LAKE RESTORATION STUDY
NAGAWICKA LAKE
CITY OF DELAFIELD, WISCONSIN

Lake Restoration Study
Nagawicka Lake
City of Delafield, Wisconsin

Prepared for:
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INTRODUCTION

In the spring of 2003, Vierbicher Associates, Inc. began assisting the City of Delafield's Lake Welfare Committee with planning for the restoration of Nagawicka Lake. Nagawicka Lake is a relatively deep impoundment lake with about 900 acres of surface area in the northeastern corner of Waukesha County, Wisconsin (Figure 1). Restoration is being considered along the shallow shoreline and embayments of Nagawicka Lake primarily to rehabilitate aquatic habitat degraded by excessive accumulation of material on the bed of the lake. The removal of this accumulated material will also improve watercraft navigation and help to reduce excessive internal nutrient sources in the Lake. The restoration study was supported in part by a Grant from the Wisconsin Department of Natural Resources.

Purpose and Scope

The study of the possible restoration of the lake began with the consideration of the amount of material accumulated on the bed of Nagawicka Lake since its impoundment. The investigation also considered the amount of this material that would need to be removed to create deeper near shore aquatic habitats and to provide adequate watercraft movement throughout the lake. The costs of removing this accumulated material are related to its particle size distribution, its chemical composition, and its distribution throughout the lake. Especially important in estimating restoration cost is the relative proximity of adequate disposal sites. The feasibility of lake restoration is also closely linked to the future movement of material into the lake and to our ability to obtain permits from regulatory agencies to complete the project.

The scope of this investigation considered details of the project including the socio-political environment of the City and surrounding communities that will be affected by the project. The scope also included detail construction plans at the specific lake restoration sites and material disposal sites such that bidding documents and cost estimates could be prepared and regulatory agencies permit applications completed. At this point the results of the restoration study will be used by the City to make decisions regarding implementation of the project.

A number of issues related to restoring Nagawicka Lake were addressed during this investigation. Following is a brief identification of these issues.

- The volume and characteristics of unconsolidated material accumulated on the bed of Nagawicka Lake.

- The source and volume of sediment and nutrients coming to Nagawicka Lake from its watershed.

- The extent of environmentally sensitive areas in Nagawicka Lake that might restrict restoration activities.

- The possible consequences on the water quality and aquatic habitat of Nagawicka Lake and downstream lakes from construction.

- The most effective method of restoration and material disposal.

- The most likely costs and sources of funding for the project.

STUDY COMPONENTS

Accumulated Lake Bed Material

In addressing the issues described above, eight primary areas around Nagawicka Lake where near shore aquatic habitat is in filling and watercraft access is restricted were identified (Figure 1 and 2). These eight areas are:

1. St. Johns Bay and the Bleeker Street Boat Landing, is the embayment adjacent to the dam in the southwest corner of the lake.

2. Zastrow's Bay is a wide embayment across the lake along the eastern shoreline.

3. The Bark River Inlet, is along the northeastern shoreline where the Bark River enters the lake.

4. The Northeast Channel Area, is where several east-west oriented narrow canals were dug into the shoreline to access developments in the far northeastern corner of the lake.

5. The Kettle Channels include the narrow channel connecting Nagawicka Lake to a wide kettle embayment to the north of the main lake and developed areas along the shoreline with the kettle embayment.

6. The Northwest Channels are numerous east-west and north-south oriented channels dug into the shoreline to access developments along the lake's northwestern shoreline.

7. The West Channels are several relatively short east-west oriented channels dug into the lake's western shoreline, just north of St. Johns Bay.

8. The Mill Pond area, is another small impoundment downstream from Nagawicka Lake about one-mile.

The depth of accumulated material on the bed of Nagawicka Lake was measured using horizontal location control established with Global Positioning System (GPS) technology and probed measurements with a long metal rod or with a fiberglass surveying rod (See plans). Using the lake bed measurements, a total volume of about 158,900 cubic yards of material may be removed from the lakebed within the study areas. This accumulated material is distributed around Nagawicka Lake in eight primary depositional areas described previously (Table 1).

It is important to note that this total volume represents removal of material to create deeper water in the near shore areas to enhance aquatic habitat and to improve watercraft access, not wholesale shoreline to shoreline dredging. One goal is creating a navigational channel with a long-term useable bottom width of 50-feet, a depth of 5-feet and side slopes of 5 to 1 as a standard. An exception is in some of the previously channeled areas, where existing channel widths are narrower than this 50-feet minimum. In these narrow areas anticipated restoration would be done only along the channel centerline and the existing shoreline would remain undisturbed where the 5 to 1 side slopes begin.

