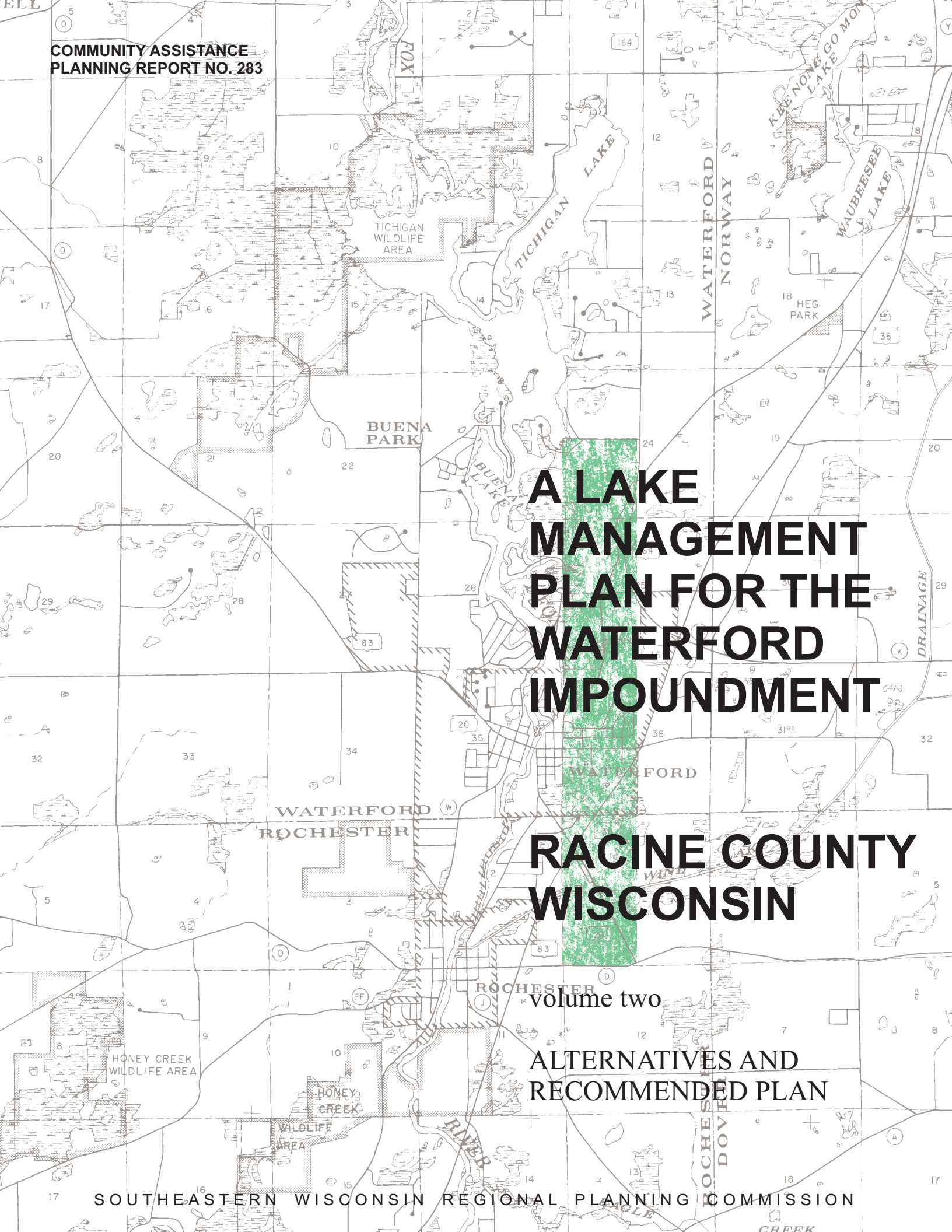
COMMUNITY ASSISTANCE
PLANNING REPORT NO. 283



A LAKE MANAGEMENT PLAN FOR THE WATERFORD IMPOUNDMENT

RACINE COUNTY WISCONSIN

volume two

ALTERNATIVES AND RECOMMENDED PLAN

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

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RACINE COUNTY, WISCONSIN

Volume Two

ALTERNATIVES AND RECOMMENDED PLAN

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Chapter I

BACKGROUND AND SUMMARY OF INVENTORY FINDINGS

INTRODUCTION

The Waterford Impoundment is a 1,132-acre waterbody located within U.S. Public Land Survey Sections 10 through 15, 23, 26, and 35, Township 4 North, Range 19 East, Town and Village of Waterford, Racine County. The tributary area draining to the Impoundment is about 358 square miles in areal extent. While the tributary basin has historically encompassed large tracts of agricultural land, increasing portions of the tributary area are in urban land usage and the trend toward urban development remains ongoing.

The Impoundment provides a range of complementary recreational services to the lake-oriented municipalities and wider community, and is a popular destination for recreational users. Nevertheless, continuing changes within both the direct and total areas tributary to the Waterford Impoundment have created a range of current concerns among this lake-centered community, including surface water use conflicts, siltation and sedimentation, protection of environmentally sensitive areas, and abundant aquatic plant growths in the shallower portions of the lake basins. In addition, present and future residential and commercial growth within the area tributary to the Impoundment is perceived to have impacted the Impoundment and its ecosystem. Other issues raised by lake residents and users include concerns over variable water quality conditions and contamination of Impoundment waters by nonpoint source pollution. These issues have been quantified to the extent possible and documented in the lake and tributary area inventory, comprising Volume I of this lake management plan for the Waterford Impoundment.

Based upon the documented issues identified in the aforementioned inventory, this plan sets forth alternative and recommended management actions for the Impoundment and its tributary area.

This plan represents an ongoing commitment of the Waterford Waterway Management District (WWMD), and the Village and Town of Waterford, to sound environmental planning with respect to the Impoundment. This plan describes both tributary area management and in-lake management measures that may be applied to enhance the water quality conditions, biological communities, and recreational opportunities in the Lake.

This plan is intended to provide the recommended means to achieve the following current water use objectives of the Waterford Impoundment:

1. Providing water quality suitable for full-body contact recreational use and the maintenance of a healthy fishery and other desirable forms of aquatic life;

2. Significantly reducing the severity of the nuisance problems associated with deposition of silt sediments, and excessive aquatic plant and algal growths in Buena and Tichigan Lakes, which constrain or preclude intended water uses at sites throughout the Impoundment;

3. Restoring and rehabilitating the aquatic flora and fauna, especially within the riverine portions of the Impoundment, which lack the abundant growths observed in the Lakes; and

4. Improving opportunities for both active and passive water-based recreation, navigation and human use.

5. Maintaining and improving the hydrologic functioning of the lakes, river and impoundment to promote a healthy native flora and fauna and multiple human uses.

This plan should serve as a practical guide over time for achieving these objectives in a technically sound manner.

INVENTORY AND ANALYSIS FINDINGS

Physical Description

- The Waterford Impoundment is a through flow waterbody with both a defined inflow and outflow, comprised of the Fox River. In addition to the flowage portions of the Fox River, the Impoundment includes the Buena Lake and Tichigan Lake subbasins.

- Silt and muck are the predominant impoundment bottom materials throughout most of the Waterford Impoundment, although the Tichigan Lake subbasin additionally exhibits large areas of sand and gravel, primarily along the shoreline.

- The shoreline of the Waterford Impoundment is comprised of vast stretches of wetlands in the northernmost areas, while the Tichigan Lake-Buena Lake areas downstream to the Waterford Dam are developed mostly for residential uses.

Water Budget

- The long-term water budget for the Waterford Impoundment was computed using the U.S. Geological Survey (USGS) data for the Fox River, as well as long term climatic data from the National Weather Service (NWS) and the National Oceanic and Atmospheric Administration (NOAA). It is estimated that, annually, about 219,954 acre-feet of water enter the Waterford Impoundment, about 90 percent of which enters by surface runoff and about 10 percent through direct precipitation onto the Impoundment surface.

- Of these inflows, about 92 percent of the total inflow to the Waterford Impoundment is discharged as outflow to the Fox River; about 8 percent of the total inflow is lost through evaporation.

Population

- The 2000 resident population in the area directly tributary to the Waterford Impoundment was estimated to be about 8,000 persons, an increase of about 60 percent over the 1990 population; about 209,300 persons resided within the total drainage area tributary to the Impoundment.

- The 2000 resident population occupied approximately 2,900 dwelling units within the area directly tributary to the Impoundment; there were approximately 78,900 dwelling units located within the total drainage area tributary to the Waterford Impoundment.

Land Use and Zoning

- As of 2000, approximately 2,440 acres, or about 17 percent of the direct tributary area to the Waterford Impoundment, were in urban land use, with the dominant urban land use being residential,

encompassing about 1,500 acres or about 63 percent of the urban lands in the tributary area. Commercial, industrial, governmental and institutional, transportation, communications and utilities, and recreational lands comprised the balance of the urban lands.

- As of 2000, approximately 12,367 acres, or 83 percent of the direct tributary area to the Waterford Impoundment, were in rural land use, with the dominant rural land use being agricultural, encompassing about 7,553 acres or about 61 percent of the rural lands in the tributary area. Woodlands, wetlands, surface water, and open lands comprised the largest portion of the balance of the rural lands.

Water Quality

- Physical and chemical characteristics of the Waterford Impoundment, in particular, the Tichigan Lake subbasin, have been measured as part of the Wisconsin Department of Natural Resources (WDNR) Self-Help Monitoring Program periodically since 1988; the U.S. Geological Survey (USGS) has collected water quality data in both Tichigan Lake and in the "Widespread" portion of the river periodically between 1994 and 2004.

- The Tichigan Lake subbasin is dimictic, mixing completely twice per year during spring and fall. Temperature and dissolved oxygen concentrations indicate that complete mixing of Tichigan Lake is restricted during summer and winter by thermal stratification. Conservancy Bay and the riverine portions of the Impoundment do not thermally stratify for any significant period of time during summer.

- Water clarity, as measured by a Secchi disc, in Tichigan Lake for the period from 1998 to 2004 as part of the WDNR Self-Help Program averaged about 6.5 feet in spring, 5.5 feet in summer, and about 5.2 feet in fall. Secchi disc readings collected by the USGS for the period from 1994 through 2004 for Tichigan Lake averaged about 5.5 feet in spring and summer; for Conservancy Bay readings averaged about 1.2 feet in spring and summer for the period 2003 and 2004. The values reported for the Waterford Impoundment are lower than other lakes in the Southeastern Wisconsin Region, which typically have average water clarity measurements that are below that of other lakes statewide.

- Chlorophyll-*a* concentrations in the Tichigan Lake subbasin averaged about 23 µg/l in the spring, about 12 µg/l in summer, and about 15 µg/l in fall. Concentrations above 10 µg/l generally result in a visible green coloration of the water, especially during spring when the maximum concentrations were recorded. The Tichigan Lake measurements indicated poor to very poor water quality.

- The total phosphorus concentrations reported by the USGS during the current study period averaged about 0.09 mg/l in the spring, about 0.11 mg/l in the summer, and about 0.22 mg/l in the fall in Tichigan Lake; in the Widespread, the averages were reported to be about 0.12 mg/l in the spring, 0.25 mg/l in the summer, and about 0.16 mg/l in the fall. The seasonal gradients of phosphorus concentration in the Tichigan Lake subbasin indicate that there may be internal loading of phosphorus from the bottom sediments of the Lake, although this internal loading is unlikely to significantly influence the growth of aquatic plants in the Impoundment.

- Values for total phosphorus concentrations generally exceed the Southeastern Wisconsin Regional Planning Commission (SEWRPC)-recommended water quality standard of 20.0 mg/l for recreational use and maintenance of warmwater fish and aquatic life, indicating fair to poor water quality.

- Data for mean annual phosphorus concentrations, chlorophyll-*a* concentrations, and Secchi-disc readings indicate that the Waterford Impoundment should be classified as a eutrophic waterbody. Eutrophic lakes, being nutrient-rich, often exhibit excessive aquatic plant growth and/or experience frequent algae blooms; eutrophic lakes may support very productive fisheries.

Pollutant Loadings

- Significant point source discharges of pollutants to the Waterford Impoundment, or to the surface waters tributary to the Waterford Impoundment, include wastewater treatment facilities in the Village of Sussex, the City of Brookfield, the City of Waukesha, and the Village of Mukwonago. These four plants, at their design loading rates, would discharge an estimated 190 tons each of BOD and suspended solids, and 28.5 tons of phosphorus, to the Fox River annually.

- Nonpoint sources of phosphorus to the Waterford Impoundment were dominated by agricultural operations within the area tributary to the Impoundment. Although agricultural land uses are a declining form of land use within the watershed, it is anticipated that such land uses will remain the single largest contributor of phosphorus to the Impoundment during the planning period.

- Urban land uses were the source of nonpoint sourced metals.

Aquatic Plants

- Aquatic macrophyte growth in the Waterford Impoundment was found to be limited and sparse in comparison to other waterbodies within the Southeastern Wisconsin Region. During the 2003 survey conducted by SEWRPC staff, the dominant submerged macrophytes identified were coontail (*Ceratophyllum demersum*) and Eurasian water milfoil (*Myriophyllum spicatum*), which exhibited moderate growth in portions of the Impoundment.

- Invasive wetland plant species, purple and golden or yellow loosestrife, are known to exist in the drainage area tributary to the Waterford Impoundment, although purple loosestrife in currently being controlled through the use of biological control agents with a high degree of success. Golden or yellow loosestrife observed in the drainage area directly tributary to the Impoundment has been controlled by manual control measures, and is subject to ongoing surveillance by the WWMD.

Fishery

- WDNR fisheries surveys, conducted during April and August 2000, suggest a relatively diverse fish population in the Impoundment, with 16 species of fishes being recorded. Largemouth bass, walleye, and northern pike were important gamefish surveyed with walleye being the most abundant. A wide range of panfish, the most dominant species being bluegill, was also present.

Natural Resource Base

- In 1985, wildlife habitat covered about 4,269 acres, or 29 percent of the area directly tributary to the Waterford Impoundment. Of the current area of wildlife habitat, about 2,088 acres, or about 14 percent, of the area directly tributary to the Waterford Impoundment were rated as high-value habitat capable of supporting a diverse population of wildlife, with adequate land area and appropriate vegetative cover for nesting, cover, and subsistence, and minimal levels of disturbance.

- Wetlands covered about 15 percent of the area directly tributary to the Waterford Impoundment; woodlands covered about 8 percent of the area directly tributary to the Waterford Impoundment.

- Natural areas and critical species habitat within the area directly tributary to the Waterford Impoundment include Elm Island-Bog Island Oak Woods, Tichigan Fen, Norris Marsh and Slough, Tichigan Marsh, Tichigan Wetlands and Low Woods, VanValin Woods, and Tichigan Wet Prairie.

- Primary environmental corridors, or contiguous lands containing the majority of the high value woodlands, wetlands, and wildlife habitat and surface waters within the area directly tributary to the Waterford Impoundment, comprised about 19 percent of the area directly tributary to the Impoundment.

Recreational Use

- As of 2004, there were two public recreational boating access sites on the Waterford Impoundment; the Impoundment continues to be assessed as having adequate public recreational boating access pursuant to Chapter NR 1 of the *Wisconsin Administrative Code*.

- During July 2005, approximately 1,440 watercraft were observed on and around the Waterford Impoundment. Of these, about 200 were power boats, about 500 craft were pontoon boats, about 275 were fishing boats, and 170 were personal watercraft. The balance was comprised of sailboats, rowboats, canoes, and similar nonmotorized watercraft. Tichigan Lake appears to be utilized by more active recreational users, including water skiers and power boaters, than is the riverine portion of the Impoundment.

- In a recreational rating technique developed by the WDNR to characterize the recreational value of inland lakes, the Waterford Impoundment received 50 out of a possible total of 72 points. This score indicates that the Impoundment provides a wide range of recreational opportunities, including angling, some areas of moderately good swimming substrate, boat launch sites along with water quality and depth conditions adequate for boating, and aesthetic viewing opportunities.

Based upon these inventory findings, lake management actions appear warranted to maintain and preserve the aesthetic, recreational, and natural resource functions served by the Waterford Impoundment. Consequently, Chapter II of this volume presents an overview of alternative lake management measures from which feasible alternatives are identified and set forth in the recommended lake management plan, which is formulated in Chapter III of Volume Two of this plan.

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Chapter II

ALTERNATIVE LAKE MANAGEMENT MEASURES

INTRODUCTION

Based upon review of the inventories and analyses set forth in Chapters II through VI in Volume One of this report, issues were identified requiring consideration in the formulation of alternative and recommended lake management measures. These issues are related to: 1) land use; 2) pollution sources, including stormwater and wastewater; 3) in-lake water quality; 4) aquatic biota; and, 5) water uses. The management measures considered herein are focused primarily on those measures which are applicable to the Waterford Waterway Management District (WWMD) and to the Town and Village of Waterford.

TRIBUTARY AREA MANAGEMENT ALTERNATIVES

Land Use Management and Zoning

A basic element of any water quality management effort for a lake is the promotion of sound land use development and management in the tributary area. The type and location of future urban and rural land uses in the area tributary to Waterford Impoundment will determine, to a large degree, the character, magnitude, and distribution of nonpoint sources of pollution; the location and nature of wastewater treatment facilities; the practicality of, as well as the need for, stormwater management practices; and, consequently, to some degree, the water quality of the waterbody.

Development in the Shoreland Zone and Tributary Area

Existing 2000 and planned land use patterns and existing zoning regulations in the area tributary to the Waterford Impoundment have been described in Chapter II in Volume One of this report. If the recommendations set forth in the adopted regional land use plan are followed,[1] under year 2035 conditions, some additional urban residential development within the area tributary to the Waterford Impoundment would occur. Much of this residential development is likely to occur on agricultural lands. Infilling of existing platted lots and some backlot development, as well as the redevelopment and reconstruction of existing single-family homes and commercial structures on lakefront properties, also may be expected to occur. Recent surveillance indicates that this type of development is currently occurring. Accordingly, given the potential impact of lakeshore development on the lake resources, land use development or redevelopment proposals around the shoreline of Waterford Impoundment and within the area tributary to the waterbody should be evaluated for potential impacts on the waterbody, as such proposals are advanced.

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[1] *SEWRPC Planning Report No. 48,* A Regional Land Use Plan for Southeastern Wisconsin: 2035*, June 2006.*

The level of development envisioned in the regional land use plan for the area tributary to the Waterford Impoundment includes continuing urban development, generally on large suburban-density lots. Careful review of applicable zoning ordinances to incorporate levels and patterns of development consistent with the plan within the tributary area is recommended. Changes in the zoning ordinances could be considered to better reflect the land use patterns recommended in the regional land use plan. Consideration should be given to minimizing the areal extent of development by providing specific provisions and incentives to cluster residential development on smaller lots while preserving portions of the open space on each property or group of properties considered for development, utilizing the principles of conservation development.[2] In addition, development plans should be reviewed for consistency with applicable stormwater and wastewater management practices, as described below.

Studies of the potential impact of riparian landscaping activities on nutrient loadings to lakes in southeastern Wisconsin have suggested that urban residential lands can contribute up to twice the mass of phosphorus to a lake when subjected to an active program of urban lawn care than similar lands managed in a more natural fashion.[3] The application of agrochemicals to such lands, in excess of the plant requirements, therefore, results in enhanced nutrient loading directly to the adjacent waterbodies. To address these concerns, some communities, such as the portion of the Town of West Bend served by the Big Cedar Lake Protection and Rehabilitation District, have purchased bulk lots of phosphorus-free lawn and garden fertilizers for resale to riparian landowners. Alternatively, a number of communities have enacted turf management or fertilizer control ordinances. In the case of the Waterford Impoundment, the Town of Waterford is one such community that has enacted a ban on the use of phosphate-containing fertilizers in residential areas. Other communities have relied on informational programs to encourage landowners to reduce the use of phosphorus fertilizers in southeastern Wisconsin. Given the increasing importance of urban land uses within the riparian area of Waterford Impoundment, and within its tributary area, consideration of a comprehensive program to regulate urban lawn and gardening practices appears to be warranted.

In addition to urban residential areas, recreational lands, such as golf courses, are major sources of phosphorus rich runoff, due to their extensive use of agrochemicals. To address concerns over the impacts of such runoff on natural waters and waterways, several national programs to encourage owners and operators of recreational areas to reduce nutrient applications have been proposed. Among these, the Audubon [International] Cooperative Sanctuary Program for Golf Courses (ACSP) is an education and certification program that helps golf courses protect the environment by helping participants in the program enhance the valuable natural areas and wildlife habitats that golf courses provide, while improving efficiency and minimizing the potentially harmful impacts of golf operations. In southeastern Wisconsin, the Lauderdale Lakes Lake Management District, owner of the Lauderdale Lakes Country Club, is one lake organization that has subscribed to this program with no loss of quality in the recreational activities but a significant cost savings to the organization and its contractor-operator in terms of course maintenance and concomitant benefits to the Lakes. Consequently, the use of this type of integrated nutrient and pest management best practices should be considered by the Rivermore Country Club and Edgewood Golf Course, where maintenance of these facilities may promote control of nutrient runoff to the Impoundment.

