places such as caves and mines

- Whooping Crane (*Grus americana*) – Endangered – Breed in shallow, grassy wetlands interspersed with grasslands of scattered evergreens; stop over during migration on wide shallow river flats

Based on the information listed above, site assessments and preliminary consultation with the USFWS under Section 7 in a letter dated 20 November 2007, the proposed project is within the range of the above listed species. There is no habitat in the Cedar Lake watershed for the Karner Blue Butterfly or Pitcher's Thistle. There may be suitable summer nursery habitat for the Indiana Bat and Northern Long-eared Bat within the general area, such as along Founders Creek and Cedar Creek where forested riparian habitat is present. Mead’s Milkweed has been reestablished at Biesecker Prairie State Nature Preserve which is northwest of Cedar Lake but outside the lake’s watershed.

As discussed in *Section 2.1.2 Ecological Resources, Birds*, a Whooping Crane was identified at Cedar Lake in 2013. The species is considered Federally endangered when found within its current range (i.e., Canada to Texas). However, the individual observed at Cedar Lake was likely from a population of Whooping Cranes reintroduced outside of their current range but within their historic range (i.e., Wisconsin to Florida). They are labeled as “non-essential” per Section 10 of the Endangered Species Act because they were reintroduced. The reintroduced Whooping Cranes are the same genus and species as the population listed as Federally endangered and are afforded protection under the Endangered Species Act through the prohibitions of Section 9 and the requirements of section 7.

There are 330 State-listed endangered, threatened, rare, and species of special concern in Lake County. The following State-listed species would likely benefit from the restoration of the Cedar Lake ecosystem: Blue-spotted Salamander (*Ambystoma laterale*), Common Mudpuppy (*Necturus maculosus*), Northern Leopard Frog (*Rana pipiens*), Spotted Turtle (*Clemmys guttata*), Kirtland’s Snake (*Clonophis kirtlandii*), Blanding’s Turtle (*Emydoidea blandingii*), Great Egret, American Bittern (*Botaurus lentiginosus*), Marsh Wren, Least Bittern (*Ixobrychus exilis*), Virginia Rail (*Rallus limicola*), and Black-crowned Night-heron (*Nycticorax nycticorax*).

2.1.3 Cultural & Archaeological Resources*

Archaeological Properties:

The Town of Cedar Lake is located about 20 miles south of Lake Michigan in Lake County, Indiana. Communities neighboring Cedar Lake include Merrillville, Crown Point, and Schererville. There are two properties listed on the National Register of Historic Places located within Cedar Lake. The Lassen Hotel (added in 1981), and the Monon Park Dancing Pavilion (added in 2001).

Cultural Setting:

The first European settlers to the Cedar Lake area were primarily farmers from Ohio, Pennsylvania and New York who founded a number of small communities on the lake in the 1830s. By 1838 the area had one of the first schools in Indiana. The various lake side communities were officially grouped into the Town of Cedar Lake in 1870 with the opening of the Cedar Lake Post Office. Construction of the Monon Railroad in 1882 connected Cedar Lake to the Chicago area and turned Cedar Lake into a tourist destination. With the decline in tourism in the 1950s, Cedar Lake developed into a bedroom community for Chicago and the towns of northern Lake County, Indiana such as Merrillville, Crown Point, and Schererville. The Town of Cedar Lake was finally incorporated in 1970.

<u>Social Setting:</u>

Cedar Lake is a prosperous middle-class community of 11,706 inhabitants in an area of approximately 3.1 square miles. Minorities comprise 5.1 percent of the Cedar Lake population compared to 15.7 percent for the State of Indiana as a whole. Between 2008 and 2012 the Cedar Lake median home value was $151,400 (for the State of Indiana the medium home value was $123,400). The median household income for the residents of Cedar Lake was $59,090 (for the State of Indiana as a whole medium household income was $48,374).

<u>Recreation:</u>

Cedar Lake is highly used for active water recreation. Recreational motor and sail boating is very popular on the lake. Two marinas and one public boat ramp provide lake access for boating, fishing, and water-skiing. An inventory of recreational motor boats, sailboats and personal watercrafts was completed in June 2009. Nearly 400 water craft were docked along the shores of Cedar Lake. Peak usage occurs on weekends during summer months and approximately 50 vessels have been observed during these times. The size of Cedar Lake easily accommodates this level of water recreational activity.

Nineteen parks are operated by the Cedar Lake Park District. These include a number of playgrounds, as well as soccer and baseball diamonds. A number of the parks include nature areas for hiking and bird watching. Bartlett Park on the Cedar Lake lakeshore provides both fishing and swimming areas. There are a number of golf courses in the Cedar Lake area. The South Shore Country Club, adjacent to the lake itself, features an 18-hole golf course. Lemon Lake Park, located just west of Cedar Lake, is operated by Lake County.

2.2 Future Without-Project Condition

The future without-project condition (FWOP) of Cedar Lake is the basis for comparing restoration plans evaluated for this study. In forecasting the condition, effort was made to look into the future and describe the most important aspects of the study area over the 50 year period of analysis (i.e., 2016 – 2066). This forecasting is based on observed existing conditions described earlier. The future without-project condition describes what will result if no action is taken to address existing degradation. When formulating alternative plans, National Environmental Policy Act (NEPA) regulations require that a No Action alternative always be considered. In essence, this requires any action proposed must be more in the public interest than doing nothing.

Cedar Lake was formed when the melt-water of retreating glaciers collected on clay deposits in a narrow valley. Processes that formed the lake created a relatively small and limited watershed covering about 7.6 square miles or 4,864 acres, with all but the southern portions of the lake confined by steep slopes. One significant exception to the steep slopes of the surrounding basin is the 400 acre Cedar Lake Marsh on the south end of the lake. In addition to the marsh, two small riparian wetlands are associated with intermittent tributaries on the north end of the lake. Due to human disturbance within the watershed (e.g., agriculture, community expansion, etc.) natural substrates of sand and gravel have been covered with fine silts and clays. The presence of fine-grained sediments has precluded the establishment of native aquatic macrophytes due to reduced light penetration (i.e., needed for photosynthesis) and roots being unable to adhere to substrates. The lack of natural substrates and aquatic macrophytes has resulted in the fish community and aquatic macroinvertebrate community being dominated by non-native, invasive, and tolerant species. Overall, the current aquatic ecosystem is unable to support diverse native plant and aquatic species communities due to the lack of physical habitat.

Future without-project habitat conditions are not expected to change significantly without a large-scale ecosystem restoration project. There have been significant and ongoing efforts by the Town of Cedar Lake to address sediment and nutrient loadings from the lake's watershed that have negatively affected aquatic resources. However, there has been no systematic effort to address physical habitat conditions within Cedar Lake. Physical habitat structure within the lake is deficient and is expected to remain that way without restoration. As a result of the lack of physical habitat structure, undesirable fish and macroinvertebrate species currently dominate the Cedar Lake aquatic ecosystem. In addition, lake substrates have become covered with silt precluding the establishment of native aquatic macrophytes which can provide critical habitat for juvenile fish species and aquatic macroinvertebrates. Continuing to maintain the lake as is will prevent the reestablishment of native aquatic macrophytes and an aquatic community indicative of a glacial lake. Minor ecological restoration projects within the watershed may be implemented in the future; however, none are planned at this time. Overall, the aquatic ecosystem of Cedar Lake would remain severely impaired and would continue to provide insufficient habitat to sustain even a minimal native glacial lake fish community due to lack of appropriate substrates, aquatic macrophytes, and homogenous physical habitat structure. Previous restoration efforts within the Cedar Lake watershed have concentrated on reducing sediment and nutrient loadings, but have not dealt with the legacy effects of habitat degradation within the lake. The lake's ecosystem will continue to function significantly below its ecological potential and will continue to limit species diversity and abundance.

2.3 Habitat Assessment

In order to restore the aquatic ecosystem of Cedar Lake, both physical habitat structure and biological function must be addressed. The level of habitat suitability, which takes into account the function and structure of the ecosystem, was calculated by developing a habitat suitability index (HSI). The HSI is an algebraic function that uses various indicators of the quality of habitat structure and biological function. Many species-specific HSIs were developed by the USFWS; however, there are limitations to using a species-specific index when the goal is to restore a cohesive aquatic ecosystem. There is not an established HSI for lake habitats within the region; therefore, one was developed for Cedar Lake specifically. The development of the HSI for Cedar Lake is detailed in *Appendix B – Plan Formulation*.

The habitat suitability index derived for Cedar Lake takes into account both physical habitat structure (TSI – Trophic State Index) and biological function (fish and plants). This value is multiplied by the affected area to determine total habitat output in terms of habitat units (HUs). The HSI developed for Cedar Lake is shown in the equation below:

HSI = SQRT [(Structural HSI) x (Biological Function HSI)]

$$HSI = \sqrt{\left[1 - \frac{(AvgTSI - 30) + (MaxTSI - 30)}{2 \times (80 - 30)}\right] \times \left[\frac{\left(\frac{SR_{Macrophytes}}{Total_{Macrophytes}}\right) + \left(\frac{SR_{Fishes}}{Total_{Fishes}}\right)}{2}\right]}$$

where HSI is the habitat suitability index, AvgTSI is the average trophic state index of the lake during ice-off conditions, MaxTSI is the maximum trophic state index of the lake during the year, $SR_{Macrophytes}$ (Species Richness Macrophytes) is the number of macrophyte species present, $Total_{Macrophytes}$ is the total number of macrophyte species possible, SR_{Fishes} (Species Richness Fishes) is the number of fish species present, and $Total_{Fishes}$ is the total number of fish species possible.

Habitat units were calculated for without-project conditions and each restoration measure and alternative plan over a 50-year period of analysis by multiplying the HSI by area restored. Average annual habitat units (AAHUs) are computed by averaging habitat units over the period of analysis and are used in selecting an alternative plan using cost effective and incremental cost analyses (CE/ICA). Habitat output of restoration measures and alternative plans are determined by calculating the difference between the with- and without-project condition.

As laid out in the previous section, the future without-project condition is projected to remain static due to the significant lack in physical habitat structure in terms of substrates and aquatic macrophytes. ***Table 5*** provides a breakdown of habitat output for the future without-project condition.

Table 5: Habitat Outputs for the Future Without-Project Condition

Metric	Year						
	0	1	10	20	30	40	50
AvgTSI	53.5	53.5	53.5	53.5	53.5	53.5	53.5
MaxTSI	76.3	76.3	76.3	76.3	76.3	76.3	76.3
$SR_{Macrophytes}$	2	2	2	2	2	2	2
SR_{Fishes}	6	6	6	6	6	6	6
HSI	0.19	0.19	0.19	0.19	0.19	0.19	0.19
AREA	780	780	780	780	780	780	780
HU	148.6	148.6	148.6	148.6	148.6	148.6	148.6
AAHU	148.6						

CHAPTER 3 – Problems & Opportunities

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

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

3.1 Problems and Opportunities

Human activity over the past 100 plus years has altered the connectivity of aquatic habitat, aquatic communities, plant communities, and natural lake processes of Cedar Lake. These alterations have subsequently caused structural habitat degradation, fragmentation of tributaries, reduction of littoral zone and fringe wetlands, prevalence of non-native species, and nutrient saturation, all of which are intertwined in a negative feedback loop. Although desirable native species such as Bowfin, Northern Pike, Yellow Perch, Ring-necked Duck, American Coot, Great Blue Heron, Snapping Turtle, Redear Slider, and Northern Water Snake inhabit Cedar Lake, modifications within the watershed have significantly reduced native species diversity and abundance, and have suppressed biodiversity as a whole. These trending problems can be lessened via on-the-ground and institutional efforts. This study provides a look at lines of opportunity to provide restored physical habitat structure and function, fish, wildlife, and migratory bird habitat.

3.1.1 Study Area Problem

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 has decreased in response to the loss of aquatic habitat connectivity, alteration of littoral processes, and land use change; collectively a reduction in physical complexity.

Historically, the Cedar Lake watershed was dominated by naturally occurring habitat types including wetlands, glacial ponds, forests, woodlands, savannas and prairies. By the late 1800s, many of these habitats, particularly prairies, savannas and wetlands, were converted to agricultural fields or developed for residential use. Remnant parcels of natural habitat types remain under pressure from ongoing human activities. Human induced disturbances to the remaining natural habitats generally include fire suppression, altered hydrology and hydraulics, landscape alterations, and introduction of invasive species.

While the natural habitat types can be described in terms of dominant organisms, the quality and function of the habitat they provide are directly related to the level at which natural processes function. For Cedar Lake, these natural processes include, but are not limited to groundwater recharge/discharge, nutrient cycling, water column mixing, and wave energy and patterns. Habitat quality displays a negative relationship to the amount of human disturbance in which the disturbance affects these driving functions and physical structure of the habitat itself.

The native glacial lake species assemblages have become significantly reduced in both species diversity and abundance due to past disturbances. Past impairments to the lake, as previously described include lake level lowering, fragmentation through damming the outlet, removal of littoral zone plant communities, manipulation of inflowing streams, removal of fringe wetlands, residential development within the immediate coastal zone and adverse manipulation of the native fish community.

Cedar Lake is a naturally vulnerable system due to its small drainage area, its isolated location on top of the Valparaiso end moraine, and its natural condition as an oligotrophic lake (i.e., lake with low primary productivity). These factors limit natural processes from repairing past damages to physical and chemical components because the lack of flow coming into the system and the inability to flush unsuitable substrates downstream. As a result, any small addition of nutrients to such a nutrient starved and isolated ecosystem quickly pushes the system into disequilibrium resulting in rapid change to the biological community. The cumulative effects over time of the physical and chemical alterations to hydrology, littoral processes, and structural habitats has caused Cedar Lake's ecosystem to become imbalanced and hypereutrophic (i.e., very nutrient-rich lakes characterized by frequent and severe nuisance algal blooms and low transparency).

3.1.2 Opportunities

Due to the level of aquatic ecosystem degradation caused by past sediment and nutrient inputs and continued loading indicative of a developed watershed, Cedar Lake cannot be restored to pre-settlement oligotrophic conditions, which require extremely low nutrient conditions. In order to restore to oligotrophic conditions, all fine-grained nutrient rich sediments would have to be removed and future sediment and nutrient inputs from the watershed would have to be eliminated, which is neither realistic nor cost effective.

However opportunities exist to restore Cedar Lake to mesotrophic (i.e., lake with an intermediate level of productivity) conditions. There have been significant efforts by the Town of Cedar Lake to address sediment and nutrient loadings from the lake's watershed. These efforts along with a projected conversion of the basin land use from agricultural to residential and watershed management practives will further reduce sediment and nutrient loadings to the lake. Opportunities now exist to address the degradation within the lake caused by legacy watershed loadings and restore the ecosystem to increase biodiversity.

Opportunity also exists to implement a project that incorporates the USACE Environmental Operating Principles (EOPs) and technical expertise to achieve a sustainable ecological restoration with minimal operation and maintenance requirements, find balance between the natural ecosystem and desired recreational activities, build upon previous studies with newly developed analyses to ascertain the most cost-effective and beneficial restoration plan, actively seek out varied Local, Regional and Federal perspectives to find integrated solutions, and support public education on ecosystem restoration and the value of our nation's environmental resources.

Specifically, the following aquatic resources problems within Cedar Lake in which this aquatic ecosystem restoration project may take opportunity to address are as follows:

- Lack of suitable substrates for aquatic macrophytes, macroinvertebrates and benthic fishes
- Lack of submerged aquatic macrophyte beds within the littoral zone
- Lack of fringe emergent marsh along shallow flats of the littoral zone
- Absence of a functioning native glacial lake fish assemblage
- Inability for native fish to visually hunt, forage and spawn due to turbidity and unsuitable substrates
- Fragmentation of tributaries preventing passage of native fishes
- Dominance of non-native invasive species due to overall physical and chemical impairments
- Imbalance of the physical matrix and chemical parameters of the physical habitat (i.e. substrate, water, soils)

3.2 Project Goal, Objectives & Constraints

3.2.1 Goal

The principal goal of this study is to determine a cost effective and ecologically beneficial plan which would increase biodiversity throughout the entire Cedar Lake ecosystem by targeting structural habitat and biological function within the fringe, littoral and profundal lake zones as well as tributary riparian zones.

3.2.2 Objectives

Federal Ecosystem Objectives

The Federal objective of water and related land resources planning is to contribute to national economic and/or ecosystem development in accordance with national environmental statutes, applicable executive orders, and other Federal planning requirements and policies. The use of the term "Federal objective" should be distinguished from planning/study objectives, which are more specific in terms of expected or desired outputs whereas the Federal objective is considered more of a National goal. Water and related land resource 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 output of national goods, services, and ecosystem integrity. Contributions to the Federal objective includes increases in the net value of those goods, services and ecosystems that are or are not marketable.

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

- Endangered Species Act of 1973, as amended (16 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.)
- Clean Water Act of 1977, as amended (33 USC 1251 et seq.)
- National Environmental Policy Act of 1969, as amended (42 USC 4321 et seq.)
- Nonindigenous Aquatic Nuisance Prevention & Control Act of 1990, as amended (16 USC 4701 et seq.)
- National Invasive Species Act of 1996 (P.L. 104-332)
- Protection and Enhancement of Environmental Quality (E.O. 11514)
- Protection of Wetlands (E.O. 11990)
- Floodplain Management (E.O. 11988)
- Invasive Species (E.O. 13112)
- Responsibilities of Federal Agencies to Protect Migratory Birds (E.O. 13186)
- Preparing the United States for the Impacts of Climate Change (E.O. 13653)

Planning Objectives

As part of the USACE Civil Works mission, the Federal objective of aquatic ecosystem restoration projects is to restore the structure, function and dynamic processes of degraded ecosystems to a less degraded, more natural condition. The non-Federal sponsor has an ecosystem restoration objective that partners well with the Federal objective stated above. Study objectives are statements that describe the desired results of the planning process by solving the problems associated with the study purpose, problems and opportunities. 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.

Five (5) planning objectives were identified by the PDT (Project Delivery Team), the non-Federal sponsor and various stakeholders. These will be used as targets for solving aquatic resource problems within the study area:

<u>1. Restore Littoral Currents & Nutrient Cycling</u> – This objective seeks to naturalize the lake functional processes such as littoral currents and nutrient cycling. It is expected that if addressed, this objective could be achieved within approximately 5 years and restoration of the littoral currents and nutrient cycling would be sustainable.

It is well documented that two parameters are adversely affecting how the littoral currents and nutrient cycling influence the aquatic habitat structure of Cedar Lake. One is the absence of submerged aquatic macrophyte beds and fringe emergent wetland which would naturally reduce the force of waves and currents. The second is the presence of significant quantities of mobile silts and clays that are unsuitable and are continually resuspended by currents, natural wave action, recreational boating and non-native benthic fishes. These two problems are trapped in a feedback loop. The lack of submergent aquatic macrophyte beds and fringe emergent wetland prevents nutrient absorption and a reduction of resuspended sediment. The presence of nutrient rich silts and clays which are easily suspended in the water column, cause turbidity which in turn causes nuisance algal blooms that restrict sunlight penetration into the water column. Without breaking this adverse feedback loop, Cedar Lake will continue to be an overly turbid lake with little or no aquatic macrophyte beds or emergent wetland habitat. This objective targets breaking the adverse feedback loop at the water-sediment interface. Once this feedback loop is broken, then the following objectives may be achievable.

2. Increase Spatial Coverage of Viable In-Lake Habitat – This objective seeks to increase the area of viable fringe wetland, littoral zone and profundal zone habitat within Cedar Lake. It is expected that if addressed, this objective could be achieved within approximately 5 years and the increase of viable in-lake habitat would be sustainable.

It is documented that little to no submergent aquatic macrophyte beds and emergent fringe wetland currently exist within the littoral zone of Cedar Lake. It is also well documented that substrates within the deep littoral and profundal zone are not physically or chemically suitable for aquatic macrophytes, macroinvertebrates and subsequently native fishes. Based on the existing percentages of cover for these habitat types, this objective targets an increase of about 35 acres of emergent fringe wetland, 95 acres of aquatic macrophyte bed, and about 400 acres of deep littoral and profundal zone habitat.

3. Eradicate/Control Non-Native Species – This objective seeks to remove or ease the adverse impacts of non-native and invasive species, such as Common Carp and White Perch (*Morone americana*). It is expected that if addressed, this objective could be achieved immediately since non-native and invasive fish species could be eradicated with a single dose of piscicide (i.e., Rotenone). Eradication of non-native and invasive species is expected to be sustainable because there are no connected sources for reintroduction of these species.

Typically, non-native species that invade an impaired ecosystem can eventually become the dominant species because they are generally more tolerant to system impairments (e.g., hydrology, hydraulics, chemical properties, etc.) than native species. Once an ecosystem's physical parameters and functional processes are restored, then non-native plant and wildlife species may effectively be controlled, especially if recolonization routes are unavailable. It is not uncommon to keep non-native plant and wildlife species to less than 1% of a site's spatial coverage or relative abundance. Based on the current dominance of non-native fishes and the absence of a glacial lake fish assemblage, this objective targets to control non-native fish species to less than 5% of the total relative abundance.

4. Reestablish Fish Passage / Recolonization – This objective seeks to reestablish fish passage and recolonization by restoring connectivity between Cedar Lake and its tributaries. It is expected that if addressed, this objective could be achieved immediately once fish passage between Cedar Lake and its tributaries is restored. The restoration of tributary connectivity and fish passage would be sustainable.

It is well documented that fragmentation of stream connectivity can lead to ecological and biological problems such as decreases in the number of species, decreases in the abundance of species, inbreeding, and food chain collapse. These problems are apparent in Cedar Lake, where past management of the native fish population has caused the number of native species to be reduced by 54% and the relative abundance of native species to be reduced by 90%. There are only two creeks, Founders Creek and Cedar Creek, which have been fragmented from Cedar Lake and could potentially have their connections restored.

The first option is the outlet of Cedar Lake, Cedar Creek, which was the historic source of native fish species for Cedar Lake which formerly flowed unimpeded to the Kankakee River. However, Cedar Creek has had its connection with Cedar Lake severed by the construction of an overflow structure (refer to Section 2.2.1 Physical Resources, Surface Waters) that prevents non-native Common Carp from moving upstream into Cedar Lake from Lake Delacaria via Cedar Creek. Therefore, this connection should never be restored, else non-native species will be able to continually colonize Cedar Lake.

Founders Creek is the only other fragmented tributary to Cedar Lake. Historically, Founders Creek drained an area northeast directly into Cedar Lake. Portions of the creek were channelized and cleared of all viable habitats for small stream fishes and aquatic organisms. In the late 1800s this tributary was rerouted to bypass the lake and enter Cedar Creek yards downstream of the outlet weir from Cedar Lake. Reconnection of this tributary would allow stream fishes to migrate downstream to Cedar Lake to utilize the littoral zone while reintroduced lake fishes would be able to migrate upstream to spawn within the newly reconnected tributary.

Based on the current dominance of non-native fishes, the absence of a glacial lake fish assemblage, and the absence of a natural recolonization stream, this objective targets to increase native glacial lake fish species diversity to at least 25 and overall abundance of native fishes to at least 2,000 [Gizzard Shad (*Dorosoma cepedianum*) abundance should be decreased even though it’s a native species].

<u>5. Increase Cedar Lake’s Biodiversity</u> – This objective seeks to increase biodiversity, or the total native species diversity, abundance and population(s) health of the Cedar Lake ecosystem. It is expected that if addressed, this objective could be achieved within approximately 5 years and an increase in Cedar Lake’s biodiversity is expected to be sustainable.

Currently, the number of native species within Cedar Lake is a small percentage of the historic assemblages. The abundance and health of the species/populations that still exist are impaired. Once biological and physical resource problems are addressed, the lake would have the potential to provide life requisites for numerous native plant, insect, fish, macroinvertebrate, amphibian, reptile, bird and mammal species. Biodiversity change would be measured through species richness and abundance. It is expected, based on previous restoration projects that have been implemented by USACE, that once physical restoration was completed, species would begin to recolonize Cedar Lake. Additionally, native fish species would be restocked into the lake. This objective would be measured by comparing past data sets of Cedar Lake plant and wildlife inventories with new inventory data collected during the monitoring phase of this project.

3.3 Planning Constraints

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

- Minimize costs associated with procuring lands for restoration features
- Minimize adverse effects to existing recreational features and uses
- Avoid adverse effects to existing cultural and archeological resources

CHAPTER 4 – Plan Formulation & Evaluation

The formulation, evaluation, and comparison of alternative plans comprise the third, fourth, and fifth steps of the USACE planning process. These steps are often referred to collectively as plan formulation. Plan formulation is an iterative process that involves cycling through these steps to develop a reasonable range of measures to address planning objectives and formulate concepts and strategies to combine measures into alternative plans. Alternative plans are then evaluated and compared in an effort to select a final recommended plan, which is feasible for implementation.

Plan formulation for ecosystem restoration presents a challenge because alternatives have non-monetary benefits. To facilitate the plan formulation process, the PDT used the methodology outlined in USACE E.R. 1105-2-100, Planning Guidance Notebook. The steps in the methodology are:

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

Additional details associated with plan formulation and evaluation of restoration measures for Cedar Lake are included in *Appendix B – Plan Formulation*.