Table 1
Volume of Material to be Removed from Nagawicka Lake
(Cubic Yards)

St. Johns Bay	27,100
Zastrow's Bay	5,600
The Bark River Inlet	32,600
Northeast Channel Area	9,600
The Kettle Channels	12,000
The Northwest Channels	37,000
The West Channels	15,000
The Mill Pond	20,000
TOTAL	**158,900**

Characteristics of Accumulated Lakebed Materials

Following the volume estimates, the chemical and physical characteristics of the material accumulated on the lakebed must be determined. Core samples from representative restoration areas have been collected. These samples are at the laboratory to be analyzed for particle size, total suspended sediment, and the concentration of pesticides, trace elements, polynuclear aromatic hydrocarbons (PAH's), PCB's, oils and greases, and nutrients. The chemical and physical characteristics of samples will then be summarized in a data table similar to that shown below. We have already collected samples from nine representative sites around the lake. (See plans) However, the data have not yet been analyzed by the laboratory or reviewed by WDNR. Once the chemical characteristics of the samples are known, the restoration plans will be further evaluated based on each samples concentration of contaminants and their location relative to restoration plans and the environmentally sensitive areas on the lake.

Table 2 Physical and Chemical Characteristics of Accumulated Lakebed Material									
	St. John's Bay				**Northwest Channels**			**Zastrow's Bay**	
	A	B	C	D	E	H	I	F	G
Percent Solids									
Percent Sand									
Percent Silt									
Percent Clay									
Percent Organic Content									
Suspended Sediment									
Total Ammonia Nitrogen									
Total Phosphorous									
Copper									
Arsenic									
Lead									
Cadmium									
Pesticides									
Oils and Greases									
PCB's									
PAH's									

Restoration Method Selection

Once the volume of material to be removed was determined, possible removal methods were considered. The site access, the characteristics and volume of accumulated material, the anticipated costs, and the proximity of an adequate disposal site were factors in selecting a restoration method.

Hydraulic and mechanical removal were the primary methods considered. Hydraulic removal involves the vacuum extraction of material from the lakebed and pumping of the extracted material through a pipeline to a disposal site. Hydraulic dredges are typically rated by the size (diameter) of pipeline, which they use to move material. For example, an eight-inch dredge would use an eight-inch diameter pipeline. The costs of removing an equal volume of material are less for larger size hydraulic dredges but the costs to mobilize a larger dredge is greater. Additionally, the costs for hydraulic dredging are closely related to the distance that lakebed material must be moved. For example, for sandy material a distance greater than about 3,500 feet between the dredging and disposal sites typically requires an additional pumping station along the pipeline, which substantially increases the cost of moving material and mobilizing the equipment. Furthermore, if the elevation above the lakebed where disposal of the material is more than 15-20 feet above the lake, additional pumping stations can also be required, which will increase costs substantially.

Mechanical removal typically involves more commonly used excavation equipment such as backhoes, draglines, scrappers, or bulldozers. To facilitate this type of removal, the accumulated material must be exposed and water levels in Nagawicka Lake need to be lowered considerably. Disposal sites also need to be easily accessible with the equipment or trucks to deposit the excavated material. Costs for mechanical removal commonly can be as little as one-half that of hydraulic. However, few identified restoration sites on Nagawicka Lake will be easily accessible with typical excavation equipment as a result of limited capacity to drawdown Nagawicka Lake's water level. The dam crest elevation at the Nagawicka Lake dam is adjustable but only about three to four feet of water level lowering is possible.

As a result of the physical limitations on water level lowering and the subsequent limits on lakebed access, typical mechanical removal methods do not appear to be practical at Nagawicka Lake. Another option might be to use a dragline floating on a barge or an amphibious excavator where lakebed material could be removed and transported to shore for disposal. The costs of this option would likely be excessive because this method would involve handling the material several times. For this study it seems most feasible to evaluate hydraulic dredging as the preferred method.

Disposal Site Identification

Once a restoration method was selected, possible material disposal sites were investigated (Figure 2). The size of a disposal area, its distance away from the proposed restoration areas, and its elevation above the lakebed are the primary disposal site characteristics that control its economic use (Table 3). The type of soil and vegetation on the disposal site, the site topography, and the depth to groundwater are also noteworthy site characteristics to be considered at each potential disposal site. The availability or associated high land

value of adequate disposal sites can be a serious limitation to the feasibility of restoring Nagawicka Lake.

