Lake Koshkonong Section 206
Aquatic Ecosystem Restoration
Preliminary Alternatives Report

1. PROJECT BACKGROUND

1.1 Introduction

1.1.1 Purpose. TheUS Army Corps of Engineers, Rock Island District of the Mississippi Valley Division (Corps), received a letter from the Rock-Koshkonong Lake District (RKLD) in 1999 requesting assistance for shoreline and wetland protection and restoration, and to initiate anaquatic ecosystem restoration project at Lake Koshkonong under Section 206 of the Water Resources Development Act (WRDA). The request culminated in the development of a Preliminary Restoration Plan (PRP) for this project, dated January 2001. The proposed aquatic ecosystem restoration project would protect shorelines and existing wetlands from erosion, and restore degraded wetlands by providing sheltered areas for submergent and emergent vegetation re-establishment through construction of breakwaters. An additional objective would be rough fish, primarily common carp, exclusion for successful vegetation establishment, particularly during carp spawning times. Additional benefits from the proposed project would be increased water quality by reducing turbidity, and improved fish and wildlife habitat within the breakwater areas.

The purpose of the Preliminary Alternatives Report is to present a detailed outline of the planning involved for the proposed Lake Koshkonong project. This report outlines the results of the first level of alternatives screening report. In addition, this report will also serve as the framework for the feasibility report. The feasibility report will provide sufficient planning, engineering and construction details of the recommended plan to allow final design and construction to proceed subsequent to the approval of the document.

1.1.2 Project Location. Lake Koshkonong is located on the Rock River in Jefferson (83%), Dane (3%), and Rock (14%) Counties, in south central Wisconsin (Plate 2). Lake Koshkonong was originally a natural shallow and deep-water marsh. A shallow lake was formed in the 1850s when Indianford Dam was constructed at Indianford, Rock County, north of Janesville, Wisconsin. The water level was raised 2 feet when the dam was rebuilt in 1917. The drainage area above the lake encompasses 2,640 square miles. Lake Koshkonong is the eighth largest lake in Wisconsin, covering approximately 10,460 acres, but has a very shallow and fairly featureless bottom, with a maximum depth of 7 feet and an average depth of 5 feet. The Rock-Koshkonong Lake District (RKLD), the project sponsor, was formed in 1999 to provide a representative body to protect, preserve, and improve the natural resources of the lake and river for an equal balance of wildlife, habitat, and recreation. The district boundaries are from the Rock River at the Jefferson City limits to the Indianford Dam.

1.1.3 Project Authorization. The Lake Koshkonong Aquatic Ecosystem Restoration Feasibility Study has been undertaken through the Corps of Engineers Continuing Authorities Program. The feasibility study is funded under the authority of Section 206 of the Water Resources Development Act (WRDA), 1996, as amended. Total costs for projects developed under this authority are cost shared with the project sponsor; 65% federal, 35% sponsor. At the time of signing the Project Cooperation Agreement (PCA), the sponsor assumes responsibility for their share of the project costs. All lands (fee-title or easements) required to support the project, for construction and operation and maintenance (O&M), must be provided by the non-federal sponsor. Upon completion of the project construction, O&M operations are the sole responsibility of the sponsor.

1.1.4 Scope of Study. The primary wetland areas around Lake Koshkonong were included for consideration at the following key locations: Koshkonong Creek Delta (including Cresent Bay and White Crow Bay), Pike Bay, Krumps Creek, Mud Lake, Gilberts Bay, Haights Bay, and Lautz Bay. These areas contain the largest, most important remaining wetland areas at Lake Koshkonong. The PRP identified breakwater construction with carp gates as the most likely project feature. Numerous construction methods have been identified. Other potential features considered include shoreline protection, island construction, and permanently lower water levels. All potential project feature locations are in Jefferson County, Wisconsin, and are shown on Plate 3.

1.2 Assessment of Existing Resources

1.2.1 Related Studies, Reports and Projects. Several projects and studies are currently underway or have been completed in the Lake Koshkonong watershed:

1.2.1.1 *Federal*.

Lake Koshkonong Aquatic Ecosystem Restoration Preliminary Restoration Plan, Section 206 Program, Mississippi Valley Division, Rock Island District, January 2000. This plan identified potential project features, determined level of federal interest, provided cost estimates for feasibility phase, and assessed support from local interests.

Koshkonong Creek Aquatic Ecosystem Restoration Project, Section 206 Program. The Koshkonong Creek Section 206 project involving wetland restoration and creek channel restoration is located in Sun Prairie, Wisconsin, approximately 10 miles northeast of Madison, Wisconsin, and 25 miles north of Lake Koshkonong. Water quality improvements at Koshkonong Creek could benefit Lake Koshkonong by providing improved habitat for spawning, migration to, and use of upstream areas. This project is in the Feasibility Phase; the Plans and Specifications Phase is scheduled to begin during Fiscal Year (FY) 2004.

Rock River Ecosystem Restoration General Investigation. The largest Corps of Engineers study in the area is the Rock River Ecosystem Restoration General Investigation (GI). The scope of this project currently encompasses the whole Rock River Basin in the state of Illinois, from the Wisconsin state line to the Mississippi River, with opportunities to restore fish passage, provide stream stabilization and restoration, improve water quality, and restore portions of the floodplain. Discussions are currently ongoing with the Wisconsin Department of Natural Resources (WIDNR) in an effort to include the Rock River basin in Wisconsin as part of this study. As a result, a comprehensive lake management plan for Lake Koshkonong could be considered. The Feasibility Phase is scheduled for completion in FY 2004.