Within the area tributary to the Waterford Impoundment, agricultural lands remain an important land use. As a consequence of nutrient export in the form of agricultural produce, agricultural operations need to replace these nutrients and engage in other agrochemical-based practices to ensure crop quality and production levels. This need underlies the fact that agriculture remains the single largest source of nutrients to the Impoundment. Nevertheless, the widespread adoption of integrated nutrient and pest management practices within the industry as a consequence of nonpoint source pollution abatement programs implemented by the U.S. Department of

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[2]*See SEWRPC Planning Guide No. 7,* Rural Cluster Development Guide*, December 1996.*

[3]*U.S. Geological Survey Water-Resources Investigations Report No. 02-4130,* Effects of Lawn Fertilizer on Nutrient Concentration in Runoff from Lakeshore Lawns, Lauderdale Lakes, Wisconsin*, July 2002.*

Agriculture (USDA) and Wisconsin Department of Agriculture, Trade and Consumer Protection (WDATCP), among others, has contributed to improved agrochemical management within the agricultural industry. In the Fox River watershed, these practices have been promoted by WDATCP and the Wisconsin Department of Natural Resources (WDNR) through the Upper Fox River Priority Watershed Project.[4] This plan identified resource issues of concern and recommended specific nonpoint source pollutant reduction goals by subwatershed for the portion of the Fox River within Waukesha County. Urban nonpoint source pollution reductions of between 50 percent and 60 percent, based upon total suspended solids concentrations, were recommended, increasing to between 70 percent and 90 percent in urban areas yet to be developed. The plan also recommended reductions in pollutants from croplands ranging from 25 percent to 50 percent in most subbasins to 90 percent or more in areas of new urban development. Reductions in instream generated pollutants, such as sediments mobilized by streambank erosion, of between 10 percent and 80 percent were recommended, with the greater reductions being recommended for the Deer Creek, Poplar Creek, and Pebble Creek subwatersheds. Overall, the program proposed reductions in nonpoint sourced pollution loads from the Upper Fox River watershed of between 50 percent and 75 percent of the then-existing loads.[5] In the Upper Fox River watershed, the most common use of landowner cost sharing grants was for conservation tillage.

Stormwater Management on Development Site

With respect to stormwater management on development sites, Racine County does not have specific erosion control and stormwater management ordinances. As of 2006, the Town of Waterford had an ordinance governing erosion control and was considering development of a specific stormwater management ordinance covering both the construction and post-construction phases of development. The Village of Waterford had neither an erosion control ordinance nor a stormwater management ordinance, covering these concerns within their building code. Upstream of the Waterford Impoundment, Waukesha County has adopted both construction erosion control and stormwater management ordinances for unincorporated areas. These ordinances reflect current best practices insofar as the determination of stormwater flows, mitigation of flooding potentials, and control of contaminants from land use activities are concerned. Periodic review of these ordinances and their provisions for consistency with best management practices, and to ensure their currency with the state-of-the-art, should be undertaken on a regular basis to facilitate control of urban-source contaminants that would likely be delivered to the Impoundment.

Protection of Environmentally Significant Lands

Environmentally significant lands within the area tributary to the Waterford Impoundment include wetlands, woodlands, and wildlife habitat areas. Nearly all of these areas within the Waterford Impoundment tributary area are included in the environmental corridors and isolated natural resource features delineated by the Southeastern Wisconsin Regional Planning Commission (SEWRPC). Upland areas, woodlands, and wildlife habitat areas, currently, are protected primarily through local land use regulation, while wetlands enjoy a wider range of protections set forth in State and Federal legislation.

Wetland protection can be accomplished through land use regulation and, in cases where land use regulations may not offer an adequate degree of protection, through public acquisition of sensitive sites. These wetland areas are currently protected to a degree by current zoning and regulatory programs administered by the U.S. Army Corps of Engineers, WDNR, counties, and municipal authorities under one or more of the Federal, State, county, and local regulations.

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[4] *Wisconsin Department of Natural Resources Publication No. WR-366-94,* Upper Fox River Priority Watershed Project: A Nonpoint Source Control Plan*, June 1994.*

[5] *The priority watershed program was discontinued as of December 31, 2005; consequently, no other portions of the Fox River watershed were included within this planning program. Currently, state cost share programs under Chapter NR 120 of the* Wisconsin Administrative Code *continue but are focused on* ad hoc *Targeted Runoff Management and Urban Nonpoint Source Pollution Control activities.*

Some of the wetland, woodland, and wildlife habitat areas within the area tributary to the Waterford Impoundment have been recommended specifically for public acquisition in the adopted regional natural areas and critical species habitat management and protection plan.[6] These lands include the 68 acres of the privately-owned Elm Island Bog and Island Oak Woods, the 23 acres of the Tichigan Fen, all 212 acres of the Norris Marsh and Slough, and the 30 acres of Van Valin Woods.[7] Public acquisition of these lands by the WDNR in the case of Tichigan Fen, and by the respective counties in the cases of the other areas, as recommended in the adopted regional natural areas and critical species habitat protection and management plan is endorsed.

Pollution Abatement and Stormwater Management

All human activities upon the land surface result in some degree of mobilization of contaminants and modification of surface runoff patterns that can affect lakes and streams, their quality, and biotic conditions. Many human activities can be mitigated to a large extent by undertaking sound land use planning, appropriate nonpoint source pollution abatement measures, and individual action by an informed public. In the first instance, sound land use development and management in the tributary area, and protection of environmentally sensitive lands, are the fundamental building blocks for protecting lake and stream water quality and habitat, and preserving human use opportunities that will support a broadly-based recreational and residential community. In addition, specific nonpoint source pollution control and abatement measures should be integrated into land use regulations and promoted by a far-reaching informational and educational program within the area tributary to individual lakes and streams.

Nonpoint Source Pollution Abatement

Tributary area management measures may be used to minimize nonpoint source pollutant loadings from the watershed by locating development within a tributary basin in accordance with sound planning principles and practices. Beyond such actions, specific interventions may be required to control the mass of contaminants, generated by various types of land use activity, that are transported to the Impoundment. Rural sources of contaminants arise as pollutants transported by runoff from cropland and pastureland; urban sources include contaminants transported by runoff from residential, commercial, industrial, transportation, and recreational land uses, and from construction activities. Alternative, tributary area-based nonpoint source pollution control measures considered in this report are based upon the recommendations set forth in the regional water quality management plan,[8] in the Upper Fox River priority watershed plan,[9] and in the Racine County land and water resource management plan.[10]

The regional water quality management plan recommended that the nonpoint source pollutant loadings from the areas tributary to the Waterford Impoundment be reduced by up to 50 percent in urban areas and by up to 75 percent in rural areas, in addition to implementation of urban construction erosion controls, stream bank erosion controls, and onsite sewage disposal system management practices. The Upper Fox River Priority Watershed plan

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[6]*SEWRPC Planning Report No. 42,* A Regional Natural Areas and Critical Species Habitat Protection and Management Plan for Southeastern Wisconsin*, September 1997.*

[7]Ibid.

[8]*SEWRPC Planning Report No. 30,* A Regional Water Quality Management Plan for Southeastern Wisconsin: 2000*, Volume One,* Inventory Findings*, September 1978; Volume Two,* Alternative Plans*, February 1979; and Volume Three,* Recommended Plan*, June 1979; SEWRPC Memorandum Report No. 93,* A Regional Water Quality Management Plan for Southeastern Wisconsin: An Update and Status Report*, March 1995.*

[9]*Wisconsin Department of Natural Resources Publication No. WR-366-94*, op. cit.

[10]*SEWRPC Community Assistance Planning Report No. 259,* A Land and Water Resource Management Plan for Racine County: 2000-2004, *September 2000.*

refined these recommendations, and proposed an overall reduction of phosphorus loading of between 50 percent and 75 percent in rural areas, and between 40 percent and 90 percent in urban areas, as previously described.

As set forth in Chapter IV in Volume One of this report, the most readily controllable loadings are associated primarily with runoff from urban lands within the area tributary to the Impoundment and from urbanizing lands throughout the tributary area that are linked to the Impoundment by way of streams and stormwater drainage systems. These loadings constituted about 30 percent of the total phosphorus and about 15 percent of the sediment loadings to the Waterford Impoundment, and 100 percent of the heavy metals loadings, based upon 2000 land uses. Phosphorus loadings from the remainder of the tributary area, and from direct deposition onto the Impoundment surface, contributed the balance of the total loadings. The contributions of phosphorus, sediment, and heavy metals from urban lands are expected to increase as agricultural lands are progressively converted to urban uses.

While some proportion of these contaminant loads may be attenuated as a consequence of the extensive wetland areas, the ability of these wetlands to assimilate pollutants is wholly dependent upon the maintenance of their structure and function within their ecosystems. These features can be overwhelmed by inappropriate land uses that result in the degradation of the wetlands, diminishing their ability to capture contaminants, or creating contaminant loads of such magnitude that the wetlands are overloaded. Thus, the control of nonpoint sources of water pollution at their sources is an important consideration. Properly applied, such controls can reduce the pollutant loadings to a lake by about 25 percent or more.

Appendix A presents a list of alternative nonpoint source pollution management measures that could be considered for use in the Waterford Impoundment area to reduce loadings from nonpoint sources of pollution. Information on the cost and effectiveness of the measures is also presented in Appendix A. It should be noted that appropriate public informational programming, described below, provides a means of disseminating information on various nonpoint source control measures that can be targeted to specific sectors of the community. Many of the measures are low-cost or no-cost measures that can be implemented by individual landowners. Selected measures are discussed below.

Rural Nonpoint Source Controls

Upland erosion from agricultural and other rural lands is a contributor of sediment to streams and lakes. Estimated phosphorus and sediment loadings from croplands, woodlots, pastures, and grasslands in the area tributary to the Waterford Impoundment were presented in Chapter IV in Volume One of this report. These data were utilized in determining the pollutant load reduction that could be achieved, the types of practices needed, and the extent of the areas to which the practices need to be applied within the area tributary to the Waterford Impoundment.

Based upon the pollutant loading analysis set forth in Chapter IV in Volume One of this report, a total annual phosphorus load of about 110,000 pounds is estimated to be contributed to the Waterford Impoundment. Of that mass, it is estimated that about 85,000 pounds per year, or about 70 percent of the total loading, were contributed by runoff from rural land. In addition, it is estimated that about 20,850 tons of sediment, or about 80 percent of the total annual sediment load to the Waterford Impoundment, were contributed by agricultural lands in the tributary area. As of 2000, such lands comprised about 92,600 acres, or about 40 percent of the area tributary to the Waterford Impoundment, and about 7,500 acres, or about 50 percent of the area directly tributary to the Impoundment. By 2020, these areas are expected to diminish to about 62,000 acres, or about 25 percent, of the tributary area, and to about 6,200 acres, or about 40 percent of the area directly tributary to the Impoundment.

While agricultural land uses are anticipated to be a declining form of land use within the area tributary to the Waterford Impoundment, the agricultural operations that remain within the tributary area will continue to contribute a significant proportion of the sediment load to the waterbody. Table 14 in Volume One of this report suggests that, based upon estimated contaminant loadings, agricultural land uses will continue to contribute about 65 percent of the total sediment load, or about 14,000 tons of sediment annually, to the Waterford Impoundment. Thus, detailed farm conservation plans are likely to continue to be required to adapt and refine erosion control and nutrient and pest management practices for individual farm units. Generally prepared with the assistance of staff

from the USDA Natural Resources Conservation Service (NRCS) or County Land Conservation Departments, such plans identify desirable tillage practices, cropping patterns, and rotation cycles. The plans also consider the specific topography, hydrology, and soil characteristics of the farm; identify the specific resources of the farm operator; and articulate the operator objectives of the owners and managers of the land. As noted above, conservation tillage practices were the principal nonpoint source pollution abatement measure installed during the Upper Fox River Priority Watershed Project.

Urban Nonpoint Source Controls

As of 2000, established urban land uses comprised about 76,250 acres, or about 30 percent, of the area tributary to the Waterford Impoundment and about 2,400 acres, or about 15 percent of the area directly tributary to the Waterford Impoundment. The annual phosphorus loading from these urban lands was estimated to be about 23,400 pounds, or about 30 percent of the total load of phosphorus to the Impoundment. This is anticipated to increase to about 36 percent of the total load of phosphorus under planned land use conditions. Those urban-sourced pollutant loadings that are most controllable include runoff from the residential lands adjacent to the Impoundment, and urban runoff from areas with a high proportion of impervious surface. The potential also exists within the Waterford Impoundment tributary area for significant construction site erosion impacts if development continues in the tributary area as has been the recent trend.

Potentially applicable urban nonpoint source control measures include stormwater management measures such as wet detention basins, grassed swales, and good urban "housekeeping" practices. Generally, the application of low-cost urban housekeeping practices may be expected to reduce nonpoint source loadings from urban lands by about 25 percent. Public informational programs can be developed to encourage good urban housekeeping practices, to promote the selection of building and construction materials which reduce the runoff contribution of metals and other toxic pollutants, and to promote the acceptance and understanding of the proposed pollution abatement measures and the importance of lake water quality protection. Urban housekeeping practices and source controls include restricted use of fertilizers and pesticides, improved pet waste and litter control, the substitution of plastic for galvanized steel and copper roofing materials and gutters, proper disposal of motor vehicle fluids, increased leaf collection, and continued use of reduced quantities of street deicing salt.

Particular attention also should be given to reducing pollutant loadings from high pollutant loading areas, such as commercial sites, parking lots, and material storage areas. To the extent practicable, parking lot stormwater runoff should be diverted to areas covered by pervious soils and appropriate vegetation, rather than being directly discharged to surface waters. Material storage areas may be enclosed or periodically cleaned, and diversion of stormwater away from these sites may further reduce pollutant loadings. Street sweeping, increased catch basin cleaning, stream protection, leaf litter and vegetation debris collection, and stormwater storage and infiltration measures can enhance the control of nonpoint-source pollutants from urban and urbanizing areas, and reduce urban nonpoint source pollution loads by up to about 50 percent.

As has been noted, Racine County does not have specific erosion control and stormwater management ordinances; rather, these concerns are managed through local government ordinances. As of 2006, only the Town of Waterford within Racine County had a specific ordinance governing construction site erosion control. Within the upstream watershed, Waukesha County, several of the incorporated municipalities, and about one-half of the towns had such ordinances—those towns having an ordinance generally having adopted the Waukesha County stormwater ordinance, as set forth in Chapter III in Volume One of this report. While these measures limit the potential impacts of new development, they do not address impacts from existing land uses nor do they address the cumulative impacts of past development. Therefore, additional measures to reduce nonpoint source pollution from existing development would appear to be warranted. Proper design and application of structural urban nonpoint source control measures, such as grassed swales and detention basins, requires the preparation of a detailed stormwater management system plan that addresses stormwater drainage problems and recommends controls on nonpoint sources of pollution. These measures should be supported by appropriate ordinances at all levels that are consistent with the current *Wisconsin Administrative Code* provisions governing stormwater management, and, to the extent practicable, with the best practices adopted within the profession.

Development Area Nonpoint Source Controls
Development areas can generate significantly higher pollutant loadings than established areas of similar size. Development areas include a wide array of activities, including urban renewal projects, individual site development within the existing urban area, and new land subdivision development. The regional land use plan envisions only limited new urban development within the tributary area. However, as previously noted, some large-lot suburban-density development is currently taking place in the area tributary to Waterford Impoundment, together with the redevelopment of existing, platted lakefront lots.

During this process of land conversion and redevelopment, construction sites generally produce suspended solids and phosphorus loads at rates several times higher than those of established urban land uses. Control of sediment loss from construction sites can be provided by measures set forth by the WDNR in their construction erosion control handbook and in stormwater management and construction erosion control standards prepared by the WDNR in cooperation with the State of Wisconsin Standards Oversight Council.[11] These controls are temporary measures taken to reduce pollutant loadings from construction sites during stormwater runoff events. Construction erosion controls may be expected to reduce pollutant loadings from construction sites by about 75 percent. While such practices are expected to have only a minimal impact on the total pollutant loading to the Impoundment—due to the relatively small amount of land proposed to be developed, such controls are important pollution control measures that can abate localized short-term loadings of phosphorus and sediment from the tributary area and upstream watershed. Control measures include such revegetation practices as temporary seeding, mulching, and sodding, and such runoff control measures as filter fabric fences, straw bale barriers, storm sewer inlet protection devices, diversion swales, sediment traps, and sedimentation basins.

At the present time, the counties upstream of the Impoundment have adopted construction site erosion control ordinances which they administer and enforce in the unincorporated areas of the watershed. Because of the potential for development, some of it albeit unplanned, in the area tributary to the Waterford Impoundment, it is important that adequate construction erosion control programs, including enforcement, be in place.

Public Sanitary Sewerage System Management
At the present time, the lands directly tributary to the Waterford Impoundment are served by public sanitary sewer services operated by the Village of Waterford and the Town of Waterford Sanitary District No. 1. All of the lands within the service areas were proposed to be served by the Western Racine County Sewerage District Treatment Plant. Concentrations of urban development within the Town and Village, located along the shoreline of Waterford Impoundment, have been included within this public sanitary sewer service area, as recommended in the regional water quality management plan, as amended.[12] In addition, significant portions of the watershed also are served by public sanitary sewerage systems, including Mukwonago, Mukwonago County Park, Rainbow Springs, Eagle Spring Lake, Muskego, Waukesha, Pewaukee, Brookfield, Menomonee Falls, Sussex, and Lannon, or are planned to be served by public sanitary sewerage systems, including the eastern part of Genesee and Wales.[13] Even so, the regional water quality management plan recommends that the sewerage needs in such areas be periodically reevaluated in light of changing conditions.

Onsite Sewage Disposal System Management
Portions of the area tributary to the Waterford Impoundment continue to utilize onsite wastewater treatment systems for the treatment of sanitary and household wastewaters. As reported in Chapter IV in Volume One of this report, total phosphorus loadings from onsite sewage disposal systems are estimated to contribute only a

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[11] *Wisconsin Department of Natural Resources,* Wisconsin Construction Site Best Management Practices Handbook*, April 1994, and http://www.dnr.state.wi.us/org/water/wm/nps/stormwater/techstds.htm.*.

[12] *Amendment to SEWRPC Community Assistance Planning Report No. 141, 2nd Edition,* Sanitary Sewer Service Area for the Waterford/Rochester Area, Racine County, Wisconsin, *June 2005.*

[13] *SEWRPC Planning Report No. 48,* op. cit.

minor proportion of the total phosphorus load to the Impoundment, which proportion is anticipated to continue to decline as public sanitary sewerage services are extended within the tributary area, as recommended in the adopted regional water quality management plan[14] and sewer service area plans.[15] In addition to lake water quality considerations, sewage disposal options in the area have implications for groundwater quality and property values. Thus, onsite sewage disposal is an important consideration in the portions of the tributary area not within the planned public sanitary sewer service area. Two basic alternatives are available for the abatement of pollution from onsite sewage disposal systems: continued reliance on, and management of, the onsite sewage disposal systems, and, alternatively, the expansion of the existing public sanitary sewer system.

Where onsite sewage disposal systems are anticipated to remain the primary wastewater treatment method, it is recommended that an onsite sewage disposal system management program be carried out, including the conduct of an ongoing informational and educational effort. Homeowners in areas served by onsite systems should be advised of the rules, regulations, and system limitations governing onsite sewage disposal systems, and should be encouraged to undertake preventive maintenance programs. Both Racine and Waukesha Counties currently have such a program in place, pursuant to Chapter Comm 83 of the *Wisconsin Administrative Code* for onsite sewage disposal systems installed after 1983. As of 2006, consideration was being given by the Wisconsin Legislature to extending this inspection program to all onsite sewage disposal systems.

IN-LAKE MANAGEMENT ALTERNATIVES

The reduction of external nutrient loadings to the Waterford Impoundment by the measures described above should help to prevent further deterioration of lake water quality conditions. These measures, however, may not completely eliminate existing water quality and lake-use problems. In eutrophic lakes, the nutrients previously delivered to, and retained in, such lakes often result in excessive aquatic macrophyte growth and/or frequent algae blooms, that can result in restricted water use potentials, even after the implementation of tributary area-based management measures. Given that the Waterford Impoundment falls within the eutrophic range, the awareness of in-lake rehabilitation techniques is of value.

The applicability of specific in-lake rehabilitation techniques is highly dependent on lake-specific characteristics. The success of any lake rehabilitation technique can seldom be guaranteed, and because of the relatively high cost of applying most techniques, a cautious approach to implementing in-lake rehabilitation techniques is generally recommended. Certain in-lake rehabilitation techniques should be applied only to lakes in which: 1) nutrient inputs have been reduced below the critical level; 2) there is a high probability of success in applications of the

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[14] *SEWRPC Memorandum Report No. 93,* op. cit.