There are four primary disposal sites in proximity to the lake (See plans). No single one of these is practical to use for all the potential restoration because the sites along the lake are wide spread and no single spoil site has adequate volume for all the material in the lake. It seems more practical to align specific restoration sites with specific spoil sites based on location and size. For example the site at the end of Hirschman Lane (See plans, Table 3) appears to provide an adequate disposal area and the smallest elevation gain above the lakebed for servicing the eastern and northeastern areas of the lake. Therefore, this restoration plan proposes to combine spoils from several restoration sites according to proximity and the available storage volume. Then the projects total costs for restoration are estimated by adding up the costs to prepare these four primary spoil sites for material storage, to transport lake bed material to each site, and to restore each spoil site.

Table 3
Disposal Site Data

Location	Greatest Distance From Restoration Site (Feet)	Elevation Above Lakebed (Feet)	Available Land Area (Acres)
Site 1 Mertens Farm	5,000	40-55	20
Site 2 Hirschman Lane	6,500	20-30	14
Site 3 St. John's Academy	6,000	5-15	2.5
Site 4 Cushing Park	2,000	5-10	1.5

Cost Estimates for Lake Restoration

Preliminary estimates for removing accumulated material from the bed of Nagawicka Lake were obtained from several contractors familiar with similar projects (Appendix).

- Dennis Cole at Inland Dredge Company, Inc.
  Burlington, WI
  (262) 763-3620

- Steve Tennant at Tennants Industrial Dredging Inc.

Terre Haute, IN
(812) 466-5187

- Glen Green at J.F. Brennan
  LaCrosse, WI
  (608) 784-7173

The cost estimates ranged from $4 to $12 per cubic yard depending on where on the lake the material was removed relative to a disposal site and how the material was removed (mechanical or hydraulic dredging and whether the project used a large or small hydraulic dredge). Using an average cost of $8 per cubic yard, removing the entire 158,900 cubic yards of accumulated material would cost about $1,271,200. However, some areas may be more expensive to restore. Additionally permitting and disposal site acquisition, preparation, and restoration costs would likely be in excess of $500,000 for a large project such as this.

Because this large expense would most likely be beyond the annual capabilities of local funding sources, an alternative strategy of removing only a portion of the accumulated material in any given year was also considered. The results of the public survey indicate a priority order of the potential restoration sites as follows:

Table 4
The Public's Priority Order of Restoration Sites

1. St. Johns Bay Bleeker Street Landing
2. Bark River Inlet
3. Northwest Channels
4. Kettle Access
5. West Channels
6. Northeast Channels
7. Zastrow's Bay
8. Mill Pond

If these sites were done, one per year, in their priority order, it would considerably reduce City expenditures on an annual basis, but increase overall costs because labor rates and land values will increase over time.

In the existing channelized areas of the lake, (Northeast, Northwest and West Channels) the proposed restoration plan would remove accumulated material along the entire length of each channel out to the shoreline of the main lake. This standard scenario would

propose to create a usable long-term channel width of 50-feet with a depth of five feet. Where the existing channel width is too narrow for this standard approach, the restoration plan would create a minimum channel depth of five feet with the greatest width possible allowing for 5 to 1 side slopes up to the existing channel shoreline.

Restoration Costs

The anticipated cost of the lake restoration project including spoil site acquisition, preparation, and restoration was estimated or each disposal area as follows:

St. John's Academy

This potential disposal site is on the southeastern edge of the military academy grounds where composting fill from the City and surrounding area is presently accumulating (Figure). The site borders the Bark River on the south, the commercial businesses along CTH C to the east, and the academy buildings and grounds to the north and west respectively. About 2.5 acres are available for use at this site and could store about 44,000 cubic yards of material if configured as shown on our plans (Figure). The cost to prepare this site for storing lakebed material would be about $25,000. In addition, there may be some additional costs for acquisition or leasing and restoration of the site or removal of the stored material. These additional costs may be as high as $40,000 if removal of the stored material is required. The result is an anticipated cost of about $65,000 to use the St. John's Academy site for lakebed material disposal.

The estimated 27,100 cubic yards of lake bed material removed to create a standard 50-feet wide restoration channel from the main lake to the Bleeker St. boat landing, another channel to the dam at the head of St. John's Bay, a channel along the north shore of St. John's Bay, and a connecting channel from St. John's Bay to the West Channels restoration area could be stored at this site.