Evaluation of Alternative Reservoir-Management Practices in the Rock River Basin, Wisconsin, Water-Resources Investigations Report 83-4186, United States Geological Survey (USGS), March 1984. This report determined the impacts of proposed alternative reservoir-management practices on discharges and lake levels in the Rock River basin. Alternative management practices for operating Indianford Dam were evaluated based on the effects in water levels at Lake Koshkonong.

1.2.1.2 *Non-Federal*.

The WIDNR, the Rock River Coalition, and the Rock River Partnership are working together to improve water quality in the Rock River basin in Wisconsin. The WIDNR developed and published the Lower Rock River Basin Water Quality Management Plan in 1998, which includes Lake Koshkonong, in an attempt to identify and improve water quality problems in the Rock River basin.

Several projects between the WIDNR and RKLD are currently ongoing or being proposed including studies to evaluate historical water levels and to determine ordinary high water marks and the affects of winter drawdown on shoreline habitat, fish migration, and wildlife populations. Another project involves development of an updated USGS model to simulate various dam management options and the resulting water levels at the lake. In addition, the WIDNR recently funded two Lake Planning Grants to the RKLD and their consultant, RSV Engineering, for the following tasks, which were completed in 2001.

Grant 1 ($9,996):

- Prepare and distribute a survey to identify concerns of the RKLD and public to assess consensus of opinion;
- Assess current vegetation of the lake and its associated wetlands to establish a baseline for future monitoring;
- Begin monitoring Secchi clarity through a volunteer program;
- Perform nutrient load modeling to assess current water quality of the lake and use this data to plan for future projects to maintain or enhance water quality; and,
- Prepare summary report of findings of data and provide recommendations for future projects to protect and restore water quality.

Grant 2 ($10,000):

- Increase rough fish removal;
- Ensure establishment of breakwaters for shoreline protection;
- Gather land use data from counties for basin plan to reduce nutrient loading; and,

- Analyze sediments to study vegetation and wetland losses.

Lake Butte Des Morts Habitat Restoration Project. A similar aquatic ecosystem restoration project to the one proposed in this report was constructed by the WIDNR at Lake Butte des Morts, part of the Lake Winnebago System in Wisconsin (Land and Water Magazine, July/August 2000, pages 26-29). Historical accounts described this area as a river marsh with vast adjoining wetlands. A dam, built in the mid-1850s and since modified, currently controls lake water levels. Lake Butte des Morts suffers from many of the same problems as Lake Koshkonong such as artificially higher water levels resulting from the construction of 9 Federal dams and 4 private ones. Other similar problems include wind and wave induced erosion, high carp populations, poor water quality (Secchi Disk readings of 6 inches or less), and severe losses of emergent and submergent vegetation. These problems led to significant wetland losses, reduced populations of desirable fish species, and steep declines in waterfowl populations.

In an attempt to remediate these problems, the WIDNR and local citizens formed a partnership in order to restore 630 acres of shallow water and wetland remnants. The project included the construction of a 10,645-foot-long rubble mound breakwater, completed in 1997. In addition, five waterfowl nesting islands were constructed within the protected area in 1997 and 1998. Also in 1998, a navigable carp barrier was installed. The WIDNR believes that this carp barrier is the most significant reason the restoration project was successful. Since the breakwater and carp gate were installed, water turbidity has decreased markedly, allowing submergent and emergent vegetation re-establishment, including such plants as wild rice, lotus, pondweeds, and wild celery. According to a status update prepared in September 2000 by the WIDNR, Secchi disc readings were up to one foot greater within the breakwater than on the main lake with an 80% increase in vegetation from 1999 to 2000. Concurrent increases in fish populations and species composition, as well as waterfowl usage, have been recorded. These changes are a significant improvement over previously existing conditions.

Lower Rock River Water Quality Management Plan, Lower Koshkonong Creek Watershed, Wisconsin Department of Natural Resources, 2001. This plan summarizes the municipalities, streams, lakes, soil loss rates, resources of concern, and recommendations for water quality improvement within the watershed.

Restoration of Canvasback Migrational Staging Habitat in Wisconsin, A Research Plan with Implications for Shallow Lake Management, Technical Bulletin No. 172, Wisconsin Department of Natural Resources, 1991. This plan assessed the status of canvasback staging populations and habitat in Wisconsin, described goals for management of canvasback staging populations and habitat, outlined the research strategy necessary to formulate management plans for restoration of staging habitats in the southeastern half of Wisconsin, and discussed an ecosystem approach to managing large, shallow lakes that typify canvasback staging habitat.

Establish Water Levels and Operating Orders for the Indianford Dam on the Rock River, Environmental Impact Assessment Screening Worksheet, Wisconsin Department of

Natural Resources, December 1981. This document contains a proposal to establish minimum and maximum water levels for Lake Koshkonong as modifications to the dam and its operating procedures. Also included is the history and operating authority of the Indianford Dam.

1.2.2 Resource History. Early European settlers to the Lake Koshkonong area in the 1830s described the original riverine marsh as a magnificent, enormous meadow during the summer months and as a vast grain field in the fall with the open water area limited to the main channel of the Rock River. A natural constriction at the downstream end acted as a dam, creating an estimated 7,500 acres of shallow and deep-water marsh with maximum water depths of 2 feet. Emergent macrophytes, especially wild rice, were dense, supplying Native Americans and ducks, mainly canvasbacks, with an abundant water and food source, including an excellent fishery comprised of bluegill, yellow perch, and largemouth bass.