[15] *See, for example, SEWRPC Amendment to Community Assistance Planning Report No. 141,* op. cit.*; Amendment to SEWRPC Community Assistance Planning Report No. 191,* Sanitary Sewer Service Area for the Village of Mukwonago, Waukesha County, Wisconsin*, March 2006; Amendment to SEWRPC Community Assistance Planning Report No. 64, 3rd Edition,* Sanitary Sewer Service Area for the City of Muskego, Waukesha County, Wisconsin*, June 2006; Amendment to SEWRPC Community Assistance Planning Report No. 84, 2nd Edition,* Sanitary Sewer Service Area for the Village of Sussex, Waukesha County, Wisconsin, *March 2006; Amendment to SEWRPC Community Assistance Planning Report No. 100, 2nd Edition ,* Sanitary Sewer Service Area for the City of Waukesha and Environs, Waukesha County, Wisconsin*, September 2006; Amendment to SEWRPC Community Assistance Planning Report No. 109,* Sanitary Sewer Service Area for the City and Town of Brookfield and the Village of Elm Grove, Waukesha County, Wisconsin*, June 1998; Amendment to SEWRPC Community Assistance Planning Report No. 113,* Sanitary Sewer Service Area for the Town of Pewaukee Sanitary District No. 3, Lake Pewaukee Sanitary District, and Village of Pewaukee, Waukesha County, Wisconsin*, December 2005; Amendment to SEWRPC Community Assistance Planning Report No. 157,* Sanitary Sewer Service Area for the City of New Berlin, Waukesha County, Wisconsin*, June 2005; Amendment to SEWRPC Community Assistance Planning Report No. 208,* Sanitary Sewer Service Areas for the Villages of Lannon and Menomonee Falls, Waukesha County, Wisconsin*, December 2005.*

particular technology to lakes of similar size, shape, and quality; and 3) the possibility of adverse environmental impacts is minimal. Finally, it should be noted that some in-lake rehabilitation techniques require the issuance of permits from appropriate State and Federal agencies prior to implementation.

Alternative lake rehabilitation measures include in-lake water quality management, water level management, and aquatic plant and fisheries management measures. Each of these groups of management measures is described further below.

Water Quality Monitoring Measures

As discussed in Chapter IV in Volume One of this report, water quality information for Waterford Impoundment has been compiled during the current study period through efforts involving the USGS and WDNR both in the Tichigan Lake subbasin and in the "Widespread" area of the main riverway just downstream of the Tichigan Lake outlet.

The WDNR supports a Self-Help Monitoring Program volunteer who has acquired water clarity data on Tichigan Lake over a period of several years. Because pollution tends to reduce water clarity, Secchi disk transparency measurements are generally considered one of the key parameters in determining the overall quality of a lake's water as well as a lake's trophic status. Secchi disk measurement data are added to the WDNR-sponsored data base containing lake water quality information for those lakes in Wisconsin that participate in the Self-Help Monitoring Program. These data are accessible on-line through the WDNR website.

The WDNR also offers an Expanded Self-Help Monitoring Program that involves collecting data on several key physical and chemical parameters in addition to the Secchi disk measurements. Under the expanded program, samples of lake water are collected by volunteers at regular intervals and analyzed for total phosphorus and chlorophyll *a* concentrations by the State Laboratory of Hygiene. Data collection also is more extensive, including temperature and dissolved oxygen concentrations, which, consequently, places more of a burden on the volunteers.

The USGS offers an extensive water quality monitoring program, within which Federal field personnel conduct a series of approximately five monthly samplings beginning with the spring turnover. Samples are analyzed by the State Laboratory of Hygiene for an extensive array of physical and chemical parameters. These data have been summarized in Chapter IV in Volume One of this report. The USGS also offers an array of other specialist services, including groundwater modeling and monitoring. An alternative to the USGS program is the analytical services provided by the University of Wisconsin-Stevens Point. However, this program requires volunteers to obtain and transmit the water quality samples to the laboratory. In both cases, the WDNR offers Chapter NR 190 Small Grant funding that can be applied for to defray the costs for laboratory analysis and sampling equipment.

Ongoing water quality monitoring by volunteer monitors, supplemented by periodic more detailed water quality monitoring, is considered to be a viable option for the Waterford Impoundment.

Water Quality Improvement Measures

This group of in-lake management practices includes a variety of measures designed to directly modify the magnitude of either a water quality determinant or biological response. Specific measures aimed at managing aquatic plants and the fisheries are separately considered below.

Phosphorus Precipitation and Inactivation

Nutrient inactivation is a restoration measure that is designed to limit the biological availability of phosphorus by chemically binding the element in the lake sediments using a variety of divalent or trivalent cations, highly positively charged elements. Aluminum sulfate (alum), ferric chloride, and ferric sulfate are commonly used cation sources. The use of these techniques to remove phosphorus from nutrient-rich lake waters is an extension of common water supply and wastewater treatment processes. Costs depend on the lake volume and type and dosage of chemical used. Approximately 100 tons of alum, costing about $150 per ton, can treat a lake area of about 40 acres. Effectiveness depends, in part, on the ability of the alum flocculent to form a stable "blanket" on

the lakebed; to wit, on flushing time, turbulence, lake water acidity (pH), and rate of continued sedimentation. Impacts can include the release of toxic quantities of free aluminum into the water. The resulting improved water clarity can also encourage the spread of rooted aquatic plants.

Nutrient inactivation is not considered a viable option for the Waterford Impoundment due to the generally soft sediments and shallow depth of management areas, the susceptibility to wind- and boat motor-induced mixing, and the overall pollutant loading all of which mediate against the effective use of nutrient inactivation.

Nutrient Load Reduction

Nutrient diversion is a restoration measure which is designed to reduce the trophic state or degree of over-feeding of a waterbody and thereby control the growth response of the aquatic plants in the system. Control of nutrients in surface water runoff in the tributary area, as described in the tributary area management section above, is generally preferable to attempting such control within a lake.

In-lake control of nutrients generally involves removal of contaminated sediments or encapsulation of nutrients by chemical binding. Costs are generally high, involving an engineered design and usually some form of pumping or excavation. Effectiveness is variable, and impacts include the rerelease of nutrients into the environment. While some limited deepening of specific areas within the Impoundment may be warranted for navigational purposes, the widespread use of in-lake nutrient load reduction measures is not warranted in the Waterford Impoundment, especially given that internal loading from the lake sediments does not appear to be an important nutrient course to the water column. As noted in Chapter IV in Volume One of this report, the good agreement between predicted and observed phosphorus concentrations in the Impoundment strongly suggests that the external nutrient load to the Impoundment accounts for the entire phosphorus concentration in the Impoundment water column.

Hydraulic and Hydrologic Management

This group of in-lake management measures consists of actions designed to modify the depth of water in the waterbody. Generally, the objectives of such manipulation are to enhance a particular class of recreational uses, to control the types and densities of organisms within a waterbody, or to minimize high water or flooding problems. Consideration can be given to outlet control modifications, drawdown, and dredging.

Outlet Control Operations

The outflow from the Waterford Impoundment is controlled by the Waterford Dam located in the Village of Waterford. The outlet structure, as described in Volume One of this report, consists of twin sluice gates whose crest was established at an elevation of 773.4 feet above the National Geodetic Vertical Datum of 1929 (NGVD29). Given the intensive use of the Impoundment for recreational purposes, no changes in this level are indicated. However, periodic inspection of the dam and spillway structures will continue to be required by the WDNR pursuant to the requirements of Chapter 31 of the *Wisconsin Statutes* to ensure future integrity and safe operation.

Drawdown

Drawdown refers to a the manipulation of lake water levels, especially in impounded lakes, in order to change or create specific types of habitat and thereby manage species composition within a waterbody. Drawdown may be used to control aquatic plant growth and to manage fisheries. With regard to aquatic plant management, periodic drawdowns can reduce the growth of some shoreland plants by exposing the plants to climatic extremes, while the growth of others is unaffected or enhanced. Both desirable and undesirable plants are affected by such actions. Costs are primarily associated with loss of use of the waterbody surface area during drawdown, provided there is a means of controlling water level in place, such as a dam or other outlet control structure. Effectiveness is variable with the most significant side effect being the potential for increased plant growth.

Drawdown can also affect the lake fisheries both indirectly, by reducing the numbers of food organisms, and directly, by reducing available habitat and desiccating (drying out) eggs and spawning habitat. In contrast, increasing water levels, especially during spring, can provide enhanced fish breeding habitat for some species, such as pike and muskellunge, and increase the food supply for opportunistic feeders, such as bass, by providing

access to terrestrial insects, for example. Costs are primarily associated with loss of use. Effectiveness is better than for aquatic plant control, but the potential for side effects remains high given that undesirable fish species may also benefit from water level changes.

Sediment exposure and desiccation by means of lake drawdown has been used as a means of stabilizing bottom sediments, retarding nutrient release, reducing macrophyte growth, and reducing the volume of bottom sediments. During the period of drawdown, the exposed sediments are allowed to oxidize and consolidate. It is believed that by reducing the sediment oxygen demand and increasing the oxidation state of the surface layer of the sediments, drawdown may retard the subsequent movement of phosphorus from the sediments. Sediment exposure may also curb sediment nutrient release by physically stabilizing the upper flocculent, sediment-water interface zone of the sediments which plays an important role in the exchange reaction and mixing of the sediments with the overlying water. Drawdown may thus deepen the lake by dewatering and compacting the bottom sediments. The amount of compaction depends upon the organic content of the sediment, the thickness of sediment exposed above the water table, and the timing and duration of the drawdown.

Possible improvements resulting from a lake drawdown include reduced turbidity from wind action, improved game fishing, an opportunity to collect fish more effectively in fish removal programs, an opportunity to improve docks and dams, and an opportunity to clean and repair shorelines and deepen areas using conventional earth-moving equipment. Limited, over-winter drawdowns are designed to limit shoreland damage by ice and ice movements during the winter months.

In contrast, depending on the timing and duration of the drawdown, drawbacks include loss of fish breeding habitat, loss of benthic food organisms, and disruption of waterfowl feeding and roosting patterns. Increased turbidity and unpleasant odors from rotting organic matter may occur during the period of the drawdown. Other adverse impacts of lake drawdown include algal blooms after reflooding, loss of use of the lake during the drawdown, changes in species composition, and a reduction in the density of benthic organisms following drawdown and reflooding. In some drawdown projects, it has been found that several years after reflooding, flocculent sediments began to reappear because of algae and macrophyte sedimentation. Therefore, to maintain the benefits of a drawdown project, a lake may have to be drawn down every five to 10 years to recompact any new sediments.

Because of the unpredictability of the results, the impairment of recreational uses, and the temporary nature of the beneficial effects of a drawdown, drawdown is not a viable option for the Waterford Impoundment.

Water Level Stabilization

Water level fluctuation does not appear to be a significant concern of the Waterford Impoundment users. While water level management in a lake is a common technique for managing fish and aquatic macrophytes, the consequences of manipulating lake water levels can be both beneficial and deleterious. The major impacts from the standpoint of riparian owners is that the fluctuating water levels affect shoreline erosion and interfere with proper pier height and placement and the correct placement of shoreline protection structures.

Periodic changes in precipitation and weather patterns between years often result in fluctuation of water loads to a lake. These fluctuations in turn can affect lake levels. Most plant and animal species can cope with this level of water surface fluctuation without experiencing the consequences, both positive and negative, noted above. Nevertheless, while artificial stabilization of the water surface is not considered a viable option for the Waterford Impoundment, it is desirable from the point of view of aquatic habitat that water level fluctuations be maintained within natural limits.

Dredging

Sediment removal is a restoration measure that is carried out using a variety of techniques, both land-based and water-based, depending on the extent and nature of the sediment removal to be carried out. For larger-scale applications, a barge-mounted hydraulic or cutter-head dredge is generally used. For smaller-scale operations a shore-based drag-line system is typically employed. Both methods are expensive, especially if a suitable disposal

site is not located close to the dredge site. Costs for removal and disposal begin at between $10 and $15 per cubic yard, with the cost of sediment removal alone beginning at between $3 and $5 per cubic yard. Effectiveness of dredging varies with the effectiveness of tributary area controls in reducing or minimizing the sediment sources. Federal and State permits are required for use of this option.

Dredging in the Waterford Impoundment could be accomplished using several different types of equipment, including a hydraulic cutterhead dredge mounted on a floating barge in deeper water areas; a bulldozer and backhoe equipment in the shoreland area, especially if the Impoundment was drawn down; and a clamshell, or bucket, dragline dredge from the shoreline. While the use of conventional earth-moving equipment and shore-based draglines has some advantages over hydraulic dredging, particularly since these methods would not require large disposal and dewatering sites in close proximity to the project area, these methods would be dependent, to some extent, on the drawdown of the Impoundment. Reducing the water level in the Impoundment would be especially advantageous for dragline dredging because it would not require the removal of shoreland trees, resulting in less disturbance of the shoreline to provide access for trucks and equipment. Likewise, reduced water levels would allow conventional construction equipment access to the littoral portions of the Impoundment. Nevertheless, given the potential recreational use impacts of a drawdown during the summer and winter recreational seasons, use of these methods is not considered feasible.

Hydraulic cutterhead dredging is the most commonly employed method in the United States. The dredge is typically a rotating auger or cutterhead on the end of an arm that is lowered to the sediment-water interface. Sediment excavated by the cutterhead is pumped as a slurry of 10 to 20 percent solids by a centrifugal pump to the disposal site. This pumping usually limits the distance between the lake and disposal site to less than a mile, even using intermediate booster pumps. Because of the large volume of slurry produced, a relatively large disposal site is typically required. Water returned from the disposal site, whether returned to the lake or a stream, would have to meet effluent water quality standards of the State and would be subject to State permitting.

Dredging is the only restoration technique that directly removes the accumulated products of degradation and sediment from a lake system and can return a lake to a younger “age.” If carried to the extreme, dredging can be used, in effect, to construct a new lake with a size and depth to suit the management objectives. Dredging has been used in other lakes to increase water depth; remove toxic materials; decrease sediment oxygen demand, prevent fish winterkills and nutrient recycling; restore fish breeding habitat; and decrease macrophyte growth. The objective of a dredging program at the Waterford Impoundment would be to increase water depth to maintain recreational boating access and increased public safety.

Even so, dredging may have serious, though generally short-term, adverse effects on the Impoundment. These adverse effects could include increased turbidity caused by sediment resuspension, toxicity from dissolved constituents released by the dredging, oxygen depletion as organic sediments mix with the overlying water, water temperature alterations, removal of native plant seeds, and destruction of benthic and fisheries habitats. There may also be impacts at upland spoil disposal sites, such as odor problems, restricted use of the site, and disturbances associated with heavy truck traffic. In the longer term, disruption of the lake ecosystem by dredging can encourage the colonization of disturbed portions of the lakebed by less desirable species of aquatic plants and animals, including Eurasian water milfoil, which is present in the Waterford Impoundment.

In addition, while dredging can result in an immediate increase in lake depth, such increases may be short-lived if the sources of sediment being deposited in the lake are not controlled within the area tributary to the lake. The sediment load reaching the Waterford Impoundment comes from both urban and agricultural lands within the area tributary to the Waterford Impoundment. Sediment also may be generated from streambank and shoreland erosion. Many of these sources can be effectively controlled through the adoption, implementation, and maintenance of recommended control measures within the tributary area. Such practices should be implemented in the area tributary to the Impoundment, as noted above, regardless of the likely conduct of any dredging project.

Dredging of lakebed material from the navigable waters of the State requires a Chapter 30 permit to be issued by the WDNR and a Federal Chapter 404 permit to be issued by the U.S. Army Corps of Engineers. In addition,

current solid waste disposal regulations define dredged material as a solid waste. Chapter NR 180 of the *Wisconsin Administrative Code* requires that any dredging project of over 3,000 cubic yards submit preliminary disposal plans to the WDNR for review and potential solid waste licensing of the disposal site. Because sodium arsenite was applied to the Waterford Impoundment during the 1950s and 1960s, as noted in Chapter V in Volume One of this report, sediment samples may need to be analyzed to determine the extent and severity of any residual arsenic contamination.

Because of the considerations noted above, extensive widespread dredging of the Waterford Impoundment is not considered a viable alternative at this time, although limited dredging may be a viable option in specific targeted areas, such as Conservancy Bay, and in the riverine portions of the Impoundment, where constriction of the riverway poses navigational safety hazards to boat traffic, especially during peak recreational water use periods. These areas are discussed further below.

The Commission staff has identified portions of the waterway for consideration of selected deepening in order to improve the hydraulic and hydrologic integrity of the Impoundment.[16] These areas include portions of Conservancy Bay, the Widespread in the vicinity of the outlet of Tichigan Lake, the embayments tributary to the Impoundment between Tichigan Lake and Buena Lake, Buena Lake, and the embayments between Buena Lake and the dam, in addition to portions of the Fox River downstream of the IH-43 bridge crossing in the Town of Vernon.

Aquatic Plant and Fisheries Management

Fisheries Management Measures

The Waterford Impoundment, like most eutrophic waterbodies, is a nutrient-rich environment that is capable of providing a very productive, warmwater fishery. Currently, adequate water quality, dissolved oxygen levels, and diverse plant community exist for the maintenance of a sportfish population in the Impoundment. Winterkill is currently not a problem. As described in Chapter V in Volume One of this report, WDNR fisheries surveys conducted in Tichigan Lake during 2000 indicated that the waterbody supports a relatively large and diverse fish community with walleye being the most abundant gamefish. Given the intensity of recreational use of this waterbody, fisheries management measures are indicated. Applicable management measures are reviewed below, focusing on habitat management and shoreland protection.

Habitat Protection and Restoration

Habitat protection refers to a range of conservation measures designed to maintain existing fish spawning habitat, including measures such as restricting recreational use and other intrusions into gravel-bottomed shoreline areas during the spawning season. For bass this is mid-April to mid-June. Use of natural vegetation in shoreland management zones and other "soft" shoreline protection options aids in habitat protection. Costs are generally low, unless the habitat is already degraded. Modification of aquatic plant harvesting operations, if being utilized, may be considered to support restoration and protection of native aquatic plant beds and maintenance of fish breeding habitat during the early summer period. Effectiveness is variable depending in part on community acceptance and enforcement. Generally, it is more effective to maintain a good habitat than to restore a habitat after it is degraded.

Protection and provision of habitat should be a primary focus of any fisheries management program. The environmentally valuable areas identified within the Impoundment and its tributary area are the most important areas to be protected. In addition, limiting or restricting certain activities in sensitive areas of the Impoundment will prevent significant disturbance of fish nests and aquatic plant beds. There are no areas currently designated by the WDNR pursuant to Chapter NR 107 of the *Wisconsin Administrative Code* as Environmentally Sensitive Areas within the Waterford Impoundment. Nevertheless, it is worth acknowledging that within such areas, aquatic

[16]*SEWRPC Memorandum Report No. 102,* Water Level Control Plan for the Waterford-Vernon Area of the Middle Fox River Watershed, Racine and Waukesha Counties, Wisconsin*, March 1995.*

plant management measures may be restricted, and dredging, filling, and the construction of piers and docks are commonly discouraged. Outside of the designated areas, these activities may be expedited with respect to required permitting. It also should be noted that water level fluctuations other than those consequent to natural climatic variability and water quality conditions can affect fish habitat and the breeding success of fishes. In this regard, the maintenance of Impoundment water levels within natural limits, and the maintenance of good water quality, cannot be overemphasized as fish habitat protection measures.

Habitat restoration measures apply to an array of techniques aimed at the creation of environmental conditions favorable to the protection of native species through the reclaiming of natural habitat. The removal of excessive sediment, replacement of natural bottom substrate, removal or relocation of materials or objects considered detrimental to the natural landscape or presenting a possible safety hazard to natural biota or human use, and consolidation or species modification of plant communities all are habitat restoration measures considered viable options in selected riverine portions of the Impoundment. Priority areas for habitat protection and restoration include the cold water streams tributary to Conservancy Bay, draining from the WDNR lands located along the western shoreline of the Bay. Habitat restoration also is recommended as an essential element of the hydrology and hydraulic maintenance program recommended above and the navigational access enhancement program set forth below.

Shoreline Maintenance

Shoreline maintenance refers to a group of measures designed to reduce and minimize shoreline loss due to erosion by waves, ice, or related actions of the water. Most of the shoreline of the Waterford Impoundment is protected by some type of structural measure. Four shoreline erosion control techniques were in use in 2000: vegetative buffer strips, rock revetments, wooden and concrete bulkheads, and beaches. Maintenance of a vegetated buffer strip immediately adjacent to the Impoundment is the simplest, least costly, and most natural method of reducing shoreline erosion. This technique employs 1) natural vegetation, rather than maintained lawns, within five to 10 feet of the lakeshore and 2) the establishment of emergent aquatic vegetation from two to six feet lakeward of the shoreline.