The Bleeker St. channel is about 1750 feet long and has about two feet of material needing removal. This results in about 7,800 cubic yards of restoration. At $8 per yard this requires about $62,400 to remove.

Creating a navigational channel to the dam would increase the restored channel length by about 1200 feet. In this area of the bay there is also about two feet of material accumulated. As a result there is about 5,400 cubic yards of additional material requiring removal at a cost of about $43,200.

Extending a navigational channel along the north shore of St. John's Bay to about the intersection with a new cross-bay connecting channel would add about 1,500 feet of channel. Increasing the channel depth in this area by about 1-foot would require removal of 3,100 cubic yards of material at a costs about $24,800.

Creating the cross-bay connecting channel that looped around the north shore of the bay to S. West Shore Drive and connected to the new Bleeker Street navigational channel would require adding an additional 1,500 feet to the channel length. This restoration channel requires removal of about three feet of material or about 10,800 cubic yards of material at a cost of $86,400.

The restoration plans described above result in an anticipated costs of $216,800 to deepen and restore a near shore channel for aquatic habitat enhancement and improved recreational watercraft access along the perimeter of St. John's Bay. Combining that with the estimated spoil site costs of $65,000 results in anticipated total restoration costs of $281,800 for the St. John's Academy disposal site project.

Merten's Farm

At Mertens Farm there is a twenty-acre site along Mission Avenue that could potentially contain up to 128,000 cubic yards of material if configured as shown in the site plan (See plans). The costs to prepare this site to store lake bed material and restore it could be as high as $100,000 considering the height and length of containment berms and the necessary erosion control practices. In addition, the value of this land is likely quite high, as a result of the potential for development. Therefore permanent use of the site that would preclude future development would be very costly and temporary use of the site may cost as much as $20,000 based on current crop values. In addition, since this site is quite far from the lake and considerably higher in elevation, lakebed material transport costs will be as high as $16 per yard.

The volume of material anticipated to be stored at this site is much less than its capacity. For example, the West Channels may require 15,000 cubic yards, the Northwest Channels, 37,000 cubic yards, and the Kettle another 12,000 cubic yards, for a total of 64,000 cubic yards. This low storage volume will result in lower berms and less erosion control costs. Furthermore, the Kettle is considered environmentally sensitive and the planned restoration there may not be permitted. These considerations could reduce the total volume of material to be removed to about 52,000 cubic yards, which could then be spread over the 20-acre site with an average depth of less than two feet. The result would be lower site acquisition, preparation and restoration costs.

The West Channels have a total length of 4,700 feet and an average sediment depth of 1.5 feet. If restored to a useable bottom width of 50-feet about 15,000 cubic yards of material would be removed at a cost of $240,000.

The Northwest Channels have a total length of about 11,550 feet. They run north to south and east to west and some were previously dredged. There are lengths of these channels needing little or no dredging in the southern areas and some needing near complete cleaning in the northern areas. Overall an average of 1.5 feet of material needs to be removed from these channels that vary in width from 25 to 75 feet. A restoration plan

that removes material from the channel centerline and leaves the shoreline essentially undisturbed will remove about 37,000 cubic yards of material. The result is a lake bed removal cost of about $592,000.

The Kettle Access Channels have a total length of about 2,700 feet and would require removal of about 12,000 cubic yards of material to maintain an average depth of five feet. The costs to remove this material would be about $192,000.

When these three sites are considered as a lake restoration project associated with a single disposal site total costs could be as high as $1,144,000. This cost estimate includes site acquisition cost of about $20,000, and site preparation and restoration cost of $100,000.

Hirschman Lane Site

This potential spoil site has a fairly easily accessible area that could contain as much as 65,000 cubic yards of material if configured as shown on the plans (See plans). Acquisition costs are low since the parcel is City owned and preparation of the site should be easier since only a portion of the area will be needed. In addition restoration costs should be low since the site topography lends itself to long term lakebed material storage. As a result the site preparation cost will only be about $20,000. The site is not very high above the lake and it is relatively close to some restoration sites such as Zastrow's Bay and as a result transportation cost should be close to the $8 per cubic yard average.

This spoil site is anticipated to contain material from Zastrow's Bay, the Bark River Inlet and the Northeast Channels. Zastrow's Bay is expected to require removal of about 5,600 cubic yards of material. The Bark River Inlet another 32,600 cubic yards and the Northeast Channels about 9,600 cubic yards. The result is removal of 47,800 cubic yards of material and use of less than the full storage capacity at the disposal site.