In the 1850s, the Indianford Dam was constructed at Indianford, in Rock County, to power a sawmill. This millpond dam created a shallow lake with less emergent and more submergent macrophytes such as wild celery and various pondweeds. In the late 1800s and early 1900s, Lake Koshkonong attracted large numbers of migrating canvasbacks in addition to other species of diving ducks and coots and was considered to be one of the best waterfowl hunting areas in the Nation, second only to Chesapeake Bay. The area was and continues to be an important stopover for migratory waterfowl. However, after a 2-foot increase in lake water levels (3 to 4 feet above natural stage) by a dam modification in 1917, which converted the millpond dam to a hydroelectric dam, macrophytes abundance, water quality, and waterfowl populations declined dramatically.

Others factors contributing to this decrease in habitat quality included wave action and an increasing undesirable fish population. Carp were introduced to the lake before 1900, but were not considered a problem associated with habitat deterioration until after 1900, when game fish populations declined. In the late 1920s, commercial crews began carp seining operations with state crews initiating their own operations in 1936. State crews removed an average of over one million pounds of rough fish per year up until 1974. During the early 1940s, Secchi disc readings were in the range of 5 to 30 inches, indicating highly turbid water. Also at this time, sago pondweed, bladderwort, and coontail made up the sparse amount of submerged macrophytes.

1.2.3 Land Use and Management. Lake Koshkonong is a popular recreation destination, bringing in millions of tourist dollars per year. The lake provides hunting and fishing resources as well as recreational boating opportunities during the summer months. The lands surrounding the lake are primarily in private ownership; approximately 50% are developed, mainly in the lower half of the lake. However, much of the undeveloped land, mainly wetlands, is managed for waterfowl by various private hunting clubs. The lake is also utilized for commercial carp fishing.

The WIDNR has overseen the water level management of Lake Koshkonong since the 1980s. Water levels are primarily controlled by the Indianford Dam. However, during high flows, the dam does not have sufficient discharge capacity to be operated for flood control. A study by USGS in the 1980s reported that at high discharges, stage changes in Lake Koshkonong also are fairly representative of stage changes elsewhere along the Rock River, assuming all of the gates at the dam would be open throughout any significant flood. The fixed relation of stage and discharge for the dam and channel then determines the stage of the lake. This study also found that operating the dam with reference to stage at the lake, rather than at the dam, simplifies the decision making process for operating the gates.

Today, lake levels are closely monitored in order to maintain a stable pool. High and fluctuating lake water levels in the past have been linked to accelerated erosion and losses of peripheral wetlands at Lake Koshkonong. A more stable pool elevation improves recreational use during the open water season, while reducing erosion from fluctuating water levels and providing greater control during periods of flooding. Flooding typically occurs throughout April and May; a result of seasonal high flows in combination with a constricted channel at the downstream end of the lake. Therefore, as discharge in this channel increases, the stage of the lake is controlled less by the dam and more by this natural constriction. Under the most recent order established by the WIDNR in April 2000, the summer pool elevation (May 1 to October 31) shall range from 775.73 to 776.33 feet mean sea level (MSL) (target level is 776.2 feet MSL). The winter pool elevation (November 1 to April 30) shall range from 775.00 to 775.77 feet MSL (dam crest is 775.27 feet MSL). This winter drawdown is designed to reduce damage by wave and ice action to peripheral wetlands. Lower winter water levels are considered to be a first step toward restoration of in-lake stands of aquatic vegetation. Conversely, losses of wetlands have been linked to high and fluctuating water levels, largely in conjunction with dam construction and later modification.

Rock County presently owns and operates the Indianford Dam under the order previously mentioned, that not only mandates seasonal water levels, but also establishes minimum flow requirements, as well as operation and maintenance procedures. However, Rock County and the RKLD signed an agreement in January 2002 to set forth the terms and conditions by which the County shall complete certain WIDNR mandated repairs to the dam and transfer title of the property to the RKLD. This transfer of ownership is anticipated to occur in 2003. Jefferson and Rock Counties will provide financial support for dam repair and maintenance for a limited duration. The Corps of Engineers is not a partner in this local initiative. The WIDNR will not mandate inclusion of fish passage as part of the dam repair. Indianford Water Power Company is pursuing the feasibility of generating hydropower at the existing facility and may apply for a preliminary Federal Energy Regulatory Commission (FERC) permit. Hydropower generation at Indianford Dam had ceased in 1962 due to a net operating loss on the facility. In general, hydropower generation results in more stable lake water levels, which is considered a benefit to the ecosystem.

1.2.4 Aquatic Resources. Lake Koshkonong is a large, shallow lake with little structure in the lakebed. The abundance of aquatic macrophytes, primarily sago pondweed, varies from year to year, but generally covers less than 2% of the lake’s water surface area. In the late 1980s, the WIDNR unofficially estimated that less than 100 to 200 acres of sago pondweed existed. It was also assumed that some species of macro benthos exist due to the high use of ruddy ducks during migration periods. A sediment survey determined that the majority of the bottom substrates consist of muck (approximately 70%), with the reminder including sand, rubble, and gravel at percentages of 15%, 10%, and 5%, respectively. Today, several small rock piles can be found in the eastern part of the lake. In addition, current area maps of Lake Koshkonong show the location of numerous springs within the lakebed.

During the summer months, algal blooms are common, a result of high nutrient loads coupled with warm water, limiting light penetration into the water. During periods of high turbidity, aquatic plant growth is limited, since suspended sediments interfere with light penetration into the water. This lack of vegetation becomes a limiting factor for the amount of fish spawning habitat and shelter such plant beds provide. Suspended sediments are likely the result of wave action, which can be severe due to the southwest – northeast orientation of the lake that produces the longest possible fetch for prevailing summer winds. In addition, rough fish browse on and dislodge rooted aquatic vegetation and increase the turbidity of the water, keeping sediments and pollutants in suspension. Although the lake is rather shallow, fish kills during the winter months are very rare. The amount of water entering the lake, primarily from the Rock River, allows for a complete turnover of the lake volume in approximately 20 to 30 days, therefore, oxygen supplies are constantly replenished.