4.1 Measure Identification & Screening*

A wide range of restoration measures were identified for Cedar Lake. The advantages, disadvantages and unknowns associated with each type of measure were also determined. Each restoration measure was initially evaluated for their effectiveness in addressing study area problems and achieving the project goals and objectives, while maintaining the ability to be implemented under the project authority. Some measures were eliminated from further consideration due to various factors including cost, effectiveness in achieving restoration objectives, and ability to implement under the project authority. Measures that were kept for further consideration were evaluated for cost-effectiveness based on habitat output and costs.

As previously discussed, the Town of Cedar Lake and other local organizations have taken many steps to reduce external nutrient loadings from the watershed. The evaluation of plans assumes watershed loading will remain at current levels over the period of analysis. This is a conservative estimate given it is expected that planned land use changes and future local efforts will be implemented to achieve further reductions in external loading, which will ensure long term effectiveness and sustainability of restoration measures.

Costs include implementation and operations, maintenance, repair, replacement and rehabilitation (OMRR&R) requirements. Restoration measures were formulated to minimize OMRR&R requirements where possible to ensure project sustainability. Combinations of restoration measures were formulated into restoration alternative plans for evaluation.

Thirteen separate types of restoration measures were considered for addressing ecosystem degradation at Cedar Lake. Through the initial screening process, six were eliminated from further analysis due to various reasons outlined in *Appendix B – Plan Formulation*. The remaining seven categories of restoration measures were kept for further analysis. Below is a list of remaining restoration measures formulated and evaluated for Cedar Lake:

A. Physical Substrate Restoration
B. Chemical Substrate Restoration
C. Tributary Restoration
D. Creation of Habitat Islands
E. Littoral Macrophyte Restoration
F. Institutional Controls
G. Fish Community Management

Descriptions of site-specific restoration measures formulated and evaluated, including their various scales, are included in the following sub-sections. Please see ***Table 6*** for a brief summary of the planning objectives targeted by each restoration measure.

Table 6: Restoration Measure Outputs by Planning Objective

Restoration Measure	**Planning Objective /1**				
	1	**2**	**3**	**4**	**5**
	Restore Littoral Currents & Nutrient Cycling	**Increase Spatial Coverage of Viable In-Lake Habitat**	**Eradicate/Control Non-Native Species**	**Reestablish Fish Passage / Recolonization**	**Increase Cedar Lake's Biodiversity**
Physical Substrate Restoration	X	X			
Chemical Substrate Restoration	X				
Tributary Restoration	X			X	X
Creation of Habitat Islands	X	X			X
Littoral Macrophyte Restoration	X	X	X		X
Institutional Controls	X				
Fish Community Management	X		X	X	X

/1 It is important to note that each measure will have some impact on all planning objectives; only those objectives having significant impact for each measure are identified.

<u>A. Physical Substrate Restoration:</u>
This measure primarily supports Objective 1 (*Restore Littoral Currents & Nutrient Cycling*) and Objective 2 (*Increase Spatial Coverage of Viable In-Lake Habitat*), but would aid in allowing for all other objectives to be met. Due to agricultural practices, development, and an increase of

impermeable surfaces, runoff to Cedar Lake increased and sedimentation from this runoff began to fill in the lake bottom. Between 1954 and 2005 the average depth of Cedar Lake was reduced by 0.9 ft and the maximum depth of the lake was reduced by 2.1 ft. Sedimentation within the lake has caused a reduction in available aquatic habitat and has created a more homogenous lake bed. Additionally, runoff with high levels of nutrients has prohibited aquatic macrophyte growth by increasing turbidity in the system which has in turn hindered sunlight penetration affecting photosynthesis by plants.

Since the external nutrient loading in the watershed has been largely addressed within the lake, measures under this category involve physical removal of bottom sediments. Eight dredging scenarios were formulated, varying the location and quantity of material to be physically removed. The long term effectiveness of physical substrate restoration would vary according to the quantity and location of dredging. None of the evaluated scenarios completely remove all bottom sediments. Modeling analyses as detailed in *Appendix A – Hydrology & Hydraulics* show that turbidity would continue as a result of remaining fine-grained nutrient rich sediments day lighted by dredging. Scales of the physical substrate restoration measure consisting of varying quantities of sediment to be removed were developed based on physical and environmental parameters to meet the project objectives. The detailed scales of the physical substrate restoration measures are discussed in *Appendix B – Plan Formulation*.

A major consideration in the evaluation of this measure is the disposal of the physically removed sediment. Several placement options were considered including both in-lake and upland options. In-lake options were investigated for both cost and implementability. Associated habitat benefits were evaluated as part of the "creation of habitat islands" measure described later. Several undeveloped lands throughout the watershed were evaluated as potential upland placement sites, and three sites were evaluated in detail.

The dredging method selected for consideration is a mechanical-hydraulic hybrid. Although hydraulic dredging is generally less expensive than mechanical dredging, the hydraulic method produces a significantly greater volume of effluent. Since the effluent would contain elevated levels of phosphorus, ammonia, and suspended solids and would require treatment before being returned to the lake, reducing the amount of effluent generated can greatly reduce costs associated with this measure. To minimize costs associated with this treatment, sediment would be physically removed and then hydraulically offloaded from the barge to the dewatering facility site. The effluent will be recycled to the barge and used to slurry additional material for hydraulic offloading. Once dredging operations are completed, any remaining effluent would be treated before its return to the lake.

The feasibility and cost of various effluent treatment methods were reviewed to select an appropriate process for use in estimated treatment costs. The method selected originally was the installation of a temporary wastewater treatment plant at the dewatering facility. The preliminary processes to be used in the treatment train included the addition of alum and polymers, chlorination, and filtration. A subsequent value engineering (VE) study (*Appendix J – VE Study*) and additional analyses (*Appendix G – 404(b)(1)*) resulted in the development of an optimized design for effluent treatment.

B. Chemical Substrate Restoration:

This measure primarily supports Objective 1 (*Restore Littoral Currents & Nutrient Cycling*), but would aid in allowing for all other objectives to be met. Sediments within Cedar Lake are not only physically unacceptable to this type of glacial lake, but contain high levels of nutrients that create conditions in the lake (i.e., turbidity) that preclude sunlight penetration which is needed by aquatic macrophytes for photosynthesis. Since the external nutrient loading in the watershed has been largely addressed through better management of sanitary flows and better land management practices, sediments within the lake can now be appropriately restored. Measures under this category involve physical solidification of bottom sediments creating a firmer, inert lake bottom. This measure is aimed at breaking the adverse feedback loop between lack of macrophytes and excessive turbidity.

Iron, calcium, and aluminum have salts that can combine and sorb with inorganic phosphorus from the water column as part of a floc. In addition, these salts can solidify the top inch or two of the existing unsuitable sediment, which would provide an inert lake bottom, suitable for native aquatic macrophytes. The introduction of alum to water forms an Aluminum hydroxide salt (i.e., the principle ingredient in common antacids such as Maalox) which binds with phosphorus to form an aluminum phosphate compound. Buffering agents are also included in the treatment to prevent adverse pH impacts. Alum has been shown to increase the number of macroinvertebrate species (i.e., species richness) as well as abundance. Steinman and Ogdahl (2008) found macroinvertebrate species richness and abundance declined during the year immediately following alum treatment; however, richness and abundance rebounded within two years to pretreatment levels and significantly increased above pretreatment levels within 10 years post-treatment.

With higher doses, the reaction continues at the sediment-water interface, binding phosphorus that would otherwise be released from the sediment. Very high doses (i.e., in excess of 50 g/m^2) are used to bind phosphorus not only in the water column and at the sediment-water interface, but also within the sub-surface sediment column. The treatment achieves an “effective depth” – the depth to which the aluminum compounds migrate downward, binding with buried sediment. Two scales of the chemical substrate restoration measure, dosages effective to depths of 10 cm and 20 cm, were evaluated for solidifying sediments within Cedar Lake.

All flocculation agents lose their effectiveness over time; therefore the long term effectiveness for an alum treatment in Cedar Lake was assessed as detailed in *Appendix H - Alum Treatment Analysis*. The analysis determined that the long-term effectiveness of the treatment is dependent on reducing both internal and external loading. Scenarios where internal load reduction is combined with additional reductions in external phosphorus loading were analyzed.

C. Tributary Restoration:

This measure primarily supports Objective 1 (*Restore Littoral Currents & Nutrient Cycling*), Objective 4 (*Reestablish Fish Passage/Recolonization*) and Objective 5 (*Increase Cedar Lake’s Biodiversity*), but would aid in allowing for all objectives to be met. Measures under this category involve reconnecting tributary streams that used to flow into Cedar Lake. The reconnecting of tributary streams would allow lake fish to migrate into these streams to spawn and forage as well as allow stream fish to migrate to the lake. Secondarily, reconnection of tributary streams would increase the amount of fresh water entering Cedar Lake which in turn would support the establishment of aquatic macrophyte beds and fringe emergent marsh as well as support diverse fish, bird and wildlife communities. This measure is aimed at breaking the adverse feedback loop between lack of macrophytes and excessive turbidity.

Cedar Lake has a small watershed size and thus the amount of surface runoff that drains into the lake is limited by drainage area. During most of the year the lake acts as a water source to the underlying aquifer. Due to the small drainage basin size and the loss of water to groundwater, the residence time for Cedar Lake is extremely long, in the range of 1.5 to 2 years, based on a water budget analysis. Any increased dilution to the water column within the lake could potentially reduce nutrient concentrations.

Only one stream was identified that could be rerouted to its historic channel which would flow into Cedar Lake. Founders Creek historically drained an area northeast directly into Cedar Lake. Portions of the creek were channelized and cleared of all viable habitats for small stream fishes and aquatic organisms. In the late 1800s this tributary was rerouted to bypass the lake and enter Cedar Creek yards downstream of the outlet weir from Cedar Lake.

This measure would involve rerouting Founders Creek back to its historic channel so the creek would once again flow unimpeded into the lake. Additionally, a riparian corridor of 50 feet on each side of the creek would be restored along with the rerouting and re-meandering of Founders Creek. The rerouting would allow stream fishes to migrate downstream to Cedar Lake to utilize the littoral zone while lake fishes would be able to migrate upstream to spawn within the newly reconnected tributary. The restored riparian corridor would provide habitat to wildlife such as reptiles, amphibians, and avian species like the Belted Kingfisher (*Megaceryle alcyon*). Additionally, rerouting Founders Creek would provide an additional source of a higher level of oxygenated water that could help sustain the aquatic resources in Cedar Lake.

<u>D. Creation of Habitat Islands:</u>

This measure primarily supports Objective 1 (*Restore Littoral Currents & Nutrient Cycling*), Objective 2 (*Increase Spatial Coverage of Viable In-Lake Habitat*) and Objective 5 (*Increase Cedar Lake's Biodiversity*), but would aid in allowing for all objectives to be met. Due to sedimentation within the lake, non-native and invasive fish species, and anthropogenic activities, physical habitat within Cedar Lake is nearly absent. Measures under this category involve increasing the amount of structural habitat which would provide habitat for fish, aquatic macroinvertebrates, waterfowl, shore birds, and migratory bird species. The strategic placement of this structural habitat would also aid in breaking the adverse feedback loop between lack of macrophytes and excessive turbidity.

Four habitat island scenarios were evaluated including above and below water longitudinal wave breaks, wetland creation and island creation. Habitat islands would provide habitat for fish and aquatic macroinvertebrates seeking shelter within the interstitial spaces created by the rocks comprising the structures. The structures would also provide foraging, resting, and potentially nesting habitat for waterfowl, shore birds, and migratory bird species. Additionally, the creation of habitat islands could effectively reduce fetch length within the lake thereby potentially reducing wind induced wave forces that impact the stability of aquatic vegetation as well as sediment transport in the lake. Cedar Lake has a relatively long fetch length in the north-south direction due to its shape. Coupled with the fact that the primary wind direction is nearly along this same axis, wind induced forces play a dominant role in the hydrodynamic circulation and sediment transport in the lake. Development of the type, size, and locations of habitat islands must take into consideration limits associated with the recreational use of the lake.

E. Littoral Macrophyte Restoration:

This measure is most important in achieving Objective 1 (*Restore Littoral Currents & Nutrient Cycling*), Objective 2 (*Increase Spatial Coverage of Viable In-Lake Habitat*), Objective 3 (*Eradicate/Control Non-Native Species*) and Objective 5 (*Increase Cedar Lake's Biodiversity*), but would aid in allowing for all objectives to be met. Currently Cedar Lake is absent any appreciable aquatic vegetation (i.e., aquatic macrophytes). The lack of native vegetation has many causes including the presence of non-native invasive fish species (i.e. Common Carp), turbidity, high nutrients, wave action, and removal by humans. There are major ecosystem benefits in the establishment of emergent and submergent vegetation that include: structural habitat for aquatic species, food sources, dissolved oxygen production, shoreline stabilization, and nutrient absorption. Restoration of submergent and emergent vegetation to the littoral zone of Cedar Lake would provide spawning habitat for fishes such as Bowfin, Northern Pike, and Yellow Perch which either build nests or lay their eggs on or among submerged vegetation in shallow water. Later, the restored vegetation would provide foraging habitat for juveniles of these species. Additionally, littoral zone vegetation provides habitat structure for aquatic macroinvertebrates such as Odonates (i.e., damselflies and dragonflies) to lay their eggs upon, support their emerging larvae, and provide perches for foraging adults. Two types of aquatic macrophyte beds were considered depending on water depth. Emergent vegetation can be established in depths of water up to one foot while submergent vegetation can grow in deeper depths depending on water clarity. It was assumed that submergent vegetation can be established in areas up to 4 feet in depth. The restoration of both emergent and submergent vegetation within Cedar Lake was evaluated.

In conjunction with restoration of aquatic vegetation, monitoring and control of aquatic invasive species should be done to ensure sustainability of this restoration measure. Currently Eurasian Watermilfoil does not occur within Cedar Lake. If this species was to become a nuisance in Cedar Lake after restoration, it is recommended the non-Federal sponsors reduce or eradicate this species with chemical herbicides since mechanical harvesting promotes further growth and dispersal. The non-Federal sponsor should, to the best of their abilities, keep this species out of the lake.

F. Institutional Controls:

This measure primarily supports Objective 1 (*Restore Littoral Currents & Nutrient Cycling*), but would aid in allowing for all objectives to be met. Measures under this category involve reducing propeller induced wave disturbance to aquatic macroinvertebrates colonizing the littoral zone, reducing the forced detachment of aquatic macroinvertebrates from lake bed substrates, and reducing the resuspension of bottom sediments via placing additional controls on recreational boating. This measure is aimed at protecting macrophyte beds which provide habitat for fish, aquatic macroinvertebrates, waterfowl, and shore birds, and at breaking the adverse feedback loop between lack of macrophytes and excessive turbidity.

Cedar Lake is a significant recreational lake that is used for passive and active uses. Many residents in the Town of Cedar Lake own and operate recreational and fishing boats on Cedar Lake. Waves produced by these small boats contribute to bottom sediment resuspension. The levels at which restrictions to recreational boating are considered must take into account public support and willingness to adhere to the restrictions. Two measures to reduce the effects of boat-induced waves on aquatic vegetation, shoreline erosion and sediment resuspension were considered. Extending No Wake Zones within the littoral zone of Cedar Lake and placing limitations on motor boat engine sizes were evaluated.

G. Fish Community Management:

This measure primarily supports Objectives 1 (*Restore Littoral Currents & Nutrient Cycling*), 3 (*Eradicate/Control Non-Native Species*), 4 (*Reestablish Fish Passage/Recolonization*) and 5 (*Increase Cedar Lake's Biodiversity*), but would aid in allowing for all objectives to be met. Currently, Cedar Lake is primarily inhabited by two non-native invasive fish species, Common Carp (*Cyprinus carpio*) and White Perch, which accounted for 92% of the total catch during a 2005 USACE survey. Common Carp are capable of uprooting native aquatic vegetation when feeding and decimating the littoral zone of a lake which provides spawning, nursery, and foraging habitat for native fishes as well as foraging habitat for shore birds and waterfowl. White Perch can harm native fish populations by consuming the eggs of desirable species. Additionally, non-native, benthic (i.e., bottom-dwelling) fish are a key contributor to the resuspension of sediments and associated contaminants in shallow, nutrient rich lakes. In Cedar Lake, the impact of Common Carp and White Perch on lake eutrophication is largely attributed to their benthic feeding activities. Common carp and young White Perch feed by sucking in sediment and straining macroinvertebrates trapped in the sediment with their gill rakers, thus resuspending sediments released from their gills. As a result, these species increase aquatic phosphorus concentrations, which in turn increase phytoplankton biomass and turbidity and reduce the abundance of submerged aquatic macrophytes.

Complete eradication of non-native fish species would be the most beneficial and has been successful in other large lakes (Brastrup 2001); however, this is not always feasible depending on the depth, volume, and required dosage of piscicide. Therefore, this measure seeks to eradicate and/or significantly reduce the non-native fish species population within Cedar Lake. This measure would be sustainable because there is no possible recolonization from Lake Delacaria, located downstream, due to Cedar Lake's outlet weir. Eradication or reduction of both species would provide ideal conditions for aquatic macrophyte and macroinvertebrate reestablishment. Cedar Lake fish community management would utilize a three-step process involving target species reduction, predatory fish introduction, and community stabilization. This process is aimed at restructuring the native glacial lake fish community indicative of what historically occurred within the lake. This is also aimed at breaking the adverse feedback loop between lack of aquatic macrophytes and excessive turbidity. This measure is not aimed at establishing a recreational fishery.

Although it was determined that fish community management is crucial for the sustainable establishment of aquatic macrophytes and reduction of turbidity within Cedar Lake, it has been determined that the reduction of non-native fish species through the one-time application of Rotenone (i.e., piscicide) should be excluded from the NER Plan. Therefore, this measure will not be implemented by the USACE, but by the non-Federal sponsor and the IDNR, as a pre-existing condition.

Scales of Restoration Measures Evaluated

From the six types of restoration features considered, specific measures were formulated to address both structural habitat and biological function, which have been determined to be the major cause of ecosystem degradation in Cedar Lake. Where practical, varied scales of each measure were formulated and evaluated in order to identify the most efficient restoration plan. The development of these scales for measures A (*Physical Substrate Restoration*), B (*Chemical Substrate Restoration*), D (*Habitat Islands*), and F (*Institutional Controls*) are detailed in *Appendix B – Plan Formulation*. A summarized list of restoration measures formulated to address ecosystem impairments in Cedar Lake are shown in ***Table 7***.

Table 7: Summary of Restoration Measures Evaluated

Measure /Scale	Type	Description
Baseline	No Action	No Action Plan as required
A.1	Physical Substrate Restoration	Physical removal of 717,000 cy of unsuitable sediments through dredging (i.e., dredge 444 ac across lake to depth of 1.0 ft)
A.2	Physical Substrate Restoration	Physical removal of 717,000 cy of unsuitable sediments through dredging (i.e., dredge 83 ac in deep areas to depth of 5.4 ft)
A.3	Physical Substrate Restoration	Physical removal of 358,000 cy of unsuitable sediments through dredging (i.e., dredge 83 ac in deep areas to depth of 2.7 ft)
A.4	Physical Substrate Restoration	Physical removal of 362,000 cy of unsuitable sediments through dredging (i.e., dredge 224 ac across lake to depth of 1.0 ft)
A.5	Physical Substrate Restoration	Physical removal of 265,000 cy of unsuitable sediments through dredging (i.e., dredge 61 ac in north basin to depth of 2.7 ft)
A.6	Physical Substrate Restoration	Physical removal of approximately 8,240,000 cy of unsuitable sediments through dredging (i.e., dredge 444 ac across lake down to glacial till)
A.7	Physical Substrate Restoration	Physical removal of 263,000 cy of unsuitable sediments through dredging (i.e., dredge 163 ac in central and south basins to depth of 1.0 ft)
A.8	Physical Substrate Restoration	Physical removal of 140,000 cy of unsuitable sediment through dredging (i.e., dredge 87 ac in south basin to depth of 1.0 ft)
B.1	Chemical Substrate Restoration	Stabilize 400 ac of lake bottom sediments with alum to a treatment depth of 10 cm with target residual ASP levels of <20 mg/kg across entire lake
B.2	Chemical Substrate Restoration	Stabilize 400 ac of lake bottom sediments with alum to a treatment depth of 20 cm with target residual ASP levels of <20 mg/kg across entire lake
C.1	Tributary Restoration	Reroute Founder Creek back to Cedar Lake
/1 D.1	Habitat Islands	Insert a break water in the throat to the southern lobe
/1 D.2	Habitat Islands	Insert floating wave break in same area as D.1
/1 D.3	Habitat Islands	Create 4 islands within the lake
/1 D.4	Habitat Islands	Create 2 islands within the lake
E.1	Littoral Macrophyte Restoration	Establish 35 ac emergent and 95 ac submergent aquatic vegetation within the littoral zone
F.1	Institutional Controls	Extend No Wake Zone from 200 to 400 ft from shoreline corresponding to approximately 35% of lake
F.2	Institutional Controls	Restrict motorboats to engines having less than 10 HP. No Wake Zone over entire lake
G.1	Fish Community Management	Complete eradication and/or significant reduction (i.e., 75% of target species) within the lake and adjacent Cedar Lake Marsh (Completed by the non-Federal sponsor)

/1 Due to negligible habitat output in model results, all habitat island measures were screened from further analysis.

The four scales of the "Creation of Habitat Islands" measure were modeled and evaluated using the Environmental Fluid Dynamics Code (EFDC) model (James 2007). Results showed that the creation of habitat islands were not effective at reducing the force of surface waves and currents within the lake, which in turn was not effective at reducing turbidity. Additionally, the creation of habitat islands, while providing upland and wetland habitat benefits, would have been at the expense of aquatic habitat. That is, building habitat islands would have destroyed aquatic habitat currently present at that location. Therefore, the creation of habitat islands measures were removed from further consideration due to significant environmental, social and recreational impacts.

4.2 Measures Cost & Assumptions

Conceptual, planning-level cost estimates were prepared for evaluated restoration measures. These cost estimates for individual measures were used to provide an economic basis for the evaluation of alternative plans. National Economic Development (NED) costs are used for the economic analysis of alternative plans and reflect the opportunity costs of direct or indirect resources consumed by project implementation. It should be noted that NED costs are solely used for economic justification and differ from financial costs used in determining total project and associated cost sharing. All NED costs were referenced to October 2010 price levels.

First NED costs include construction, lands, easements, rights-of-way, relocations and disposal areas (LERRDs), PED, construction management, engineering during construction (EDC), and project management and associated contingencies. The PED costs include any future sampling, testing and modeling, as well as more typical design analysis activities. All of these additional costs are estimated based on a percentage of implementation costs. These assumed costs are revised prior to the execution of a Project Partnership Agreement (PPA).

In addition to first costs associated with implementing each restoration measure, interest during construction was determined as another direct cost. Interest during construction (IDC) is based on estimated implementation duration for each measure and compounded monthly using current discount rate. Since the true economic cost of implementation can vary over time depending on restoration measure, first costs and IDC were distributed over the entire 50-year project life and discounted based on the FY2011 Federal discount rate of 4 1/8% as per Economic Guidance Memorandum 11-01, Federal Interest Rates for Corps of Engineers Projects. Costs used in planning formulation would be discounted uniformly, and therefore would not change the outcome of the comparison to select a plan. Once all implementation distributed costs were converted to present values, the annual equivalent cost of implementing each measure was determined.

Annual OMRR&R costs, which are the responsibility of the non-Federal sponsor, were estimated for each measure based on experience with similarly implemented features and projected operational requirements. Annualized OMRR&R costs were added to annualized first and IDC costs to establish the total annual equivalent cost of each measure used in the economic evaluation of plans using cost effectiveness and incremental cost analyses. A summary of total NED economic costs for each measure is shown in ***Table 8***.

Table 8: Summary of NED Economic Costs/1

Measure /Scale	Total First Cost /2	Annual Equivalent First Cost	IDC /3	Annualized IDC	Annual OMRR&R	Total Annualized Cost
Baseline	[redacted]	[redacted]			[redacted]	[redacted]
/4 A.1	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
/5 A.2	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
/6 A.3	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
/7 A.4	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
/8 A.5	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
/9 A.6	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
A.7	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
A.8	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
B.1	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
B.2	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
C.1	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
E.1	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
F.1	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
/11 F.2	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
G.1	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

/1 Costs used in planning formulation would be escalated uniformly, and therefore would not change the outcome of the comparison to select a plan.
/2 Total first cost includes costs associated with implementation, contingencies, lands, easements, rights-of-way, relocations and disposal areas (LERRDs), preconstruction engineering and design (PED), construction management, engineering during construction (EDC), and project management referenced to October 2010 price level. Costs associated with-project planning and FS are sunk costs and are not included in total first costs.
/3 Interest During Construction (IDC) was compounded monthly using current Federal discount rate and estimated implementation duration for each measure
/4 Cost for Measure A.1 estimated by scaling A.4 based on total dredge volume.
/5 Cost for Measure A.2 estimated by scaling A.3 based on total dredge volume.
/6 Cost for Measure A.3 estimated by scaling components of A.7/A.8 based on total dredge volume.
/7 Cost for Measure A.4 estimated by scaling components of A.7/A.8 based on total dredge volume.
/8 Cost for Measure A.5 estimated by scaling A.3 based on total dredge volume.
/9 Cost for Measure A.6 estimated by scaling A.3 based on total dredge volume.
/10 OMRR&R for Measure B.1 includes cost for retreatment estimated at 25 years past first treatment.
/11 Cost for Measure F.2 estimated by scaling F.1 based on percentage of No Wake Zone area.