The overall costs of transportation of material to this disposal site, and the preparation and restoration of the site will be about $402,400 or $382,400 for removal and transport of lake bed material and $20,000 for site preparation/restoration.

Cushing Park

At Cushing Park we plan to store material removed from the Mill Pond. However the capacity at Cushing Park, where there is only about 1.5 acres of disposal area, is only about 8,000 cubic yards and about 20,000 cubic yards are anticipated to be removed from the Mill Pond. The result is the need to store material removed from the Mill Pond somewhere else or forego completing lakebed removal per the plans. The Mill Pond is a low priority site but there is some excess capacity at the St. John's Academy site. The site acquisition, preparation and restoration cost at Cushing Park are expected to be high about $40,000. These costs are high primarily because it is waterfront site with high public use. In addition, six large old trees will need removal to accommodate spoil disposal at this site.

The Mill Pond has about 20,000 cubic yards of material needing removal. The portion stored at Cushing Park will require about $64,000 to remove at $8 per yard. The portion stored at St. Johns Academy will require about $144,000 to remove at $12 per yard. This results in a total cost to dredging the Mill Pond of about $248,000.

Sediment and Phosphorus Inflow

Following measurements of the lakebed, data from a recently completed Nagawicka Lake Management Plan (SEWRPC, 2001) were used to estimate the source and volume of sediment and phosphorus flowing into Nagawicka Lake from throughout its watershed. Understanding the inflow of sediment and nutrients to Nagawicka Lake provided data to tentatively select appropriate Best Management Practices (BMPs) to help control these inflows and predict the life expectancy of the proposed restoration projects.

The inflow of phosphorus and sediment to Nagawicka Lake is from two primary sources: The Bark River and the Nagawicka Lake shoreline. In 1995 these two sources contributed about 3,759 tons of sediment and about 14,769 pounds of phosphorus to the lake (SEWRPC, 2001). This equates to about 2,950 cubic yards of sediment per year to Nagawicka Lake (Table 4). The sediment and phosphorus come primarily from agricultural land (SEWRPC, 2001). Both sources should be declining in the future as a result of an ongoing conversion of cropland to residential and urban landuse. For this current restoration study, the use of the 1995, more conservative values, for inflow of sediment and phosphorus is recommended, especially for estimating the life expectancy and maintenance requirements of the restoration project. This inflow of sediment prompted the plan to create sediment trapping and storage capacity at the Bark River Inlet to extend the life of the restoration project by about ten years. As a result the restoration plans at the mouth of the river include removal of 29,500 cubic yards of material to create storage of ten years of sediment inflow at the 1995 rate.

Table 5
Annual Sediment (S) and Phosphorus (P) Inflow to Nagawicka Lake

	S (Tons)	S (Cubic Yards)	P (Pounds)
Watershed	3,759	2,950	14,769

Water Quality Concerns and Aquatic Habitat

The feasibility of restoring Nagawicka Lake must also consider the possible consequences to water quality and aquatic habitat from any restoration plan. The

degradation of existing water quality and aquatic habitat in Nagawicka Lake or downstream in Nemahbin Lake is a serious concern of regulatory agencies. The possibility that restoration plans may expose unacceptable or harmful materials accumulated on the lakebed is the primary motivation for requiring chemical analysis on the lakebed material before any removal is permitted. Concerns for the fishery and for public health and safety commonly limit the methods used for lakebed material removal, the timing of removal, the design requirements for disposal of lakebed material, and the treatment of any return water. Near shore, aquatic habitat needs protection

For Nagawicka Lake, the concerns about water quality and habitat include protecting environmentally sensitive areas, important aquatic habitat and the existing shoreline (See plans). To address this concern we plan to restrict removal of the lakebed adjacent to the shoreline and our plans provide for protection of sensitive shoreline areas.

Phosphorus mobilization during restoration should be minor because the majority of phosphorus will be attached to sediment particles that will either be removed by the restoration or will quickly settle back to the lakebed. Close monitoring of restoration work to ensure a uniform navigational channel is constructed will help ensure long-term stability of the channel. It will also help reduce surface area exposure of phosphorus rich sediments and the subsequent internal phosphorus recycling (Moore and others, 1988).