Desirable plant species that may be expected and encouraged to invade a buffer strip, or which could be planted, include arrowhead (*Sagittaria latifolia*), cattail (*Typha* spp.), common reed (*Phragmites communis*), water plantain (*Alisma plantago-aquatica*), bur-reed (*Sparganium eurycarpum*), and blue flag (*Iris versicolo*r) in the wetter areas; and jewelweed (*Impatiens biflora*), elderberry (*Sambucus canadensis*), giant goldenrod (*Solidago gigantea*), marsh aster (*Aster simplex*), red-stem aster (*Aster puniceus*), and white cedar (*Thuja occidentalis*) in the drier areas. In addition, trees and shrubs such as silver maple (*Acer saccharinum*), American elm (*Ulmus americana*), black willow (*Salix nigra*), and red-osier dogwood (*Cornus stolonifera*) could become established in the shoreland area. These plants will develop a more extensive root system than turf grass and the aboveground portion of the plants will protect the soil against the erosive forces of rainfall and wave action. On individual properties, a narrow, 10- to 30-foot-wide path to the Impoundment could be maintained as lake access for boating, swimming, fishing, scenic viewing, and other activities. A vegetative buffer strip would also serve to trap nutrients and sediments washing into the Impoundment via direct overland flow. This alternative can be undertaken by individual landowners and would involve only minimal cost as it is incorporated into the property landscaping scheme.

Rock revetments, or riprap, are a highly effective method of shoreline erosion control applicable to many types of erosion problems, especially in areas of low banks and shallow water. Many of these structures are already in place along the shores of the Waterford Impoundment. The technique involves the shaping of the shoreline slope; the placement of a porous filter material, such as sand, gravel, pebbles, or geosynthetic fabric on the slope; and, the placement of rocks on top of the filter material to protect the slope against the actions of waves and ice. The advantages of rock revetments are that they are highly flexible and not readily weakened by movements caused by settling or ice expansion, they can be constructed in stages, and they require little or no maintenance. The disadvantages of rock revetments are that they limit some uses of the immediate shoreline. The rough, irregular rock surfaces are unsuitable for walking; require a relatively large amount of filter material and rocks to be transported to the lakeshore; and can cause temporary disruptions and contribute sediment to the lake. If

improperly constructed, revetments may fail because of washout of the filter material. A rock revetment is estimated to cost $25 to $35 per linear foot.

The use of vegetated buffer strips and riprap, as shown in Figure 1, is recommended, especially in those areas subject to significant wind-wave, boat wake, and ice scour erosion. In those portions of the Impoundment subject to direct action of wind waves and ice scour, the use of riprap would provide a more robust means of stabilizing shorelines, while elsewhere along the lakeshore creation of vegetated buffer strips would provide not only shoreline erosion protection but also enhanced shoreland habitat for fish and wildlife. In this regard, it should be noted that the selection of appropriate shoreland protection structures is subject to the provisions of Chapter NR 328 of the *Wisconsin Administrative Code*. Where recreational boating traffic is a concern, use of the long-form worksheet, included in Chapter NR 328, is recommended as this form takes into account boat wakes as well as wind waves in determining the shoreline erosion intensity index, which in turn determines the type of shoreline protection that can be permitted.

Modification of Species Composition
Species composition management refers to a group of conservation and restoration measures that include selective harvesting of undesirable fish species and stocking of desirable species designed to enhance the angling resource value of a lake. These measures also include water level manipulation both to aid in the breeding of desirable species, for example, increasing water levels in spring to provide additional breeding habitat for pike, and to disadvantage undesirable species, for example, drawing a lake down to concentrate forage fish and increase predation success and also to strand juveniles and desiccate the eggs of undesirable species. Costs, as with water level management above, are primarily associated with loss of use; effectiveness is good, but by no means certain; and side effects include collateral damage to desirable fish populations.

More extreme measures include organized fishing events and selective cropping of certain fish species, poisoning, and enhancement of predation by stocking. In lakes with an unbalanced fishery, dominated by carp and other rough fish, chemical eradication has been used to manage the fishery. Lake drawdown is often used along with chemical treatments to expose spawning areas and eggs and concentrate fish in shallow pools, thereby increasing their availability to anglers, commercial harvesters, or chemical eradication treatments. Fish barriers are usually used to prevent reintroduction of undesirable species from upstream or downstream, and the habitat thus created will benefit the desired gamefish populations. Chemical eradication is a drastic, costly measure and the end result may be highly unpredictable. Although effectiveness is generally good, such extreme measures are not considered viable for the Waterford Impoundment.

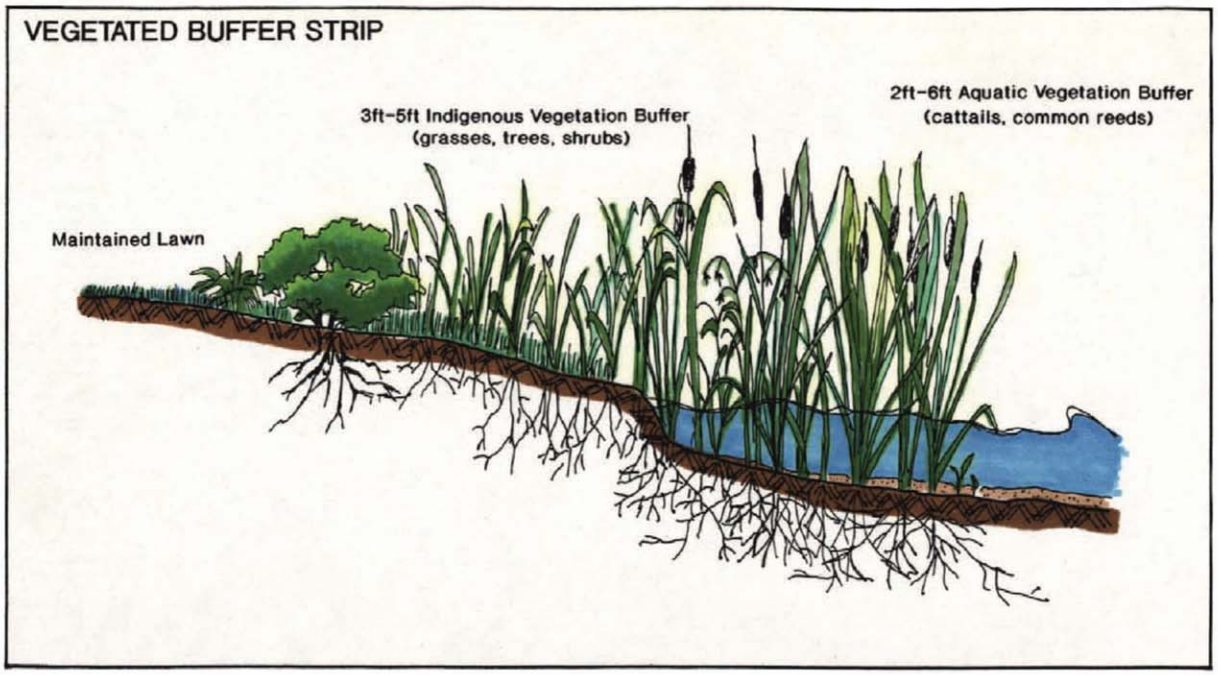
As noted in Chapter V in Volume One of this report, the Waterford Impoundment is currently managed for warmwater sportfish; selective stocking has been undertaken historically by the WDNR, with northern pike and walleye being stocked in alternate years. Continued fish stocking by the WDNR is a viable option for the Waterford Impoundment, subject to monitoring and creel surveying data collected from the Impoundment by the WDNR. Supplemental stocking by other interested parties may be warranted, subject to WDNR permitting. Additional fish population control measures do not appear to be warranted at this time, although monitoring of rough fish populations should continue.

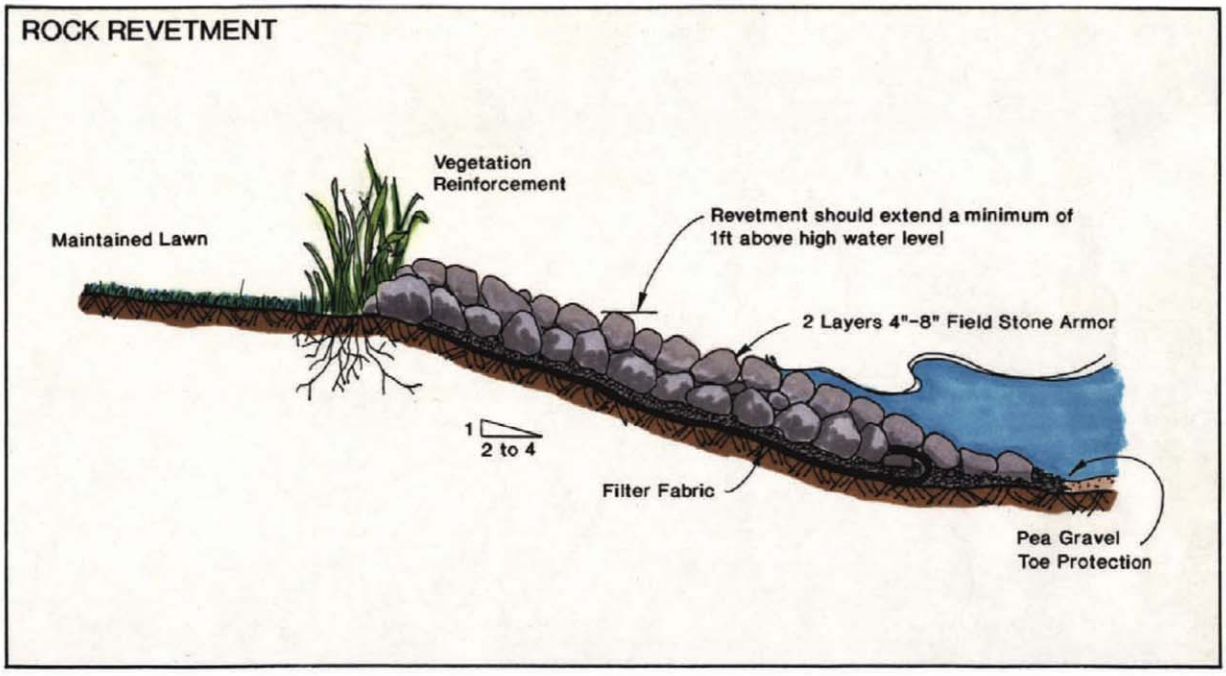
Regulations and Public Information
To reduce the risk of overharvest, the WDNR has placed restrictions on the number and size of certain fish species caught by anglers. The open season, size limits, and bag limits for the fish species of the Waterford Impoundment are given in Table 22 in Volume One of this report. Enforcement of these regulations is critical to the success of any sound fish management program.

Aquatic Plant Management Measures
Aquatic plant management refers to a group of management and restoration measures aimed at both removal of nuisance vegetation and manipulation of species composition in order to enhance and provide for recreational water use. Generally, aquatic plant management measures are classified into four groups: physical measures, which include lake bottom coverings and water level management; mechanical removal measures, which include

Figure 1

RECOMMENDED ALTERNATIVES FOR SHORELINE EROSION CONTROL





NOTE: Design specifications shown herein are for typical structures. The detailed design of shoreline protection structures must be based upon analysis of local conditions.

Source: SEWRPC.

harvesting and manual removal; chemical measures, which include using aquatic herbicides; and biological control measures, which in turn include the use of various organisms, such as insects. All of these measures are stringently regulated and require a State permit available through the WDNR pursuant to Chapters NR 107 and NR 109 of the *Wisconsin Administrative Code*.

Costs of aquatic plant management measures range from minimal for manual removal of plants using rakes and hand-pulling to upwards of $100,000 for the purchase of a mechanical plant harvester and ancillary equipment, the operational costs for which can approach $10,000 to $20,000 per year, depending on staffing and operating policies. Harvesting is probably the measure best applicable to larger, deeper areas while chemical controls may be best suited to use in confined areas and for initial control of invasive plants. Planting of native plant species is largely experimental in lakes, but can be considered a specialized shoreland management zone at the water's edge. Physical controls and mechanical harvesting may have side effects in the expansion of plant habitat and the spread of reproductive vegetative fragments.

Periodic reconnaissance surveys of aquatic plant communities and periodic updates of in-place aquatic plant management plans are valuable data gathering tools in the determination of any aquatic plant management actions and, as such, are considered viable options.

Aquatic Herbicides

Chemical treatment with aquatic herbicides is a short-term method of controlling heavy growths of aquatic macrophytes and algae. Chemicals are applied to the growing plants in either liquid or granular form. The advantages of using chemical herbicides to control aquatic macrophyte growth are the relative ease, speed, and convenience of application. Herbicides also offer a degree of selectivity, targeting specific types of aquatic plants. However, the disadvantages associated with chemical control include the following:

1. The short-term, lethal effects of chemicals are relatively well known. However, properly applied, chemical applications should not result in such effects. Potential long-term, sublethal effects, especially on fish, fish-food organisms, and humans, are relatively unknown.

2. The elimination of macrophytes eliminates their competition with algae for light and nutrients. Algal blooms may then develop unless steps are taken simultaneously to control the sources of nutrient input.

3. Since much of the dead plant materials are left to decay in the lake, nutrients contained in them are rapidly released into the water and fuel the growth of algae. The decomposition of the dead plant material also consumes dissolved oxygen and increases the potential for fish kills. Accretion of additional organic matter in the sediments as a result of decomposition also increases the organic content of the soils and predisposes the sediments toward reintroduction of other (or the same) nuisance plant species. Long-term deposition of plant material may result in the need for other management measures, such as dredging.

4. The elimination of macrophyte beds destroys important cover, food sources, and spawning areas for desirable fish species.

5. Adverse impacts on other aquatic organisms may be expected. At the concentrations used for macrophyte control, Diquat has been known to kill the zooplankton *Daphnia* and *Hyalella*, both important fish foods. *Daphnia* is the primary food for the young of nearly all fish species found in the Region's lakes.[17]

[17] *P.A. Gilderhus, "Effects of Diquat on Bluegills and Their Food Organisms,"* The Progressive Fish-Culturist*, Vol. 2, No. 9, 1967, pp. 67-74.*

6. Areas generally must be treated again in the following season and weedbeds may need to be treated more than once in a summer, although certain herbicides may give relief over a period of up to three years in some lakes.

7. Many of the chemicals available often affect nontarget, desirable species, such as water lilies, as well as the target "weeds," such as Eurasian water milfoil, as both species are dicotyledons which share similar biological characteristics.

The advantages and disadvantages of chemical macrophyte control also apply to the chemical control of algae. Copper, the active ingredient in algicides, may accumulate in the bottom sediments, where excessive amounts are toxic to fish and benthic animals. Fortunately, copper is rapidly eliminated from human systems and few cases of copper sensitivity among humans are known.[18]

Costs of chemical treatments vary widely. Large, organized treatments are more efficient and tend to decrease unit costs for commercial applications compared to individual treatments. Other factors, such as the type of chemical used and the number of treatments needed, are also important. Estimated costs for lakes in southeastern Wisconsin range from $240 to $480 per acre. Chemical treatments must be permitted by the State under Chapter NR 107 of the *Wisconsin Administrative Code*.

Because there is a demonstrated need to control aquatic plants in selected areas of the Waterford Impoundment, chemical treatment is considered to be a viable management option best suited for nearshore areas of the Impoundment, around piers and structures. Widespread use of chemical herbicides is not considered a viable option.

Aquatic Plant Harvesting

Aquatic macrophytes are mechanically harvested with specialized equipment consisting of a cutting apparatus which cuts up to five feet below the water surface and a conveyor system that picks up the cut plants and hauls them to shore. Advantages of macrophyte harvesting include the following:

1. Harvesting removes the plants from the lake. The removal of this plant biomass decreases the rate of accumulation of organic sediment. A typical harvest of submerged macrophytes from eutrophic lakes in southeastern Wisconsin can yield between 140 and 1,100 pounds of biomass per acre per year.[19]

2. Harvesting removes plant nutrients, including nitrogen and phosphorus, which would otherwise "refertilize" the lake as the plants decay. A typical harvest of submerged macrophytes from eutrophic lakes in southeastern Wisconsin can remove between four and 34 pounds of nitrogen and 0.4 to 3.4 pounds of phosphorus per acre per year. In addition to the physical removal of nutrients, plant harvesting may reduce internal nutrient recycling. Several studies have shown that aquatic macrophytes can act as nutrient pumps, recycling nutrients from the bottom sediments into the water column. Ecosystem modeling results have indicated that a harvest of 50 percent of the macrophytes in Lake Wingra, Wisconsin, could reduce instantaneous phosphorus availability by about 30 percent, with a maximum reduction of 40 to 60 percent, depending on the season.

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[18] *J.A. Thornton, and W. Rast, "The Use of Copper and Copper Compounds as an Algicide,"* Copper Compounds Applications Handbook*, H.W. Richardson, ed., Marcel Dekker, New York, 1997.*

[19] *James E. Breck, Richard T. Prentki, and Orie L. Loucks, editors,* Aquatic Plants, Lake Management, and Ecosystem Consequences of Lake Harvesting*, Proceedings of Conference at Madison, Wisconsin, February 14-16, 1979.*

3. Repeated macrophyte harvesting may reduce the regrowth of certain aquatic macrophytes. The regrowth of milfoil has been reported to have decreased as harvesting frequency was increased.

4. Where dense growths of filamentous algae are closely associated with macrophyte stands, they may be harvested simultaneously.

5. The macrophyte stalks remaining after harvesting provide cover for fish and fish-food organisms, and stabilize the bottom sediment against wind erosion.

6. Selective macrophyte harvesting may reduce stunted populations of panfish in lakes where excessive cover has adversely influenced predator-prey relationships. By allowing an increase in predation on young panfish, both gamefish and the remaining panfish may show increased growth.[20]

7. The cut plant material can be used as mulch.

The disadvantages of macrophyte harvesting include the following:

1. Harvesting is most effective in water depths greater than two feet. Large harvesters cannot operate in shallow water or around docks and buoys. Operation of harvesting equipment in shallow waters can result in significant increases in turbidity and disruption of the lake bottom and lake bottom-dwelling fauna.

2. The reduction in aquatic macrophytes by harvesting reduces their competition with algae for light and nutrients. Thus, algal blooms may develop.

3. Fish, especially young-of-the-year bluegills and largemouth bass, as well as fish-food organisms, are frequently caught in the harvester. As much as 5 percent of the juvenile fish population can be removed by harvesting. A WDNR study found that four pounds of fish were removed per ton of plants harvested.[21]

4. The reduction in aquatic macrophyte biomass by harvesting or chemical control can reduce the diversity and productivity of macroinvertebrate fish-food organisms feeding on the epibiota. Bluegills generally move into the shoreline area after sunset, where they consume these macroinvertebrates. After sunrise they migrate to open water, where they graze, primarily on zooplankton. If harvesting or chemical control shifts the dominance of the littoral macroinvertebrate fauna to sediment dwellers, the macroinvertebrate component of the bluegill diet could be restricted.[22] This would increase predation pressure on zooplankton and reduce the growth rate of the panfish; it could eventually lead to undesirable ramifications throughout the food web in a lake.

5. Macrophyte harvesting may influence the community structure of macrophytes by favoring such plants as milfoil (*Myriophyllum* spp.) that propagate from cut fractions. This may allow these plants to spread into new areas through the rerooting of the cut fractions.

6. Certain species of plants, such as coontail, are difficult to harvest due to lack of root system.

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[20] *James E. Breck, and J.F. Kitchell, "Effects of Macrophyte Harvesting on Simulated Predator-Prey Interactions," edited by Breck et al., 1979, pp. 211-228.*

[21] *Wisconsin Department of Natural Resources,* Environmental Assessment Aquatic Nuisance Control (NR 107) Program*, 3rd Edition, 1990, 213 pp.*

[22] *James E. Breck, et. al.,* op. cit.

7. The efficiency of macrophyte harvesting is greatly reduced around piers, rafts, and buoys because of the difficulty in maneuvering the harvesting equipment in those restricted areas. Manual methods have to be used in these areas.

8. High capital and labor costs may be associated with harvesting programs. Macrophyte harvesting on the Waterford Impoundment could be conducted through cooperative agreements among various municipalities or be contracted to a private company. These costs are largely staff costs and operating costs such as fuel, oil, and maintenance. The cost of new harvesting equipment, when needed, would be about $282,500.

Harvesting programs should be designed to provide optimal benefits and minimal adverse impacts. Small fish are common in dense macrophyte beds, but larger fish, such as largemouth bass, do not utilize these dense beds.[23] Narrow channels may be harvested to provide navigational access and "cruising lanes" for predator fish to migrate into the macrophyte beds to feed on smaller fish. "Shared access" lanes may also be cut, allowing several residents to use the same lane. Increased use of these lanes should keep them open for longer periods than would be the case if a less directed harvesting program was followed. "Clear cutting" of aquatic plants and denuding the lake bottom of flora should be avoided. However, top cutting of plans such as Eurasian water milfoil, as shown in Figure 2, is suggested.