1.2.5 Terrestrial and Wetland Resources. Koshkonong Marsh, primarily publicly owned, is one of the remaining wetland areas along the lake. It is a large cattail-common reed marsh on the east side of Lake Koshkonong and is bisected by the Rock River. Pockets of open water support submerged aquatics and water lilies. This area has a diverse wildlife population and is extensively used by hunters. The WIDNR owns and manages approximately 600 acres of this marsh from the mouth of the Rock River south, adjoining Gilbert's Bay. The WIDNR tried 15 years ago to re-establish aquatic vegetation by planting wild celery and sago pondweed and was unsuccessful. High turbidity is thought to be the primary factor, compounded by rough fish activity, for the lack of success of this effort.

Thiebeau Marsh, on the south side of Lake Koshkonong near the mouth of Otter Creek, is a large wetland complex located in the terminal moraine region of Rock County. Large expanses of cattail-bulrush are interspersed with smaller pockets of open water. The marsh is rich in wildlife, including nesting sandhill cranes. An area of floodplain forest is found near the mouth of Koshkonong Creek. The diverse habitat of this area includes shrub swamp, marsh, hardwood swamp, and scrubby disturbed forest.

Although acreages for the individual wetland areas are not available, they are available by county for wetlands contiguous to Lake Koshkonong. These figures are: 3,050 acres for Jefferson County; 640 acres for Rock County; and 30 acres for Dane County; for a total of 3,720 acres. While these wetlands are not threatened by development, they continue to be threatened by wind and wave induced erosion, and high water levels. In addition, turbid water and lack of sheltered areas inhibit submergent and emergent plant growth, which contributes to continuing wetland losses. A review of aerial photography in the late 1980s by the WIDNR found that approximately 52 acres of bank line had disappeared between 1950 and 1963. Further review discovered an additional loss of approximately 270 acres between 1963 and 1975.

1.2.6 Fish and Wildlife Resources. Lake Koshkonong, because of its size and location, is an important resource for fish and waterfowl. In spite of the dam at Indianford that blocks some upstream fish passage, the lake supports a diverse warm water fishery. Fish from Lake Koshkonong move upstream, utilizing habitat in the Rock River and its tributaries. Fish species present include catfish, black crappie, white bass, bluegill, carp, bigmouth buffalo, walleye, northern pike, and sauger. Walleye, northern pike, and sauger populations are supplemented by yearly stocking from the Bark River Hatchery, partially funded by the Rock River-Koshkonong Association (RRKA) and managed by the WIDNR. Bluegill and other panfish are stocked from nearby lakes. Despite a commercial carp fishery, which harvests 1 to 2 million pounds of carp per year, rough fish populations remain high. Rough fish are detrimental to the sport fishery and other aquatic resources since they browse on and dislodge rooted aquatic vegetation and increase the turbidity of the water keeping sediments and pollutants in suspension.

During the spring of 1984, nearly 10,000 panfish and gamefish were netted and tagged using fyke nets in the Upper Rock River. Upstream returns came from as far as Lowell on the Beaver Dam River and from Danville on the Crawfish River, both 48-river miles upstream from Lake Koshkonong

Most continental populations of diving ducks depend on large lakes and riverine impoundments in the upper portions of the Mississippi Flyway to feed and rest during migration. The Rock River provides a significant migratory travel corridor for birds during spring and fall migration and contains sites for important bird habitat in its watershed, such as Horicon Marsh and Lake Koshkonong. However, the dominant land uses of agriculture and rural residential housing have significantly constrained this important wildlife habitat type. Damage to wetlands can lead to losses of invertebrates and wetland plant foods, which, in turn, can seriously affect the numbers and distribution of waterfowl, such as scaup, ring-necked ducks, and canvasbacks. In the late 1980s, the local nesting population of waterfowl consisted of dabbling ducks. However, the lake and adjacent wetlands were able to provide habitat for herons and other shorebirds, double crested cormorants, and an occasional eagle or osprey. Lake Koshkonong is a priority habitat area as described in the North American Waterfowl Management Plan.

1.2.7 Historical and Cultural Resources. The opinion of the Corps is that no significant historic properties within the area of potential effect will be affected by construction efforts on the lake bottom. Furthermore, the Corps proposes a Phase I intensive archeological survey within the area of potential effect where (1) breakwater features terminate on terrestrial lands, (2) roadways will be improved or modified, and (3) new excavations are proposed for borrowing for fill or rock quarrying which are undisturbed or have never been subjected to any Phase I investigations. It is expected that all construction activities associated with the proposed project will occur on state or private lands. Permits on state lands will be obtained from the Wisconsin State Archeologist prior to any archeological investigations.

The Corps requested comment or concurrence with the Corps opinion and recommendations from the Wisconsin Historical Society, and other consulting parties, as promulgated under Section 106 of the National Historic Preservation Act of 1966, as amended and its implementing regulations 36 CFR Part 800: "Protection of Historic Properties." By letter dated 8 August 2001, the Wisconsin Historical Society concurred with the Corps recommendations. As consulting parties, the Sac and Fox Nation of Missouri in Kansas and Nebraska, and the Menominee Indian tribe of Wisconsin replied to the Corps correspondence and requested further consultation.