4.3 Measure Benefits*

The evaluation of habitat benefits is a comparison of the future without-project habitat units and the future with-project habitat units for each measure. A comparison of the net gain in habitat units was performed in order to determine if measures, or a group of measures (i.e., alternative), would have beneficial effects to the Cedar Lake aquatic ecosystem. Using the habitat assessment methodology established for Cedar Lake, habitat function and structure parameters along with HUs were computed for the without-project (baseline) and with-project conditions over the 50-year period of analysis. The AAHUs were then computed by averaging annual scores over the entire project life. A summary of outputs for each measure is presented in ***Table 9***.

Table 9: Summary of Restoration Measure Habitat Outputs

Measure /Scale	Target AvgTSI	Target MaxTSI	/1 Target SR_{Macro}	/2 Target SR_{Fishes}	Target HSI	Target HU	Compute AAHUs	Incr. AAHUs
Baseline	53.5	76.3	2	6	.19	148.6	148.6	0.0
A.1	47.6	67.9	8	10	.34	266.1	256.7	108.1
A.2	50.0	71.1	5	7	.26	203.6	199.3	50.6
A.3	50.1	71.4	5	7	.26	202.6	198.3	49.7
A.4	48.1	68.7	7	9	.32	247.3	239.5	90.9
A.5	51.2	72.4	4	6	.23	180.0	177.9	29.3
A.6	/3 35.0	/3 55.0	17	12	.54	418.5	392.2	243.5
A.7	/4 48.9	/4 69.8	6	8	.29	226.4	221.8	73.2
A.8	/4 50.8	/4 71.7	5	7	.26	199.9	196.9	48.2
/5 B.1	42.8	66.0	8	10	.19	148.5	240.3	91.6
/6 B.2	42.8	66.0	8	10	.19	148.5	261.5	112.8
C.1	53.2	76.3	3	6	.20	157.2	157.1	8.4
/7 E.1	52.1	74.7	18	8	.35	45.1	43.9	43.9
F.1	53.1	76.2	3	6	.20	157.7	157.6	8.9
F.2	53.1	76.1	3	6	.20	158.0	157.8	9.2
G.1	53.4	76.3	8	16	.33	255.9	251.0	102.4

/1 Rate of macrophyte natural recolonization (when applicable) estimated at 5 years. Total number of native macrophyte species or species richness of macrophytes (SR_{Macro}) possible within Cedar Lake is 38.
/2 Rate of fish natural recolonization (when applicable) estimated at 5 years. Total number of native fish species or species richness of fishes (SR_{Fishes}) possible within Cedar Lake is 32.
/3 Average Trophic State Index (AvgTSI) and Maximum Trophic State Index (MaxTSI) values estimated based on professional judgement.
/4 AvgTSI and MaxTSI values estimated based on model results of similar scaled dredge volumes and depths.
/5 Measure B.1 requires reapplication estimated at 25 years. HUs assumed to decrease at constant rate as treatment effectiveness diminishes.
/6 Measure B.2 estimated to last 50 years. HUs assumed to remain constant for 25 years after initial application and then assumed to decrease at constant rate as treatment effectiveness diminishes over remaining project life.
/7 Habitat area affected is 130 acres corresponding to zone of emergent and submergent aquatic vegetation.

4.4 Alternative Plan Generation

Fourteen (14) measures, including the No Action measure, were input into the IWR-Planning Suite in terms of costs and benefits shown in ***Table 9*** and ***Table 10***. Two sets of plan dependencies were specified to ensure unrealistic combinations were not generated. Both aquatic vegetation restoration and fish community management must be done in conjunction with either physical substrate restoration or chemical substrate restoration. Physical substrate restoration measure A.6 was not included in the analysis because the cost of this measure is outside the scope of implementation. Based on these inputs and criteria, the IWR Planning Software generated 396 alternative combinations for aquatic ecosystem restoration. These alternative combinations were processed for Cost Effectiveness analyses via the certified USACE IWR-Planning Suite (IWR-PLAN) version 1.0.9.0 software, and are presented in the following sections.

4.5 Cost Effectiveness and 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.

Incremental cost analysis takes the cost effective plans and identifies the increment of additional cost required for an additional output. The subset of cost effective plans are examined sequentially (by increasing scale and increment of output) to ascertain which *plans* are most efficient in the production of environmental benefits. Those most efficient plans are called "best buys." 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. Usually, 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 PDT select and recommend a particular plan.

4.5.1 Cost Effectiveness

The cost effectiveness analysis was used to ensure that certain options would be screened out if they produced the same amount or less output at a greater cost than other options with a lesser cost. Three hundred ninety-six (396) alternative combinations were analyzed for cost effectiveness (***Figure 6***). Of these, 59 cost effective combinations were identified, with a subset of 10 plans being identified as "best buys".

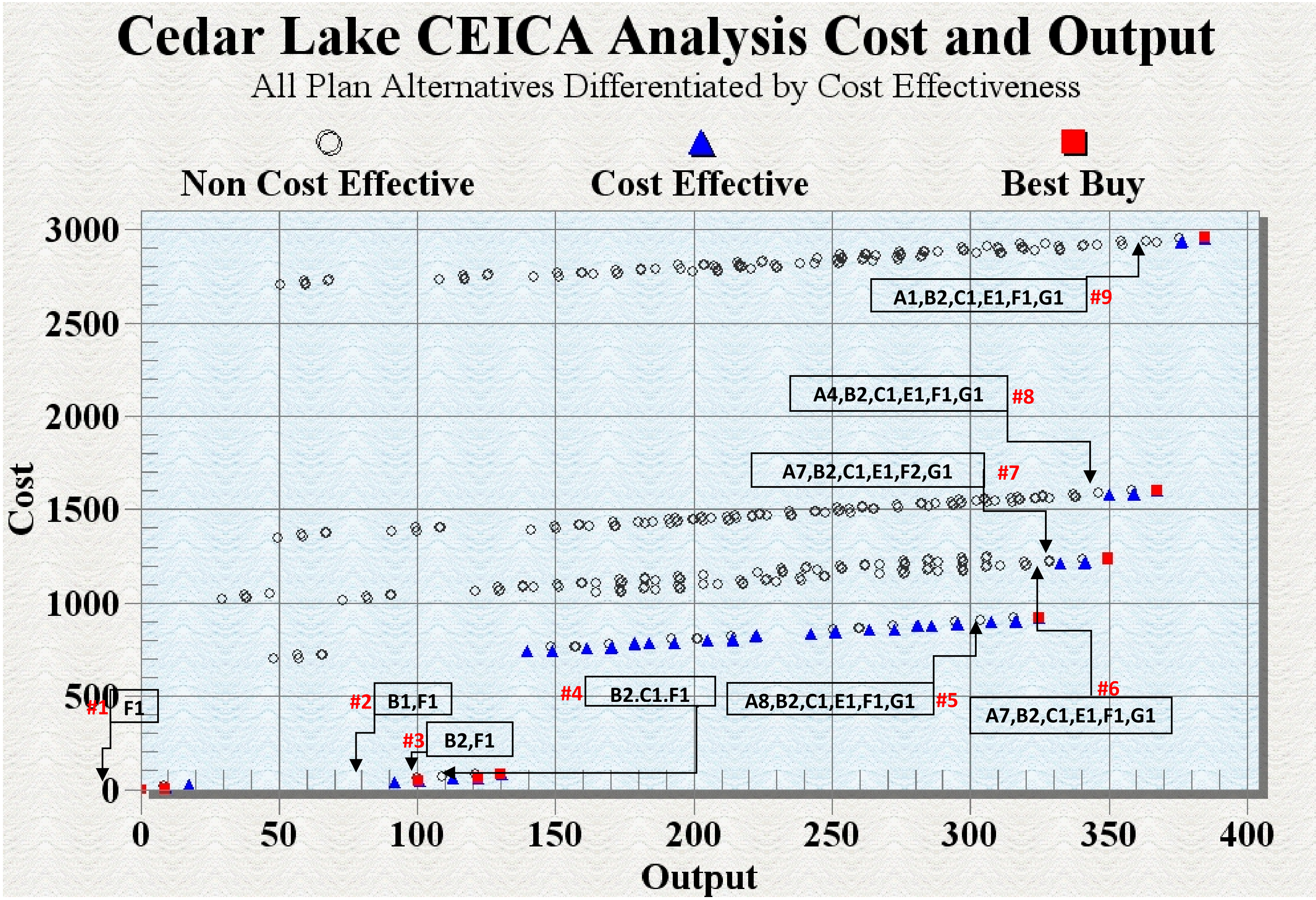

Figure 6: Cost and Output Results of Plans Generated by IWR-Plan

4.5.2 Incremental Cost Analysis

An incremental cost analysis was performed on the ten (10) best buy plans identified from the cost effectiveness analysis, including the No Action plan. The objective of the incremental cost analysis is to assist in determining whether the additional output provided by each successive plan is worth the additional cost. This incremental analysis (***Table 10*** and ***Figure 7***) compares the alternative combinations for ecological restoration that were considered for selection as the NER plan.

Table 10: Summary of CE/ICA "Best Buy" Plans

	"Best Buy" Plan	Average Annual Output (AHHUs)	Average Annual Cost ($)	Cost per Output ($/AAHUs)	Inc. Cost ($)	Inc. Output (AAHUs)	Inc. Cost per Output
0	No Action	0.00	[redacted]	[redacted]	[redacted]	-	[redacted]
1	F1	8.93	[redacted]	[redacted]	[redacted]	8.93	[redacted]
2	B1,F1	100.55	[redacted]	[redacted]	[redacted]	91.62	[redacted]
3	B2,F1	121.78	[redacted]	[redacted]	[redacted]	21.23	[redacted]
4	B2,C1,F1	130.21	[redacted]	[redacted]	[redacted]	8.43	[redacted]
5	A8,B2,C1,E1,F1,G1	324.76	[redacted]	[redacted]	[redacted]	194.55	[redacted]
6	A7,B2,C1,E1,F1,G1	349.69	[redacted]	[redacted]	[redacted]	24.93	[redacted]
7	A7,B2,C1,E1,F2,G1	349.94	[redacted]	[redacted]	[redacted]	.25	[redacted]
8	A4,B2,C1,E1,F2,G1	367.63	[redacted]	[redacted]	[redacted]	17.69	[redacted]
9	A1,B2,C1,E1,F2,G1	384.88	[redacted]	[redacted]	[redacted]	17.25	[redacted]

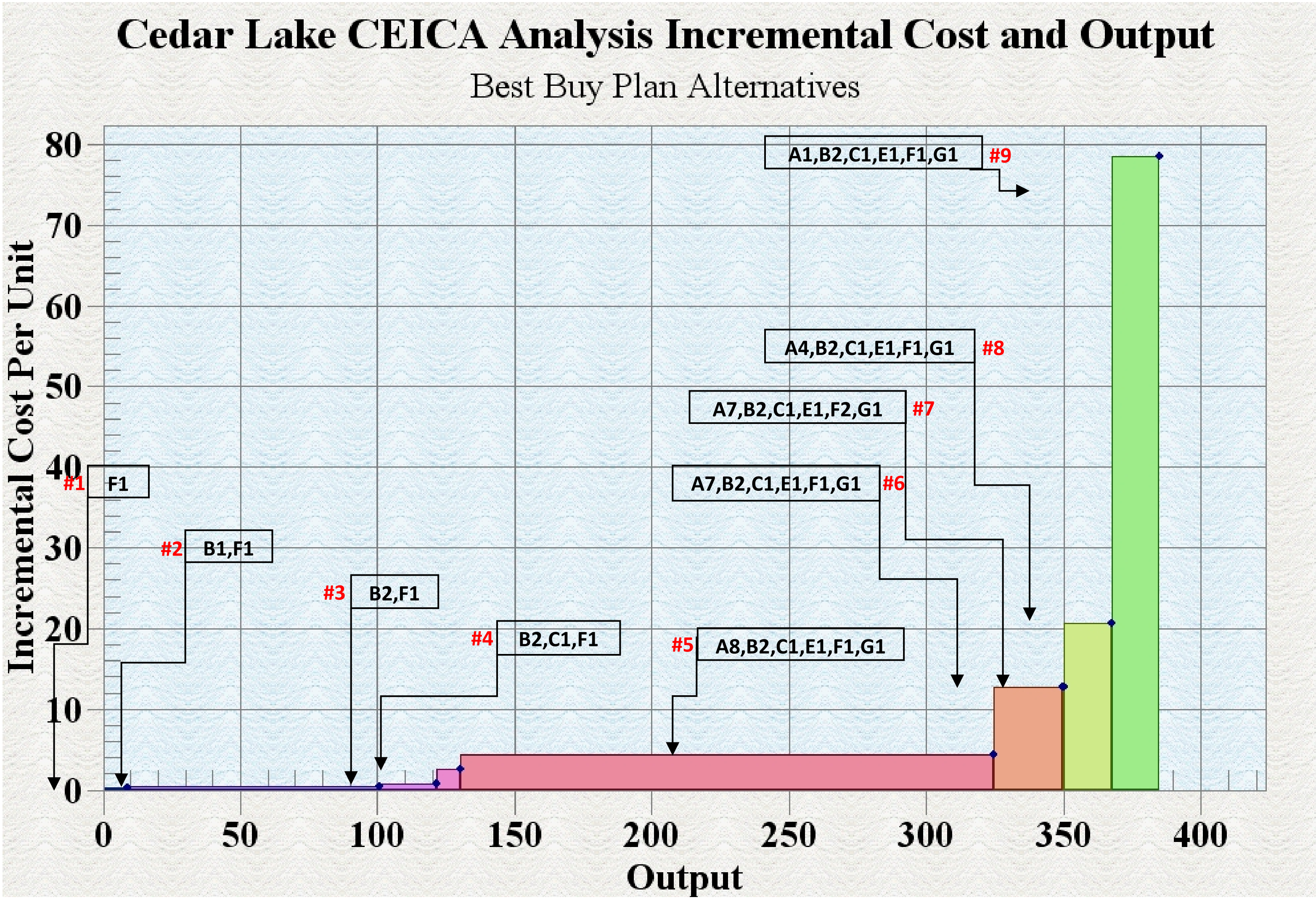

Figure 7: Incremental Cost and Output of "Best Buy" Plans

4.6 Alternative Plan Evaluation

To completely restore Cedar Lake to its pre-settlement oligotrophic state, all fine-grained nutrient rich sediments would need to be removed and nutrient inputs from the watershed would have to be eliminated, which is neither realistic nor cost effective. As such, the removal of all fine-grained nutrient-rich sediments, which corresponds to approximately 8 million cubic yards, was screened from further analysis because its cost is outside the scope of implementation authority.

When comparing ecological output from individual alternative plans, the ability for the plan to achieve ecosystem objectives must be evaluated. For this analysis, a minimum threshold of habitat outputs was established to ensure the selected plan meets all ecosystem objectives. Specifically for Cedar Lake, it was determined that plans must achieve a minimum of 150 AAHUs in order to meet all of the ecosystem objectives of restoring ecosystem function and habitat structure to Cedar Lake. Plans that have output less than 150 AAHUs would not completely address all of the project objectives nor restore a sustainably functioning ecosystem. Using this criterion, Alternative Plans 1, 2, 3 and 4 do not meet the minimum requirements for habitat outputs to address the holistic restoration of both physical habitat structure and biological function at Cedar Lake. Alternative Plans 5, 6, 7, 8 and 9 do meet the minimum requirements (***Table 11***).

In comparing plans that meet the requirements for habitat output, incremental costs should be evaluated. Although Alternative Plan 9 removes a greater portion of the sediment than Alternative Plans 5, 6, 7 and 8, it does not significantly increase the benefits enough to justify the increased cost. The incremental increase in cost per unit output of Alternative Plans 5, 6, 7 and 8 is similar in relative magnitude with nearly a linearly increasing trend. Alternative Plan 5 has the least incremental cost of all the plans meeting the minimum habitat output requirements.

Table 11: Summary of Alternative Plan Outputs

Plan #	Measures	Average Annual Output (AHHUs)	Project Objectives				
			1	2	3	4	5
			Restore Littoral Currents & Nutrient Cycling	Increase Spatial Coverage of Viable In-Lake Habitat	Eradicate/Control Non-Native Species	Reestablish Fish Passage / Recolonization	Increase Cedar Lake's Biodiversity
< 150 AAHUs							
0	No Action	0.00					
1	F1	8.93	X				
2	B1,F1	100.55	X				
3	B2,F1	121.78	X				
4	B2,C1,F1	130.21	X			X	X
> 150 AAHUs							
5	A8,B2,C1,E1,F1,G1	324.76	X	X	X	X	X
6	A7,B2,C1,E1,F1,G1	349.69	X	X	X	X	X
7	A7,B2,C1,E1,F2,G1	349.94	X	X	X	X	X
8	A4,B2,C1,E1,F2,G1	367.63	X	X	X	X	X
9	A1,B2,C1,E1,F2,G1	384.88	X	X	X	X	X

4.6.2 Significance of Ecosystem Outputs

Due to the challenges associated with comparing 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 Cedar Lake habitat restoration outputs are herein recognized in terms of institutional, public, and/or technical importance.

<u>Institutional Recognition:</u>

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.

Table 12 outlines significant institutional recognition for the identified Alternative Plans; with a discussion pertinent to each individual act and/or policy following.

Table 12: Institutional Significance of Alternative Plans

Reference	Environmental Regulation	Applicability	Alternative Plan 5	6	7	8
16 USC 1531-1544	Endangered Species Act of 1973	Would promote the restoration of habitat that could potentially be utilized by 3 Federally listed species.	Yes	Yes	Yes	Yes
IC 14-22-34	Indiana Nongame and Endangered Species Conservation Act	Would promote the restoration of critical habitat for 7 to 10 State listed species.	Yes	Yes	Yes	Yes
16 USC 460L-12	Federal Water Project Recreation Act, as amended	Would restore approximately 781 acres of glacial lake for a significant recreational boating and fishing industry.	Yes	Yes	Yes	Yes
16 USC 661	Fish and Wildlife Coordination Act, as amended	Would restore 651 acres of glacial lake and 130 acres of marsh for fish & wildlife habitat.	Yes	Yes	Yes	Yes
16 USC 703 et seq.	Migratory Bird Treaty Act of 1918,as amended	Would restore 651 acres of glacial lake and 130 acres of wetland that migratory birds would utilize.	Yes	Yes	Yes	Yes
33 USC. 1251 et seq.	Clean Water Act, of 1977, as amended	Would prevent nutrient laden sediment from impairing water quality of Cedar Lake and downstream in the Kankakee River.	Yes	Yes	Yes	Yes
E.O. 11514	Protection and Enhancement of Environmental Quality	Would eliminate legacy phosphorus exposure to fish, wildlife and humans.	Yes	Yes	Yes	Yes
E.O. 11988	Floodplain Management	Would restore 130 acres of lake marsh.	Yes	Yes	Yes	Yes
E.O. 11990	Protection of Wetlands	Would restore 130 acres of lake marsh.	Yes	Yes	Yes	Yes
E.O. 12088	Federal Compliance with Pollution Control Standards	Would eliminate legacy phosphorus exposure to fish, wildlife and humans.	Yes	Yes	Yes	Yes
E.O. 12898	Federal Actions to Address Environmental Justice in Minority and Low-Income Populations	Would enhance subsistence fishing of low income populations through restoring the glacial lake fishery.	Yes	Yes	Yes	Yes
E.O. 13112	Invasive Species	Would eradicate non-native and invasive fish species such as White Perch and Common Carp.	Yes	Yes	Yes	Yes
E.O. 13186	Responsibilities of Federal Agencies to Protect Migratory Birds	Would restore 651 acres of glacial lake and 130 acres of fringe wetland habitat that migratory birds would utilize.	Yes	Yes	Yes	Yes
E.O. 13653	Preparing the United States for the Impacts of Climate Change	Would restore 130 acres of lake fringe emergent marsh and shallow/deep littoral zone.	Yes	Yes	Yes	Yes

Endangered Species Act of 1973 – All Federal departments and agencies shall seek to conserve endangered species and threatened species. The purpose of the act is to provide a means whereby the ecosystems upon which endangered and threatened species depend may be conserved and to provide a program for the conservation of such endangered and threatened species. Alternative Plans 5, 6, 7 and 8 would restore riparian habitat that could potentially be used by two Federally listed species: Indiana Bat and Northern Long-eared Bat. A third species, the Whooping Crane, has been seen at the site; however, the individual observed at Cedar Lake was likely from a population of Whooping Cranes reintroduced outside of their current range (i.e., Canada to Texas) but within their historic range (i.e., Wisconsin to Florida). They are labeled as "non-essential" per Section 10 of the Endangered Species Act because they were reintroduced. The reintroduced Whooping Cranes are the same genus and species as the population listed as Federally endangered and are afforded protection under the Endangered Species Act through the prohibitions of Section 9 and the requirements of section 7.

Indiana Nongame and Endangered Species Conservation Act of 1973 – charges the Division of Fish & Wildlife to manage and conserve nongame and endangered species. A non-game species is any wild mammal, bird, amphibian, reptile, fish, mollusk, or crustacean that is not hunted or trapped for sport or commercial use. Cedar Lake has potential for supporting State endangered species and species of special concern including Blue-spotted Salamander, Common Mudpuppy, Northern Leopard Frog, Spotted Turtle, Kirtland's Snake, Blanding's Turtle, Great Egret, American Bittern, Marsh Wren, Least Bittern, Virginia Rail, and Black-crowned Night-heron. Alternative Plans 5, 6, 7 and 8 would protect and restore these habitats.

Federal Water Project Recreation Act, as amended – declares the intent of Congress that recreation and fish and wildlife enhancement be given full consideration as purposes of Federal water development projects. Alternative Plans 5, 6, 7 and 8 would restore lake aquatic habitat at Cedar Lake thereby enhancing fish and wildlife.

Fish and Wildlife Conservation Act of 1980 – all Federal departments and agencies to the extent practicable and consistent with the agency's authorities should promote the conservation of non-game fish, wildlife, and their habitats. Alternative Plans 5, 6, 7 and 8 would restore fringe wetland and littoral zone habitat, profundal zone habitat, and tributary riparian habitat, which is in full support of this Act.

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

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

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

This route is ideal for migratory waterfowl because it is uninterrupted by mountains, dotted with tens of thousands of lakes, wetlands, ponds, streams and rivers, and is well timbered in certain reaches. Northwestern Indiana is located within the Mississippi Flyway and approximately 325 species of birds pass along Lake Michigan's shoreline annually. This reach is also one of America's most important migration routes for songbirds, with an estimated 5 million songbirds using the north-south shoreline of Lake Michigan as their migratory sight line during the migration season. 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 foraging. Northwestern Indiana's parks, natural areas, and even residential backyards are particularly important, because they are the only patches of habitat left within a highly developed landscape. The preservation of parkland and natural areas along water bodies is critical to the survival of millions of birds that migrate through northwest Indiana every spring and fall. The Cedar Lake aquatic ecosystem restoration project has great potential to provide increased critical migratory bird habitat.

According to a letter provided by the Chicago Region Audubon (letter dated October 13, 2015, *Appendix O – Coordination*) the aquatic ecosystem restoration of, "[…] Cedar Lake and its surrounding shoreline and fringe wetlands will contribute to the conservation of not only the Sandhill Crane, but also play a critical role in the preservation of this continentally important Flyway and the millions of birds that use its scant stopover habitats annually."

Alternative Plans 5, 6, 7, and 8 are in full support of the Migratory Bird Treaty Act because they would effectively restore aquatic habitat and structure to Cedar Lake, in turn providing an increase in the availability of high quality stopover and foraging habitat for migratory birds.

Clean Water Act – restore the chemical and biological integrity of the Nation's waters. Although water quality improvement is not within the USACE Mission, policy acknowledges that habitat restoration provides incidental water quality improvements most of the time. The Clean Water Act also has provisions for wetland and biological integrity protection. The No Action Alternative does not support this Act by foregoing the opportunity to restore viable wetland acres. Alternative Plans 5, 6, 7 and 8 are in full support of the Clean Water Act because they would effectively restore the Cedar Lake aquatic ecosystem.

Protection and Enhancement of Environmental Quality (E.O. 11514) – the Federal Government shall provide leadership in protecting and enhancing the quality of the Nation's environment to sustain and enrich human life. Significant improvements to aquatic habitat of Cedar Lake would be achieved by Alternative Plans 5, 6, 7 and 8.

Floodplain Management (E.O. 11988) – requires all Federal agencies to avoid to the extent possible the long and short-term adverse impacts associated with the occupancy and modification of floodplains and to avoid direct and indirect support of floodplain development wherever there is a practicable alternative. Alternative Plans 5, 6, 7 and 8 would not have any adverse impacts or modify any floodplains.

Protection of Wetlands (E.O. 11990) – each agency shall provide leadership and shall take action to minimize the destruction, loss or degradation of wetlands, and to preserve and enhance the natural and beneficial values of wetlands. According to a U.S. Department of Interior and U.S. Fish and Wildlife Service Report to Congress (Dahl, 1990) the State of Indiana lost 87% of its original wetland acreage from 1780 to 1980; making Cedar Lake's basin and fringe wetlands a scarce and significant resource for the restoration of Cedar Lake into a more natural glacial lake ecosystem. Alternative Plans 5, 6, 7, and 8 would protect and restore some or all of these wetland communities as well as restore approximately 130 acres of lake marsh habitat.