Water depth, numbers and arrangement of docks and moored boats, and nature of bottom substrate are important factors when considering mechanical harvesting. Most harvesting equipment is large and not well-suited to close operation around docks and moored boats where precise control of movement is needed. Areas of shallow depth—two to three feet or less containing muck or other soft, loose bottom materials—are generally not considered to be well suited to harvesting as the equipment tends to churn up these bottom materials, creating turbid water conditions, affecting established benthic communities and fragmenting rooted aquatic macrophytes. Additionally, plants such as Eurasian water milfoil, which propagate through the spread of plant fragments, may actually be given a reproductive advantage as a result of the chopping action of harvesting equipment. Mechanical harvesting is best suited to areas free of docks and moored watercraft or recreational equipment, where lake bottom materials are firm and water is of sufficient depth to offer a degree of protection against potential lake bottom disruption by harvester equipment. The harvest of water lilies and emergent native plants should be avoided.

Protecting native aquatic plant communities from disturbances can help prevent Eurasian water milfoil from spreading within a lake. Recent studies show that native plants can effectively compete with Eurasian water milfoil. However, the exotic species tends to outcompete native plants when the lake's ecosystem is stressed.[24] Stress can be brought on by tributary area pollution, shoreline development, changing water levels, boating activity, carp, and aquatic nuisance controls. This maintenance of a healthy aquatic plant community has been found to be the most efficient way of managing aquatic plants, as opposed to other means of managing problems once they occur. Furthermore, native aquatic plant communities contribute most effectively to the maintenance of good water quality by providing suitable habitat for desirable fish and other aquatic organisms which promote stable or increased property values and quality of life.[25]

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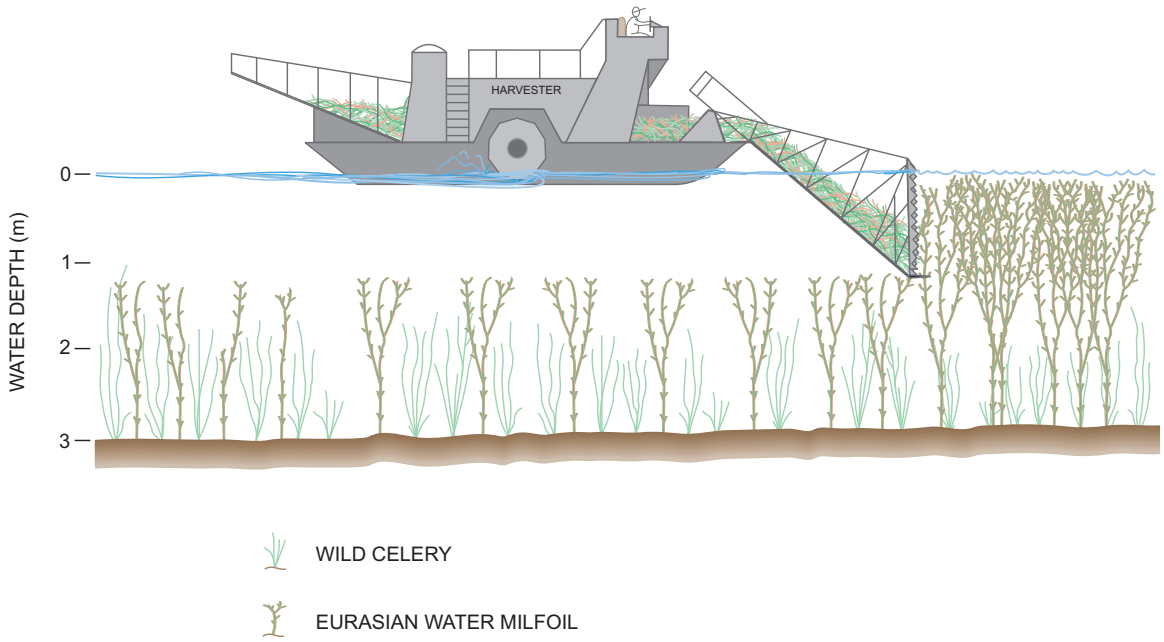
[23] *S. Nichols, Wisconsin Department of Natural Resources Technical Bulletin No. 77,* Mechanical and Habitat Manipulation for Aquatic Plant Management: A Review of Techniques*, 1974.*

[24] *Wisconsin Department of Natural Resources,* Eurasian Water Milfoil in Wisconsin: A Report to the Legislature*, 1992.*

[25] *Roy Bouchard, Kevin J. Boyle, and Holly J. Michael,* Water Quality Affects Property Prices: A Case Study of Selected Maine Lakes*, Miscellaneous Report 398, February 1996.*

Figure 2

PLANT CANOPY REMOVAL WITH AN AQUATIC PLANT HARVESTER



NOTE: Selective cutting or seasonal harvesting can be done by aquatic plant harvesters. Removing the canopy of Eurasian water milfoil may allow native species to reemerge.

Source: Wisconsin Department of Natural Resources and SEWRPC.

Because of the demonstrated need for control of aquatic plants, harvesting is considered a viable option in areas of the Waterford Impoundment that are conducive to this method of management, principally within the Tichigan Lake subbasin. Mechanical harvesting of aquatic plants must be permitted by the WDNR pursuant to authorities set forth in Chapter NR 109 of the *Wisconsin Administrative Code*.

Manual Harvesting

Due to water depth limitations imposed by the size and maneuverability of the harvesters, it is not always possible for harvesters to reach the shoreline of every property. Likewise, because of the cost and other concerns relating to the use of chemical herbicides, alternative measures for the control of aquatic plant growth in specific areas of the Impoundment should be considered. A number of specially designed rakes are available from commercial outlets to assist lakefront homeowners in manually removing aquatic plants from the shoreline area. The WWMD has acquired a number of these rakes, which are made available to lakefront property owners upon request. The advantages of these rakes are that they are easy and quick to use, and result in an immediate result, in contrast to chemical treatments that involve a waiting period. This method also removes the plants from the lake avoiding the accumulation of organic matter on the lake bottom.

Manual harvesting is feasible in only very limited areas and is not practical for large-scale use. Nevertheless, manual harvesting does offer a reasonable level of aquatic plant control in the vicinity of docks and piers, and is therefore considered a viable option. Manual harvesting beyond a 30-foot-wide recreational corridor, or within a WDNR-delineated environmentally sensitive area, must be permitted by the WDNR pursuant to authorities set forth in Chapter NR 109 of the *Wisconsin Administrative Code*. Pursuant to the provision of this Chapter, piers and other recreational areas must be placed within the 30-foot-wide recreational corridor.

Biological Controls

Another alternative approach to controlling nuisance weed conditions, in this particular case Eurasian water milfoil, is biological control. Classical biological control has been successfully used to control both weeds and herbivorous insects.[26] Recent documentation states that *Eurhychiopsis lecontei*, an aquatic weevil species, has the potential as a biological control agent for Eurasian water milfoil. In 1989, the weevil was discovered during a study investigating a decline of Eurasian water milfoil growth in a Vermont pond. *Eurhychiopsis* proved to have significant negative effects on Eurasian water milfoil in the field and in the lab. The adult weevil feeds on the milfoil causing lesions which make the plant more susceptible to pathogens, such as bacteria or fungi, while the weevil larvae burrows in the stem of the plant causing enough tissue damage for the plant to lose buoyancy and collapse.[27] The few studies that have been done since that time have indicated the following potential advantages to use of this weevil as a means of Eurasian water milfoil control:

1. *Eurhychiopsis lecontei* is known to cause fatal damage to the Eurasian water milfoil plant and over a period of time has the potential to cause a decrease in the milfoil population.

2. *Eurhychiopsis lecontei* larvae are easy to produce.

3. *Eurhychiopsis lecontei* are not known to cause damage to existing native aquatic plants.

The potential disadvantages of using *Eurhychiopsis lecontei* include:

1. Relatively little experience in southeastern Wisconsin in the use of biological control agents for the management of Eurasian water milfoil. The studies done on *Eurhychiopsis* are very recent and many suggest that, while the weevil is usually present in lakes infested with Eurasian water milfoil, it is only effective periodically when its populations grow to a level sufficient to cause significant damage to the milfoil plant stems.[28]

2. Since the upper portion of the Eurasian water milfoil plant is preferred by the weevil, harvesting would have to be extremely limited or not used at all in conjunction with this type of aquatic plant management control. The studies done on *Eurhychiopsis* also suggest that the organism is susceptible to wash-off from the plant stem by boat wakes and wind waves, and that the organisms are subject to predation by bluegill and other fishes.

3. Adequate overwintering habitat, consisting of natural shoreland areas, must be present to ensure continuity of the Eurasian water milfoil weevil. Extensive lengths of shoreland protection structure may limit the ability of the organisms to survive from year-to-year.

Relatively few studies concerning the use of *Eurhychiopsis lecontei* as a means of aquatic plant management control have been completed. Such cases have resulted in variable levels of control, and, although priced competitively with aquatic herbicides, the use of *Eurhychiopsis lecontei* is not considered a viable option for the

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[26]*C.B. Huffacker, D.L. Dahlsen, D.H. Janzen, and G.G. Kennedy,* Insect Influences in the Regulation of Plant Population and Communities*, 1984, pp. 659-696; C.B. Huffacker and R.L. Rabb, editors,* Ecological Entomology*, John Wiley, New York, New York, USA.*

[27]*Sally P. Sheldon, "*The Potential for Biological Control of Eurasian Water Milfoil (*Myriophyllum spicatum*) 1990-1995 Final Report*," Department of Biology, Middlebury College, February 1995.*

[28]*The use of* Eurhychiopsis *sp. on an experimental basis to control Eurasian water milfoil was monitored in selected Wisconsin lakes by the Wisconsin Department of Natural Resources and the University of Wisconsin-Stevens Point from 1995 through 1998. These results indicated mixed success, suggesting that this organism has specific habitat requirements that limit its utility as a Eurasian water milfoil control agent within Wisconsin.*

Waterford Impoundment at this time. Use of biological control agents must be permitted by the State under Chapter NR 109 of the *Wisconsin Administrative Code*.

In contrast, the use of biological control agents such as the purple loosestrife beetles, *Hylobius transversovittatus*, *Galerucella pusilla*, *Galerucella calmariensis*, *Nanophyes brevis*, and *Nanophyes marmoratus,* is recommended to control infestations of purple loosestrife (*Lythrum salicaria*) in wetlands and along shorelands. These biological control agents have been shown to be beneficial in a variety of circumstances throughout the Southeastern Wisconsin Region. Recently some stands of golden or yellow loosestrife (*Lysimachia vulgaris*) have been observed in the shoreland areas of the Impoundment. This plant reportedly is a vigorous invader in shoreland wetlands and even more prolific than the purple loosestrife and cannot be controlled using biological agents; hence, monitoring and manual control of incipient infestations is recommended.

The use of other biological control agents is prohibited in Wisconsin; the use of the grass carp, *Ctenopharyngodon idella*, for aquatic plant control is expressly prohibited.

Lake Bottom Covering

Lake bottom covers and light screens provide limited control of rooted plants by creating a physical barrier which reduces or eliminates the sunlight available to the plants. They have been used to create swimming beaches on muddy shores, to improve the appearance of lakefront property, and to open channels for motorboats. Sand and gravel are usually readily available and relatively inexpensive to use as cover materials, but plants readily recolonize areas so covered in about a year. Synthetic materials, such as polyethylene, polypropylene, fiberglass, and nylon, can provide relief from rooted plants for several years. The screens are flexible and can be anchored to the lakebed in spring or draped over plants in summer.

The advantages of bottom covers and screens are that control can be confined to specific areas, the covers and screens are usually unobtrusive and create no disturbance on shore, and the covers are relatively easy to install over small areas. The disadvantages of bottom covers and screens are that they do not reduce eutrophication of the lake, they are expensive, they are difficult to spread and anchor over large areas or obstructions, they can slip on steep grades or float to the surface after trapping gases beneath them, and they may be difficult to remove or relocate.

Screens and covers should not be used in areas of strong surfs, heavy angling, or shallow waters where there is motorboat traffic. They should also not be used where aquatic vegetation is desired for fish and wildlife habitat. To minimize interference with fish spawning, screens should be placed before or after spawning. A permit from the WDNR is required for use of sediment covers and light screens. Permits require inspection by the WDNR staff during the first two years, with subsequent permits issued for three-year periods. Annual removal of such barriers is generally required as a permit condition.

The estimated cost of lake bottom covers that would control plant growth along a typical shoreline property, an area of about 700 square feet, ranges from $100 for burlap to $300 for aquascreen. Placement of lake bottom screens requires a WDNR permit pursuant to Chapter 30 of the *Wisconsin Statutes*. Because of the limitations involved, placement of lake bottom covers as a method to control aquatic plant growth is not a viable option for the Waterford Impoundment.

Use of sand blankets and pea gravel deposits has also been proposed as a physical barrier to aquatic plant growth in certain situations. Placement of materials on the bed of a navigable lake or waterway also requires a WDNR permit pursuant to Chapter 30 of the *Wisconsin Statutes*, and the use of these materials is generally confined to the creation and augmentation of swimming beaches. Use of these materials for aquatic plant management purposes is not a viable option as deposition of sediments above the sand or gravel layer limits the longer term viability of this technique.

Public Informational Programming

Aquatic plant management usually centers on the eradication of nuisance aquatic plants for the improvement of recreational lake use. The majority of the public views all aquatic plants as "weeds" and residents often spend considerable time and money removing desirable plant species from a lake without considering their environmental impacts. As shown in Table 17 in Chapter V in Volume One of this report, many aquatic plants have positive ecological value within the lake ecosystem, and most native aquatic plants rarely interfere with human water uses. Thus, public information is an important component of an aquatic plant management program and should include informational programming on:

1. The types of aquatic plants in the Waterford Impoundment and their value to water quality, fish, and wildlife.

2. The preservation of existing stands of desirable plant species.

3. The identification of nuisance species and the methods of preventing their spread.

4. Alternative methods for controlling existing nuisance plants, including the positive and negative aspects of each method.

An organized aquatic plant identification/education day is one method of providing hands-on education to lake residents. Other sources of information and technical assistance include the WDNR and the University of Wisconsin-Extension (UWEX). The aquatic plant species lists provided in Chapter V in Volume One of this report, and the illustrations of common aquatic plants present in the Waterford Impoundment, appended to Volume One of this report as Appendix A, may serve as a checklist for individuals interested in identifying the plants near their residences. Residents can observe and record changes in the abundance and types of plants in their part of a lake on an annual basis.

Of the submerged floating and free-floating aquatic plant species found in the Waterford Impoundment, Eurasian water milfoil is one of the few species likely to cause lake-use problems. Eurasian water milfoil, unlike most aquatic plants, can reproduce from fragments and often forms dense, monotypic beds with little habitat value for fish or waterfowl. Lakeshore residents should be encouraged to collect fragments that wash ashore after storms and, especially, from weekend boat traffic. The plant fragments can be used as mulch on flower gardens or ornamental planting areas. Likewise, lake users should be encouraged to inspect boats and trailers both prior to launch and following recovery as Eurasian water milfoil and other aquatic plants can be transported between lakes as fragments on boats and boat trailers. This effort also limits the likelihood of transporting zebra mussel, *Dreissena polymorpha*, between lakes and into new areas of the Impoundment.

To prevent unwanted introductions of plants and invasive aquatic animals into lakes, boaters should remove all plant fragments from their boats and trailers when exiting a lake, and allow wet wells, engine water jackets, and bilges to dry thoroughly for up to one week—alternatively, boaters can run their vessels through a car wash, where high pressure, high temperature water sprays can remove and destroy organisms such as the zebra mussel juveniles (veligers).[29] Providing the opportunity for the removal of plant fragments at the boat landings on the Waterford Impoundment, and provision of signage at the boat landing, including provision of disposal containers at the boat landing, may help motivate boaters to utilize this practice. Posters and pamphlets are available from the WDNR and UWEX that provide information and illustrations of milfoil, zebra mussel, and other nonnative aquatic species; discuss the importance of removing plant fragments from boats; and, remind boaters of their duty in this regard.

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[29]*See Wisconsin Department of Natural Resources Publication No. PUBL-WR-383 95-REV.,* Zebra Mussel Boater's Guide*, 1995; Wisconsin Department of Natural Resources Publication No. PUBL-WR-463 96-REV.,* The Facts...On Eurasian Water Milfoil*, February 1996.*

Recreational Use Management
Regulatory measures provide a basis for controlling lake use and use of the shorelands around a waterbody. On land, shoreland zoning, requiring set backs and shoreland buffers can protect and preserve views both from the water and from the land, controls development around a lake to minimize its environmental impacts and manages public and private access to a waterbody. On water, recreational use zoning can provide for safe and multiple-purpose use of lakes by various groups of lake users and protect environmentally sensitive areas of a lake. Use zoning can take the form of allocating times of use, such as the annual fishing season established by the State, or areas of use, wherein the types or rate of use is controlled, as in the case of shallow water, slow-no-wake speed limits. A key issue in zoning a waterbody for use is equity; the same rules must apply to both riparian owners/residents and off-lake users. This condition is usually met in situations where use zoning is motivated by the protection of fish habitat, for example, as both on- and off-lake users would appreciate an enhanced fishery. Costs are relatively low, associated with creating and posting the ordinance, and effectiveness can be good with regular/consistent enforcement. Costs increase for measures requiring buoyage.

Currently, watercraft are restricted to slow-no-wake speeds within 100 feet of pierheads; personal watercraft (PWCs) or jetskis® are restricted to slow-no-wake speeds within 200 feet of shore and 100 feet of other watercraft.[30] The 100 foot to 200 foot nearshore zone typically coincides with water depths of less than five feet. Demarcation of Eurasian water milfoil control areas, and similar environmentally valuable or sensitive areas of the Impoundment is recommended. It is also recommended that the governmental bodies surrounding the Waterford Impoundment continue to enforce the recreational boating ordinance appended hereto as Appendix B in Volume One of this report.

Improvement of demarcation of navigable channels, especially in Conservancy Bay and in constricted riverine portions of the Impoundment, are also considered viable options. Removal or relocation of underwater obstructions that could pose a possible safety hazard in narrow riverine areas as well as the consolidation of emergent vegetation to enhance the cones of visibility for on-water users navigating through constricted areas are also considered viable options. In addition, maintenance of navigation access to the Impoundment through selective deepening of recreational boating access lanes is considered to be a viable option. Priority in this regard should be given to ensuring access to the Impoundment from the WDNR access site in the vicinity of Bridge Drive, and maintaining navigation traffic lanes within the Impoundment.[31] In addition, navigational access to private properties within Buena Lake and the embayments locally known as Elm Island Bay and Island View Bay is recommended to be maintained, subject to WDNR permitting requirements.

Public Informational and Educational Programming
Educational and informational brochures and pamphlets, of interest to homeowners and supportive of the recreational use and shoreland zoning regulations, are available from UWEX and the WDNR. These cover topics such as beneficial lawn care practices and household chemical use guidelines. These brochures could be provided to homeowners through local media, direct distribution, or targeted school or public library displays. Many of these ideas can be integrated into ongoing, larger-scale municipal activities such as anti-littering campaigns, recycling drives, and similar pro-environment activities. The WWMD publishes a periodic newsletter and maintains an internet website to inform electors, property owners, and other interested individuals of the District's activities.

In addition, the WWMD regularly presents seminars and informational programs of general interest to community residents. These programs have included aquatic plant identification, lake history, lake water quality, and related topics. In addition to public informational programming, or informal educational programming, discussed above,

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[30] *Wisconsin Department of Natural Resources Publication No. PUBL-LE-301 2006,* Wisconsin Boating Regulations*, 2006.*

[31] *See SEWRPC Memorandum Report No. 102,* op. cit.

there are a number of school-based educational opportunities that the community can utilize at the middle school level and at the high school level. Such programming as Project WET are available from and supported by the UWEX and provide youth the opportunity to experience "hands on" the aquatic environment and become better informed about current and future lake issues and concerns. To this end, the WWMD has conducted an annual "pontoon classroom" that provides an opportunity for scholars to learn about the Impoundment while on the water. Such programs are considered a viable option.

Finally, reporting of USGS water quality sampling results to the public should be continued and participation in the WDNR Self-Help Monitoring Program should be continued. Volunteer monitoring under the auspices of the WDNR "Self-Help Monitoring Program" involves citizens in taking Secchi-disc transparency readings in the Impoundment at regular intervals. The Lake Coordinator of the WDNR-Southeast Region can assist in enlisting volunteers in this program. The information gained at first hand by the public during participation in this program increases the credibility of the proposed changes in the nature and intensity of use to which the Impoundment is subjected.