Pursuant to Section 800.3 of the Council's regulations and, in part, to meet the responsibilities under the NEPA of 1969, the Corps and the DNR developed a preliminary Consulting Parties List. Those on the list will be provided with study newsletters, public meeting announcements, special releases, and notifications of the availability of report(s), including all draft agreement documentation, as stipulated by 36 CFR Part 800.14(b)(ii) of the NHPA. Consulting parties may request correspondence on future topics relevant to compliance and to provide comments. All consulting parties must be aware that the specific locations of historic and archaeological properties are subject to protection through nondisclosure under Section 304 of the National Historic Preservation Act. All maps subject to public review/access shall not contain any information on archeological sites. This information is not to be released in order to protect the resources within the area of potential effect.

1.2.8 Water Quality. Lake impoundment, increased agriculture and urbanization, and introduction of common carp in the Rock River system have all contributed to the declining water quality conditions of Lake Koshkonong. Additionally, high and fluctuating water levels have also complicated many of the problems occurring on the lake, such as turbidity, nutrient availability from resuspended sediments, and shoreline erosion. In the late 1980s, the WIDNR found Secchi disc readings in the range of 18 to 29 inches during the spring and 7 to 24 inches during the summer. In lake waters less than 3 feet deep, Secchi disc readings were in the range of 29 to 47 inches during the spring with an apparent decrease during the summer of 11 to 37 inches. These turbid readings are partly due to the large sediment and nutrient loads brought to the lake by the Rock River, Koshkonong Creek, and other tributaries. These loads are primarily from agricultural and some urban sources. Approximately 1 million pounds of phosphorus enter the lake annually from the Rock River alone.

High turbidity can limit plant growth. For example, wild celery cannot produce overwintering tubers without at least 9% of the surface light reaching the plants. Large numbers of common carp further increase turbidity and decrease aquatic vegetation by uprooting vegetation and resuspending sediments while scavenging. High nutrient inflow, high turbidity, and reduced aquatic vegetation have produced a severe nuisance growth of algae. Algae blooms are common during the late spring and summer.

2. PROJECT FORMULATION

2.1 Goals and Objectives

2.1.1 Habitat Problems and Opportunities. As stated by the RKLD and WIDNR, the primary problems affecting present habitat quality are eutrophication, undesirable fish, high and fluctuating water levels, wave action, sedimentation, and ice damage. Due to its orientation parallel to the prevailing wind (southwest) and its long fetch of approximately 7 miles, wave induced shoreline erosion continues to be a major problem. High summer use by recreational boats exacerbates this problem. Wave action has eroded the shorelines, contributing to the sediment deposition in the lakebed immediately offshore, and threatens adjoining marshes and wetlands. Severe wave action also interferes with submergent and emergent plant establishment and growth, and increases turbidity, further hampering plant growth. In addition, both times the lake water level has been raised (1850's and 1917), wetlands and marshes have been lost. Based on aerial photographs, the RKLD believes that an additional 400 to 700 acres of wetlands have been lost since the 1950s. A review of aerial photography by the WIDNR staff documented the loss of approximately 52 acres of shoreland between 1950 and 1963. Photographs revealed that at least an additional 270 acres of wetland had disappeared between 1963 and 1975. The WIDNR attributed this loss to higher water levels and attendant erosion by waves and ice action. Lack of aquatic vegetation hampers use of the lake by fish for spawning, nursery areas, and cover, as well as becoming less valuable to waterfowl. High summer lake levels, instead of historical low summer water levels, prevent compaction of sediments and may inhibit growth of vegetation.

Under the **without-project** condition, the lake would remain turbid, with little aquatic vegetation. In addition, wave and wind induced erosion would continue to threaten the remaining wetlands, further reducing these important areas. The rate of erosion at each area will be determined in the course of this study. Lack of aquatic vegetation would negatively impact desired fish and wildlife species. Erosion and sedimentation would continue to keep turbidity high. High numbers of rough fish would continue to destroy vegetation and resuspend lake sediments. The combination of these factors would contribute to continued losses of wetlands and fish and wildlife habitat. Opportunities exist to restore and enhance wetland habitat degraded by lake impoundment, increased agriculture and urbanization, and the proliferation of common carp.

The **with-project** condition would significantly change factors that currently threaten wetlands and limit habitat suitability for a variety of fish and wildlife and improve water quality within the breakwater areas. The proposed project would protect several significant wetland areas. These efforts could protect 100 to 300 acres of existing wetlands at each site and provide sheltered areas for submergent and emergent vegetation re-establishment. Results would be increased biological diversity, improved conditions for aquatic life, and an improved lake fishery. Restored wetlands would provide habitat for shorebirds, migratory waterfowl, and local wildlife. Restoration of wetland vegetation would bind nutrients and trap sediments from several creeks. Re-establishing aquatic vegetation and reducing sediment input to the lake would further decrease turbidity and improve water quality. This water quality benefit would have beneficial impacts, though these benefits would be confined to the areas sheltered by the breakwaters. As an important resource for waterfowl, as well as other migratory and resident birds, protection of existing wetlands and re-establishment of aquatic vegetation would increase the habitat value of this important area.

2.1.2 Project Goals, Objectives, and Potential Features. Based on the identified problems and the fish and wildlife management goals of the cooperating agencies, the following goals, objectives, and potential features are proposed:

Table 1. Project Goals, Objectives, and Potential Features

GOAL	OBJECTIVES	POTENTIAL FEATURES
Protect and Enhance Wetland Habitat	Reduce erosion of wetland areas Provide sheltered areas for re-establishment of aquatic vegetation Eliminate carp from wetland areas, while maintaining recreational boat use	Breakwaters Carp Gates Shoreline Protection Island Construction Permanently lower water levels

The project involves the enhancement and protection of wetland habitat. The following objectives have been identified to meet this goal: (1) reduce erosion of wetland areas, (2) provide sheltered areas for re-establishment of aquatic vegetation, and (3) eliminate carp from wetland areas.