Federal Compliance with Pollution Control Standards (E.O. 12088) – ensures that Federal agencies would comply with Federal, State and Local pollution control requirements. Alternative Plans 5, 6, 7 and 8 comply with all applicable Federal, State and Local pollution control requirements.

Federal Actions to Address Environmental Justice in Minority and Low-Income Populations (E.O. 12898) – purpose is to focus Federal attention on the environmental and human health effects of Federal actions on minority and low-income populations with the goal of achieving environmental protection for all communities. A database search of the USEPA EJView mapping tool (accessed 6 March 2014), revealed that within the portion containing the Cedar Lake project site, 0-20% of the population is considered below the poverty line and 0-10% of the population is considered a minority. Alternative Plans 5, 6, 7 and 8 are considered ecosystem restoration and will only benefit the surrounding environment and communities.

Invasive Species (E.O. 13112) – prevent the introduction of invasive species and provide for their control and to minimize associated economic, ecological, and human health impacts. Alternative Plans 5, 6, 7 and 8 would effectively remove the non-native and invasive fish species White Perch and Common Carp from Cedar Lake. It would reduce the effects Common Carp have on aquatic habitat by preventing these species from continually resuspending the fine-grained nutrient rich sediments and preventing growth of aquatic vegetation. Additionally, it would reduce the effects White Perch has on native species by preventing this species from consuming native fish species eggs.

Responsibilities of Federal Agencies to Protect Migratory Birds (E.O. 13186) – "Federal agencies shall restore or enhance the habitat for migratory birds and prevent or abate pollution or detrimental alteration of the environment for migratory birds." The western shoreline of Lake Michigan is recognized as "one of the most important flyways for migrant songbirds in the United States by many ornithologists and birdwatchers worldwide" (Shilling and Williamson) and is considered globally significant. An estimated 325 bird species use the north-south shoreline of Lake Michigan as their migratory sight line. Areas restored near the southern tip of Lake Michigan could provide migrants with high calorie, high protein seeds, fruits, and insects along with shelter from severe weather and predators. Restored habitat along this urbanized migratory route can reduce the stress of migration allowing more migrants to reach their destinations. The Cedar Lake aquatic ecosystem restoration project would restore littoral zone habitat, riparian habitat, fish habitat, and aquatic macroinvertebrate habitat, thus providing forage and shelter for numerous migratory bird species. This project lies within a significant portion of the Mississippi Flyway along the coast of Lake Michigan that particularly favors both ecological and economically valuable waterfowl species. Alternative Plans 5, 6, 7 and 8 fulfill the USACE's role and responsibility by utilizing its Ecosystem Restoration Mission, authority and supporting policies to restore lake and riparian habitat for Migratory Waterfowl and the aquatic vegetation, fishes, and aquatic macroinvertebrates that support these bird species.

<u>Preparing the United States for the Impacts of Climate Change (E.O. 13653)</u> – The impacts of climate change – including an increase in prolonged periods of excessively high temperatures, more heavy downpours, an increase in wildfires, more severe droughts, permafrost thawing, ocean acidification, and sea-level rise – are already affecting communities, natural resources, ecosystems, economies, and public health across the Nation. These impacts are often most significant for communities that already face economic or health-related challenges, and for species and habitats that are already facing other pressures. Managing these risks requires deliberate preparation, close cooperation, and coordinated planning by the Federal Government, as well as by stakeholders, to facilitate Federal, State, local, tribal, private-sector, and nonprofit-sector efforts to improve climate preparedness and resilience; help safeguard our economy, infrastructure, environment, and natural resources; and provide for the continuity of executive department and agency (agency) operations, services, and programs. The Federal Government must build on recent progress and pursue new strategies to improve the Nation's preparedness and resilience. In doing so, agencies should promote: (1) engaged and strong partnerships and information sharing at all levels of government, (2) risk-informed decision-making and the tools to facilitate it, (3) adaptive learning in which experiences serve as opportunities to inform and adjust future actions, and (4) preparedness planning.

Alternative Plans 5, 6, 7, and 8 support this E.O. via the sequestration of carbon and carbon dioxide by increasing the acreage and biomass of native plants (i.e., emergent and submergent vegetation). Even dead plant material in the form of peat, detritus and mucks prevents carbon from entering the atmosphere. Additionally, to mitigate for uncertainties regarding future climate change and its potential to impact reestablished emergent and submergent vegetation, a broad pallet of adaptive plant species will be used to compensate for climatic shifts.

<u>Public Recognition:</u>

Public recognition means that some segment of the general public recognizes the importance of an environmental resource, as evidenced by people engaged in activities that reflect an interest or concern for that particular resource. Such activities may involve membership in an organization, financial contributions to resource-related efforts, and providing volunteer labor and correspondence regarding the importance of the resource.

The CLEA was formed over 40 years ago as a non-profit grass roots organization with the goal of making Cedar Lake into a more valuable resource. The organization is made up of many area residents concerned with the well-being of Cedar Lake. By securing Indiana State grants and through private donations from its members, CLEA has implemented several ecosystem restoration and bank stabilization projects throughout the watershed. CLEA was instrumental in kicking off this FS and helping the Town of Cedar Lake secure Federal funds to continue ongoing study efforts. Cedar Lake is recognized as a highly coveted resource within both the local community and northwest Indiana region and the long standing works of CLEA are a fine example of the public's willingness to work towards protecting and restoring the resource.

Stakeholder Support

Support for the Cedar Lake Aquatic Ecosystem Restoration Project presented in this FS includes, but is not limited to: the USEPA, USFWS, IDEM, IDNR, and the Audubon Society are all critical and involved stakeholders. State of Indiana support for the project is further evidenced by the many Indiana Lake and River Enhancement (LARE) Program grants for CLEA projects and the $2 million grant approved in 2008 in support of non-Federal sponsor lands responsibilities.

<u>Technical Recognition:</u>

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.

According to the Midwest Glacial Lakes Partnership whose mission is to protect, rehabilitate, and enhance sustainable fish habitat in glacial lakes of the Midwest for the use and enjoyment of current and future generations, there are approximately 40,000 glacial lakes occurring within the upper Midwest. While the number of glacial lakes has not necessarily decreased since they are a geological feature; high quality glacial lake habitat is scarce due to alterations of the aquatic habitat, development of the surrounding watershed, presence of non-native species, and other land use changes which are increasingly affecting the sustainability of healthy glacial lake aquatic ecosystems. The Midwest Glacial Lakes Partnership (2009) specifically states, "From small, productive potholes to the large windswept walleye "factories", glacial lakes are an integral part of the communities within which they are found and taken collectively are a resource of national importance." Additionally, Weitzell et al. (2003) concluded, "…glacial lakes are among the most endangered of aquatic systems, currently threatened with a multitude of anthropogenic disturbances."

These anthropogenic disturbances threaten the two fundamental wetland categories seen at Cedar Lake: basin and fringe. These effects hinder Cedar Lake's potential for more closely resembling its historic glacial ecosystem. Remaining wetlands have taken on additional elemental processing from altered wetlands, which exceed their assimilative capacity. The disturbed wetlands created a functional loss to biogeochemical processes that historically provided a healthy response to high nutrient constituents. Additionally, according to a U.S. Department of Interior and U.S. Fish and Wildlife Service Report to Congress (Dahl, 1990) the State of Indiana lost 87% of its original wetland acreage from 1780 to 1980.

The restoration of Cedar Lake as well as the restoration of Cedar Lake's basin and fringe wetlands, a scarce and significant resource, would restore scarce high quality glacial lake habitat within northwestern Indiana and to a larger extent the Midwest Region. Alternative Plans 5, 6, 7, and 8 would protect and restore basin and fringe wetland habitat as well as glacial lake habitat.

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.

The joint presence of fringe and basin habitats surrounding Cedar Lake creates a proper ecosystem for a natural glacial lake. The geomorphological settings of these habitats have relevance for restoring habitat structure, physical, and biological function. Fringe wetlands are small in comparison to the large bodies of water that flush them, and therefore do not play a major role in assimilation, but serve as critical habitats for glacial lake flora and fauna. Cedar Lake Marsh, serving as a basin wetland, possesses a high capacity for absorbing nutrients from almost half of the Cedar Lake watershed. The basin wetlands of Cedar Lake, in conjunction with proposed substrate restoration and removal of benthic fish, will create favorable conditions for a healthy establishment of fringe wetlands. Biogeochemical processes of wetlands are major mechanisms that influence nutrient constituents in water. The basin and fringe wetlands of Cedar Lake exemplify the natural habitat needed to restore a healthy glacial lake ecosystem. Alternative Plans 5, 6, 7 and 8 would protect and restore this habitat complex.

Status and Trend measures the relationship between previous, current and future conditions. Biogeochemical processes are functional at Cedar Lake and analyses of monitoring of Cedar Lake by the State of Indiana throughout the past four decades suggests that the lake has been improving and seems to be reaching steady state conditions; however, the lake will maintain near current conditions due to internal loading. Alternative Plans 5, 6, 7 and 8 would restore bottom substrates providing bathymetric diversity more suitable for glacial fishes, reduce internal nutrient loading, and decrease turbidity caused by resuspension of sediments, thus restoring the absorptive ability lost by altered wetlands and returning historic function to Cedar Lake's basin and fringe wetlands.

Connectivity is the measure of a resource's connection to other significant natural habitats. Within the Cedar Lake watershed, the connectivity of basin and fringe wetlands has been weakened from increased nutrient loading and degraded biological and physical function. Additionally, Cedar Lake is near several nature preserves and USACE projects within northwestern Indiana providing connectivity between these high quality habitats: Indiana Dunes National Lakeshore, Biesecker Prairie Nature Preserve, Plum Creek Forest Preserve, Brownwell Woods, Sauk Trail Woods, Continuing Authorities Program (CAP) 206 Wolf Lake Indiana , Great Lakes Fishery & Ecosystem Restoration (GLFER) 506 Little Calumet River Riparian Restoration, and GLFER 506 Calumet Prairie and Ivanhoe South Ridge and Swale Restoration. Alternative Plans 5, 6, 7 and 8 would protect and restore healthy connectivity between basin and fringe wetlands to trigger Cedar Lake's potential for historic glacial lake conditions, in addition to providing connectivity between high quality habitats within northwestern Indiana.

Limiting Habitat is the measure of resources present supporting significant species. Cedar Lake has potential for supporting State endangered species and species of special concern including Black-crowned Night-heron, Marsh Wren, Blanding's Turtle, Northern Leopard Frog, and the Common Mudpuppy. Additionally, there may be suitable summer nursery habitat for the Federally endangered Indiana Bat and the Federally threatened Northern Long-eared Bat within the general area, such as along Founders Creek and Cedar Creek where forested riparian habitat is present. Alternative Plans 5, 6, 7, and 8 would protect and restore these habitats.

Cedar Lake also has great potential to support bird species listed under the Federal Migratory Bird Treaty Act. Species listed and noted from Cedar Lake include Lesser Scaup (*Aythya affinis*), Ring-necked Duck, Wood Duck, American Coot, Great Blue Heron, Great Egret, Redtail Hawk (*Buteo jamaicensis*) and gulls (*Laridae* sp.). These species would benefit through:

- An increase in quality and size of viable habitat through physical removal of fine-grained nutrient rich sediments
- Removal of bird migration barriers by creating viable littoral and fringe zones on the lake
- Implementation of effective management practices on forage fishes for piscivorous diving birds
- Restoration of fringe and littoral vegetation to benefit waterfowl

4.6.3 Acceptability, Completeness, Effectiveness & Efficiency

Acceptability, completeness, effectiveness, and efficiency are the four evaluation criteria USACE uses in evaluating alternative plans. Alternatives considered in any planning study must meet minimum subjective standards of these criteria in order to qualify for further consideration and comparison with other plans.

<u>Acceptability:</u>

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

The suite of restoration measures and plans outlined within this study were developed in a collaborative fashion with input from stakeholders and the non-Federal sponsor. Ecosystem restoration measures were proposed, screened, refined and retained for further consideration through a series of collaborations. Alternative Plan 0 provides no ecosystem improvements and is not acceptable to the Federal objective, the non-Federal sponsor's goals and stakeholder desires. Alternative Plans 1, 2, 3, and 4 provide limited ecosystem restoration benefits, do not address all of the study objectives, and would not holistically restore the ecosystem. Therefore, these alternative plans are unacceptable and were eliminated from further consideration. Taking the Federal Objective, study objectives, and non-Federal sponsor/stakeholder needs into consideration, Alternative Plans 5, 6, 7, 8, and 9 provide the most diverse ecosystem restoration possible and thus are acceptable.

The USFWS provided their support for aquatic ecosystem restoration at Cedar Lake in their FWCA Report letter dated November 20, 2007. The letter specifically states, "We support the reestablishment of a native fishery in Cedar Lake, including those that may now be considered rare within the area due to habitat losses at natural glacial lakes."

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 an adaptive management plan should be proposed and must be accounted for in the implementation plan.

All of these factors were considered in the evaluation of alternative plans. Alternative Plan 0 does not provide any action to restore degraded habitats and therefore is incomplete in the realization of ecosystem improvements. Alternative Plans 1,2, 3, and 4 are incomplete in terms of completely restoring the Cedar Lake ecosystem and are inconsistent with non-Federal sponsor/stakeholder goals and needs. Alternative Plans 5, 6, 7, 8, and 9 are the most complete in that they would completely address all study objectives, holistically restore the Cedar Lake ecosystem, and achieve restoration in the most comprehensive and sustainable way.

Effectiveness:

An ecosystem restoration plan must make a significant contribution to addressing the specified restoration problems or opportunities (i.e., restore important ecosystem structure or function to some meaningful degree). The problems identified that may be addressed under this ecosystem restoration authority are the impaired aquatic diversity, poor quality (i.e., fine-grained nutrient rich) substrates, and aquatic habitat abundance and health. In addition to focusing on the identified problems, opportunities were also considered when establishing study objectives. Taking into account how each Alternative Plan meets the planning objectives and how engineering analyses were utilized to validate the functionality and sustainability of plan habitat output, Alternative Plans 5, 6, 7, and 8 would be most effective at restoring the

Cedar Lake aquatic ecosystem and would make significant contributions to fish, macroinvertebrate, wildlife, and migratory bird habitat within the Great Lakes, a biogeographically significant region of the nation.

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 any other plan.

Through the CE/ICA analyses, Alternative Plans 1 through 59 were identified as cost-effective using IWR-Plan software. All inefficient options were removed from consideration and only the 10 best buy plans having the least incremental increase in cost per unit habitat output were retained for further consideration and the identification of the NER Plan. As identified through trade-off analyses, Alternative Plans 5, 6 and 8 were determined to be the most efficient plans in terms of costs and benefits that meet project objectives. Alternative 7 was determined to not be as efficient at Alternative Plans 5, 6, and 8 since it was similar to Alternative Plan 6 except for the implementation of a different institutional control (i.e., No Wake Zone extended over entire lake and motors limited to 10 HP). The implementation of the different institutional control provided minimal additional output (i.e., 0.25 average annual habitat units) for a significant incremental cost ($12,703.60). In contrast, Alternative plans 5, 6, and 8 completely addressed all five ecosystem objectives (1. *Restore Littoral Currents & Nutrient Cycling*, 2. *Increase Spatial Coverage of Viable In-Lake Habitat*, 3. *Eradicate/Control Non-Native Species*, 4. *Reestablish Fish Passage/Recolonization*, 5. *Increase Cedar Lake's Biodiversity*), as well as provided the greatest additional output (i.e., average annual habitat units) for the least incremental cost.

4.6.4 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 tentatively recommended plan becomes more complex. It is essential to document the assumptions made and uncertainties encountered during the course of planning analyses. 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. While estimating habitat output and associated costs for each restoration measure, risk and uncertainty were considered.

Habitat output was determined by first estimating the effects of the measure on average and maximum trophic state using modeling results and then projecting species richness that could be sustained by those conditions. Critical parameters were identified during model development, additional data was collected and observed conditions were used for model calibration to reduce the overall uncertainty of modeling results. The same model was used to analyze all restoration measures; therefore the relative uncertainty between measures was reduced.

Uncertainties exist with respect to concentrations of sediments that are day lighted by physical substrate restoration. Estimated concentrations used in model analyses were based on limited sediment core sampling. Based on these sampling results and knowledge of how nutrients migrate vertically through sediment strata, it is anticipated that uncovered sediments will be lower in nutrient concentration than those being removed. In order to minimize the risk of fine-grained nutrient rich sediments uncovered from physical removal contributing to internal nutrient recycling, chemical substrate restoration using alum will be implemented after substrate restoration operations are conducted across all areas of the lake, including areas where physical removal occurs. The use of alum will help solidify sediments, reduce turbidity and promote growth of native macrophytes by providing a suitable growth matrix for root attachment and increased sunlight penetration (i.e., reduction in turbidity), which in turn will benefit aquatic fauna.

An uncertainty associated with the long term effectiveness of chemical substrate restoration exists. Several factors impact the effectiveness of alum treatments. Alum treatments work best in deeper lakes that are dimictic (i.e., turnover twice a year); however, they have also been shown to be effective in shallow polymictic (i.e., fully mixed) lakes that have low external nutrient inputs. Variability in future watershed nutrient loading, storm-induced waves, and benthic organism activity all can impact the longevity of alum treatments. An alum treatability analysis using field collected sediment samples was conducted to determine proper application based on various potential external loading scenarios. In order to minimize the risk of undesired effects, periodic monitoring is included in the tentatively selected plan.

Native plantings also have an associated risk of not establishing due to a variety of unforeseen events. Herbivory from animals is a possibility; however, this risk will be reduced with the control of Common Carp within Cedar Lake (e.g., application of Rotenone by the non-Federal sponsor). Weather also plays a large role in the establishment success of new plantings. Periods of drought, flood or early frost can alter the survival percentage of plantings. 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 may or may not affect project outcomes. Increased temperatures or rainfall may lead to changes in the ecosystem of the project area; however, Lake Michigan primarily drives the weather in the region and may partly mitigate climate change concerns for the near future. This climate concern is alleviated by having a broader pallet of adaptive plant species to compensate for climatic shifts.

Implementation costs were estimated using feasibility-level designs and associated quantities. In order to account for uncertainties in actual quantities and unit costs, contingencies were utilized. The level of contingency assigned to various features was based upon uncertainties in the design and the likelihood of cost variations.

4.7 Selection of the Tentatively Selected Plan (TSP)

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, is within planning constraints and reasonably maximizes environmental benefits while passing tests of cost effectiveness and incremental cost analyses, significance of outputs, acceptability, completeness, efficiency, and effectiveness.

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 estimates were based on current ecosystem restoration projects that are in construction and design phases. 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.

Non-monetary values associated with the Cedar Lake aquatic ecosystem restoration project include a variety of ecological, social and educational benefits. The importance of migratory birds in terms of human uses and aesthetics has been documented through numerous sources, most importantly the Migratory Bird Treaty Act (1918) and EO 13186 Responsibilities of Federal Agencies to Protect Migratory Birds. The project will provide stop-over habitat for birds traveling along the Great Lakes portion of the Mississippi Flyways, a migratory route recognized as nationally significant by the Audubon Society. An estimated 325 bird species, and more specifically tropical song birds and waterfowl, utilize this route. In addition, the native habitat types planned will benefit native resident species. A variety of native aquatic species such as fish, macroinvertebrates, and amphibians will greatly benefit through the addition of important foraging, refuge, and spawning habitat. The restoration of the Cedar Lake aquatic ecosystem will markedly increase the ecological integrity of the surrounding area and is well worth the investment.

4.7.1 NER Plan

The plan that reasonably maximizes net NER benefits and is consistent with the Federal objective, authorities and policies, is identified as the NER plan. The NER plan direct, indirect and cumulative effects under NEPA are discussed in the following Chapter. The NER Plan was determined to be Alternative 5 (***Table 13*** and ***Figure 8***) and addresses both the functional and structural ecosystem impairments existing at Cedar Lake.

Table 13: Description of NER Plan

Measure /Scale	Type	Description
A.8	Physical Substrate Restoration	Mechanically dredge 87 ac in south basin to depth of 1.0 ft for a total of 140,000 cy. Extent of dredging corresponds to areas with available sediment phosphorus >100 mg/kg based on sampling and analysis completed in April 2008. Physically removed material will be hydraulically offloaded to a sediment dewatering facility (SDF) by slurrying using recycled effluent. Implementation costs include dredging, reslurrying, pumping, SDF construction, SDF closure, and effluent treatment. Annual OMRR&R costs include maintenance of SDF site including mowing and fence repair.
B.2	Chemical Substrate Restoration	Dose 400 ac with alum to a treatment depth of 20 cm. Area roughly corresponds to ASP concentrations > 30 mg/kg. Target alum dose varies by location in lake, with target residual ASP < 20 mg/kg. Implementation costs include one lake treatment. Annual OMRR&R costs include periodic monitoring to determine effectiveness of the treatment used and whether adaptive management is needed. Long term effectiveness of single treatment computed at least 50-years based on projected external loadings.
C.1	Tributary Restoration	Reroute Founders Creek back to Cedar Lake. Implementation costs based on provided stream centerline and typical channel and riparian cross-section. Annual OMRR&R costs include invasive species control on the approximate 2 acre riparian area site.
E.1	Littoral Macrophyte Restoration	Establish 35 ac emergent and 95 ac submergent aquatic vegetation along the shoreline of the lake within the littoral zone. Implementation costs based on generated native species list. Annual OMRR&R costs include periodic invasive species control.
F.1	Institutional Controls	Increase No Wake Zone from 200 to 400 ft from shoreline corresponding to approximately 35% of lake. Implementation costs include adding additional marker buoys within the lake. Annual OMRR&R costs include removal of buoys prior to ice conditions and replacement of damaged markers.
G.1	Fish Community Management	Completely eradicate and/or significantly reduce (i.e., 75% of target species) Common Carp and White Perch within Cedar Lake and adjacent Cedar Lake Marsh. Implementation costs do not include the application of Rotenone, but do include the introduction of native fish species. Annual OMRR&R costs include periodic monitoring on an approximate 5 year cycle to determine species composition and assess the need for restocking of native fish species (Completed by non-Federal sponsor).

In order to reduce the estimated costs of Alternative Plan 5, recommendations outlined in a 2009 Value Engineering (VE) study were evaluated. It was found that the on-site waste-water treatment plant originally included in Alternative Plan 5 as part of the dredging operations (A.8 Physical Substrate Restoration) could be eliminated. Instead, suspended solids and phosphorous could be removed by gravity settling, along with the introduction of cationic polymer to speed the settling time (refer to *Section 4.1 Measure Identification and Screening* for additional detail. These changes reduced the NER Plan cost estimate by approximately $[redacted].

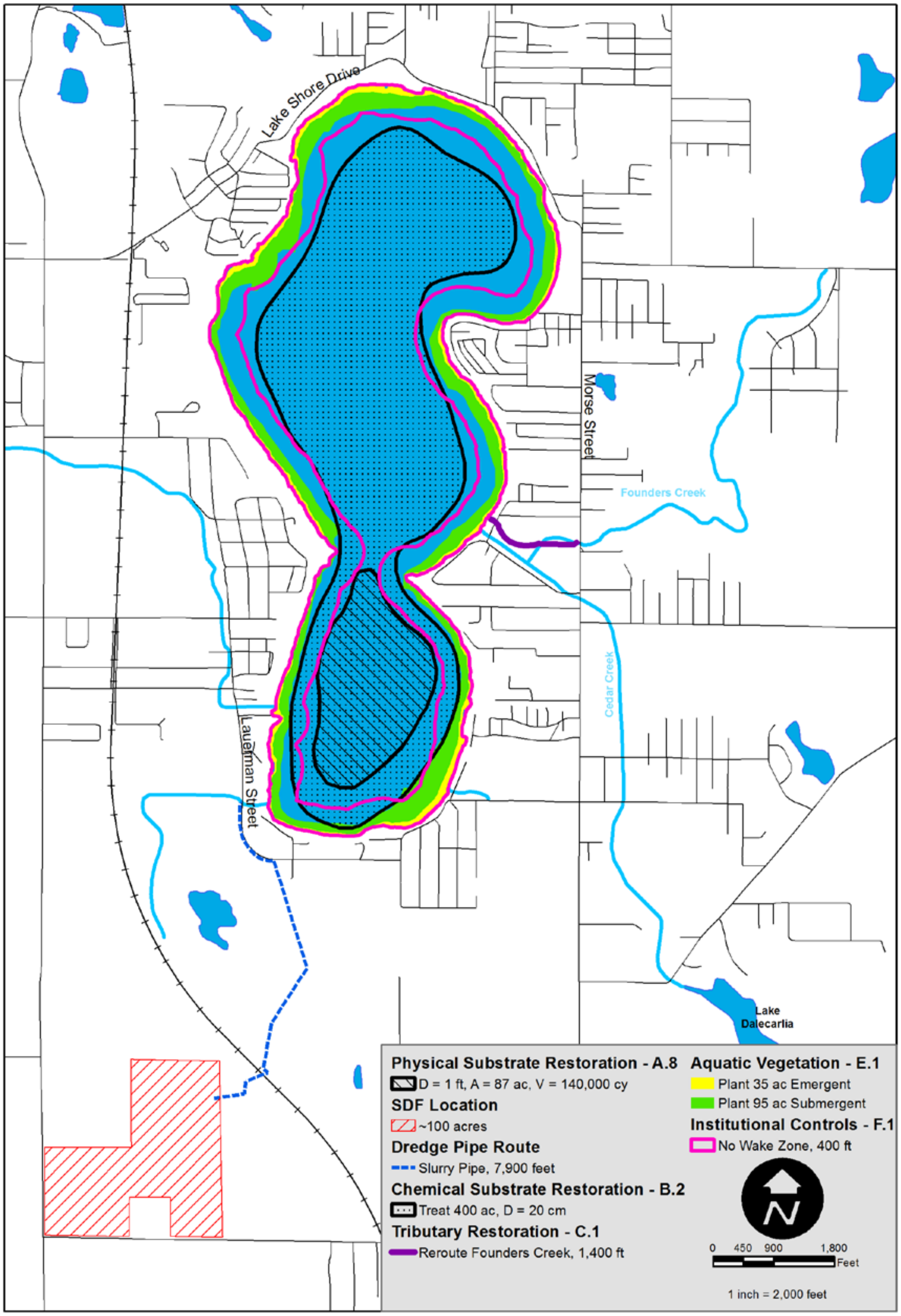

Figure 8: Layout Map of NER Plan

4.7.2 Locally Preferred Plan

Projects may deviate from the NER Plan if requested by the non-Federal sponsor and approved by Assistant Secretary of the Army for Civil Works [ASA(CW)] and are identified as the Locally Preferred Plan (LPP). When the LPP is clearly of less scope and cost and meets the Administration's policies for high-priority outputs, an exception for deviation is usually granted by ASA(CW). The LPP must have greater net benefits than smaller scale plans, and enough alternatives must be analyzed during the formulation and evaluation process to insure that net benefits do not maximize at a smaller scale than the sponsor's preferred plan. If the sponsor prefers a plan more costly than the NER Plan and the increased scope of the plan is not sufficient to warrant full Federal participation, ASA(CW) may grant an exception as long as the sponsor pays the difference in cost between the NER plan and the locally preferred plan. The LPP, in this case, must have outputs similar in kind, and equal to or greater than the outputs of the Federal plan.