Fish should be capable of avoiding equipment during its operation and be able to move to suitable areas if water turbidity becomes elevated, so harm to the fishery should be minimal. Because the shoreline and some sensitive areas can generally be avoided, damage to them should be minimal or preventable. The need to restore deep near shore aquatic habitat and to improve watercraft access to public and private property is essential to maintain the economic viability of the City of Delafield and surrounding communities. Restoration plans will include planting vegetation that provides fish and wildlife with appropriate habitat, where practical. For example, along the shoreline of St. John's Bay, Bull Rush can be planted along the navigational channel to provide cover for spawning and rearing fish, and food for waterfowl.

Potential Funding Sources for Restoration

As clearly evident in this report, restoration can be very expensive. As a result, numerous and various sources may be required to obtain adequate funding to complete this restoration project. Furthermore, local residents and organizations, which benefit directly from the improved use of Nagawicka Lake, will be encouraged to contribute to project costs by most State and Federal funding assistance programs. Nagawicka Lake is surrounded by private and public land and the lake supports a popular and productive fishery. Potential funding sources include:

- Soliciting donations from local lake user groups such as sportsmen clubs.

- Obtaining funds from local units of government such as the City of Delafield, Village of Nashotah, and Waukesha County that each benefit from Nagawicka Lake as a tourist attraction.

- Acquiring funds through County Parks Appropriations to enhance public access to the park where it may be currently impeded by accumulated material on the lakebed.

- Applying for funding through the State's Recreational Boating Facility Program also known as the Navigational Aids Program which helps support dredging when it is dedicated to creating access for recreational watercraft.

- Soliciting funds from the US Army Corps of Engineers 206 Program.

- Special budget appropriation from State and/or Federal government.

All these funding sources are scarce and competitive.

Regulatory Requirements for Restoration

It is anticipated that regulatory agency permit requirements for this restoration project on Nagawicka Lake will be extensive but that it will be possible to obtain the required permits. Of special concern are the variable and often untractable expenses associated with obtaining the required permits. Examples are additional sediment chemistry requirements, collecting data for a detailed environmental assessment, and evaluating construction of a sediment trap along the Bark River or storm sewer inflows. Also, it is currently unclear whether groundwater susceptibility investigations will be required at disposal sites or how detailed the multiple cell berm/dike and return water plans will have to be at the planned lake bed material disposal sites.

It can require several months and tens of thousands of dollars to comply with the regulatory requirements described above. Furthermore, regulatory agency requirements and staff can change between the time of planning investigations and actual restoration.

An Environmental Assessment would be required from WDNR for removing more than 3,000 cubic yards of material from Nagawicka Lake. This process would include a detailed review of the environmental assessment by WDNR staff and a minimum of 30 days of public notice and comment.

SUMMARY

Restoring Nagawicka Lake to provide deeper near shore aquatic habitat and adequate recreational boat access to all areas is expected to cost about $2,076,200 (Table 6). This restoration effort is anticipated to cost about an average of $13 per cubic yard including all land preparation, land use, land restoration, engineering and permitting expenses.

Table 6
Summary of Nagawicka Lake Restoration Project Costs

Site Identification	Cubic Yards Stored	Costs
St John's Academy	39,100	$425,800
Mertens Farm	64,000	$1,144,000
Hirschman Lane	47,800	$402,400
Cushing Park	8,000	$104,000
TOTAL	158,900	$2,076,200

Financing a restoration project of this size can be challenging. Although some funding assistance programs are available, funding is scarce and often very competitive among potential users. Because Nagawicka Lake is a popular recreational destination in Southeastern Wisconsin this project may compete well for funding. Furthermore, state agencies will most likely recognize the economical and ecological importance of restoring Nagawicka Lake and support funding the project. It is most likely that considerable local funding will still be needed even if state program or agency funding assistance can be obtained. Because funding is so important, estimating anticipated costs for the proposed restoration is also very important. Local lake restoration contractors should complete a review of the cost estimate for this project to verify its accuracy.

In summary, our involvement in this restoration study results in the following observations and recommendations:

- Lake restoration is needed to enhance near shore aquatic habitat and to improve and maintain recreational boat access to Nagawicka Lake.

- Non-point sources of pollution, especially sediment inflows from the Bark River and local storm sewers, need to be controlled by implementing appropriate Best

Management Practices in the watershed prior to undertaking the proposed restoration project.

- Additional priority ranking of potential restoration sites may need to be completed to identify sites where work is needed first, so limited funds can be expended most efficiently.

Thorough agency review of this restoration study should be solicited so that concerns with water quality, fish, wildlife, and natural resources are addressed adequately. Potential agency concerns with permitting the proposed lake restoration project on Nagawicka Lake should be identified early in the planning process.

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