2.2 Potential Project Features

2.2.1 Potential Project Features. Features to be evaluated in the feasibility study included: breakwater construction, carp gates, shoreline protection, island construction, and permanently lower water levels.

Breakwaters would protect existing wetlands from further erosion, provide a sheltered area for submergent and emergent vegetation re-establishment, and allow rough fish exclusion. This potential project feature provides a barrier to wave propagation from the main lake to the wetland areas. Wave-induced erosion is drastically reduced using this technique, and its beneficial effects are well documented for the Lake Butte des Morts project. Wetland areas, sheltered by a breakwater, would have less shoreline erosion and less turbidity, which will yield clearer water and a higher quality and more diverse wetland. Protection and re-establishment of aquatic vegetation would benefit the lake's fish and wildlife resources. Increased aquatic vegetation would increase habitat diversity and quality for shorebirds and migratory waterfowl. Construction of breakwaters could also reduce turbidity by trapping incoming sediments from the many streams that enter the lake, such as Koshkonong Creek at Cresent Bay and Otter Creek at Haights Bay. The protected and improved wetlands will also have the ability to remove nutrients from the water, thereby improving water quality within the breakwater areas. Wetland vegetation removes nutrients, primarily nitrogen and other pollutants, from the water. Aquatic plants also add dissolved oxygen to the water. All of these wetland features contribute to improved water quality, though these water quality benefits would be most measurable within the areas sheltered by the breakwaters.

Carp gates, either as part of the breakwater construction or as a stand-alone feature as at Mud Lake, a sheltered backwater wetland, would provide benefits by preventing carp from entering the areas to spawn and disturb the aquatic vegetation. These activities also increase turbidity, further reducing the aquatic vegetation. Protected areas with carp exclusion would better function as nursery areas for desired fish species, as well as reducing carp spawning habitat.

Shoreline protection, using riprap along the bankline, was proposed at several areas, such as the Bulkhead Line at Stinkers Bay and Mud Lake, along the northeastern shore of the lake. While riprap would stabilize the shoreline at these locations and prevent further losses of the existing wetlands, this feature would not address the need to reestablish emergent and submergent vegetation in areas where they previously existed. This action also serves to isolate the remaining wetland from the lake, preventing fish from using the protected wetland areas very effectively.

Island construction was considered as a means to reduce the fetch and therefore the degree of wave force. The premise was that this feature would meet the goals and objectives by reducing erosion in the wetland areas by reducing wind fetch. This feature would require numerous construction locations because the length of the lake, thereby impacting recreational navigation. In addition, the opportunity to eliminate carp from the wetlands could not be occur.

Permanently lower water levels more closely resembling the historic water levels of the marsh were considered, as was using periodic or summer drawdowns. The most desirable water level for Lake Koshkonong is a subject of considerable debate among the various users of the lake. It has been estimated that removing the dam would decrease the average water depth from 5 feet currently to 3 feet, reducing the acreage from approximately 10,460 acres to approximately 7,500 acres. Drawdowns during the summer months would simulate a more natural management scheme and would allow compaction of the sediments, facilitating vegetative growth. Both of these methods would reduce erosion of existing wetlands and facilitate aquatic vegetation reestablishment but do not eliminate the carp from the wetland areas.

2.2.2 Features Dropped from Further Consideration. During the initial screening of features, shoreline protection, island construction, and permanently lower water levels were dropped from further consideration.

Shoreline protection was proposed at several areas along the northeastern shore of the lake. The areas protected would be on private property. If this feature were to be implemented as part of the proposed aquatic ecosystem restoration project, the protected areas would need to be open to the public. In addition, this feature is achievable in a more cost effective manner at the local level. Finally, the landowners for the Bulkhead Line, an area previously considered as a potential project site, are proceeding with shoreline protection on their own. The owners of the lands separating Mud Lake from Lake Koshkonong are considering a similar venture. These reasons caused the feature to be dropped from further consideration. Shoreline protection of private property should remain a local initiative.

Island construction in the center of the lake was proposed as a potential feature. Preliminary analysis indicated that island construction in the center of the lake would not accomplish the objectives of this project. The prevailing winds would again build up energy before reaching the shoreline. Islands would either 1) need to be constructed immediately offshore or 2) built to such a large size to break up the fetch. In addition, this feature would not allow for rough fish exclusion. Finally, island construction may interfere with recreational use. Therefore, island construction was dropped as a potential feature during preliminary screening.

Permanently lower water levels were dropped from further consideration for both its adverse effects and from a project viability standpoint. Permanently lowering water levels could hinder recreation and recreation support services, reduce potential hydropower generation, increase water temperatures, promote rough fish reproduction, and drain wetlands formed since impoundment and dam modification in 1917. In addition, the WIDNR currently oversees the water levels, which are legally mandated and were adopted after a prolonged legal battle (1982-1989). The current water level operating order is a compromise between the request of the low-water interests and the high-water interests. If the lake were managed more like a natural system, summer drawdowns would be a part of that management. However, the WIDNR believes this drawdown during the height of the boating season would be politically unpopular and perhaps impossible. Lower water levels may negatively impact private landowners, recreational navigation, and recreation industries around the lake. Finally, the project sponsor does not support lower water levels.

2.2.3 Potential Project Features and Measures. To further develop the remaining features, specific measures were proposed. Criteria for each feature will be developed, to include minimum project life, resistance to ice damage, resistance to vandalism, structure reliability, and operation and maintenance requirements.