Institutional Development

While lake management activities fall under the general powers of municipalities—in the case of the Village of Waterford pursuant to Section 61.34(1), *Wisconsin Statutes*, and in the case of the Town of Waterford pursuant to Section 60.23(6) if authorized by the town meeting under Section 60.10(3)(a), *Wisconsin Statutes*, other public and private organizational alternatives exist for the management of lakes in the State of Wisconsin.[32] Private lake organizations have the option to be incorporated, generally as nonstock, not-for-profit corporations under Chapter 181, *Wisconsin Statutes*. Public lake organizations include special-purpose units of government that are created as public inland lake protection and rehabilitation districts under Subchapter IV of Chapter 33, *Wisconsin Statutes*; utility districts created pursuant to Subchapter VIII of Chapter 66, *Wisconsin Statutes;* and town sanitary districts created under Subchapter IX of Chapter 60, *Wisconsin Statutes*. The specific type (or types) of organization created is based upon the decision of the community.

Current Lake Management Structure

In the case of the Waterford Impoundment, general oversight of lake management activities currently is provided by the WWMD with advisory input from the Town and Village of Waterford (the Town of Waterford appoints a commissioner to serve on the WWMD Board of Commissioners), and in cooperation with Racine County (Racine County appoints a commissioner to serve on the WWMD Board of Commissioners), the Southeastern Wisconsin Fox River Commission (FRC) (an intergovernmental Commission created pursuant to Subchapter VI of Chapter 33, *Wisconsin Statutes*), and the Fox River Committee Against Underwater Sediment and Erosion (Fox River CAUSE), a nongovernmental organization. The FRC has statutory authority within the Illinois Fox River basin between the City of Waukesha and the Waterford Dam in the Village of Waterford. In addition, two farm drainage districts, created pursuant to Chapter 88 of the *Wisconsin Statutes*, and a town sanitary district, created pursuant to Chapter 60 of the *Wisconsin Statutes*, exist within or adjacent to the area tributary to the Waterford Impoundment; namely, the Waukesha Genesee Farm Drainage District No. 1 located along the Pebble Creek tributary to the Fox River in Waukesha County, the Racine County Farm Drainage District No. 1 located along the Wind Lake Drainage Canal immediately south of the Impoundment, and the Town of Waterford Sanitary District No. 1. Drainage districts are special purpose units of government created by petition of the landowners within the proposed district for the purpose of draining land, primarily for agricultural purposes, while town sanitary districts are special purpose units of government created by town boards or by petition of the landowners within the proposed district for the purpose of providing liquid and/or solid waste management services.

No change in this organizational arrangement is anticipated.

[32]*See University of Wisconsin-Extension Publication No. G3216,* The Lake in Your Community*, 1986.*

Proposed Lake Management Structure

The Waterford Impoundment community may wish to consider the modification of the boundary of the WWMD to enhance the ability of this government unit to provide lake management services. The WWMD was created by Racine County during 2003, and currently encompasses those lands riparian to the Impoundment. The boundary review was predicated upon consideration of the following criteria:

1. Consistency with Chapter 33, *Wisconsin Statutes*, requirements that properties included within a public inland lake protection and rehabilitation district be benefited by inclusion in the district;

2. Consistency with UWEX guidance set forth in *People of the Lakes: A Guide for Wisconsin Lake Organizations—Lake Associations & Lake Districts, Eleventh Edition*,[33] that recommends that the district, at a minimum, include the entire lakeshore, all riparian property, areas directly affecting the lake and/or which are included in planned service areas, and entire parcels; and

3. Consistency with applicable regional and local plans including the County land and water resource management plan and other applicable plans.

Based upon consideration of the current boundary of the District, as shown on Map 1, no immediate action would appear to be necessary to enable the WWMD to fulfill its functions under Chapter 33 of the *Wisconsin Statutes*. However, when the WWMD is compared to other Districts serving waterbodies of similar areal extent within the Southeastern Wisconsin Region, future expansion of the District to additional lands tributary to the Impoundment is not unreasonable. Should the expansion of the WWMD be contemplated, and for such expansion to be consistent with the guidance referred to above, it is suggested that specific consideration be given to inclusion of lake-oriented subdivisions and off-lake lands having deeded or preferential access to the Impoundment. These lands, together with those lands that are riparian to the Impoundment, contribute to long-term impacts influencing Impoundment water quality and aquatic plant growths. Recognition of these impacts has resulted in a discussion of the need to refine the institutional structure for lake management.

Lands may be attached to an existing lake management district pursuant to requirements set forth in Section 33.33(2), *Wisconsin Statutes*. Attachment may be initiated either by petition of the affected landowners within the district, or by motion of the district commissioners to attach lands to the district. In both cases, the district commissioners must make a finding that the lands to be attached are benefited by inclusion within the district, benefit being assessed based upon the relative benefit to the lake of the affected lands being included within the district.[34] While bound by the specific process and requirements of Section 33.33(2)(a), and of Section 33.26 insofar as these may be applicable, the district commissioners have full discretion regarding the granting of a petition for attachment.

Alternatively, should the district commissioners initiate the attachment of lands to a district, the commissioners must provide written notice to the affected landowners and to the governmental unit that created the district. In this case, the WWMD Board of Commissioners must provide written notice under Section 33.33(2)(b) to the affected landowners and to Racine County. Following receipt of which notice, the County must convene a hearing pursuant to the process and requirements of Section 33.33(2), and Section 33.26 insofar as it may be applicable. Following the hearing, the County must make a determination on the attachment proposal. Attachment findings made pursuant to Sections 33.33(2) and 33.26 of the *Wisconsin Statutes* can be appealed to the circuit court for judicial review. Attachment of lands to a district should not create a "hole" within the district.

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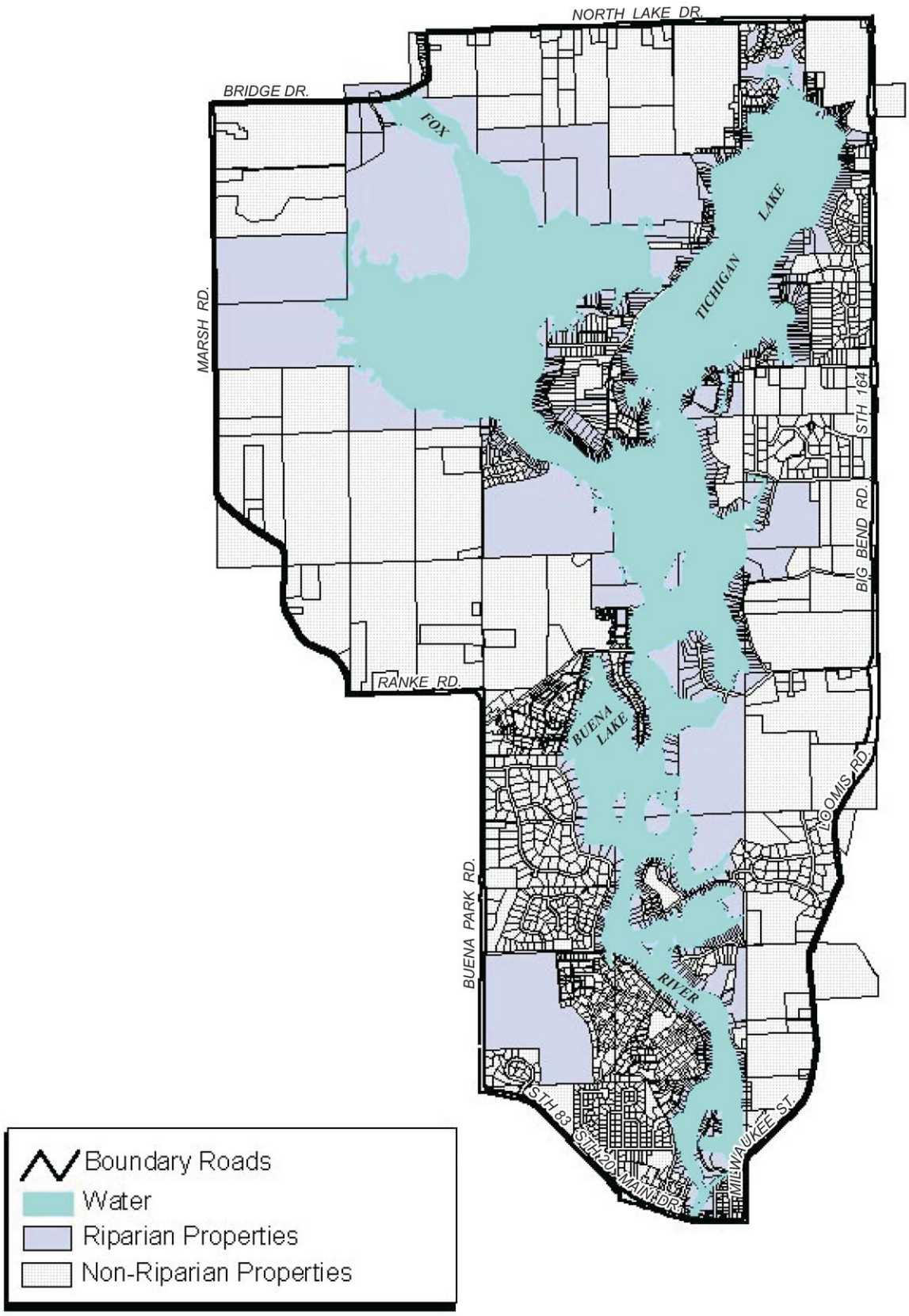
[33]*Wisconsin Lakes Partnership, WDNR Publication No. PUB-FH-821-2006 and UWEX Publication No. G3818,* People of the Lakes: A Guide for Wisconsin Lake Organizations—Lake Associations & Lake Districts, Eleventh Edition*, 2006.*

[34]Ibid.

Map 1

EXISTING BOUNDARY OF THE WATERFORD WATERWAY MANAGEMENT DISTRICT



Source: Racine County Real Estate Description Department.

Since the most direct source of nonpoint source pollutant input to the Waterford Impoundment is the result of land use in the area directly tributary to the Waterford Impoundment, inclusion of the lands located immediately upstream of the "Iron Bridge" on Bridge Drive at the northern end of the Impoundment within the area directly tributary to the Waterford Impoundment and lying along the streambanks of the Fox River, and of lake-oriented subdivisions and off-lake lands having deeded or preferential access to the Impoundment, to the extent possible, would provide the District with the ability to better protect and/or rehabilitate the water quality condition of the Impoundment and better manage the Impoundment, and is, therefore, considered a viable option.

SUMMARY

This chapter has described options that could be employed in managing the types of problems recorded as occurring in the Waterford Impoundment and which could assist, singly or in combination, in achieving and maintaining the water quality and water use objectives set forth in Chapter VI in Volume One of this report. Selected characteristics of these measures are summarized in Table 1.

An evaluation of the potential management measures for improving the Waterford Impoundment water quality was carried out on the basis of the effectiveness, cost, and technical feasibility of the measures. Those alternative measures not considered further at this time include: phosphorus precipitation and inactivation, drawdown by water level control modifications, biological control of aquatic plants—except for biological control of purple loosestrife, and lake bottom covering. The remaining measures are considered viable options to be considered further for incorporation in the recommended plan described in Chapter III.

Table 1

SELECTED CHARACTERISTICS OF ALTERNATIVE LAKE MANAGEMENT MEASURES FOR WATERFORD IMPOUNDMENT

Plan Element	Subelement	Alternative Management Measure	Considered Viable for Inclusion in Recommended Lake Management Plan
Land Use	Zoning	Implement regional land use and county development plans within tributary area	Yes
		Maintain existing density management in lakeshore areas; consider conservation development principles	Yes
		Develop and implement consistent stormwater management ordinances in all riparian communities; periodic review of stormwater ordinances	Yes
	Protecting environmentally significant lands	Implement regional natural areas and critical species habitat protection and management plan recommendations within tributary area	Yes
Pollution Abatement	General nonpoint source pollution abatement	Implement regional water quality management plan, Upper Fox River priority watershed plan, and County land and water resource management plan recommendations within the watershed	Yes
	Rural nonpoint source controls	Develop farm conservation plans that encourage conservation tillage, contour farming, contour strip cropping, crop rotation, grassed waterways, and pasture and streambank management in agricultural areas of the tributary area	Yes
	Urban nonpoint source controls	Promote urban housekeeping practices, public educational programming, and grassed swales	Yes
		Implement additional urban nonpoint source controls, including street sweeping, catch basin cleaning, leaf litter and garden refuse collection, materials storage facility protection, and stormwater management measures in urban areas of the tributary area	Yes
		Consider integrated nutrient and pest control at River-more Country Club and Edgewood Golf Course	Yes
	Developing Area nonpoint source controls	Enforce construction site erosion control ordinances requiring soil stabilization, surface roughening, barriers, diversion swales, sediment traps, and detention/retention/infiltration basins	Yes
	Public sanitary sewerage system management	Conduct periodic review of sewer service area needs within sewered areas of the tributary area	Yes
	Onsite sewage disposal system management	Implement onsite sewage disposal system management, including inspection and maintenance protocols	Yes
Water Quality	Water quality monitoring	Continue participation in WDNR Self-Help Monitoring Program and periodic participation in the USGS Trophic State Index (TSI) water quality monitoring program; alternatively, consider participation in University of Wisconsin-Stevens Point TSI monitoring program	Yes
	Water quality improvement	Conduct alum treatment to achieve phosphorus inactivation in lake sediments	No
		Promote nutrient load reduction within the Lake basin through sediment management	No
Water Quantity	Dam operations	Modify outlet control operations	No
		Drawdown	No
		Water level stabilization	No
		Dredging	Yes[a]
		Dam inspection	Yes

Table 1 (continued)

Plan Element	Subelement	Alternative Management Measure	Considered Viable for Inclusion in Recommended Lake Management Plan
Aquatic Biota	Fisheries management	Protect fish habitat	Yes
		Maintain shoreline and littoral zone fish habitat by maintaining existing shoreline structures and repair as necessary using vegetative means insofar as practicable (reconstruction may require WDNR Chapter 30 permits)	Yes
		Continue stocking of selected game fish species and monitor rough fish populations	Yes
		Enforce size and catch limit regulations	Yes
		Conduct habitat restoration measures	Yes
	Aquatic plant management	Use (limited) aquatic herbicides for control of nuisance plants such as Eurasian water milfoil and purple loosestrife	Yes[b]
		Consider mechanical harvesting of aquatic macrophytes to provide navigational channels and fish lanes, control nuisance plants and to promote growth of native plants	Yes[c]
		Manually harvest aquatic plants from around docks and piers where feasible	Yes
		Conduct periodic aquatic plant reconnaissance surveys and periodically update aquatic plant management plan	Yes
		Employ biological controls using inocula of Eurasian water milfoil weevils	No
		Use sediment covers to shade out aquatic plant growth around piers and docks	No
		Collect floating plant fragments from shoreland areas to minimize rooting of Eurasian water milfoil	Yes
		Continue to monitor populations of invasive species; continue current efforts to control purple and yellow loosestrife	Yes
Water Use	- -	Enforce boating regulations to maximize public safety; improve signage	Yes
		Develop time and/or space zoning schemes to limit surface use conflicts	No
Ancillary Management Measures	Public Informational and Educational Programming	Conduct public informational programming utilizing seminars and distribution of informational materials	Yes
		Support participation of schools in Project WET, Adopt-A-Lake, pontoon classrooms, etc.	Yes
		Conduct public informational and educational programming on aquatic plants and options for their management	Yes
		Encourage methods of preventing unwanted intrusions of invasive biota at public recreational boat access	Yes
Institutional Development	- -	Attachment to the District of lands within the direct tributary area of the District lying along the Fox River north of the Iron Bridge, and lands having preferential lake access, such as subdivisions and deed access for second- and third-tier properties	Yes

[a]*Limited to those areas where shallow water and restricted width of recreational boating channels pose a possible safety hazard, such as Conservancy Bay and constricted riverine portions of Impoundment.*

[b]*Limited areas when necessary to control exotic, invasive species.*

[c]*In areas where water depth, bottom substrate material, and dock/moored watercraft densities are within desirable limits to promote the effectiveness of this method of aquatic plant management*.

Source: SEWRPC.

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Chapter III

RECOMMENDED MANAGEMENT PLAN FOR WATERFORD IMPOUNDMENT

INTRODUCTION

This chapter presents a recommended management plan for the Waterford Impoundment. The plan is based upon inventories and analyses of land use and land and water management practices, pollution sources in the area tributary to the Waterford Impoundment, the physical and biological quality of the waters of the Impoundment, recreational use and population forecasts, set forth in Volume One of this report, and an evaluation of alternative lake management measures, set forth in Chapter II in Volume Two of this report. The recommended plan sets forth means for: 1) providing water quality conditions suitable for full body contact recreational use and the maintenance of healthy communities of warmwater fish and other aquatic life, 2) reducing the severity of existing or perceived problems which constrain or preclude desired water uses, 3) improving opportunities for water-based recreational activities, and 4) protecting environmentally sensitive areas. The elements of the recommended plan were selected from among the alternatives described in Chapter II, and evaluated on the basis of those feasible alternatives, set forth in Table 1 in Chapter II of this report, that may be expected to best meet the foregoing lake management objectives.

Analyses of water quality and biological conditions indicate that the general condition of the water of the Waterford Impoundment is poor. Impediments to water quality include inputs of nonpoint source pollutants from riparian lands and the tributary area, which extends through Waukesha County to the headwaters of the Fox River system in Washington County, as well as inputs of treated wastewater from a number of upstream communities. Additional impediments include ongoing land use changes and loss of natural areas due to increasing urbanization in the watershed. While the lake supports an abundant fishery, impediments to fishes include poor water quality, lack of habitat within the riverine portions of the Impoundment, and siltation of tributary streams. Impediments to water-based recreation include limitations on access by recreational watercraft in portions of the Impoundment imposed by insufficient water depths and abundant growths of aquatic macrophytes, accumulations of sediment, and constrictions in the navigational lanes. Consequently, based upon a review of the inventory findings and consideration of planned development within the area tributary to the Impoundment, as set forth in the regional land use plan and associated county and local level land use plans, measures will be required to protect and maintain the water quality of the Impoundment for future lake users.

This plan sets forth recommendations for: land use management, including protecting environmentally sensitive lands in the area tributary to the Waterford Impoundment, water quality monitoring and pollution abatement, aquatic plant and fisheries management, recreational water use management, and informational programming.

These measures complement and refine the tributary area land use controls and management measures recommended in the adopted regional water quality management plan,[1] the regional land use plan,[2] the Upper Fox River priority watershed plan,[3] and the Racine County land and water resource management plan.[4]

The recommended management measures for the Waterford Impoundment are graphically summarized on Maps 2, 3, and 4 and are listed in Table 2. The recommended plan measures are more fully described in the following paragraphs. It should be noted that recreational use management and institutional development measures also were considered in developing this management plan, and are included as ancillary management measures. The recommended management agency responsibilities for tributary area land management also are set forth in Table 2.

TRIBUTARY AREA MANAGEMENT MEASURES

Land Use Control and Management

A fundamental element of a sound management plan and program for the Waterford Impoundment is the promotion of a sound land use pattern within the area tributary to the Impoundment. The type and location of rural and urban land uses in the tributary area will determine, to a considerable degree, the character, magnitude, and distribution of nonpoint sources of pollution; the practicality of, as well as the need for, various land management measures; and, ultimately, the water quality of the Impoundment.

The recommended land use plan for the area tributary to the Waterford Impoundment is described in Chapter II in Volume One of this report. The framework for the plan is the regional land use plan as prepared and adopted by the Southeastern Wisconsin Regional Planning Commission (SEWRPC).[5] The recommended land use plan envisions that urban land use development within the area tributary to the Waterford Impoundment will occur primarily at low densities and only in areas which are covered by soils suitable for the intended use; which are not subject to special hazards such as flooding; and which are not environmentally sensitive, that is, not encompassed within the SEWRPC-delineated environmental corridors described in Chapter V in Volume One of this report.