The Town of Cedar Lake as the non-Federal sponsor requested that a more costly plan be considered for implementation. The non-Federal sponsor requested that Best Buy Plan 6 (***Figure 9***) be identified as the LPP. The only difference between the LPP and NER Plan is the scale of the physical substrate restoration measure. The LPP includes 263,000 cy of sediment to be removed; this is a 123,000 cy increase (88%) over the NER Plan. Physical removal of sediments would restore spawning habitat for lake species, restore littoral zone habitat for aquatic macrophytes, and restore profundal zone habitat that would provide thermal refuge for fish as well as aquatic macroinvertebrates.

The non-Federal sponsor supports additional physical substrate restoration regardless of the increased incremental cost over the NER Plan. The Town of Cedar Lake and local organizations such as the CLEA have been working towards restoring Cedar Lake for over 40 years and would like to maximize assurance in achieving sustainable project outputs by removing as much fine-grained nutrient rich sediments from the lake as possible. Modeling analyses show that while additional physical substrate restoration produces added habitat output, the rate of habitat output per additional volume of material removed reduces making habitat restoration through physical substrate restoration less efficient by volume.

Regardless of the inefficiency of additional physical substrate restoration over the NER Plan, habitat output is greater, therefore a recommendation to the ASA(CW) to accept the LPP was made with the understanding that the non-Federal sponsor would pay the difference in cost between the NER Plan and the LPP. The LPP policy waiver request was approved.

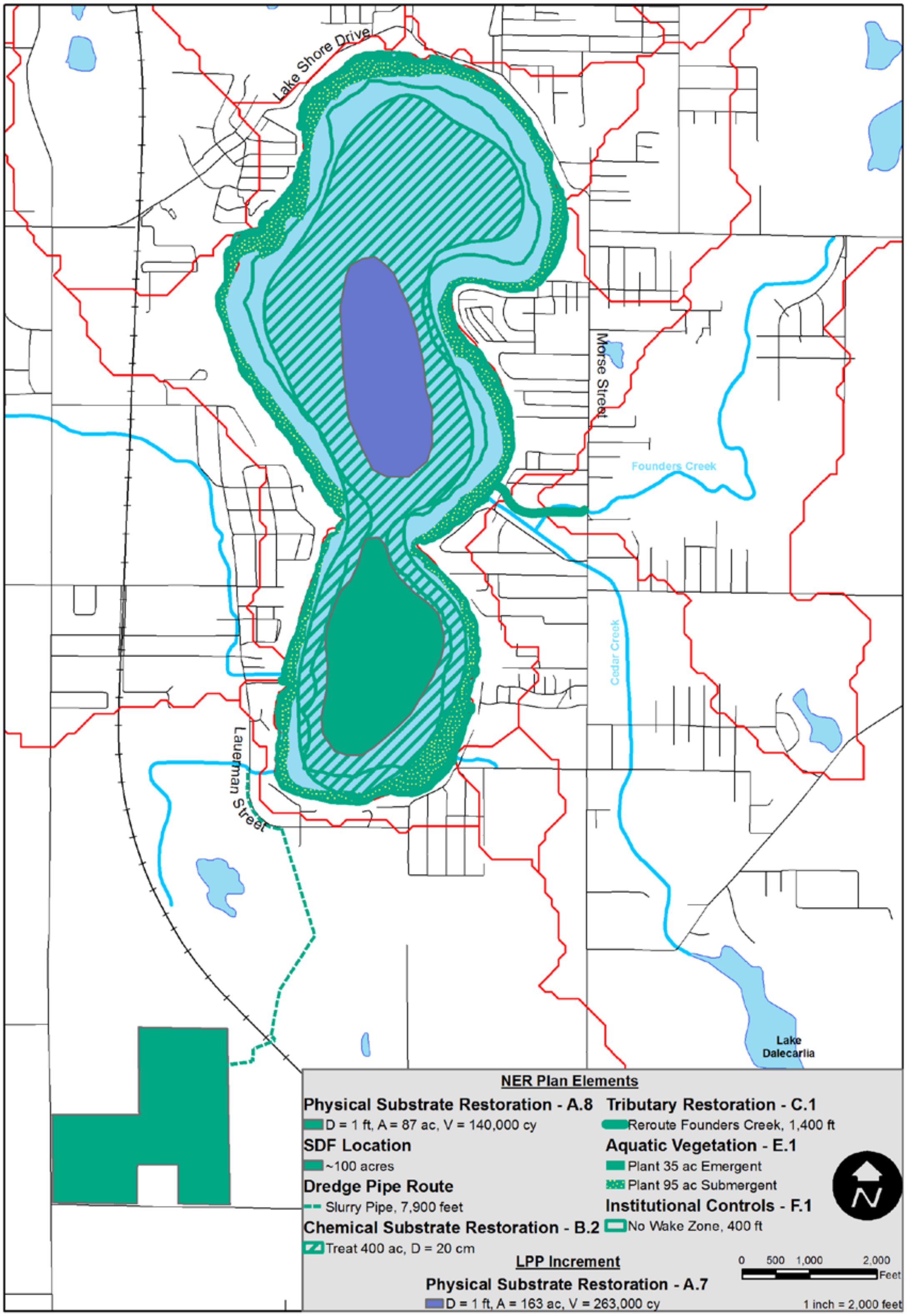

Figure 9: Layout Map of LPP versus NER Plan

4.8 Comparison of NER Plan and LPP

A comparison of NED economic costs and NER habitat outputs for the NER Plan and LPP is summarized in ***Table 14*** below. In addition to presenting the annualized economic costs, first costs are allocated by project purpose. The annualized costs are based on Fiscal Year 2014 Federal Discount rate and are annualized over a 50-year period of analysis. These economic costs include first costs, the cost of IDC, and OMRR&R costs.

Table 14: Summary of Economic Analysis for NER and LPP Plans

	NER Plan (Alt. 5)	LPP (Alt. 6)	Difference
Estimate of Total Project Costs /1			
01 Lands & Damages			
LERRDs	[redacted]	[redacted]	[redacted]
06 Fish & Wildlife Facilities			
SDF	[redacted]	[redacted]	[redacted]
Dredging	[redacted]	[redacted]	[redacted]
SDF Closure	[redacted]	[redacted]	[redacted]
Reroute Founders Creek	[redacted]	[redacted]	[redacted]
Increase No Wake Zone	[redacted]	[redacted]	[redacted]
Alum Treatment	[redacted]	[redacted]	[redacted]
Establish Aquatic Vegetation	[redacted]	[redacted]	[redacted]
Fish Restocking	[redacted]	[redacted]	[redacted]
22 Planning & Feasibility Study /2	[redacted]	[redacted]	[redacted]
30 Planning, Engineering, & Design	[redacted]	[redacted]	[redacted]
31 Construction Management	[redacted]	[redacted]	[redacted]
Total First Costs	[redacted]	[redacted]	[redacted]
Estimate of Annualized Costs			
Annualized First Costs /3	[redacted]	[redacted]	[redacted]
Annualized Interest During Construction	[redacted]	[redacted]	[redacted]
OMRR&R	[redacted]	[redacted]	[redacted]
Total Annualized Costs	[redacted]	[redacted]	[redacted]
Estimate of Benefits			
Habitat Output AAHUs	324.76	349.69	24.93
Cost Per Habitat Output	[redacted]	[redacted]	[redacted]
Incremental Cost Per Output	[redacted]	[redacted]	[redacted]

/1 Estimated project first costs are referenced to 1Q2016 (Oct 2016) price level and includes contingencies.
/2 Costs shared 65% Federal and 35% non-Federal except for FS costs where first $100,000 is 100% Federal and remaining costs are equally shared 50/50 between Federal and non-Federal.
/3 Annualization of costs based on FY14 Federal discount rate of 3 1/2%. Costs associated with-project planning and FS are sunk costs and are not included in the calculation of annualized first costs.

CHAPTER 5 – Environmental Assessment*

This chapter involves prediction of direct, indirect and cumulative environmental effects to current conditions stemming from implementation of the No Action Plan, NER Plan, and LPP.

5.1 Need & Purpose of Proposed Action

Historically, Cedar Lake supported a biologically diverse ecosystem typical of northern glacial lakes. However, modifications to the lake and contributing watershed since the late nineteenth century have resulted in adverse effects to the lake's fringe wetland habitat, littoral zone habitat, lake-bottom substrates, and aquatic species diversity and abundance. Currently, the lake provides only homogenous habitat which does not support even a moderate level of species richness. Based on site inventory and characterization by the PDT, a set of Problems and Opportunities were developed by the PDT, non-Federal sponsor and supporting stakeholders. These drive the need for action, which is summarized as the loss of significant migratory bird, fish and wildlife habitats. The purpose of this FS and integrated environmental assessment is to identify the most environmentally beneficial, cost effective, and publicly supported aquatic habitat restoration project to restore lake, littoral, profundal and riparian habitats. The need and purpose is described in detail in *Section 1.4 Study Background*.

5.2 Alternatives Considered

Se*ction 4.1 Measure Identification & Screening* provides discussion on the suite of measures that were developed to address study problems and meeting objectives. These measure were processed through the IWR Planning Suite program to generate cost effective plans. The cost effective and incremental cost analysis takes implementation and real estate costs and ecosystem outputs into consideration. Ecosystem outputs were measured via trophic state index and biological function. Ten (10) alternative plans, including the No Action Plan, were deemed best case scenarios for project implementation. Alternative Plan 5 was selected as the NER Plan and meets all USACE requirements of cost effectiveness, significance, acceptability, completeness, and efficiency. The non-Federal sponsor requests that a LPP be implemented. Alternative Plan 6 was identified as the LPP. The only difference between the LPP and NER Plan is the scale of physical substrate restoration. The LPP includes 263,000 cy of sediment to be removed, which is an additional 123,000 cy over the NER Plan. Rationale for selecting the NER Plan and LPP is presented in *Section 4.6 Alternative Plan Evaluation* and *Section 4.8 Comparison of NER Plan and LPP*, respectively

- <u>Alternative Plan 0</u> – No action plan
- <u>Alternative Plan 1</u> – Institutional controls (F.1)
- <u>Alternative Plan 2</u> – Chemical substrate restoration (B.1) to a depth of 10 cm and institutional controls (F.1)
- <u>Alternative Plan 3</u> – Chemical substrate restoration (B.2) to a depth of 20 cm and institutional controls (F.1)
- <u>Alternative Plan 4</u> – Chemical substrate restoration (B.2) to a depth of 20 cm, rerouting Founders Creek (C.1) and institutional controls (F.1)

- Alternative Plan 5 – Physical substrate restoration (A.8) – removal of 140,000 cy of sediment, chemical substrate restoration (B.2) to a depth of 20 cm, rerouting Founders Creek (C.1), littoral zone restoration (E.1), Institutional controls (F.1) – extend No Wake Zone from 200 ft to 400 ft, and fish community management (G.1)
- Alternative Plan 6 – Alternative Plan 5 with additional physical substrate restoration (A.7) – removal of 263,000 cy of sediment
- Alternative Plan 7 – Alternative Plan 6 with additional institutional controls (F.2) – increase No Wake Zone to entire lake and restrict boat horse power
- Alternative Plan 8 – Alternative Plan 7 with additional physical substrate restoration (A.4) – removal of 362,000 cy of sediment
- Alternative Plan 9 – Alternative Plan 7 with additional physical substrate restoration (A.1) – removal of 717,000 cy of sediment.

5.3 The Affected Environment

The affected environment is described in detail in *Chapter 3 – Inventory & Forecasting*. Based on data collections, analysis, and modeling conducted under this FS and coordination with Federal, State, and Local governmental agencies and published studies by academia, it was determined that the physical, chemical, and biological conditions of Cedar Lake are projected to remain static. Efforts by the Town of Cedar Lake are expected to reduce sediment and nutrient loadings to Cedar Lake. However, previous restoration efforts have not dealt with the legacy effects of habitat degradation and the lake's ecosystem is expected to continue to function significantly below its ecological potential with a continued loss of species diversity and abundance. The No Action Alternative conditions are synonymous with the Future Without-Project Conditions, which are presented in *Section 2.2 Future Without Project Condition*.

5.4 Direct & Indirect Effects of the NER Plan and LPP

5.4.1 Physical Resources

Geology:

Cedar Lake lies atop the Valparaiso Moraine of which the upper layer of glacial deposit consists of clay/loam material with intermittent deposits of sand and gravel. Beneath this deposit is a layer of glacio-fluvial sands, which the bottom of Cedar Lake does not reach. For the most part, the geology of the Cedar Lake watershed is intact. Extreme modifications were made to the lake itself in the 1870s when a channel was cut through the glacial ridges that impounded the lake on the east side, subsequently lowering the lake approximately 12 feet for the purpose of reclaiming about 200 acres of wetland at the south end of the lake. The lake morphology has also been modified due to the influx of fine-grained nutrient rich sediments stemming from agricultural practices and urbanization.

Neither the NER Plan nor the LPP are expected to have adverse effects to geology; however, beneficial impacts are expected. Physical substrate restoration as part of the NER Plan and LPP would likely have beneficial effects on abiotic and biotic function within Cedar Lake. Specifically, macroinvertebrates, fish, and aquatic macrophytes would benefit from physical substrate restoration. Physical substrate restoration would eliminate some of the fine-grained nutrient-rich sediment at the bottom of the lake, which would help restore spawning habitat for lake species, aid in the restoration of littoral zone aquatic macrophytes, and help restore profundal zone habitat.

Construction of the SDF, as part of both the NER Plan and LPP, would not be deep enough or large enough to affect any geologic features or processes; therefore, no adverse effects to geology are expected from utilizing the SDF site.

The staging area, as part of both the NER Plan and LPP, would not require excavation; therefore, no adverse effects to geology are expected from utilizing this location.

The pipeline used to transport dredge material from the offloading area to the SDF will for the most part be placed on grade, requiring no excavation which could affect geology. Excavation will be required to place the pipeline underneath a 2-lane road (Lauerman St.). Geology has already been disrupted at this location with the construction of the road. Adverse impacts to geology are not expected as a result of placing the pipeline underneath the road. In addition, the placement of the pipeline will be temporary in duration and once the pipeline is removed all areas will be restored.

<u>Soils:</u>

Historically, the Cedar Lake watershed was mostly depressional with limited physical features that allowed flow to leave the basin. Therefore, the soils within the basin are predominately dark and poorly drained. Primary soil types include Carlisle muck, Blount silt loam, Elliot silt loam, Milford silt loam, Morley silt loam, Pewamo silty clay loam, and urban fill. Soils within the watershed have been disturbed by extensive agricultural practices ongoing over the last 100-years. Physical substrate restoration, as part of both the NER Plan and LPP, is not expected to affect the integrity of the soils within the lake. Physical substrate restoration would target fine-grained nutrient rich sediments that accumulated in the lake over time as a result of runoff from nearby agricultural fields and urbanization; therefore, no adverse effects are expected.

The NER Plan and LPP are expected to adversely affect soils that occur at the existing site where the SDF would be excavated and constructed. A soil survey performed by CBBC in May 2008 revealed the presence of hydric soils at the proposed SDF location (refer to *Appendix D – Geotechnical*). However, though isolated hydric soils were found, the site was formerly formed and no longer contains wetland vegetation; therefore, the top horizon of the soils has likely already been altered but additional horizons of the soils could also be impacted with the excavation of the SDF site. The majority of the soils to be affected would likely be Morley silt loam soils that are typical of native deciduous hardwood forest. Although adverse effects to soils are expected from utilizing this site, the ecosystem restoration benefits to be achieved through implementation of the NER Plan or LPP at Cedar Lake are considered to outweigh the loss of 114 acres of predominantly Morley soils.

The staging area, as part of both the NER Plan and LPP, would not require excavation that may impact soils; therefore, no adverse effects to soils are expected from utilizing this location.

Excavation will be required to place the dredge material transport pipeline underneath a 2-lane road (Lauerman St.); however, soils have already been disrupted at this location with the construction of the road. Therefore, adverse impacts to soils are not expected. In addition, the placement of the pipeline will be temporary in duration and once the pipeline is removed all areas will be restored.

Hydrology:

The hydrology of the Cedar Lake watershed has been significantly altered from presettlement conditions. Most rainwater that falls is drained away by agricultural ditches and drain tiles. There remains enough infiltration to maintain current volumes of water in Cedar Lake and the adjoining marsh, but there has been reduction in baseflow to Cedar Lake within the watershed.

The NER Plan contains no measures that would adversely or beneficially affect the hydrology of the Cedar Lake watershed. Both the NER Plan and LPP contain the rerouting of Founders Creek back to Cedar Lake which would have a beneficial impact on hydrology within the Cedar Lake watershed. The rerouting of Founders Creek back to its historic channel and outlet would provide an additional clean water source to Cedar Lake during dry summer conditions.

The SDF location, as part of both the NER Plan and LPP, has two drainage ditches. The ditches were excavated to collect flow from road side ditches as well as drain the agricultural land. There is potential that the two ditches may need to be relocated pending final design of the SDF treatment cells. Although the ditches may require relocation, stormwater flow capacity for the relocated ditches would be equivalent to what it is currently; therefore, no long-term adverse effects to hydrology are expected.

The staging area, as part of both the NER Plan and LPP, does not include any aquatic resources; therefore, no adverse effects to hydrology are expected.

The dredged material transport pipeline is expected to primarily follow Lauerman Street/West 147th Ave and a drainage ditch adjacent to Cedar Lake Marsh. The path of the pipeline then briefly transects through the southwest corner of Cedar Lake Marsh before entering the SDF location; however, full design of the transport pipeline has not been completed at this stage of the FS. As stated above, the majority of the pipeline is expected to be placed along an existing ditch that runs adjacent to the wetland area so as to minimize any adverse impacts to hydrology. The pipeline may be placed above grade where it is expected to be unable to follow the existing ditch. Any impacts to hydrology due to placement of the pipeline are expected to be temporary in duration since it will be removed after the completion of dredging activities. Additionally, once the pipeline is removed all areas will be restored; therefore, no long-term adverse impacts to hydrology are expected.

Air Quality:

Construction activities, as part of both the NER Plan and LPP, are expected to have a short-term and relatively minor adverse impact on local air quality. Due to the small scale and short duration of this project, the main sources of emissions would be from construction equipment such as the dredge and from vehicles entering and exiting the SDF site as well as dust associated with the construction activities. Slight elevations in local concentrations of oxides of nitrogen, carbon monoxide, oxides of sulphur, and particulates, which include both visible (smoke) and nonvisible emissions are expected. Both the NER Plan and LPP do not include any stationary sources of air emissions, and a General Conformity Analysis was not completed. The temporary mobile source emissions from this project are de minimis in terms of the National Ambient Air Quality Standards and the State Implementation Plan. All construction vehicles will comply with Federal vehicle emission standards.

Overall, on the local and regional levels, the daily emissions associated with-project construction, either NER Plan or LPP, would be almost negligible. Sensitive receptors in the project area, including residents and wildlife, would not be significantly impacted. All construction related activities on unpaved roadways would include dust suppression and control measures, such as watering, as necessary to limit fugitive dust emissions. Since dredged material from the lake to the SDF would be pumped by hydraulic means, air emissions would be significantly reduced. Moreover, because the sediments to be dredged are moist and saturated, dust emissions during dredging would be minimal. The SDF will be monitored during drying activities to ensure dust is controlled, and dust suppression and control measures used as necessary. The SDF site will be stabilized using vegetation as soon as practicable.

<u>Water Quality:</u>

Data collected at Cedar Lake between 2005 and 2007 met the General Use water quality standards for the State of Indiana. The lake exhibits fluctuations in nutrient concentrations depending on the season and water temperature, with elevated concentrations of total phosphorous found in the spring and fall.

Both short-term impacts and long-term improvements in water quality are anticipated as part of both the NER Plan and LPP. In the short-term, turbidity is expected to increase during dredging (i.e., physical substrate restoration measure) and return waters from treated effluent may temporarily increase phosphorous concentrations in the lake, depending on NPDES discharge limitations imposed by the State. However, long-term water quality benefits, following completion of substrate restoration measures, are expected as a result of implementation of the NER Plan or LPP. Both the NER Plan and LPP contain proposed restoration measures such as physical substrate restoration, chemical substrate restoration, littoral macrophyte restoration, and fish community management which are expected to reduce the amount of suspended solids and phosphorous in the water column, remove algal propagules in the southern basin, reduce turbidity by stabilizing the shoreline with vegetation, reduce bioturbation by removal of invasive fish species [e.g., Common Carp] and improve water quality by removing the fine-grained nutrient rich sediments that are constantly suspended from boat action and wave dynamics. While implementing the chemical substrate restoration measure, as part of the NER Plan and LPP, a combination of aluminum sulfate and sodium aluminate will be used to control the pH of Cedar Lake and reduce temporary water quality impacts, depending on alkalinity at the time of application.

Prior to implementation of components of the NER Plan or LPP, a one-time application of Rotenone would be carried out by the non-Federal sponsor and IDNR. It will remove and/or reduce abundance of all fish species, but the primary target is the reduction of Common Carp and White Perch. Rotenone is a natural substance that is registered for use by the USEPA. Research shows that the product does not constitute a health hazard or have a long-term effect on humans or the environment. Rotenone is not expected to have any short-term or long-term effects on water quality within Cedar Lake, since the piscicide works directly on fish by inhibiting a process at the cellular level making it impossible for fish to use the oxygen absorbed in the blood and needed in the release of energy during respiration. Rotenone dissipates fairly rapidly within a system, with half-lives of 20 and 1.5 days under cold water and warm water conditions, respectively. Additionally, Rotenone can be readily deactivated through the use of oxidizing agents, such as potassium permanganate.

Additionally, both the NER Plan and LPP contain the rerouting of Founders Creek which could have ancillary water quality benefits both within the creek and Cedar Lake. With the rerouting of Founders Creek, riffle/pool sequences would be restored which would in turn likely reduce turbidity by allowing entrained fines to settle out in the pools. The rerouting of Founders Creek is also expected to provide an additional clean water source to Cedar Lake during dry summer months.

The SDF location, as part of both the NER Plan and LPP, has two drainage ditches. The ditches were excavated to collect flow from road side ditches as well as drain the agricultural land. Although there is potential that the two ditches may need to be relocated pending final design of the SDF treatment cells, water quality within the two ditches is not expected to be affected adversely since these are man-made drainage ditches and flow within them is dependent upon storm water runoff, and neither the NER nor LPP will affect source flows.

The staging area, as part of both the NER Plan and LPP, does not affect aquatic resources; therefore, no adverse effects to water quality are expected.

The dredged material transport pipeline is expected to primarily follow Lauerman Street/West 147th Ave and a drainage ditch adjacent to Cedar Lake Marsh. The path of the pipeline then briefly transects through the southwest corner of Cedar Lake Marsh before entering the SDF location; however, full design of the transport pipeline has not been completed at this stage of the FS. As stated above, the majority of the pipeline is expected to be placed along an existing ditch that runs adjacent to the wetland area so as to minimize any adverse impacts to water quality. The pipeline may be placed above grade where it is expected to be unable to follow the existing ditch. Any adverse impacts to water quality due to placement of the pipeline would be temporary in duration since it would be removed after the completion of dredging activities. Additionally, once the pipeline is removed all areas would be restored; therefore, no long-term adverse impacts to water quality are expected.