2.2.3.1 *Breakwater Feature*: The main feature of the project is the construction of breakwater structures at key locations. Sites currently being considered are Cresent Bay, White Crow Bay, Pike Bay, Krumps Creek, Gilberts Bay, Haights Bay, Lautz Bay, and the Koshkonong Creek delta. Breakwater lengths vary, depending on the alignment chosen and are shown on Plate 3. They will be constructed using local, readily available materials. The breakwaters will be constructed to allow boat passage, but will be designed to exclude rough fish from the wetland areas behind the breakwaters when possible. To determine the most feasible configuration of this feature, several measures were proposed that would yield a variety of costs and habitat benefits. To facilitate the combination of the measures, each measure was given a designation.

2.2.3.1.1 Alignment (1, 2, 3, 4): At some locations, there are as many as four potential alignments. These alignments would yield varied costs and habitat units. This measure is designated by **(1)** or **(2)** or **(3)** or **(4)**. These alignments are formulated by accessibility, habitat considerations, and landowner participation. The construction access for each alignment varies. Particular consideration was given to this access when formulating the alignments. The most feasible, cost effective access method will be chosen. Alignments are shown on Plate 3.

2.2.3.1.2 Construction Material and Design

- **Rubble Mound (r)**: This measure is designated by **(r)**. The all rock structure, as shown in cross-section on Plate 9, is to be composed of a graded riprap, sized to withstand the design wave height as determined by theoretical calculation and anecdotal evidence. It will be designed for slope stability and settlement based on an assumed unit weight of the rock and bottom material properties. This design will be adjusted when an actual rock source is determined and further bottom exploration is conducted along the selected alignments. Depending on the results of this exploration, the flank stability berms may be reduced or increased in size. The cross-section shown is based on an average water depth of five feet, structure settlement of two feet, and an exposed height of three feet over target summer pool. The exposed height will remain constant, and the dike footprint and berms will diminish as the depth lessens. The lakeside slope will be 2-horizontal to 1-vertical, and the bayside slope will be 1.5-horizontal to 1-vertical. Although requiring additional rock, the flatter lakeside slope will be more tolerant of wave attack and should mitigate ice-flow forces. An initial top width of five feet was chosen based on calculated wave overtopping, while the ten-foot top width was selected based on construction and access practicality. These breakwaters will be constructed with heavy riprap, ranging in weight to 400 pounds or more.
- **Geotextile Tube (g)**: This measure is designated by **(g)**. This option has essentially the same cross-section and external dimensions as the rubble mound and is shown on Plate 10. The addition of the geo-textile tube core is being explored to reduce the volume of rock-fill material, and therefore is a potential cost savings. The core is a synthetic fabric tube that is hydraulically filled with material dredged from the immediate vicinity of the breakwater on the lakeside. The fabric strength properties are chosen to accommodate placement of the armor layer. Major considerations are placement ability and placement rate. The explorations mentioned above will also determine the suitability of the lake bottom material for this application. Presently, there is no historical information on the practical

feasibility of this approach. As an extension of this option, breakwaters consisting solely of a geotextile tube with vegetated flank protection will be evaluated.

- **Sheet Piling (s)**: This measure is designated by **(s)**. This option consists of a single row of interlocking sheet pile driven into the bottom along the established alignment and is shown on Plate 11. The piling would be driven to a stable depth with three feet exposed above target summer pool. The material of the sheet pile could be steel, aluminum, or vinyl. Depending on bottom material, a rock toe may be required in some areas. This option would have a "top width" no wider than the piling.
- **Floating (f)**: This measure is designated by **(f)**. This option consists of installation of a floating prefabricated breakwater system, weighted on the bottom, and anchored to the shoreline at each end, and is shown on Plate 12. It is anticipated that the structure would require removal and/or storage during the winter months, to protect the structure from ice damage.
- **Timber Crib (t)**: This measure is designated by **(t)**. This option consists of timber members (6-inch by 6-inch minimum) that are stacked in alternating layers to form an open weave, boxlike structure and is shown on Plate 13. The crib may be designed to have compartments in which some have floors and some do not. The crib is then floated into position and settled onto a prepared foundation of geotextile fabric by filling the floored compartments with stone (at least 50 pounds). Once sunk, the unfloored compartments are then filled with stone to give stability. Timber cribs would require riprap on the lakeside toe for erosion protection. The structure may be capped with timber, concrete, capstones, or other suitable material or uncapped.
- **Concrete Slabs (c)**: This measure is designated by **(c)**. This option consists of vertical concrete slabs that are H-shaped in section. The tongue and groove precast slabs are placed between the flanges of the king-piles to form a heavy, continuous retaining structure and is shown on Plate 14.
- **Earthen Embankment (e)**: This measure is designated by **(e)**. This option consists of construction of an embankment with either fine-grained or course-grained material. Placement of material would essentially be "in the wet" and accomplished using end dumping, dragline, hydraulic, or other means. Ideally, it would be most economical to use adjacent bed material on the lakeside. The earthen embankment would require riprap on the lakeside slope for erosion protection. This feature is shown on Plate 15.
- **Gabion Baskets (b):** This measure is designated by (b). This option consists of stacking 36-inch gabion baskets to form a stepped up slope and is shown on Plate 16. Toe protection can be provided by extending 12-inch baskets out along the bottom at a distance sufficient to provide a cutoff in the event of scour. The structure must be stable against sliding and rotation considering any eroded depth at the toe.

<u>2.2.3.1.3</u> Top Width. This measure applies to Rubble Mound, Geotextile Tube, or Earthen Embankment construction methods only. This measure will be evaluated for operation and maintenance of the feature. If the top width is increased to ten feet for maintenance purposes, the material quantity will increase by more than ten percent.