Development in the Shoreland Zone

A major land use issue which has the potential to affect the Waterford Impoundment is the redevelopment of existing lakefront properties, replacing lower-density uses with higher-density, multi-family dwellings with potential for increased roof areas, parking areas, and other areas of impervious surfaces. Replacement of a pervious land surface with an impervious surface will increase the rate of stormwater runoff to the Impoundment, increase pollutant loadings on the Impoundment, and reduce groundwater recharge. While these effects can be moderated to some extent through structural stormwater management measures, there is likely to be an adverse impact on the Impoundment from significant redevelopment in the area tributary to the Impoundment involving

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[1]*SEWRPC Planning Report No. 30,* A Regional Water Quality Management Plan for Southeastern Wisconsin: 2000*, Volume Three,* Recommended Plan*, June 1979; as refined in SEWRPC Memorandum Report No. 93,* A Regional Water Quality Management Plan for Southeastern Wisconsin: An Update and Status Report*, March 1995; and, SEWRPC Memorandum Report No. 102,* Water Level Control Plan for the Waterford-Vernon Area of the Middle Fox River Watershed, Racine and Waukesha Counties, Wisconsin*, March 1995.*

[2]*SEWRPC Planning Report No. 48,* A Regional Land Use Plan for Southeastern Wisconsin: 2035*, June 2006.*

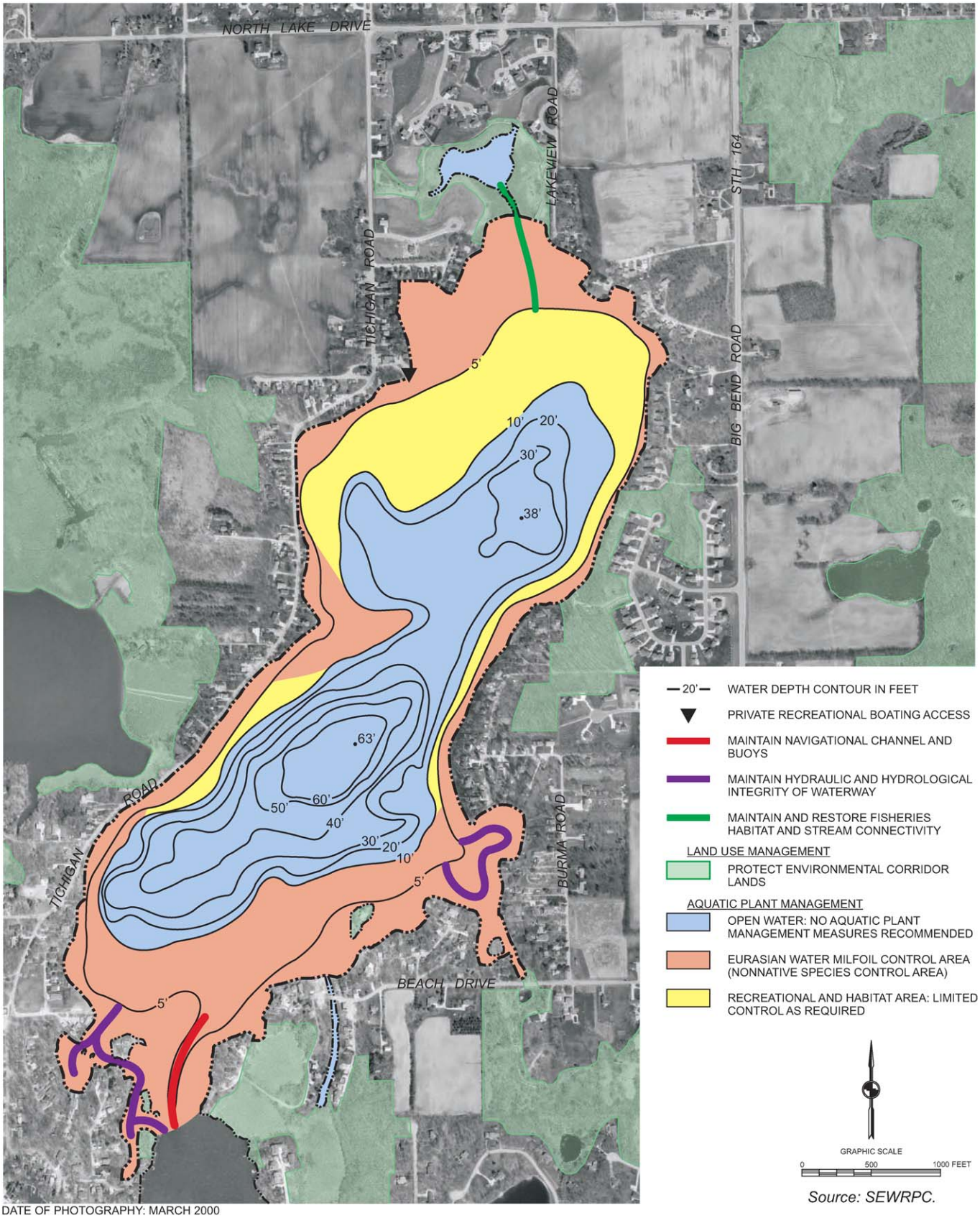
[3]*Wisconsin Department of Natural Resources Publication PUBL-WR-366-94,* Nonpoint Source Control Plan for the Upper Fox River Priority Watershed Project*, June 1994.*

[4]*SEWRPC Community Assistance Planning Report No. 259,* A Land and Water Resource Management Plan for Racine County: 2000-2004, *September 2000.*

[5]*SEWRPC Planning Report No. 48,* op. cit.

Map 2

RECOMMENDED MANAGEMENT PLAN FOR TICHIGAN LAKE

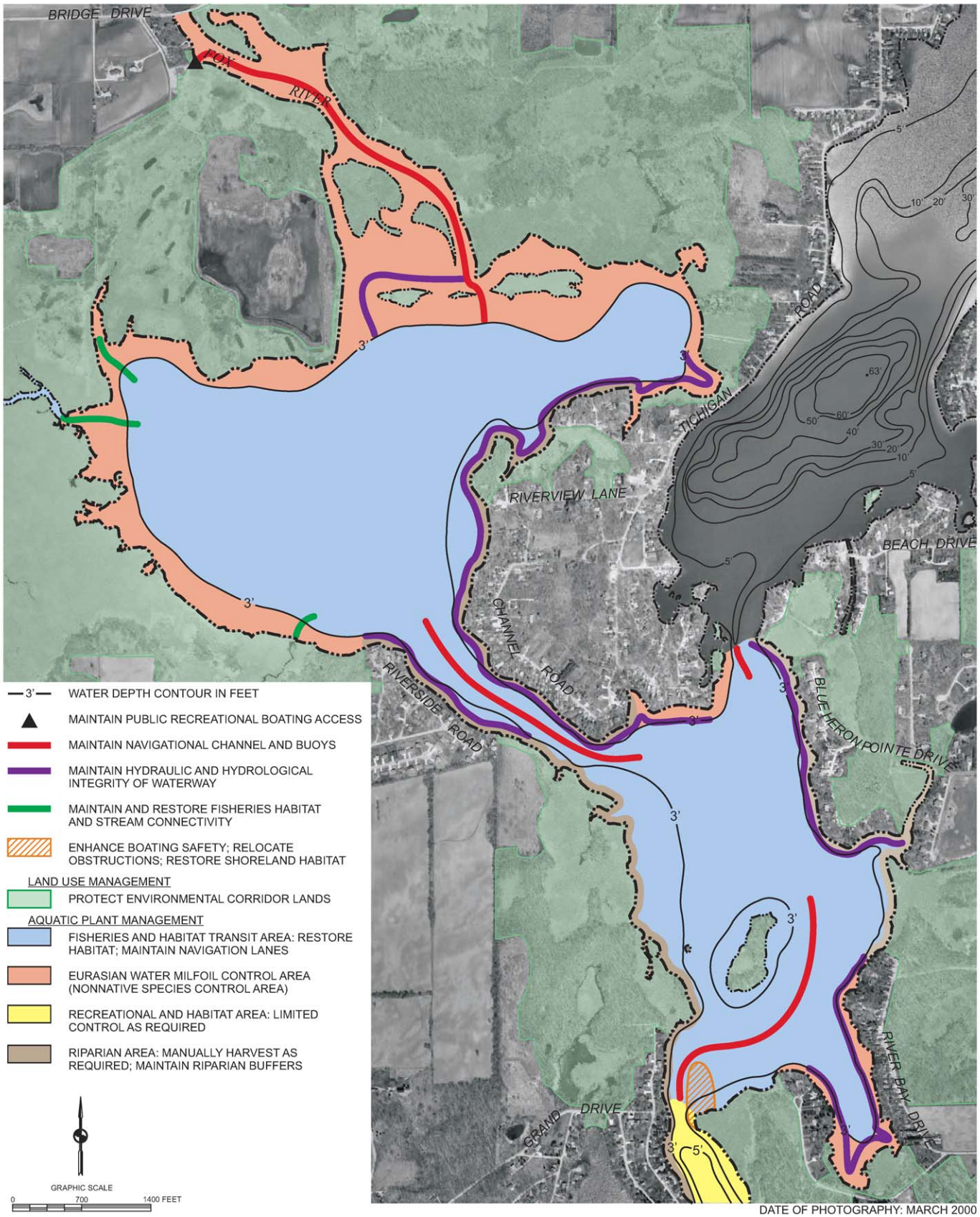


DATE OF PHOTOGRAPHY: MARCH 2000

Source: SEWRPC.

Map 3

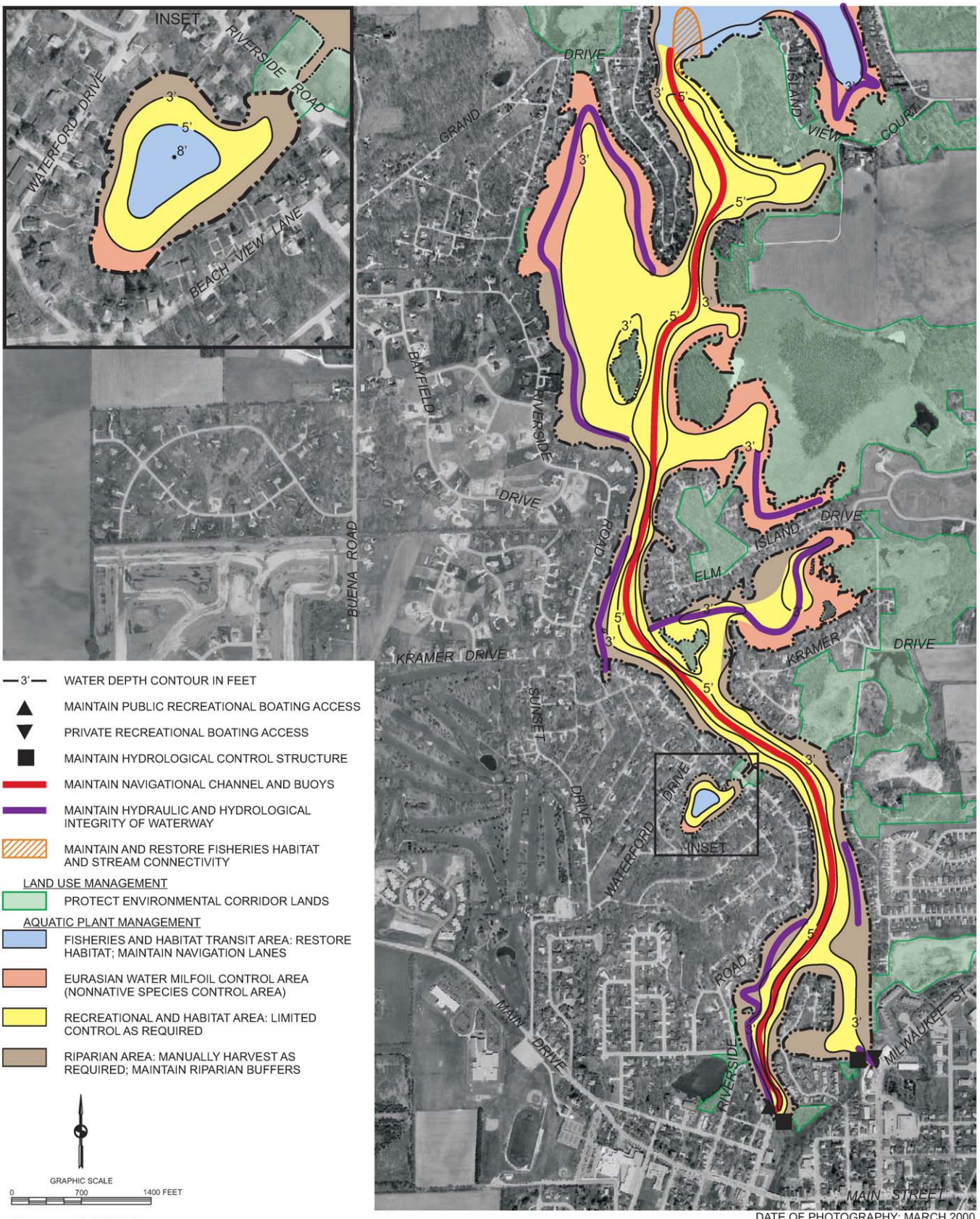
RECOMMENDED MANAGEMENT PLAN FOR THE WATERFORD IMPOUNDMENT



Source: SEWRPC.

Map 4

RECOMMENDED MANAGEMENT PLAN FOR THE WATERFORD IMPOUNDMENT AND BUENA LAKE



DATE OF PHOTOGRAPHY: MARCH 2000

Source: SEWRPC.

Table 2

RECOMMENDED MANAGEMENT PLAN ELEMENTS FOR WATERFORD IMPOUNDMENT

Plan Element	Subelement	Location	Management Measure	Management Responsibility[a]
Land Use	Zoning	Entire tributary area	Observe guidelines set forth in the local, regional and Racine County land use plans, and Waukesha County development plan	Racine County; Waukesha County; Town and Village of Waterford
		Lakeshore areas	Maintain historic lake front residential dwelling densities to extent practical; continue to enforce shoreland setback requirements; consider conservation development principles for new development or redevelopment	
		Developing areas	Enforce stormwater management ordinances, especially in developing areas	
		Entire tributary area	Develop and implement consistent stormwater management ordinances in all riparian communities; periodically review stormwater ordinances for consistency with State Administrative Codes	
	Protecting environmentally significant lands	Elm Island-Bog Island Oak Woods, Tichigan Fen, Norris Marsh and Slough, Van Valin Woods	Implement regional natural areas and critical species habitat protection and management plan recommendations within tributary area; consider public or private acquisition of features of local or greater significance	Racine County; Town and Village of Waterford; WDNR; FRC; WWMD
Pollution Abatement	General nonpoint source pollution abatement	Entire tributary area	Implement recommendations made in the county land and water resource management plans	Racine County; Waukesha County
	Rural nonpoint source controls	Entire tributary area	Promote sound rural land management practices to reduce soil loss and contaminant loadings through preparation of farm conservation plans in accordance with the county land and water resource management plans	Racine County; Waukesha County; USDA; WDATCP; UWEX
	Urban nonpoint source controls	Entire tributary area	Promote sound urban housekeeping and yard care practices through public educational programming	Racine County; Waukesha County; Town and Village of Waterford; WWMD; FRC
		Rivermore Country Club Edgewood Golf Course	Use integrated nutrient and pest management best practices	Rivermore Country Club, Edgewood Golf Course WWMD; FRC
	Developing area nonpoint source controls	Entire tributary area	Implement various urban nonpoint source controls, including storm water management	Racine County; Town and Village of Waterford; WWMD
			Develop and enforce construction site erosion control and stormwater management ordinances; review ordinances for concurrence with the NR 151 suite of nonpoint source pollution abatement and stormwater management administrative codes	
	Public sanitary sewerage system management	Sewered portions and urbanizing portions of the tributary area	Conduct periodic review and refinement of sewer service area needs within sewered areas of the tributary area	Racine County; Town and Village of Waterford; WWMD

Table 2 (continued)

Plan Element	Subelement	Location	Management Measure	Management Responsibility[a]
Pollution Abatement (continued)	Onsite sewage disposal system management	Unsewered portions of the tributary area	Implement onsite sewage disposal system management, including inspection and maintenance; provide system information to residents	Racine County; Waukesha County; Town of Waterford; WWMD; private landowners
Water Quality	Water quality monitoring	Main lake basin (west bay)	Continue participation in WDNR Self-Help Monitoring Program; consider participation in WDNR Expanded Self-Help Program, USGS Water Quality Monitoring Program or University of Wisconsin-Stevens Point Environmental Task Force TSI monitoring program	USGS; WDNR; UW-SP; WWMD
Water Quantity	Water level control structure	Waterford dam	Perform periodic inspections to confirm correct operation of the dam and spillway structures	WDNR; Racine County
	Water level monitoring	Waterford Impoundment	Install and monitor lake level gauges at various points around the Impoundment	USGS; WDNR; WWMD; FRC
	Hydrological management	Drainage districts	Continue to maintain stream flow and hydrologic integrity of streams and agricultural drains as appropriate; restore and maintain natural hydrology	Waukesha Genesee Farm Drainage District No. 1; and Racine County Farm Drainage District No. 1
Aquatic Biota	Fisheries management	Entire lake	Protect fish habitat	WDNR, WWMD, private sports organizations
			Maintain shoreline and littoral zone fish habitat by maintaining existing shoreline structures and repair as necessary using vegetative means insofar as practicable; reconstruction may require WDNR Chapter 30 permits	WDNR, WWMD, private shoreline property owners
			Continue stocking of selected game fish species and monitor rough fish populations	WDNR, WWMD, private sports organizations
			Enforce size and catch limit regulations	WDNR
		Trout streams	Restore and rehabilitate drainage ways adjacent to Conservancy Bay; continue to stock trout to sustain a recreational fishery	WDNR, WWMD, private sports organizations
	Habitat restoration and protection	Severely constricted riverine portion along Riverside Road and East Peninsula Road	Relocation of large underwater boulders, resculpturing of bottom materials and sediments, and consolidation of emergent shoreline vegetation	WDNR; WWMD
	Aquatic plant management	Entire Lake	Conduct periodic reconnaissance surveys of aquatic plant communities Update aquatic plant management plan every three to five years Provide and conduct programming on aquatic plants and various management measures	WDNR, WWMD
		Selected areas of the Lake	Use (limited) aquatic herbicides for control of nuisance plants such as Eurasian water milfoil and purple and yellow loosestrife[a]	WDNR; WWMD
			Consider mechanical harvesting of aquatic macrophytes to provide navigational channels and fish lanes, control nuisance plants and to promote growth of native plants[c]	WDNR; WWMD

Table 2 (continued)

Plan Element	Subelement	Location	Management Measure	Management Responsibility[a]
Aquatic Biota (continued)	Aquatic plant management (continued)	Selected areas of the Lake	Manually harvest aquatic plants from around docks and piers where feasible	Individual property owners, WDNR
		Lakeshore areas	Collect floating plant fragments from shoreland areas to minimize rooting of Eurasian water milfoil	WDNR; WWMD; private lakefront property owners
	Invasive species	Entire lake	Continue to monitor population size, make-up, and distribution of invasive species such as zebra mussel, purple and yellow loosestrife, Eurasian water milfoil; continue current efforts to control loosestrife	WDNR, WWMD
Water Use	Recreational use management	Entire lake	Enforce regulations governing the operation of watercraft and improve posting and notification of regulations and ordinances, including signage and materials at public recreational access site to aid in the identification and control of exotic species	Racine County; Town and Village of Waterford; WDNR; WWMD; Town Water Safety Patrol
		Constricted riverine portions of Impoundment[d]	Consider surface use zoning with no-wake zones; improve cones of visibility through consolidation of emergent shoreline vegetation; relocate potentially hazardous underwater obstructions	WDNR; WWMD
		Conservancy Bay[d]	Improve demarcation of and consider removal of bottom sediment as part of a waterway restoration project to improve navigational channels	US ACoE; WWMD
		Elm Island Bay, Island View Bay, Buena Lake, Impoundment thalweg[d]	Maintain navigability of boating channels; consider additional buoyage to demarcate navigation lanes	WWMD
Ancillary Management Measures	Public Informational and Educational Programming	Entire tributary area	Conduct public informational programming utilizing seminars and distribution of informational materials Conduct public informational and educational programming on aquatic plants and options for their management	Racine County; Town and Village of Waterford; WDNR; WWMD; Town Water Safety Patrol
		Entire lake	Support participation of schools in Project WET, Adopt-A-Lake, pontoon classroom, etc. Encourage methods of preventing unwanted intrusions of invasive biota at public recreational boat access	Racine County; Town and Village of Waterford; WDNR; UWEX; WWMD; Town Water Safety Patrol
Institutional Development	Attachment of lands	Upstream of the iron bridge at the north end of the direct tributary area to the extent of the direct tributary area	Consider the attachment of lands within the direct tributary area north of the iron bridge and lying along the streambanks of the Fox River	WWMD; Racine County; Town of Waterford
		Lands with preferential land access within the direct tributary area	Consider the attachment of lands within the direct tributary area	

Table 2 Footnotes

[a]*WWMD = Waterford Waterway Management District; WDNR = Wisconsin Department of Natural Resources; WDATCP = Wisconsin Department of Agriculture, Trade and Consumer Protection' UWEX = University of Wisconsin-Extension; US ACoE = U.S. Army Corps of Engineers.*

[b]*Limited areas when necessary to control exotic, invasive species.*

[c]*In areas where water depth, bottom substrate material, and dock/moored watercraft densities are within desirable limits to promote the effectiveness of this method of aquatic plant management*.