<u>Sediment Quality:</u>

Cedar Lake has suffered the effects of cultural eutrophication. Decades of nutrient loading from agricultural and urban runoff has enriched the sediments. Typically, an inland lake like Cedar

Lake would have natural sand and gravel substrate; however, this natural substrate has been covered by several feet of fine silts and clays that have accumulated over the years.

No adverse impacts are expected to sediment quality as a result of implementation of either the NER Plan or LPP. Implementation of either plan is expected to only improve the quality of sediment resources within Cedar Lake. Physical substrate restoration operations as part of the NER Plan and LPP will remove fine-grained nutrient rich sediments as well as some of the algal propagules that increase the number of nuisance algal blooms present in the lake, resulting in a benefit to sediment quality. Remaining lake sediments will be treated with alum, as part of the NER Plan and LPP, which will result in a firmer, inert lake bottom that will further benefit sediment quality within Cedar Lake. Finally, the introduction of aquatic vegetation as part of the NER Plan and LPP will remove nitrogen and phosphorous from the lake bed benefitting sediment quality.

Both the NER Plan and LPP also include an institutional control measure which would extend the No Wake Zone from 200 feet to 400 feet. This measure would benefit sediment quality by reducing the resuspension of fine-grained nutrient rich sediments by boat motors.

Hazardous, Toxic, & Radioactive Wastes:

There is little potential for either the NER Plan or LPP (including the staging area, pipeline and SDF) to impact any HTRW in the project area and any HTRW occurrences are not expected to impact implementation of either project.

Review of existing information and completion of database research, historical aerial photo review, telephone interviews, and a site visit, conducted as part of the HTRW investigation suggest that it is unlikely that HTRW or non-HTRW issues exist on the proposed upland SDF site. The following recommendations should be considered during the design and implementation phases of the project:

- Soils excavated from the project site should be reused to the maximum extent possible.

- The construction plans should require the proper disposal of all debris removed from the SDF site in accordance with Local, State, and Federal laws and regulations.

Review of existing information and historical aerial photographs suggest that a portion of Cedar Lake Marsh, downstream from the proposed SDF location and outside of the project limits, may have been impacted by previous automotive junkyard activities, a damaged transformer, and placement of industrial waste in open water wetlands. Results of two Phase II investigations suggest that polynuclear aromatics (PNAs) are present in the groundwater in a portion of Cedar Lake Marsh above the IDEM RISC residential and/or industrial default closure values. The contaminants appear to be isolated to the wetland fill area and have not migrated into surrounding groundwater or impacted adjacent sediments. A detailed investigation is included in *Appendix F – HTRW Investigation*.

5.4.2 Ecological Resources

Plant Communities:

Plant communities within Cedar Lake are currently highly degraded. Over 95% of the lake is devoid of aquatic macrophytes and the riparian zone consists of predominately mowed lawns. The NER Plan and LPP are not expected to have any adverse effects to the remaining portion of native vegetation within Cedar Lake or Cedar Lake Marsh. Both the LPP and NER Plan contain a littoral macrophyte restoration measure which is expected to benefit plant communities within Cedar Lake by restoring approximately 130 acres of native aquatic macrophytes. Cedar Lake Marsh is currently healthy and supports a diverse array of aquatic macrophytes. All of the proposed alternative plans are not expected to have short or long-term adverse effects on the marsh. The fish community management measure includes the application of a piscicide, known as Rotenone, to the marsh to remove Common Carp and White Perch. Rotenone is a natural substance that does not affect aquatic macrophytes. This measure is expected to benefit aquatic macrophytes by eliminating Common Carp that continually root in the substrates and vegetation thereby physically removing plants. Common Carp are also capable of creating a great degree of turbidity when rooting in the substrates for food, which in turn inhibits aquatic vegetation growth by precluding sunlight needed for photosynthesis.

Additionally, both the NER Plan and the LPP contain an institutional control measure which would extend the current No Wake Zone from 200 ft to 400 ft. This measure is expected to benefit plant communities by reducing wave disturbance during plant establishment and by reducing the destruction of aquatic macrophytes by propeller induced wave action.

High quality plant communities do not exist at the proposed SDF site, for both the NER Plan and LPP, because the current land use is agriculture. Therefore, no adverse effects or beneficial effects are expected to plant communities as a result of construction of the SDF site.

The staging area as part of the NER Plan and LPP is essentially barren land adjacent to Cedar Lake on the southwest corner and is used by a marina. The area is a mixture of mowed turf grass and crushed gravel; therefore, no impacts to plant communities are expected from use of this site since no high quality plant communities exist here.

The pipeline used for dredged material transport for both the NER Plan and LPP plan is expected to primarily follow Lauerman Street/West 147th Ave and a drainage ditch adjacent to Cedar Lake Marsh. The pipeline is then expected to briefly cut through the southwest corner of Cedar Lake Marsh before entering the SDF location. However, full design of the transport pipeline has not been completed at this stage of the FS. Overall, the transport pipeline is not expected to come into contact with any high quality plant communities along Lauerman Street/West 147th Ave and the drainage ditch due to these being man-made. The pipeline may be placed above grade where it is expected to be unable to follow the existing road or ditch, so as to limit any potential adverse impacts to high quality plant communities within the small portion of Cedar Lake Marsh that the pipeline is expected to transect. Any adverse impacts to plants are expected to be temporary in duration since it would be removed after the completion of dredging activities.

Additionally, once the pipeline is removed all areas would be restored; therefore, no long-term adverse impacts to plant communities are expected.

Aquatic Communities:

The aquatic communities that once flourished within Cedar Lake are all but gone. One species of aquatic macrophyte, spatter dock, and a few species of fish [Brown Bullhead, Yellow Perch, and Northern Pike] remain in a very limited abundance. The extreme eutrophication of the lake, due to high amounts of fine-grained nutrient rich sediments, has created conditions where vegetation and glacial lake fish cannot exist. The NER Plan and LPP would not have adverse effects on the currently degraded aquatic ecosystem. Restoration plans were formulated to eliminate existing impairments and restore the lake habitat to a sustainable aquatic ecosystem.

Prior to implementation of components of the NER Plan or LPP, a one-time application of Rotenone would be carried out by the non-Federal sponsor and IDNR. It will remove and/or reduce abundance of all fish species, but the primary target is the reduction of Common Carp and White Perch. Based on fish surveys, the abundance of these species makes up 99% of the current fish biomass. Effectiveness of Rotenone can vary depending on depth of waterbody, volume of waterbody, and dosage; therefore, the complete eradication of all target species may not be feasible. The eradication of the current fish population within Cedar Lake will be a pre-existing condition. The NER Plan and LPP both contain a fish community management measure that includes the stocking of native fish species into Cedar Lake in order to reestablish a native glacial lake fish community. This measure would benefit aquatic communities by reestablishing a native fishery.

Both the NER Plan and LPP also include the application of alum (Aluminum sulfate – $Al_2(SO_4)_3$) in conjunction with dredging areas containing the highest concentrations of fine-grained nutrient rich sediments in order to restore native glacial fishes. Alum treatments have been successfully used in lakes throughout the world for decades. It is well documented that, when applied properly, alum does not adversely affect benthic, plant and fish communities. In fact, studies have shown that alum treatments throughout the United States and Europe showed a marked increase in species diversity and abundance of native invertebrates, fishes and plants after treatments (Smeltzer 1999, Roy 1999). The longevity of the treatment is dependent upon lake conditions including external inputs, lake depth, lake stratification, wave forces, aquatic vegetation and prevailing benthic fish community. As for Cedar Lake, there is a high likelihood of success given external physical factors are being managed and projected to reduce over time, various restoration measures implemented under both the NER Plan and LPP support nutrient inactivation (physical substrate restoration and fishery management), and the lake has favorable pH and stratification parameters. It will be important to prevent the colonization or keep abundance to a minimum of Eurasian Watermilfoil (*Myriophyllum spicatum*) since this aquatic vegetation species can resuspend sediments back into the water column even with an effective alum treatment implemented.

The NER Plan and LPP also include an institutional control measure which would extend the current No Wake Zone from 200 ft to 400 ft. This would benefit aquatic macroinvertebrate communities by reducing forced detachment of aquatic macroinvertebrates from lake bed substrates and reducing disturbance of aquatic macroinvertebrates trying to colonize the littoral zone.

The SDF location, as part of both the NER Plan and LPP, includes two drainage ditches. The ditches were excavated to collect flow from road side ditches as well as drain the agricultural land. It is not likely that there are any high quality aquatic communities present within the drainage ditches due to them being man-made and dependent upon storm water runoff for flow. If any fish are present they would be able to move away from any construction activity and would be able to recolonize fairly rapidly after completion of construction activities. Aquatic macroinvertebrates that may be present within the drainage ditches could potentially be impacted; however, if present these communities are likely composed of undesirable and pollution tolerant species. The impact would also be minimal and these species are expected to rapidly recolonize after completion of construction activities. Overall, aquatic communities that may be within the two drainage ditches are not expected to be affected adversely for the long-term.

The staging area, as part of both the NER Plan and LPP, does not contain aquatic resources; therefore, no adverse effects to aquatic communities are expected.

The dredged material transport pipeline is expected to primarily follow Lauerman Street/West 147th Ave and a drainage ditch adjacent to Cedar Lake Marsh. The path of the pipeline then briefly transects through the southwest corner of Cedar Lake Marsh before entering the SDF location; however, full design of the transport pipeline has not been completed at this stage of the FS. As stated above, the majority of the pipeline is expected to be placed along an existing ditch that runs adjacent to the wetland area so as to minimize any adverse impacts to aquatic communities. The pipeline may be placed above grade where it is expected to be unable to follow the existing. Any potential adverse impacts to aquatic communities would be temporary in duration since the pipeline would be removed after the completion of dredging activities. Additionally, once the pipeline is removed all areas would be restored; therefore, no long-term adverse impacts to aquatic communities are expected.

<u>Birds:</u>

The western shoreline of Lake Michigan is recognized as "one of the most important flyways for migrant songbirds in the United States by many ornithologists and birdwatchers worldwide" (Shilling and Williamson) and is considered globally significant. An estimated 325 bird species use the north-south shoreline of Lake Michigan as their migratory sight line. Areas restored near the southern tip of Lake Michigan could provide migrants with high calorie, high protein seeds, fruits, and insects along with shelter from severe weather and predators. Restored habitat along this urbanized migratory route can reduce the stress of migration allowing migrants to reach their destinations.

The most critical factors for breeding birds are habitat availability and habitat quality, both of which are in decline at Cedar Lake and other remaining natural areas within northwestern Indiana. Records show that 73 avian species either nest or forage in the inland wetland complexes of the Lake Michigan basin in northwestern Indiana during breeding season. Among those are several species listed on Indiana's endangered species list including American Bittern, Least Bittern, Henslow's Sparrow (*Ammodramus henslowii*), Black-crowned Night-heron, and Sedge Wren (*Cistothorus platensis*). Others among the list include Gray Catbird (*Dumetella caolinensis*), Brown Thrasher (*Toxostoma rufum*), Cedar Waxwing (*Bombycilla cedrodrum*), Sora (*Porzana carolina*), Northern Harrier (*Circus cyaneus*), Yellow Warbler (*Dendroica petechia*), Northern Cardinal (*Cardinalis cardinalis*), Eastern Towhee (*Pipilo erythrophthalmus*), American Goldfinch (*Carduelis tristis*), Eastern Meadowlark (*Sturnella magna*), Red-tailed Hawk (*Buteo jamaicensis*), Virginia Rail (*Rallus limicola*), and the American Woodcock (*Scolopax minor*).

Both the NER Plan and LPP would increase the amount of high quality habitat available for migratory birds. The restoration of fringe wetland and littoral zone aquatic macrophytes would provide increased foraging and stopover habitat as well as breeding habitat for birds. Therefore, only beneficial effects for birds are expected as a result of implementation of the NER Plan or LPP.

High quality habitat does not exist at the proposed SDF site, for both the NER Plan and LPP, because the current land use is agriculture. Avian species do not likely utilize this area due to the lack of foraging and shelter habitat; therefore, no adverse effects or beneficial effects are expected towards avian species as a result of construction of the SDF site.

The staging area as part of the NER Plan and LPP is a 1 acre parking lot adjacent to Cedar Lake on the southwest corner. The parking lot is currently comprised of crushed gravel with no vegetation, and provides no foraging or shelter habitat for birds; therefore, no impacts to birds are expected from use of this site.

The dredged material transport pipeline is expected to primarily follow Lauerman Street/West 147th Ave and a drainage ditch adjacent to Cedar Lake Marsh. The path of the pipeline then briefly transects through the southwest corner of Cedar Lake Marsh before entering the SDF location; however, full design of the transport pipeline has not been completed at this stage of the FS. As stated above, the majority of the pipeline is expected to be placed along an existing ditch that runs adjacent to the wetland area so as to minimize any adverse impacts to habitats that might be used by birds. The pipeline may be placed above grade where it is expected to be unable to follow the existing. Any adverse impacts to avian species due to placement of the pipeline are expected to be temporary in duration since it would be removed after the completion of dredging activities. Additionally, once the pipeline is removed all areas would be restored; therefore, no long-term adverse impacts to birds are expected.

<u>Threatened and Endangered Species:</u>

Preliminary consultation with the USFWS under Section 7 was documented in a letter dated 20 November 2007. The proposed project is within the range of the Federally endangered Indiana Bat (*Myotis sodalis*) and Karner Blue Butterfly (*Lycaeides melissa samuelis*); and the threatened Northern Long-eared Bat (*Myotis septentrionalis*), Pitcher's Thistle (*Cirsium pitcheri*) and Mead's Milkweed (*Asclepias meadii*). There is no habitat in the Cedar Lake watershed for the Karner Blue Butterfly or Pitcher's Thistle. There may be suitable summer nursery habitat for the Indiana Bat and Northern Long-eared Bat within the general area, such as along Founders Creek and

Cedar Creek where forested riparian habitat is present. Mead's Milkweed has been reestablished at Biesecker Prairie State Nature Preserve several miles northwest of Cedar Lake and outside the lake's watershed. Although the rich prairie soils on the west uplands above Cedar Lake are suitable for this species, there are no known potential restoration sites at this time.

As discussed in *Section 2.1.2 Ecological Resources, Birds* and *Section 2.1.2 Ecological Resources, Threatened and Endangered Species*, a Whooping Crane was identified at Cedar Lake in 2013. The species is considered Federally endangered when found within its current range (i.e., Canada to Texas). However, the individual observed at Cedar Lake was likely from a population of Whooping Cranes reintroduced outside of their current range but within their historic range (i.e., Wisconsin to Florida). They are labeled as "non-essential" per Section 10 of the Endangered Species Act because they were reintroduced. The reintroduced Whooping Cranes are the same genus and species as the population listed as Federally endangered and are afforded protection under the Endangered Species Act through the prohibitions of Section 9 and the requirements of section 7.

Besides the Whooping Crane as discussed above, there are no Federally endangered or threatened species, or their critical habitats within the Cedar Lake study area. Based on this, there would be no adverse effects to Federally listed species resulting from implementation of the LPP.

5.4.3 Archaeological and Cultural Resources

<u>Archaeological & Cultural Properties:</u>

The NER Plan and LPP (including the staging area, pipeline and SDF) will have no significant adverse effects to archaeological resources. A Phase I archaeological survey conducted in 2007 showed no evidence of historic or archaeological resources within the project area. No further investigations were recommended. The Indiana Historic Preservation officer has concurred with this determination in a letter dated 3 July 2006. Consultations were conducted with Native American Tribes in a letter dated 22 January 2007.

The Miami Tribe of Oklahoma provided a response on July 10, 2007 to the USACE consultation letter (Appendix O – Coordination). The letter stated that the Cedar Lake aquatic ecosystem restoration project is located within the aboriginal homelands of the Miami Nation. Therefore, it is possible that Miami human remains and/or cultural items falling under the Native American Graves Protection and Repatriation Act (NAGPRA) could be discovered during project construction. If human remains or NAGPRA items are discovered, the Miami Nation as well as the Indiana State Historic Preservation Office should be notified immediately so that consultation may be initiated. No other responses were received.

Both the NER Plan and LPP will have no significant adverse effects to cultural resources in the Cedar Lake area. If cultural resources are discovered, consultation will begin immediately with the Indiana Historic Preservation Office as well as Native American Tribes.

Social Properties:

Schools – The Town of Cedar Lake contains two elementary schools, Jane Ball Elementary School and Douglas MacArthur Elementary School. The local high school is Hanover Central High School.

Hospitals – There are no hospitals in Cedar Lake, Indiana. The closest hospital care is available in the City of Crown Point, located approximately 5 miles to the northeast of Cedar Lake.

The proposed project area, for both the NER Plan and LPP (including the staging area, pipeline and SDF), could see increased traffic congestion during construction; however this should be localized and intermittent. Noise levels will increase during construction of the SDF, proposed under both the NER Plan and LPP, due to increased truck and heavy equipment, but both traffic and noise increases would be temporary. Based on field testing and the planned recreational end use of the SDF site, it is projected that sediment disposal activities would have no significant adverse effects to human health, social welfare, water supplies, recreation, property values or aesthetics. Local employment should increase slightly during implementation of the project.

Prime Farmlands:

The SDF portion of the NER Plan and LPP would convert approximately 114 acres of farmland ultimately to park land. In consultation with the Natural Resource Conservation Service (NRCS), the Farmland Protection Policy Act is not applicable since the land designated for the SDF has been annexed by the Town of Cedar Lake and is already committed to urban development [Section 2 (c) (1)A 7 USC 4201].

Environmental Justice:

Both the NER Plan and LPP 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 USEPA EJView mapping tool (accessed 6 March 2014), revealed that within the portion containing the Cedar Lake project site, 0-20% of the population is considered below the poverty line and 0-10% of the population is considered a minority. Since the overall project and both the NER Plan and LPP are considered ecosystem restoration and will only benefit the surrounding environment and communities, no adverse effects to any minority populations and/or low income populations are expected.

17 Points of Environmental Quality:

As specified by Section 122 of Rivers, Harbors & Flood Control Act of 1970 (P.L. 91-611), seventeen environmental quality categories of impacts were reviewed and considered in arriving at the final determination. As laid out in ***Table 15*** the following categories were considered: noise, displacement of people, aesthetic values, community cohesion, desirable community growth, tax revenues, property values, public facilities, public services, desirable regional growth, employment, business and industrial activity, displacement of farms, man-made resources, natural resources, air and water. Long term significant impacts from the preferred alternative plan to these identified points are not expected. Temporary minor impacts from construction activities would occur in some categories.

Table 15: Environmental Quality Effects Considered

	PREFERRED ALTERNATIVE PLAN						
	BENEFICIAL				ADVERSE		
CATEGORY	SIGNIFICANT	SUBSTANTIAL	MINOR	NO EFFECT	MINOR	SUBSTANTIAL	SIGNIFICANT
NOISE					T		
DISPLACEMENT OF PEOPLE				X			
AESTHETIC VALUES		X			T		
COMMUNITY COHESION				X			
DESIRABLE COMMUNITY GROWTH				X			
TAX REVENUES				X			
PROPERTY VALUES		X					
PUBLIC FACILITIES				X			
PUBLIC SERVICES				X			
DESIRABLE REGIONAL GROWTH			X				
EMPLOYMENT			T				
BUSINESS & INDUSTRIAL ACTIVITY				X			
DISPLACEMENT OF FARMS			X				
MAN-MADE RESOURCES				X			
NATURAL RESOURCES		X					
AIR					T		
WATER		X			T		

X = NER Plan and LPP
T = Temporary Effect

5.5 Cumulative Effects of Alternative Plans

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 USEPA (USEPA 315-R-99-002). This guidance provides an eleven-step process for identifying and evaluating cumulative effects in NEPA analyses.

5.5.1 Scope of Cumulative Effects Analysis

Through this environmental assessment, the cumulative effects issues and assessment goals are established, the spatial and temporal boundaries are determined, and the reasonably foreseeable future actions are identified. Cumulative effects are assessed to determine if the sustainability of any of the resources is adversely affected with the goal of determining the incremental impact to key resources that would occur should the proposal be permitted. The spatial boundary for the assessment has been broadened to consider watershed effects. 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. For this analysis, the spatial boundary is the entire Cedar Lake watershed. Since Cedar Lake lies at the outlet of the watershed, almost any action within it has the potential to affect the lake.

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* – 2016 when the decision is being made on the most beneficial ecological restoration.
- *Future* – 2066, the year used for determining project life end, although the ecological restoration should last until a geologic event disturbs the area.

Projecting the reasonably foreseeable future actions is difficult. The proposed action (ecosystem restoration) is reasonably foreseeable; however, the actions by others that may affect the same resources are not as clear. Projections of those actions must rely on judgment as to what are reasonable based on existing trends and where available, projections from qualified sources. Reasonably foreseeable does not include unfounded or speculative projections. Some future projections were taken from the recently completed Cedar Lake Comprehensive Plan (Cedar 2007). In this case, reasonably foreseeable future actions include:

- Further improvements in water quality due to large-scale projects, small best-management practices, laws and policies, and education
- Further improvements in aquatic and riparian habitat within the watershed and surrounding area
- Further improvements in natural area connectivity

5.5.2 Cumulative Effects on Resources

The plan formulation process took into account existing and planned projects, studies and known ecological restoration projects near the study area. Prior studies and reports, listed in *Section 1.6 Prior Studies and Reports* were reviewed to ensure that the modeled conditions are the best possible representation of actual conditions. The *Section 4.6.2 Significance of Ecosystem Outputs, Technical Recognition* also takes existing and future habitat restoration projects into consideration for assessing project effects. Finally, the PDT worked with Federal, State, and Local agencies to coordinate ongoing planning to address local environmental and infrastructure issues.

Physical Resources:

The past has brought significant alterations to the physical resources of Cedar Lake and its watershed. Geology, soils, topography, hydrology, and lake habitat have all been modified for community development and recreation. The surface water level of Cedar Lake was lowered in the 1870s to half of its original depth, reducing profundal zone habitat and impacting pelagic (i.e., open water) fish species. Tributary fragmentation as a result of channelization and physical structures (i.e., outlet weir) has impacted native aquatic species migration and emigration as well as availability of nursery and refuge habitat. Additionally, external nutrient loading from the watershed has impacted lake-bottom sediments, fringe wetland, and littoral zone aquatic macrophyte establishment. As a result, all natural physical resources have been impacted due to watershed-scale modifications, as well as daily operating procedures (i.e., road salting, CSO discharge, controlled hydrology, etc.). It is reasonably foreseeable that projects within the Cedar Lake watershed for ecological restoration purposes would continue to occur and begin to lessen the past significant and adverse effects (see *Appendix M – Local Existing Conditions* for list of watershed improvement efforts). Given the past, current and future condition of the Cedar Lake watershed, adverse impacts associated with the implementation of the NER Plan or LPP would be minor in terms of the vast array and quantity of adverse effects caused by past community development; however, these efforts are important in terms of beginning to address physical natural resource issues within the watershed. There are no irrecoverable losses of resources identified in terms of geology, soils, substrates, topography, hydrology, and water quality due to implementation of the NER Plan or LPP. Cumulative beneficial effects to the Cedar Lake watershed are anticipated in terms of substrates, hydrology, and ancillary water quality.

Ecological Resources:

As a result of physical resource modifications to Cedar Lake and its watershed, ecological resources have also been impacted. The watershed was once a diverse aquatic ecosystem of bottom woodlands, wetlands, and the glacially created Cedar Lake. The lake itself was comprised of fringe wetlands and a vegetated littoral zone which provided foraging, shelter, and nursery habitat for various species of fish, macroinvertebrates, waterfowl, shorebirds and other wildlife. The profundal zone of the lake provided deep aquatic habitat for fish and macroinvertebrate species as well as a thermal refuge during the summer/fall seasons. The tributaries to Cedar Lake provided spawning habitat for lake species as well as a corridor for migrating and emigrating aquatic species. Current species diversity, abundance, and quality of aquatic habitat within Cedar Lake and its watershed is drastically reduced from what it historically was. For example, it is estimated that less than 1% of Cedar Lake possesses aquatic macrophytes when historical records and photographs show significant fringe wetland and littoral zone vegetation. Additionally, the historic glacial lake fish assemblage has been altered by the presence of non-native and invasive Common Carp and White Perch. Considering these past, current and future conditions of the watershed, adverse impacts associated with the implementation of the NER Plan or LPP would be minor in terms of the vast array and quantity of significant, adverse effects cause by the development of the surrounding community; however, it is instrumental in beginning to reverse the adverse feedback loop set by the human induced problems the watershed suffers from. Therefore, there are no irrecoverable losses of resources identified in terms of plant, insect, fish, amphibian, reptile, bird, and mammal taxa or to their required habitats due to implementation of the NER Plan or LPP. Cumulative beneficial effects to migratory birds are anticipated in terms of increased stopover, foraging, and nesting habitat.

Archaeological & Cultural Resources:

There are no properties or structures within the study area that are currently protected, or listed on the National Register of Historic Properties; therefore, no cumulative effects are expected to archaeological or cultural resources resulting from implementation of the NER Plan or LPP. The aesthetic, visual, and social aspects of the resources would be greatly improved, contributing to the cumulative effects of restoring Cedar Lake for both people and wildlife.