- 5 feet (5): This measure is designated by **(5)**.
- 10 feet (10): This measure is designated by **(10)**.

<u>2.2.3.1.4</u> Construction Access Method. Access will be a challenge because current roads may not withstand truck traffic and may require reinforcement or repair, and lake water depths may preclude barge access necessary for construction.

<u>2.2.3.1.5</u> Breakwater Height. After a hydraulic analysis of wave height and lake water level fluctuation, it was determined that a standard breakwater height of 3 feet above summer operating pool (776.2 feet MSL) would be appropriate to dissipate the wave energy from the calculated significant wave height of 2.65 feet. This breakwater height does not apply to the floating breakwater measure.

<u>2.2.3.2</u> *Carp Gate Feature* (C). The criteria for gate design are: 1) successfully prohibit movement of carp into the wetland area, particularly during carp spawning times; 2) allow movement of desirable species into the wetland areas during key life cycle times; and 3) allow boat passage. The carp gates implemented at Lake Butte de Morts meet these criteria and that design will be used for this project. Figure 1 depicts the carp gate at Lake Butte des Morts. These rough fish exclosures will be constructed of 1-inch steel bars erected upright on 3-inch centers. A 12-foot-wide floating gate, hinged on the bottom, allows boats to enter and leave while still excluding most fish. This gate can be lowered to allow fish movement after peak rough fish activity and during winter months. This feature is shown on Plates 17 and 18. The only measure considered for this feature is the variance of the location of the gate within the breakwater. A critical factor in determining the location of the carp gates will be the minimum depth required for boat passage. This feature will be included in all breakwater alignments because the habitat benefits are significantly increased for only a modest increase in construction costs.

2.3 Formulation of Alternatives

2.3.1 <u>Formulation Process.</u> Further screening allowed the team to evaluate each of these measures for feasibility. As indicated above, during the process, certain measures were dropped from further consideration. The remaining measures were combined to formulate project alternatives that would meet the project goal and objectives.

2.3.2 <u>Potential Alternatives.</u> These alternatives are best discussed by organizing them by location. To do this, the different locations were identified as shown on Plate 3: Lautz

Bay, Haights Bay, Gilberts Bay, Mud Lake, Krumps Creek, Pike Bay, White Crow Bay, Crescent Bay, and the Koshkonong Creek Delta.

Lautz Bay (L) – These alternatives are designated by the letter "L" and are shown on Plate 4. Construction access is possible from both ends.

Site L: Lautz Bay	
L0	No Action
L1	Alignment length – 760 feet
L2	Alignment length – 1,310 feet
L3	Alignment length – 1,770 feet (RKLD preferred alternative)

Haights Bay (H) – These alternatives are designated by the letter "H" and are shown on Plate 5. Construction access is possible from both ends.

Site H: Haights Bay	
H0	No Action
H1	Alignment length – 2,850 feet (dropped from further consideration)
H2	Alignment length – 3,205 feet
H3	Alignment length – 1,980 feet (dropped from further consideration)
H4	Alignment length – 2,815 feet (RKLD preferred alternative)

Gilberts Bay (G) – These alternatives are designated by the letter "G" and are shown on Plate 6. Construction access is only possible from the southern end.

Site G: Gilberts Bay	
G0	No Action
G1	Alignment length – 2,310 feet (RKLD preferred alternative)

Mud Lake (M) – These alternatives are designated by the letter "M". Details are shown on Plate 17 and 18. A similar, existing carp gate is shown on Figure 1. Construction access is only possible from the northern end.

Site M: Mud Lake Carp Gate	
M0	No Action
M1	Carp Gate (RKLD preferred alternative)

Krumps Creek (C) – These alternatives are designated by the letter “C”, shown on Plate 19. Construction access is only possible at both ends. Shoreline appears stable. A large wetland is drained by Krumps Creek. The adjacent wetland area to the west has been recently protected by riprap.

Site C: Krumps Creek	
C0	No Action
C1	Alignment length – 440 feet (RKLD preferred alternative)

Pike Bay (P) – These alternatives are designated by the letter “P” and are shown on Plate 7. Construction access is possible at both ends. The shoreline appears to be stable. A large wetland has its outlet into Pike Bay.

Site P: Pike Bay	
P0	No Action
P1	Alignment length – 2,400 feet
P2	Alignment length – 3,350 feet (RKLD preferred alternative)

Koshkonong Creek Delta Area (K) – These alternatives are designated by the letter “K”, and include White Crow Bay (K1) and Cresent Bay (K2) alignment alternatives and are shown on Plate 8. Construction access is possible at the western end of Cresent Bay and the eastern end of White Crow Bay breakwaters only. Most of the shoreline has recently been stabilized with riprap. The RKLD prefers the outlet of Koshkonong Creek be located behind the breakwater structure at Cresent Bay. Minor creek channel work to re-establish old outlet may be needed. The Koshkonong Creek delta area appears to be eroding, altering the creek outlet location.

Site K: Koshkonong Creek Delta Area	
K0	No Action
K1	Alignment length (White Crow Bay) – 2,285 feet (RKLD preferred alternative)
K2	Alignment length (Cresent Bay) – 4,045 feet
K3	Alignment length (Cresent Bay) – 5,425 feet (RKLD preferred alternative)
K4	Alignment length (Delta Area) – 10,145 feet

Combination of Alternatives

One alignment will be selected at each site; hence numerous combinations may be formed, EXCEPT Alternative K1 **may** be combined with either K2 or K3 at Koshkonong Creek since there are two bays in this area.

Plates and Figures