A letter was received from the Miami Tribe of Oklahoma (July 10, 2007) in which the Cultural Preservation Officer stated that the project is located within the aboriginal homelands of the Miami Nation; therefore, it is possible that Miami human remains and/or cultural items could be discovered during the project. If such items are found immediate notification and consultation with the appropriate State Historic Preservation Office would occur.

Cumulative Effects Summary:

The cumulative effects of the NER Plan and LPP are considered to be beneficial and environmentally important, but not significant from the watershed/cumulative effects perspective. The environment and its human community are expected to benefit from restoring heterogenous habitat with increased structure from solidification of lake-bottom sediments, reestablishment of native emergent and submergent aquatic vegetation, and restoration of tributary connectivity.

5.6 Compliance with Environmental Statutes

The NER Plan and LPP presented in this integrated Environmental Assessment are in compliance with appropriate statutes, executive orders and memoranda including the National Historic Preservation Act of 1966; the Endangered Species Act of 1973; the Fish and Wildlife Coordination Act; E.O. 12898 (environmental justice); E.O. 11990 (protection of wetlands); and E.O. 11988 (floodplain management). The potential project is in compliance with the Clean Air Act; Clean Water Act; and the National Environmental Policy Act of 1969. There were no adverse environmental effects identified which cannot be avoided should the project be implemented [1502.16 (102(2)(C)(ii))]. The project will reverse some of the historic adverse effects to the environment, while maintaining and restoring the long-term productivity of Cedar Lake. The only irreversible and irretrievable commitments from implementation of the NER Plan or LPP are the expenditure of funding, energy, labor, and materials [1502.16 (102(2)(C)(v))]. ***Table 16*** provides a summary of the compliance status for the primary environmental requirements associated with the study.

<u>Section 7 of the Endangered Species Act</u> – Preliminary consultation with the USFWS under Section 7 is documented in a letter dated 20 November 2007. The USFWS concurs that any of the proposed alternatives would not have direct or indirect effects to Federally listed species. Coordination will commence through the NEPA process.

<u>Fish & Wildlife Coordination Act</u> – Coordination under the Fish & Wildlife Coordination Act (FWCA) has been initiated and documented with a letter from the USFWS dated 20 November 2007 (*Appendix O – Coordination*). Comments, suggestions and information from the letter were incorporated into this draft of the FS and Environmental Assessment.

<u>Section 404(b)(1) of the Clean Water Act</u> – A Section 404(b)(1) evaluation was completed in accordance with Guidelines for Specification of Disposal Sites for Dredged or Fill Material (40 CFR Part 230). Details of the evaluation are contained in *Appendix G - 404(b)(1) Evaluation.* Since USACE does not issue permits under 404(b)(1) for projects implemented under the Civil Works Program, the evaluation is being coordinated with the IDEM as part of the Section 401 Water Quality Certification.

<u>Section 401 of the Clean Water Act</u> – Section 401 Water Quality Certification is being sought for the chemical substrate restoration and the reroute of Founders Creek portions of the preferred alternative plan. In addition, an NPDES point source permit will be obtained for discharge of effluent from the SDF and return to Cedar Lake. Coordination with the IDEM is continuing. Currently, there are no major issues that would indicate 401 Certification and other IDEM permits would not be granted.

<u>Section 106 of the Natural Historic Preservation Act</u> – Consultation with The Indiana Historic Preservation officer (SHPO) under Section 106 is documented in a letter dated 13 August 2007 (*Appendix O – Coordination*). A Phase I archeological survey was completed on the site of the proposed SDF as outlined in *Appendix K – Phase I Archaeological Investigation*.

Archeological Investigation – The Archaeological Resources Protection Act (Public Law 96-95; 16 U.S.C. 470aa-470mm) provides for the protection of archeological sites located on public and Indian lands, establishes permit requirements for the excavation or removal of cultural properties from public or Indian lands, and establishes civil and criminal penalties for the unauthorized appropriation, alteration, exchange, or other handling of archaeological resources. The SHPO concurred that the proposed alternative does not present significant adverse effects to archaeological and historic properties.

Clean Air Act Conformity Rule – The Clean Air Act (42 U.S.C. §7401 et seq.), as amended in 1977 and 1990 was established to protect and enhance the quality of the nation's air resources to promote public health and welfare and the productive capacity of its population. The Act authorizes the USEPA to establish National Ambient Air Quality Standards to protect public health and the environment. The Act establishes emission standards for stationary sources, volatile organic compound emissions, hazardous air pollutants, and vehicles and other mobile sources. The Act requires the states to develop implementation plans applicable to particular industrial sources. Title IV of the Act includes provisions for complying with noise pollution standards. The preferred alternative is expected to be in compliance with the Act.

Farmland Protection Policy Act – The SDF portion of the project would convert approximately 114 acres of farmland ultimately to park land. In consultation with the NRCS, the Farmland Protection Policy Act is not applicable since the land designated for the SDF was recently annexed by the Town of Cedar Lake and is already committed to urban development [Section 2 (c) (1)A 7 USC 4201].

NPDES Stormwater Permit – The NPDES and all other minor permits will be acquired during the plans & specifications phase should this project proceed to implementation.

Environmental Justice E.O. 12898 – Environmental justice refers to executing a policy of the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws. Increasing concern with environmental equity or justice evolved from a series of studies, conducted in the late 1980s and early 1990s, that suggested that certain types of government and corporate environmental decisions may adversely affect low-income and minority populations to a greater extent than the general population. This finding was particularly the case with locally unpopular land uses, such as landfills and toxic waste sites. Recent guidelines addressing environmental justice include President Clinton's 1994 Executive Order 12898 and accompanying memorandum, the 1996 draft guidelines for addressing environmental justice under NEPA issued by the Council of Environmental Quality and the 1997 interim guidelines issued by the USEPA.

The NER Plan and LPP are not expected to disproportionately affect in a negative manner the low income and/or minority populations. In fact, the NER Plan and LPP are expected to improve the quality of the lake so that the public can enjoy clean and healthy recreational activities. For additional information refer to *Section 5.4.3 Archaeological and Cultural Resources, Environmental Justice*.

Regional Airport Coordination – The Federal Aviation Administration (FAA), the U.S. Air Force, the USACE, the USFWS, and the U.S. Department of Agriculture – Wildlife Services signed a Memorandum of Agreement (MOA) in July 2003 to acknowledge their respective missions in protecting aviation from wildlife hazards. Through the MOA, the agencies established procedures necessary to coordinate their missions to address more effectively existing and future environmental conditions contributing to collisions between wildlife and aircraft throughout the United States. These efforts are intended to minimize wildlife risks to aviation and human safety while protecting the Nation's valuable environmental resources. The FAA Advisory Circular 150/5200-33B, *Hazardous Wildlife Attractants on or Near Airports*, dated August 28, 2007 provides airport operators and those parties with whom they cooperate with the guidance they need to assess and address potentially hazardous wildlife attractants when locating new facilities and implementing certain land-use practices on or near public-use airports. Airports within the vicinity of Cedar Lake were identified using ArcGIS. Two airports, Sutton's Field and St. Anthony Hospital were identified as being within a 5 mile radius of Cedar Lake; however, both airports were identified as being for private-use. Neither the FAA nor the State of Indiana affords any protection of airspace for private-use airports, only public-use airports are regulated. Therefore, no coordination as specified by the MOA is necessary. A letter to the FAA is in *Appendix O – Coordination*.

Table 16: Compliance with Environmental Statutes, Executive Orders and Memoranda

Reference	Environmental Statutes/Regulations	Project Compliance /1
16 U.S.C. 1531, et seq.	Endangered Species Act, as amended	C
16 U.S.C. 460 (L),(12)	Federal Water Project Recreation Act, as amended	NA
16 U.S.C. 4601-4, et seq.	Land and Water Conservation Fund Act, as amended	NA
16 U.S.C. 470a, et seq.	National Historic Preservation Act, as amended	C
16 U.S.C. 661	Fish and Wildlife Coordination Act, as amended	C
16 U.S.C. 703 et seq.	Migratory Bird Treaty Act of 1918, as amended	C
16 U.S.C. 469, et seq.	Archaeological and Historical Preservation Act, as amended	C
25 U.S.C. 3001, et seq.	Native American Graves Protection and Repatriation Act	C
33 U.S.C. 1251 et seq.	Clean Water Act, of 1977, as amended	C
42 U.S.C. 1962	Water Resources Planning Act of 1965	C
42 U.S.C. 1996	American Indian Religious Freedom Act of 1978	C
42 U.S.C. 201	Safe Drinking Water Act of 1986, as amended	C
42 U.S.C. 4321, et seq.	National Environmental Policy Act (NEPA), as amended	C
42 U.S.C. 4901, et seq.	Quiet Communities Act of 1978	C
42 U.S.C. 6901, et seq.	Resource Conservation and Recovery Act of 1976, as amended	C
42 U.S.C. 7401	Clean Air Act of 1970 as amended	C
42 U.S.C. 9601	Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980	C
7 U.S.C. 4201, et seq.	Farmland Protection Policy Act	C
CEQ Memo Aug 11,1980	Prime or Unique Agricultural Lands	C
EO 11514	Protection and Enhancement of Environmental Quality	C
EO 11593	Protection and Enhancement of the Cultural Environment	C
EO 11988	Floodplain Management	C
EO 11990	Protection of Wetlands	C
EO 12088	Federal Compliance with Pollution Control Standards	C
EO 12898	Federal Actions to Address Environmental Justice in Minority and Low-Income Populations	C
EO 13007	Indian Sacred Sites	C
EO 13045	Protection of Children from Environmental Health Risks and Safety Risks	C
EO 13186	Responsibilities of Federal Agencies to Protect Migratory Birds	C
EO 13340	Great Lakes Designation of National Significance to Promote Protection	C
Public Law 79-525	Rivers and Harbors Act of 1946	C
AC 150/5200-33B	Hazardous Wildlife Attractants On or Near Airports	NA

/1 Designations: C = compliance; NA = not applicable; U.S.C. = United States Code; CEQ = Council on Environmental Quality; EO = Executive Order

CHAPTER 6 – Description of Tentatively Selected Plan*

This chapter outlines the details of the tentatively selected plan. The tentatively selected plan that is being recommended for implementation is the larger LPP requested by the non-Federal sponsor. Projects may deviate from the NER Plan if it is requested by the non-Federal sponsor, approved by the ASA(CW), and are identified as the LPP. Although the LPP is a more costly plan it was identified as a cost effective plan through the CE/ICA. The tentatively selected plan is outlined below. Additional details associated with the formulation of restoration measures, their evaluation and selection of the tentatively selected plan are included in *Appendix B – Plan Formulation*.

6.1 LPP Components

The LPP plan includes a combination of six restoration measures that address both the functional and structural ecosystem impairments existing at Cedar Lake. The plan meets all project objectives and a layout of the plan is shown in **Figure 10**. The LPP also includes fish community management (*Section 4.1 Measure Identification and Screening*) which was determined by the PDT to be crucial for the sustainable establishment of aquatic macrophytes and reduction of turbidity within Cedar Lake. However, it has been determined that the eradication of non-native fish species through the one-time application of Rotenone (i.e., piscicide) should not be included in the NER Plan. Therefore, this measure will be carried out by the non-Federal sponsor and the IDNR prior to implementation of the components of the LPP described below.

Physical Substrate Restoration, A.7 – Fine-grained nutrient rich sediments in the central and south basins would be removed using mechanical dredging in order to restore aquatic habitat and aquatic macrophytes. A total of 263,000 cubic yards over 163 acres would be dredged to a depth of 1 foot below the existing lake bed. Areas to be dredged correspond to sediments with available sediment phosphorus concentrations greater than 100 mg/kg based on sampling and analysis completed in April 2008. Mechanically dredged material would be slurried using recycled effluent and hydraulically pumped through an approximately 8,000 ft slurry pipe to an approximately 96 acre constructed SDF. The SDF would be located on approximately 114 acres of former farmland that is encompassed by Parrish Avenue to the east, West 155th Avenue to the south and the CSX Railroad Spur at the northeast corner of the site. As with the NER Plan, the SDF would be designed to settle out solids. Upon completion of dredged material placement, a protective cap/cover will be established over the material for final SDF site closure and stabilized with vegetation to control erosion. This measure will help restore spawning habitat for lake species, aid in restoration of littoral zone vegetation, and help restore profundal zone habitat that would provide thermal refuge for fish as well as aquatic macroinvertebrates and provide an ambush point for larger predatory fish.

Chemical Substrate Restoration, B.2 – A total area of 400 acres across the lake would be stabilized, resulting in a firmer, inert lake bottom. Target alum dosages would vary spatially across the lake. Treatment dose corresponds to an effective depth of the top 20 cm of the sediment column. Given the treatment dose and projected external nutrient loadings the long term effectiveness of a single treatment was estimated to be at least 50 years.

Tributary Restoration, C.1 – Approximately 950 linear ft of Founders Creek would be rerouted back to Cedar Lake just north of the outlet weir to Cedar Creek. This reconnection would provide a source of recolonization for fishes and aquatic macroinvertebrates, a greenway for birds and herpetofauna, and an additional clean water source during summer months when lake conditions are worse. The new channel would encompass a 100 ft riparian stream corridor (50 ft on each side) consisting of native prairie and woodland plants to combat erosion, provide habitat and shade the creek.

Littoral Macrophyte Restoration, E.1 – Areas along the shoreline with depths up to 4 ft would be restored with native aquatic plants. The establishment of aquatic plants in the littoral zone along the shoreline will not only create much needed habitat, but also can significantly reduce the amount of shoreline erosion caused by persistent wind and boat-induced waves. Two types of aquatic habitats would be restored depending on water depth within the littoral zone. Approximately 35 acres, corresponding to areas with less than 1 ft of depth, would be established with emergent plants and an additional 95 acres with depths up to 4 ft would be established with submergent plants. Temporary wave dissipation structures such as floating piers, coconut fabric rolls, wood pilings, etc. would be needed to surround the area until aquatic plants are established. Additionally, predator deterrents such as fencing or scare tactics (e.g., aluminum foil plates, owl decoys, etc.) may be implemented temporarily to scare away predators (e.g., geese, ducks, etc.) that might consume the aquatic plants before they can become established.

Restoration of submergent and emergent vegetation to the littoral zone of Cedar Lake would provide spawning habitat for native fishes such as Bowfin, Northern Pike, and Yellow Perch which either build nests or lay their eggs on or among submerged vegetation in shallow water. Later, the restored vegetation will provide foraging habitat for juveniles of these species. Additionally, littoral zone vegetation provides habitat structure for aquatic macroinvertebrates such as Odonates (i.e. damselflys and dragonflys) to lay their eggs upon, support their emerging larvae, and provide perches for foraging adults.

Institutional Controls, F.1 – The existing No Wake Zone along the perimeter of Cedar Lake would be extended from 200 ft to 400 ft from the shoreline to reduce the effects of propeller induced waves on aquatic plants, disturbance to aquatic macroinvertebrates colonizing the littoral zone, forced detachments of aquatic macroinvertebrates from lake-bed substrates, shoreline erosion, and sediment resuspension. Additional marker buoys would be placed designating the new No Wake Zone.

Fish Community Management, G.1 – After the restoration of littoral zone and fringe wetland aquatic plants, native fish species would be reintroduced to begin reconstructing the historic glacial lake fish assemblage. A list of potential species to be introduced and compiled from historic data of nearby glacial lakes is presented in *Appendix B – Plan Formulation*. This measure would restore the historic glacial lake fish assemblage within Cedar Lake.

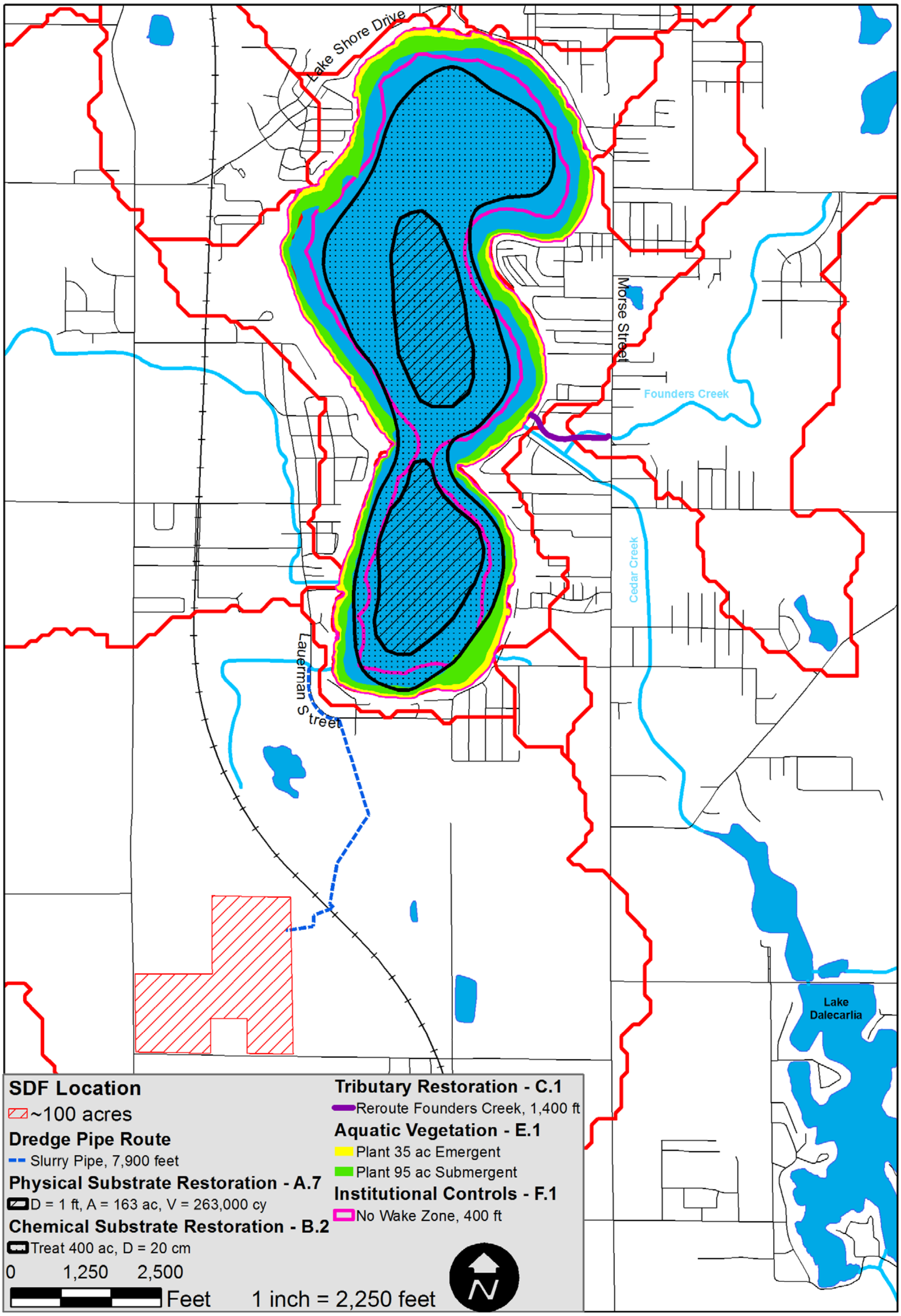

Figure 10: Layout Map of LPP

6.2 Design and Implementation Considerations

As this project enters into preconstruction engineering and design (PED) and implementation phases, more detailed analyses will be required. This section lays out key assumptions that were made during feasibility and associated additional studies needed during design to refine plans and reduce cost contingencies.

Effluent Treatability Testing – As part of the FS, an evaluation of potential effluent treatment measures was completed in order to develop a preliminary design of the SDF based on elutriate data generated in April 2007 using Cedar Lake water and sediments. Additional sediment and water samples were collected from the middle of the southern lobe of Cedar Lake in July 2013, based on elevated concentration of nutrients present in the sediment in this area, and additional elutriate analyses conducted were considered more representative of effluent water that would be generated in the SDF. A summary of sampling procedures and analytical results collected by HDR is provided in *Appendix J – VE Study*. Since Cedar Lake sediments are highly organic and tend to stay suspended, treatability testing is recommended prior to the final design of the SDF. Testing should include jar tests and settleability tests to better characterize the sedimentation property of the SDF effluent and to properly select coagulant aids and dosage rate. Additional elutriate testing with several settling times is also recommended to verify previous results. It is also recommended that final design of the SDF should incorporate the use of the SETTLE module of the Automated Dredging and Disposal Alternatives Management System (ADDAMS) to determine the optimum size and estimate the suspended solids concentration in the effluent. Precipitation contribution to the SDF effluent should also be added to the analysis.

Alum Treatment Reassessment of Daylighted Sediments – As part of the FS, an alum treatment analysis was performed in order to develop a treatment plan, quantities and associated cost estimate. Surficial sediment samples were collected and tested for ASP and reaction to simulated inactivation. Since dredging will be conducted in conjunction with chemical substrate restoration, ASP values in buried sediments that are exposed from dredging may differ from the values used for calculations in the original assessment. It is recommended that direct measurements of daylighted sediments be made following any physical substrate restoration and a re-assessment of treatment dosages and associated costs from that data.

6.3 Real Estate Considerations

The LPP involves the acquisition of LERRDs as detailed in *Appendix I – Real Estate*. The total estimated real estate costs are $[redacted] (***Table 17***). Components of the LPP that have real estate considerations are summarized as follows:

Physical Substrate Restoration, A.7 – This component will require use of land for dredging operations, a staging area, pipe route and SDF. The lake is a public freshwater lake, under the jurisdiction of the State of Indiana. Access to the lake will be obtained through a Lake Preservation Act (IC 14-26-2) permit issued by IDNR Division of Water (DOW). The staging area and pipeline work areas will be obtained through temporary and permanent easements, as appropriate. If identified during the design phase, utility relocations may be necessary at the staging area and along the pipe route.

Chemical Substrate Restoration, B.2 – This component will require access to the lake which will be obtained through a Lake Preservation Act (IC 14-26-2) permit issued by IDNR-DOW.

Tributary Restoration, C.1 – This component will require acquisition of an area 950 ft by 100 ft representing the newly constructed stream corridor. One culvert structure will be required to pass under an existing road. An existing section of Founders Creek would also be filled in to allow for rerouting.

Littoral Macrophyte Restoration, E.1 – This component will require a permanent easement along the shoreline with depths up to 4 feet where native aquatic vegetation will be reestablished.

Institutional Controls, F.1 – This component consists of the establishment of an extended No Wake Zone in the lake and does not have any LERRD requirements.

Table 17: Estimated LERRD Requirements

Parcel	Owner	Acres	Estate	Value
Cedar Lake	IDNR	783.14	IDNR Permit (Non-Standard)	[redacted]
SDF	Town of Cedar Lake	114.36	Temporary Work Area Easement (5 years)	[redacted]
Sediment Pipe	IDNR, CSX and Private Farm	2.51	Utility Easement (5 years)	[redacted]
Staging & Sediment Offloading Area	Pine Crest, Inc.	0.89	Temporary Work Area Easement (5 years)	[redacted]
Founders Creek	Paradise Cove, LLC	2.18	Drainage Ditch Easement	[redacted]
Founders Creek	Paradise Cove, LLC	1.94	Temporary Work Area Easement (5 years)	[redacted]
Total Lands				[redacted]
15% Contingency				[redacted]
Administrative Costs (Non-Fed)				[redacted]
Total with Administrative Costs				[redacted]
Total Federal Administrative Costs				[redacted]
Total Project Real Estate Costs				[redacted]

6.4 Operation and Maintenance Considerations

The LPP has costs associated with OMRR&R of plan components. The non-Federal sponsor is responsible for 100 percent of OMRR&R costs. Projected costs for each component were estimated as follows:

Physical Substrate Restoration – Annual OMRR&R costs would include maintenance of the SDF site once the site is stabilized with vegetation to control erosion. These activities would include periodic mowing and fence repair as needed. Projected annual costs are estimated to be $[redacted].

Chemical Substrate Restoration – Annual OMRR&R costs would include periodic monitoring to determine long term effectiveness and whether retreatment in certain areas is necessary. If a subsequent alum treatment is found to be necessary through project monitoring after the recommended 5 year monitoring and adaptive management period, retreatment would become the non-Federal sponsor's responsibility as part of their OMRR&R responsibilities. Based upon an evaluation by the USACE, a retreatment is not anticipated; therefore, the projected annual costs are estimated to be $[redacted].

Tributary Restoration – Annual OMRR&R costs would include invasive species control of the riparian corridor and periodic channel maintenance as necessary. Projected annual costs are estimated to be $[redacted].

Littoral Macrophyte Restoration – Annual OMRR&R costs would include invasive species control of newly established aquatic vegetation and addition or replacement of aquatic macrophytes. These efforts would be more intensive early in the project life and become less intensive as the lake stabilizes to its new equilibrium. If Eurasian Watermilfoil becomes an issue, which is unknown at this moment, it is recommended that the non-Federal sponsor should eradicate this species via chemical control since mechanical harvesting promotes growth and further dispersal of the plant. This item is not included in the OMRR&R costs since this species does not currently occur within Cedar Lake. Projected annual costs are estimated to be $[redacted].

Institutional Controls – Annual OMRR&R costs would include removal and installation of buoys prior to and after ice conditions and replacement of damaged markers as necessary. Projected annual costs are estimated to be $[redacted].

Fish Community Management – Annual OMRR&R costs would include periodic monitoring and native fish reintroduction on an approximate 5-year cycle to determine species composition and to determine key time points for reintroduction of native species. Specific items include electrofishing and netting to determine species composition, electrofishing and seining to collect native glacial lake species for reintroduction. These efforts would be more intensive early in the project life and become less intensive as the lake stabilizes to its new equilibrium. Projected annual costs are estimated to be $[redacted].

CHAPTER 7 – Plan Implementation

This chapter outlines details for implementing the LPP under Section 3065 of WRDA 2007. Plan implementation details include sequencing, environmental assessment findings, mitigation requirements, permit requirements, agency and stakeholder views, locally preferred plan considerations, project schedule, total project costs and cost sharing requirements.

7.1 Project Authorization

Project authorization has been provided for this project. Section 3065 of WRDA 2007 provides authority to construct an aquatic ecosystem restoration project at Cedar Lake. The provision authorizes $11,050,000 to be appropriated to carry out the activities authorized by Section 3065. Prior to specific authorization, Cedar Lake was originally initiated under Section 206 of WRDA 1986, during which time $683,900 in Federal funds had already been expended. Therefore, the total authorized Federal amount that may be expended on the planning, design, and construction is $11,740,000. While funding was authorized, as noted, federal funding is not guaranteed and would need to be appropriated through separate action. Appropriations are typically made through an annual appropriations bill by the United States Congress.

Following completion of this FS, implementing guidance allows the USACE to enter into a PED agreement and initiate PED activities. Upon approval by the ASA(CW), the project may be considered for implementation in accordance with existing budgetary policies and procedures.

7.2 LPP Implementation & Sequencing

Properly sequencing the order in which the LPP components are implemented is critical to the success of the project. Multiple construction seasons are anticipated for implementation. In order for habitat benefits to be fully realized, components should be implemented in the following order:

1.) *Fish community management* will be carried out by the non-Federal sponsor and the IDNR prior to the implementation of the components of the LPP. Management will entail a one-time application of Rotenone in the lake and connecting Cedar Lake Marsh. Stocking of native fish species will be delayed until components of the LPP have been implemented.

2.) *Physical substrate restoration* will then be implemented with initial activities consisting of the construction of the sediment dewatering facility and staging area followed by mechanical dredging and hydraulic offloading to occur over one construction season. It is recommended that dredging occur in springtime so that algae that sink to the bottom during winter can be removed with sediment.

3.) *Chemical substrate restoration* will follow dredging by dosing 400 ac of the lake with alum including areas that have been dredged to ensure daylighted sediments are inactivated.

4.) *Institutional controls* will be implemented by increasing No Wake Zones so that wave forces are reduced along the shoreline allowing aquatic vegetation to establish.

5.) *Littoral macrophyte restoration* would then follow once assurance that invasive benthic feeders were removed from the initial Rotenone treatment.

6) Once the aquatic vegetation had the ability to establish, the *fish community management* measure can be fully implemented by stocking of native fish species.

7.) *Tributary restoration* can be implemented anytime during the construction process.

In order to implement the project in the proper sequence, an acquisition plan outlined in ***Table 18*** for the LPP Plan was developed. Two separate construction contracts are planned for implementation of the project over 9 years. The first construction contract is expected to be a five year contract beginning in fiscal year 2017 with completion in fiscal year 2022 while the second contract is expected to be a four year contract beginning in fiscal year 2020 with completion in fiscal year 2024.

Table 18: Potential LPP Acquisition Schedule

Contract	Activity/Measure	Duration (mos)	Construction Schedule /1							
			FY 2017	FY 2018	FY 2019	FY 2020	FY 2021	FY 2022	FY 2023	FY 2024
1	LERRDs (A.7, C.1)	24	X	X	X	X	X	X	X	X
	SDF (A.7)	3		X						
	Dredging (A.7)	9		X	X					
	SDF Closure (A.7)	6						X		
	Reroute Founders Creek (C.1)	6			X					
	Increase No Wake Zone (F.1)	1				X				
2	Alum Treatment (B.2)	1				X				
2	Establish Aquatic Vegetation (E.1)	3				X	X	X	X	X
2	Restock Native Fishery (G.1)	3				X				

/1 Fiscal Year (FY) begins in October and ends in September.

7.3 Monitoring & Adaptive Management

Section 2039 of WRDA 2007 directs the Secretary to ensure that when conducting a FS for a project (or a component of a project) for ecosystem restoration that the recommended project include 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 Cedar Lake. The USACE will participate in monitoring the success of the project, along with other local groups still to be identified. Monitoring at Cedar Lake will focus on physical and biological community structure, species diversity (i.e., richness) and abundance, and fringe and littoral plant community aspects of the restoration. Specific objectives include:

- Increase aquatic macrophyte richness & coverage:
  - Target Emergent Species Richness = ≥6
  - Target Emergent Aerial Coverage = 35 acres
  - Target Submergent Species Richness = ≥10
  - Target Submergent Aerial Coverage = 95 acres
- Rectify native lake assemblage:
  - Target Richness = ≥25
  - Target Abundance = Observational
  - Target Invasive Species Reduction = <5% Abundance of Total Sample
- Restore physical habitat as measured by:
  - Target Total Phosphorus = ≤70 µg/L
  - Target Secchi Depth = ≥4 feet
  - Target Dissolved Oxygen = ~7mg/L

The detailed monitoring plan is attached as *Appendix L – Monitoring & Adaptive Management Plan*.

7.4 Implementation of Environmental Operating Principles

In assessing the environmental effects of alternative plans, the USACE implemented the following Environmental Operating Principles (EOPs) as part of the FS.

<u>Environmental Sustainability</u>:

The study was formulated to avoid and/or minimize adverse effects to all critical, unique, and diverse fish and wildlife areas where physical substrate restoration, disposal, and staging were proposed so that these areas could be conserved. Areas that are used for staging and the pipeline will be restored once construction is complete. The LPP addresses existing causes of habitat degradation to allow sustainable restoration of the ecosystem. Periodic monitoring and annual OMRR&R requirements are included in the selected plan to ensure deficiencies that may occur in project performance are addressed in a timely fashion to ensure overall restoration is sustainable.

Restoration of Cedar Lake would create a sustainable aquatic ecosystem with minimal operation and maintenance costs. The eradication of non-native species, extension of the No Wake Zone, and removal of fine-grained nutrient rich sediments would allow native aquatic plants to establish and thrive throughout the life of the project. In turn, the addition of aquatic plants and eradication of non-native fish species will provide structured aquatic habitat and reduce resource competition, allowing the successful establishment and recruitment of stocked native fish species within the lake. Finally, the rerouting of Founders Creek will restore an original tributary that was fragmented from Cedar Lake. The restoration of this tributary will provide spawning habitat for lake species while the lake will provide habitat and thermal refuge for stream species. In addition, Founders Creek would provide an additional clean water source during summer months when lake conditions are worse.

Seek Balance Between Development and Natural Systems:

Opportunity was sought to design restoration features that are compatible with recreation activities that currently occur at the lake. Reestablishing the functionality of a mesotrophic glacial lake would lend very well to enhancement of recreational activities such as swimming and fishing.

Build and Share an Integrated Scientific, Economic and Social Knowledge:

This project built upon several scientific studies completed over the years. Indiana University performed detailed studies that looked at the causes of hypereutrophication, and identified the internal load of phosphorus within the sediments as a primary problem (SPEA 1979 and SPEA 1984). Based on these findings, an integrated scientific approach was developed by USACE to combine detailed hydrodynamic modeling with a trophic status index and species richness of fish and plants to analyze the overall health of the lake. This approach builds upon foundation studies to ascertain the most cost effective and beneficial plan for restoring Cedar Lake back to a healthy functioning glacial lake.

Respect the Views of Individuals and Groups Interested in USACE Activities:

Throughout the feasibility phase, continual coordination with local stakeholders and interested agencies was paramount. Several town council meetings were attended by the USACE to ensure the stakeholders were aware of the progress and direction of the project, as well as to acquire local wishes and desires. Multiple Divisions of the IDNR, IDEM and USFWS have also provided valuable insight into restoration methods and local considerations.

7.5 Compliance with USACE Campaign Plan

In assessing the environmental effects of alternative plans, the USACE implemented the following Campaign Plan objective as part of the FS.

Modernize the Civil Works Project Planning Program and Process:

The USACE will focus its talents and energy on developing specific solutions to the Nation's water resource problems and opportunities based on transparent, risk-informed decisions developed in close collaboration with stakeholders and partners.

Opportunities were sought to identify innovative measures to address the problems at Cedar Lake. In addition, the PDT collaborated with stakeholders such as CLEA, the Town of Cedar Lake community, IDNR, IDEM, and the USFWS to develop measures that would successfully and sustainably restore the aquatic ecosystem at Cedar Lake.

7.6 NEPA Compliance

The President's Council on Environmental Quality guides public participation opportunities with respect to Feasibility Reports and Environmental Assessments, Engineering Regulations, and procedures for implementing NEPA. The Cedar Lake ecosystem restoration plan was determined to be in compliance with NEPA and all other appropriate statutes, executive orders and memoranda (*Section 5.6 - Compliance with Environmental Statutes*). Coordination and compliance for this FS included comprehensive public involvement, agency coordination, and review of and inclusion of compliance with applicable Federal statutes per the USACE Engineering Regulation 1105-2-100, Planning Guidance Notebook.

7.6.1 Mitigation Requirements

Since this is an ecosystem restoration project, environmental benefits will exceed detriments, therefore mitigation is not anticipated for this project. Real estate associated with physical substrate restoration including the temporary staging area and pipe route will be restored upon completion of construction activities. The SDF will not be restored to prior conditions, instead a protective cap/cover will be established over the physically removed material. The cap/cover will consist of topsoil which was stripped from the site to create the SDF. Finally, the cap/cover will be stabilized with vegetation to control erosion. These activities do not meet requirements for mitigation.

7.6.2 Public/Agency Comments & Views

The study team coordinated with several State and Federal agencies throughout the development of the FS including the IDEM, IDNR-DOW, IDNR-Division of Historic Preservation and Archeology (DHPA), IDNR-DFW, USFWS, USEPA, and NRCS. Scoping letters were sent out on July 2, 2007. Responses were received from the following groups and agencies as contained within *Appendix O – Coordination*:

- U.S. Environmental Protection Agency, July 16, 2007

  Recommendations by the USEPA included measures to remove invasive species, establish native plant communities, and a monitoring and maintenance program for aquatic terrestrial species within the project area. Recommendations by the USEPA were taken into consideration during the planning of the Draft Feasibility Report. Proposed measures as part of the project include the removal of invasive and non-native fish, the establishment of native submergent and emergent vegetation, and a 5-year monitoring and adaptive management plan of aquatic species and aquatic vegetation.

- Miami Tribe of Oklahoma, July 10, 2007

  The Cultural Preservation Officer stated that the project is located within the aboriginal homelands of the Miami Nation; therefore, it is possible that Miami human remains and/or cultural items could be discovered during the project. If such items are found immediate notification and consultation with the appropriate State Historic Preservation Office would occur.

- U.S. Fish and Wildlife Service, November 20, 2007

  The USFWS cited the following problems at Cedar Lake: enriched lake sediments, turbidity, shoreline erosion, and presence of non-native invasive fish species. The USFWS concurred at the time that the proposed Cedar Lake aquatic ecosystem restoration project would address the aquatic habitat issues and poor quality fishery.

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

Public Review of the Draft EA

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

Public Meeting(s) on the Draft EA

This section will be furnished when the public meeting is held during the 30-day review of the EA.

Publication of the Finding of No Significant Impact (FONSI)

This section will be furnished when the public NEPA review is completed and the Chicago District Commander signs the FONSI.

7.7 Permit Requirements

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

- Section 401 Water Quality Certification (WQC) – IDEM
- NPDES General Permit (327 IAC 15) – IDEM
- NPDES Section 402 Industrial Point Source Pollution Permit – IDEM

- ➢ Aquatic Vegetation Control Permit (312 IAC 9-10-3) - IDNR-DFW
- ➢ No Wake Zone rule change for Cedar Lake – IDNR-DOW
- ➢ Dam construction or modification (i.e., SDF) (IC 14-28-1-22) – IDNR-DOW (requirement pending coordination)
- ➢ Lakes Preservation Act (IC 14-26-2) – IDNR-DOW

7.8 Locally Preferred Plan Considerations

The intent of the Cedar Lake ecosystem restoration project is to address degraded aquatic ecosystem issues in the lake and its associated riparian zone. USACE has identified the NER plan to address ecosystem impairments including sediment issues within the lake. USACE partnered with the Town of Cedar Lake as the non-Federal sponsor to develop this FS. The Town of Cedar Lake has secured the real estate for the SDF and will secure other real estate requirements for the project.

The Town of Cedar Lake has reviewed the NER plan and recommends pursuing the LPP, which includes dredging a larger volume of the fine-grained nutrient rich sediments. The Town has reviewed the USACE analyses and previous investigations. Removal of these fine-grained nutrient rich sediments would address some of the impairments to the lake which have led to the hypereutrophic conditions within Cedar Lake. Due to the capital costs of dredging and the marginal costs of dredging additional materials, the Town recommends an alternative plan that maximizes the financial benefit of physical substrate restoration. Many of the up-front costs of physical substrate restoration are sunk costs with little variation for different sediment volumes; including mobilization, rights-of-way costs, and SDF real estate. The removal of a larger volume of sediment would provide additional benefits to the lake and the Town of Cedar Lake is willing to pay the associated additional costs between the NER Plan and the LPP.

7.9 Project Schedule & Costs

7.9.1 Project Schedule

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

Table 19: Project Implementation Schedule

Schedule Item	Completion Date
Feasibility Report Approved	August 2017
Preconstruction Engineering and Design agreement signed	September 2017
PED Complete	August 2018
PPA Signed	August 2018
Real Estate Acquisitions Complete	August 2018
Contract Award	September 2018
Implementation Complete	September 2023

7.9.2 Total Project Costs

Total project costs include costs for study, design, implementation, contingencies, construction management, EDC and project management. Costs for design and management are estimated based on a percentage of estimated implementation costs and contingencies. These costs will be revised prior to the execution of a PPA and actual costs for these activities will be used to remedy final cost sharing responsibilities during project close-out. ***Table 20*** provides a summary of estimated project first costs for the LPP. Using the fully funded escalated costs and the implementation schedule, a summary of funding requirements by fiscal year was developed as presented in ***Table 21*** for the LPP.

Table 20: LPP Implementation Schedule and Costs

Activity/Measure	Cost (1Q2016) /2	Implementation Schedule /1							
		FY2017	FY2018	FY2019	FY2020	FY2021	FY2022	FY2023	FY2024
01 Lands & Damages									
LERRDs (A.7, C.1)	$[redacted]	X	X	X	X	X	X	X	X
06 Fish & Wildlife Facilities									
SDF (A.7)	$[redacted]		X						
Dredging (A.7)	$[redacted]		X	X					
SDF Closure (A.7)	$[redacted]						X		
Reroute Founders Creek (C.1)	$[redacted]			X					
Increase 'No–Wake' Zone (F.1)	$[redacted]				X				
Alum Treatment (B.2)	$[redacted]				X				
Establish Aquatic Vegetation (E.1)	$[redacted]				X				
Restock Native Fishery (G.1)	$[redacted]				X				
22 Planning & Feasibility Study									
Feasibility Study	$[redacted]								
30 Planning, Engineering and Design /3	$[redacted]	X	X	X	X	X	X	X	X
31 Construction Management/3	$[redacted]	X	X	X	X	X	X	X	X
Total First Cost	$[redacted]								

/1 Fiscal year (FY) begins in October and end in September.
/2 Estimated project first costs are referenced to 1Q2016 (Oct 2016) price level and includes contingencies.
/3 Costs for these activities were estimated based on percentages applied to implementation costs including contingencies but without LERRDs.

Table 21: LPP Funding Schedule

Measure	FY2016	FY2017	FY2018	FY2019	FY2020	FY2021	FY2022	FY2023	FY2024	TOTAL
01 Lands and Damages										
LERRDs		[redacted]								[redacted]
06 Fish & Wildlife Facilities										
SDF			[redacted]							[redacted]
Dredging			[redacted]							[redacted]
SDF Closure							[redacted]			[redacted]
Reroute Founders Creek				[redacted]						[redacted]
'No–Wake' Zone					[redacted]					[redacted]
Alum Treatment					[redacted]					[redacted]
Establish Aquatic Vegetation					[redacted]					[redacted]
Fish Restocking					[redacted]					[redacted]
22 Planning & Feasibility Study										
Feasibility Study /1	[redacted]									[redacted]
30 Planning, Engineering & Design /1		[redacted]	[redacted]	[redacted]	[redacted]		[redacted]			[redacted]
31 Construction Management /2		[redacted]	[redacted]	[redacted]	[redacted]		[redacted]			[redacted]
TOTAL	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Federal (65% of NER Plan)	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Non-Federal (35% of NER Plan + Incr. LPP Cost)	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

/1 Costs shared 65% Federal and 35% non-Federal except for FS costs where first $100,000 is 100% Federal and remaining costs are equally shared 50/50 between Federal and non-Federal.
/2 Costs for these activities were estimated based on percentages applied to implementation costs including contingencies but without LERRDs.

7.9.3 Maximum Total Project Cost

As discussed in Section 1.2, the WRDA 2007 authorizing statute for the Cedar Lake project did not impose a total project cost limit (i.e., total Federal and non-Federal costs) as set forth in Section 902 of WRDA 1986. Instead, the authorizing statute limited just the total Federal cost to no more than $11,734,000, absent additional action by Congress.

Implementation guidance for this authority does not specify cost sharing requirements for FS costs. However, assuming that all costs would be cost-shared 65% Federal / 35% non-Federal, the total project cost (i.e., total Federal and non-Federal costs) is limited to approximately $18,050,000. The LPP does not include additional Federal costs and therefore falls within the total Federal cost limit set forth in the authorizing statute.

7.9.4 Cost Apportionment

This FS was initiated as a Continuing Authorities Program (CAP) Section 206 project in 2002, and converted to a specifically authorized study by WRDA 2007. As required by ER 1105-2-100, Paragraph F-1.b, the study has been conducted with 100 percent Federal financing. The first $100,000 of the FS is 100 percent Federal with additional costs being equally cost-shared 50/50 between Federal and non-Federal. These feasibility costs and the required non-Federal share of 50 percent are included in the total project costs. Reimbursement of FS costs will be sought through execution of the PED Agreement.

Per Section 210 of the WRDA of 1996, the non-Federal share of the implementation costs for ecosystem restoration projects will be 35 percent of the project unless project authorization specifies otherwise. The non-Federal share includes PED, implementation, construction management, EDC and project management costs. The non-Federal sponsor shall provide 100 percent of the LERRDs, and OMRR&R. The value of LERRDs shall be included in the non-Federal 35 percent share.

A summary of the estimated project first costs for the LPP over the NER Plan are shown in ***Table 22***. A breakdown of Federal and non-Federal contributions to the estimated project first cost for the LPP is provided in ***Table 23***.

Table 22: Summary of NER and LPP Estimated Project First Costs

	NER Plan	LPP	Difference
Estimate of Total Project Costs /1			
01 Lands and Damages			
LERRDs	[redacted]	[redacted]	[redacted]
06 Fish & Wildlife Facilities			
SDF	[redacted]	[redacted]	[redacted]
Dredging	[redacted]	[redacted]	[redacted]
SDF Closure	[redacted]	[redacted]	[redacted]
Reroute Founders Creek	[redacted]	[redacted]	[redacted]
Increase No Wake Zone	[redacted]	[redacted]	[redacted]
Alum Treatment	[redacted]	[redacted]	[redacted]
Establish Aquatic Vegetation	[redacted]	[redacted]	[redacted]
Fish Restocking	[redacted]	[redacted]	[redacted]
22 Planning & Feasibility			
Feasibility Study /2	[redacted]	[redacted]	[redacted]
30 Planning, Engineering & Design /3	[redacted]	[redacted]	[redacted]
31 Construction Management /3	[redacted]	[redacted]	[redacted]
Total Implementation Costs	[redacted]	[redacted]	[redacted]

/1 Estimated project first costs are referenced to 1Q2016 (Oct 2016) price level and includes contingencies.
/2 Costs shared 65% Federal and 35% non-Federal except for FS costs where first $100,000 is 100% Federal and remaining costs are equally shared 50/50 between Federal and non-Federal.
/3 Costs for these activities were estimated based on percentages applied to implementation costs including contingencies but without LERRDs.

Table 23: Cost Apportionment of LPP

	Estimated Project First Costs/1	Fully Funded Costs/2
LPP /3	[redacted]	[redacted]
NER Plan /3	[redacted]	[redacted]
Federal (65%)	[redacted]	[redacted]
Non-Federal (35%)	[redacted]	[redacted]
Incremental LPP (betterment)	[redacted]	[redacted]
Federal (0%) /4	[redacted]	[redacted]
Non-Federal (100%)	[redacted]	[redacted]
Total Federal Contribution	[redacted]	[redacted]
Total non-Federal Contribution	[redacted]	[redacted]
Cash	[redacted]	[redacted]
LERRDs	[redacted]	[redacted]

/1 Estimated project first costs are referenced to 1Q2016 (Oct 2016) price level.
/2 Fully funded costs are determined by escalating estimated first costs at 1Q2016 (Oct-Dec) price levels to the estimated mid-point of construction using EM 1110-2-1304, Civil Works Construction Cost Index System (CWCCIS)
/3 Costs shared 65% Federal and 35% non-Federal except for FS costs where first $100,000 is 100% Federal and remaining costs are equally shared 50/50 between Federal and non-Federal.
/4 Federal cost share applies only to the estimated project first cost of NER Plan; costs in excess of the NER Plan are considered betterments and are 100% non-Federal responsibility.

7.9.5 Financial Capability of Non-Federal Sponsor

In accordance with the CECW-PC Memorandum dated 12 June 2007, Non-Federal Sponsor's Self-Certification of Financial Capability, the Town of Cedar Lake certifies they are aware of the financial obligations of the non-Federal sponsor and have the financial capability to satisfy obligations for the project. A signed copy of Enclosure 3 will be included in the final document.

The non-Federal sponsor is committed to its specific cost share of the PED phase, and expresses willingness to share in the costs of construction to the extent that can be funded.

CHAPTER 8 – Recommendation*

I recommend that the LPP be implemented as a Federal project, with such modifications thereof as in the discretion of the Commander, USACE may be advisable. The estimated project first cost of the LPP is [redacted] and the estimated annual OMRR&R cost is $[redacted]. The Federal portion of the estimated total project cost is $[redacted]. The non-Federal share of the estimated first cost of the project is about $[redacted], which includes a $[redacted] increase over the NER Plan included in the LPP, and will be covered by LERRDs ($[redacted]) and a cash contribution ($[redacted]).

Federal implementation of the recommended project would be subject to the non-Federal sponsor agreeing to comply with applicable Federal laws and policies, including but not limited to:

a. Provide 35 percent of total project costs as further specified below:

   1. Provide 35 percent of design costs in accordance with the terms of a design agreement entered into prior to commencement of design work for the project;

   2. Provide all lands, easements, and rights-of-way, including those required for relocations, the borrowing of material, and the disposal of dredged or excavated material; perform or ensure the performance of all relocations; and construct all improvements required on lands, easements, and rights-of-way to enable the disposal of dredged or excavated material all as determined by the Government to be required or to be necessary for the construction, operation, and maintenance of the project;

   3. Provide, during construction, any additional funds necessary to make its total contribution equal to 35 percent of total project costs;

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

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

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

e. Comply with all applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, as amended (42 U.S.C.

4601-4655), and the Uniform Regulations contained in 49 CFR Part 24, in acquiring lands, easements, and rights-of-way required for construction, operation, and maintenance of the project, including those necessary for relocations, the borrowing of materials, or the disposal of dredged or excavated material; and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act;

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

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

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

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

j. Comply with all applicable Federal and State laws and regulations, including, but not limited to: Section 601 of the Civil Rights Act of 1964, Public Law 88-352 (42 U.S.C. 2000d) and Department of Defense Directive 5500.11 issued pursuant thereto; Army Regulation 600-7, entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army"; and all applicable Federal labor standards requirements including, but not limited to, 40 U.S.C. 3141- 3148 and 40 U.S.C. 3701 – 3708 (revising, codifying and enacting without substantial change the provisions of the Davis-Bacon Act (formerly 40 U.S.C. 276a *et seq.*), the Contract Work Hours and Safety Standards Act (formerly 40 U.S.C. 327 *et seq.*), and the Copeland Anti-Kickback Act (formerly 40 U.S.C. 276c *et seq.*);

k. Perform, or ensure performance of, any investigations for hazardous substances that are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Public Law 96-510, as amended (42 U.S.C.

9601-9675), that may exist in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be required for construction, operation, and maintenance of the project. However, for lands that the Federal Government determines to be subject to the navigation servitude, only the Federal Government shall perform such investigations unless the Federal Government provides the non-Federal sponsor with prior specific written direction, in which case the non-Federal sponsor shall perform such investigations in accordance with such written direction;

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

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

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

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

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Christopher T. Drew
Colonel, U.S. Army Corps of Engineers
District Commander

CHAPTER 9 – Bibliography

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