[d]*As indicated on Maps 2 through 4, interventions in these priority areas would provide benefit for navigation, but would also benefit water flow through the Impoundment through maintenance of the hydraulic and hydrologic integrity of the waterway and restored connectivity and continuity between the Impoundment and the streams and wetlands discharging directly to the waterway.*

Source: SEWRPC.

conversion to higher-density land uses. For this reason, maintenance of the historic low- and medium-density residential character of the shoreline of the Waterford Impoundment to the maximum extent practical is recommended.

It is further recommended that lakefront developments, as well as setback and landscaping provisions, be carefully reviewed by the Town and Village of Waterford and the Wisconsin Department of Natural Resources (WDNR). Such review would address specific shoreland zoning requirements, and could consider the stormwater and urban nonpoint source pollution abatement practices proposed to be included in shoreland development activities. Provision for shoreland buffers, use of appropriate and environmentally friendly landscaping practices, and inclusion of stormwater management measures that provide water quality benefits are practices to be encouraged. This recommendation would be applicable to shoreland redevelopment as well as to new development on platted lots. Where appropriate and practicable, the use of conservation development techniques is strongly recommended.[6]

Development in the Tributary Area

Another land use issue which has the potential to affect the Impoundment is the potential development for urban uses of agricultural and other open space lands in the tributary area. As previously noted, large-lot residential development in the watershed is occurring in areas where such development was not envisioned in the adopted regional land use plan. If this trend continues, much of the open space areas remaining in the tributary area will be replaced over time with large-lot urban development. This may significantly increase the pollutant loadings to the Impoundment and increase the pressures for recreational use of the Impoundment. A significant portion of the undeveloped lands outside of the environmental corridors and other environmentally sensitive areas could potentially be developed for low-density urban uses.

The existing zoning in the tributary area basin permits development, generally on large suburban-density lots, over much of the remaining open lands other than the environmental corridors. Control of shoreland redevelopment, and the related intensification of use, is not specifically addressed in the existing zoning codes. It is recommended that the impact of future land use development on the Waterford Impoundment be minimized through review and modification of the applicable zoning ordinance regulations and zoning district maps to address the concerns noted. Changes in zoning ordinances are recommended to minimize the areal extent of development by providing specific provisions and incentives for the clustering of residential development on smaller lots within conservation subdivisions, thus preserving significant portions of the open space within each property or group of properties considered for development. Review of current ordinances for concurrency with State stormwater management requirements also is recommended.

[6]*SEWRPC Planning Guide No. 7,* Rural Cluster Development Guide*, December 1996.*

Stormwater Management

It is recommended that the Town and Village of Waterford take an active role in promoting urban nonpoint source pollution abatement. Such actions would include the conduct of stormwater management planning within specific portions of the tributary area located within each municipality where further urban development or redevelopment is anticipated. Such a planning program should include a review of the stormwater management ordinances, to ensure that the ordinance provisions reflect state-of-the-art runoff and water quality management requirements, and to ensure that there is harmony between the ordinances governing urban density development in each of the municipalities draining to the Waterford Impoundment. Adoption by all riparian municipalities of common stormwater management ordinance provisions is strongly recommended. To this end, the Waterford Waterway Management District has proposed to the riparian municipalities the adoption of specific stormwater management ordinances that provide protection for lake water quality during both the construction and post-construction phases of development. Adoption of these ordinances is recommended.

Management of Environmentally Sensitive Lands

Wetland, woodland, and groundwater recharge area protection can be accomplished through land use regulation and public land acquisition of critical lands. Both measures are recommended for the area tributary to the Waterford Impoundment. The wetland areas within the watershed are currently largely protected through the existing regulatory framework provided by the U.S. Army Corps of Engineers permit program, State of Wisconsin shoreland zoning requirements, and local zoning ordinances. Nearly all wetland areas in the area tributary to the Waterford Impoundment are included in the environmental corridors delineated by SEWRPC and protected under one or more of the existing Federal, State, County, and local regulations. Consistent and effective application of the provisions of these regulations is recommended.

Some high quality wetland and woodland areas have been identified for acquisition in the adopted regional natural areas and critical species habitat protection and management plan, including the Elm Island and Bog Island Oak Woods, a portion of the Tichigan Fen, Norris Marsh and Slough, and Van Valin Woods.[7] Public acquisition or acquisition by private conservation organizations of these lands is recommended. In this regard, implementation of the recommendations of the adopted park and open space plans, and land and water management plans, for Racine and Waukesha Counties would complement the protection and preservation of these environmentally sensitive lands.[8]

Point and Nonpoint Source Pollution Controls

The recommended tributary area land management measures are specifically aimed at reducing the water quality impacts on the Waterford Impoundment of nonpoint sources of pollution within the tributary area. In addition, given the extent of urban density development within this tributary area, many communities currently utilize public sanitary sewerage systems to convey and treat wastewater prior to discharge into the Fox River or its tributaries. All of these measures, set forth in, among others, the regional water quality management plan and the County land and water resource management plans, are intended to protect and rehabilitate water quality within the Fox River watershed and meet the water quality objectives for the streams of the watershed established by Chapters NR 102 and NR 104 of the *Wisconsin Administrative Code*, and summarized in Chapter VI in Volume One of this report. While much of the immediate area tributary to the Waterford Impoundment is served by a public sewerage system, portions of the watershed continue to be served by onsite sewage disposal systems.

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[7]*SEWRPC Planning Report No. 42,* A Regional Natural Areas and Critical Species Habitat Protection and Management Plan for Southeastern Wisconsin*, September 1997.*

[8]*SEWRPC Community Assistance Planning Report No. 134, 2nd Edition,* A Park and Open Space Plan for Racine County*, July 2001; SEWRPC Community Assistance Planning Report No. 137,* A Park and Open Space Plan for Waukesha County*, December 1989, as refined in SEWRPC Community Assistance Planning Report No. 209,* A Development Plan for Waukesha County, Wisconsin*, August 1996; see also SEWRPC Community Assistance Planning Report No. 259,* op. cit.*; and, Waukesha County Department of Parks & Land Use, Land Resources Division,* Waukesha County Land and Water Resource Management Plan: 2006-2010*, March 2006.*

Consequently, both onsite and public sewerage systems, in addition to both urban and rural nonpoint source pollution abatement practices, are discussed below.

Public and Onsite Sewage Disposal System Management

The shoreland areas and areas tributary to the Waterford Impoundment are served by public sanitary sewerage systems operated by the Village of Waterford and the Town of Waterford Sanitary District No. 1. Wastewater from the lakeshore is conveyed by these utilities to the Western Racine County Sewerage District Treatment Plant for treatment. Additional portions of the tributary area are included within public sanitary sewer service areas, including Mukwonago, Mukwonago County Park, Rainbow Springs, Eagle Spring Lake, Muskego, Waukesha, Pewaukee, Brookfield West, Menomonee Falls South, Sussex, and Lannon, as well as Genesee East and Wales. Sewer service area facilities plans for these areas should be reviewed periodically for currency, and refined as necessary.

For those portions of the area directly tributary to the Waterford Impoundment served by public sanitary sewerage systems, it is recommended that the WWMD, in cooperation with the Village of Waterford and Town of Waterford Sanitary District No. 1 and with the assistance of the University of Wisconsin-Extension (UWEX), assume the lead in providing public informational and educational programs to encourage affected property owners to use their sewerage systems appropriately and wisely. In an analogous recommendation, stenciling of storm drains and related informational programming encourages WWMD residents to dispose of waste products safely, avoiding discharge directly to the surface waters or indirectly through the wastewater treatment works to the environment.

Within those portions of the tributary area not served by public wastewater treatment facilities, current County ordinance provisions requiring the regular inspection and maintenance of onsite sewage disposal systems should be enforced to minimize potential phosphorus loadings from this source. It also is recommended that the Counties, in cooperation with the municipalities, assume the lead in providing the public informational and educational programs to encourage affected property owners to have existing onsite systems inspected and any needed remedial measures undertaken, as appropriate. Homeowners should be advised of the rules and regulations governing, and the limitations of onsite sewage disposal systems, and should be encouraged to undertake preventive maintenance programs, especially of those older systems not yet subject to the inspection requirements of the County ordinances.

Typical costs for a basic inspection and maintenance service for onsite sewage disposal systems range from about $100 to $200 per year, although more extensive programs could be more expensive. The costs of the informational programming typically have been included within the operating budget of the Counties.

Nonpoint Source Pollution Controls

Nonpoint source control measures should be considered for the areas tributary to the Waterford Impoundment. The regional water quality management plan recommended that the nonpoint source pollutant loadings from the areas tributary to the Waterford Impoundment be reduced by up to 50 percent in urban areas and by up to 75 percent in rural areas, in addition to implementation of urban construction erosion controls, stream bank erosion controls, and onsite sewage disposal system management practices. The Upper Fox River Priority Watershed plan, which included the headwater portions of the Fox River and its tributaries from their point of origin to the City of Waukesha, refined these recommendations and proposed an overall reduction of phosphorus loading of between 50 percent and 75 percent in rural areas, and between 40 percent and 90 percent in urban areas.

Nonpoint source pollution abatement controls in the tributary area are recommended to be achieved through a combination of rural agricultural nonpoint controls, urban stormwater management, and construction site erosion controls. The implementation of the land management practices described below (see also Appendix B) may be expected to result in a reduction in nonpoint-source pollutants that is considered to be the maximum practicable given the findings of the inventories and analyses compiled during the planning effort. These measures are consistent with the recommended measures set forth in the Racine County land and water resource management plan.

Rural Nonpoint Source Pollution Controls

The implementation of nonpoint source pollution controls in rural areas requires the cooperative efforts of the Town and Village of Waterford, Racine County, and private landowners. Technical assistance can be provided by the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS); the Wisconsin Department of Agriculture, Trade and Consumer Protection (DATCP); and the Racine County Land Conservation Division (LCD). As discussed previously, it is recommended that the Town and Village of Waterford, in coordination with the WDNR and Racine County LCD, develop a strategy to address nonpoint source pollution within the area directly tributary to the Waterford Impoundment. State and Federal soil erosion control and water quality management programs, individually or in combination, can be used to achieve pollutant reduction goals. Such programs include the USDA Environmental Quality Incentive Program (EQIP), the WDNR runoff management and lake protection programs, and various local land acquisition initiatives.

Highly localized, detailed, and site-specific measures are required to effectively reduce soil loss and contaminant runoff in rural areas. These measures are best defined and implemented at the local level through the preparation of detailed farm conservation plans. Practices which are considered most applicable within the area tributary to the Waterford Impoundment include conservation tillage, integrated nutrient and pesticide management, and pasture management. Conservation tillage was the management practice most frequently cost-shared by the WDNR under the Upper Fox River priority watershed management program. In addition, it is recommended consideration be given to cropping patterns and crop rotation cycles, with attention to the specific topography, hydrology, and soil characteristics for each farm. A reduction of about 25 percent in the nonpoint source loading from agricultural lands could provide up to about an 18 percent reduction in total phosphorus loading to the Waterford Impoundment. Implementation of the recommendations and work planning activities set forth in the Racine and Waukesha County land and water resource management plans would constitute a major step toward implementation of these lake management recommendations.

The cost of the needed measures will vary depending upon the details of the recommended farm conservation plans. These costs may be expected to be incurred to a large extent for purposes of agricultural land erosion control in any case. As noted above, with the promulgation of Chapters NR 153 and NR 154 of the *Wisconsin Administrative Code*, which became effective during October 2003, cost-share funding may be available to encourage installation of appropriate land management measures. Likewise, cost-share funding may be available under the Chapter NR 120 nonpoint source pollution abatement program for the repair and maintenance of those management measures installed pursuant to the priority watershed plan.[9]

Urban Nonpoint Source Pollution Controls

The development of urban nonpoint source pollution abatement measures for the areas directly tributary to the Waterford Impoundment should be the primary responsibility of the Town and Village of Waterford. In addition to the adoption of stormwater management ordinances, the most viable measures to control urban nonpoint sources of pollution appear to be good urban land management and urban housekeeping practices. Such practices consist of fertilizer and pesticide use management including turf management, litter and pet waste controls, and management of leaf litter and yard waste. The promotion of these measures requires an ongoing public informational program. It is recommended that the WWMD, in cooperation with the Village and Town, take the lead in sponsoring such programming for the Waterford Impoundment community through regular public informational meetings and mailings. The WWMD should also ensure that relevant literature, available through UWEX and the WDNR, is made available at these meetings and at the local Public Library and government offices. To this end, it is noted that the WWMD has established a reference shelf at the Waterford Public Library dedicated to issues affecting the Waterford Impoundment. Materials in this collection should be maintained by the Waterford Public Library in cooperation with the WWMD.

[9] *Wisconsin Department of Natural Resources Publication PUBL-WR-366-94,* op. cit.

As an initial step in carrying out the recommended urban practices, it is recommended that information on specific residential land management measures beneficial to the water quality of the Waterford Impoundment be posted on the WWMD Internet website and made available through this medium to property owners. Implementation of the recommended urban nonpoint source pollution abatement measures may be expected to provide about a 25 percent reduction in urban nonpoint source pollution runoff or about a 1 percent reduction in total phosphorus loadings to the Impoundment. It is additionally recommended that the Rivermore Country Club and Edgewood Golf Course employ those practices consistent with integrated nutrient and pest management especially in regards to the use of herbicides and/or fertilizers. Guidance on turf management has been developed by the WDNR and included in the "Turf Nutrient Management" standard issued by the WDNR in early 2006.[10] This guidance covers both low-intensity and high-intensity use areas, including residential lawns and golf courses.

Developing Areas and Construction Site Erosion Control

It is recommended that Racine County and the Town and Village of Waterford continue efforts to control soil erosion attendant to construction activities in the area directly tributary to the Waterford Impoundment in accordance with existing ordinances. As noted in Chapter II, Racine County has not adopted construction erosion control ordinances, but rather includes land disturbance requirements within their subdivision authorities; in addition, provisions for erosion control are referenced in shoreland control ordinances and stormwater management is generally relegated at the level of local jurisdictions. The provisions of these ordinances apply to all development except single- and two-family residential construction. The single- and two-family construction erosion control is to be carried out as part of the building permit process. In the Town and Village of Waterford, this function is performed by the municipal Building Inspection staff.

Construction site erosion controls may include the use of silt fences, sedimentation basins, rapid revegetation of disturbed areas; control of "tracking" of soil from the site; and careful planning of the construction sequence to minimize the areas disturbed. Construction site erosion control is particularly important in minimizing the more severe localized short-term nutrient and sediment loadings to the Waterford Impoundment that can result from uncontrolled construction sites. Consideration should be given to incorporating construction site erosion control measures into a formal stormwater management system serving larger developments following construction.

Construction site erosion control measures may be expected to reduce the phosphorus loading from that source by about 75 percent. Because of the potential for development in the tributary area to the Waterford Impoundment, it is important that adequate construction erosion control programs be in place.

The cost for construction site erosion control will vary depending upon the amount of land under construction at any given time. Typical costs are $250 to $500 per acre under development.

IN-LAKE MANAGEMENT MEASURES

The recommended in-lake management measures for the Waterford Impoundment are summarized in Table 2 and are graphically summarized on Maps 2, 3, and 4.

Surface Water Quality Management

Continued water quality monitoring of the Waterford Impoundment is recommended. Continued participation in the WDNR Self-Help monitoring program is recommended. It is also recommended that consideration be given to periodic enrollment in the USGS Trophic State Index (TSI) water quality monitoring program. This latter program collects water samples and analyzes for various water quality parameters several times during the year, typically in the deepest portion of the Tichigan Lake subbasin and in the "Widespread" portion of the Impoundment. It is further recommended that consideration be given to enrollment in the WDNR expanded Self-

[10] *Wisconsin Department of Natural Resources Technical Standard No. 1100,* Turf Nutrient Management*, January 2006.*

Help Monitoring Program, or in the University of Wisconsin-Stevens Point lake monitoring program, as a means of acquiring data and maintaining the data base on an ongoing basis.

Water Quantity and Water Level Management
As indicated in Volume One of this report, outflow from the Waterford Impoundment is controlled by twin spillways located in the Village of Waterford. The present, actual operating regime of the spillways is intended to maintain the impoundment level at an elevation of 773.4 feet above the National Geodetic Vertical Datum of 1929 (NGVD29). Periodic inspections by WDNR staff to confirm the correct operation of the dam and spillway structures is recommended.

Although the water level was not a major concern among Impoundment users,[11] it is worth noting that fluctuations in water levels can present various problems to users of the waterway. The placement of shore protection structures in the Impoundment could be more or less effective depending upon the magnitude and frequency of variations in water levels; placement of piers can be similarly affected. These variations also affect fish and aquatic life habitat availability, with extreme fluctuations potentially being disadvantageous to mollusks and other less mobile life forms. Large fluctuations of water levels can affect upstream landowners who are subject to periodic seasonal flooding of lands along the Fox River.[12] Downstream landowners are subject to similar problems.

The Commission staff has identified portions of the waterway for consideration of selected deepening in order to improve the hydraulic and hydrologic integrity of the Impoundment.[13] These areas include portions of Conservancy Bay, the Widespread in the vicinity of the outlet of Tichigan Lake, the embayments tributary to the Impoundment between Tichigan Lake and Buena Lake, Buena Lake, and the embayments between Buena Lake and the dam, in addition to portions of the Fox River downstream of the IH-43 bridge crossing in the Town of Vernon. Implementation of the recommended actions set forth in the water level control plan is endorsed and incorporated, by reference, into this plan for the Waterford Impoundment.

Fisheries Management
A fishery survey could be conducted by the WDNR at the request of the WWMD or other community-based organization and should have the following objectives:

1. To identify changes in fish species composition that may have taken place in the Impoundment since the previous surveys;

2. To permit any changes in fish populations, species composition and condition factors to be related to such known interventions as stocking programs, water pollution control activities, and aquatic plant management programs;

3. To refine and update information on fish spawning areas, breeding success, and survival rates;

4. To confirm the lack of disturbance by rough fish populations; and,

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[11] *While water surface levels were not indicated as a major concern in the questionnaire survey conducted by the WWMD, lake depth was one of the primary concerns of respondents, primarily relative to the accumulation of flocculent sediments in portions of the Impoundment.*

[12] *See SEWRPC Memorandum Report No. 102,* Water Level Control Plan for the Waterford-Vernon Area of the Middle Fox River Watershed, Racine and Waukesha Counties, Wisconsin*, March 1995.*

[13] Ibid.

5. To determine the need for, and inform the timing of, any additional stocking of northern pike, walleyed pike, and/or other game fish species, as appropriate, by the WDNR, in order to maintain a continuing, viable sport fishery.

This action could provide a sound basis for the WWMD and the WDNR to consider developing a stocking program and to revise, as may be found necessary, the current fishing regulations regarding the size and number of fish to be taken seasonally.

Habitat Protection

The habitat protection measures recommended for the Waterford Impoundment are designed to provide for habitat protection by avoiding disturbances in fish breeding areas during spring and autumn, managing aquatic plants and maintaining stands of native aquatic plants. In particular, this recommendation extends to, and includes, any WDNR-delineated, Chapter NR 107 sensitive areas that may be located in the Impoundment, although at the time of publication there were no such designated sensitive areas in the Waterford Impoundment. In addition, it is recommended that environmentally sensitive lands, including wetlands along the lakeshore and in the tributary area be preserved. To this end, it is recommended that the severely constricted riverine portion of the Impoundment located approximately one-quarter mile downstream of Egg Island and adjacent to portions of Riverside Road and East Peninsula Road be improved for wildlife habitat through the replacement of several large underwater rock structures, resculpting of river bottom materials and sediments, and consolidation of emergent shoreline vegetation. These actions would have the added safety benefit of improving navigability and the cone of visibility for recreational boat traffic moving upstream and downstream through this portion of the Impoundment. Additionally, it is recommended that the trout streams located on the western perimeter of Conservancy Bay be maintained by managing the accumulated sediments in the vicinity of their debouchment into the Bay.

Shoreland Protection

Most of the Waterford Impoundment shoreline is protected and no major areas of erosion, which require additional protection against wind, wave, and wake erosion, were identified in the planning effort. Various protection options are described in Chapter II for consideration in the repair or replacement of existing protection structures. Adoption of the vegetated buffer strip method is recommended to be used in the lakeshore areas and on tributary waterways wherever practicable in order to maintain habitat value and the natural ambience of the lakeshore. Continued maintenance of existing revetments and other protection structures is also recommended. Conversion of bulkheads to revetments or natural vegetated shoreline or combinations is recommended to be considered where potentially viable at such time as major repairs are found necessary. Natural vegetated buffer strips should also be considered for shorelines, where practical. Guidance provided in Chapter NR 328 of the *Wisconsin Administrative Code* sets forth a methodology for determining appropriate shoreline protection structures for inland lakes based upon wind wave action and fetch, substrate, and likely boat wake action.

In addition to the foregoing measures, it is recommended that the Village and Town of Waterford continue to enforce existing shoreland setback requirements, and construction site erosion control and stormwater management ordinances. Provision of informational materials to shoreland property owners is recommended, as set forth in the informational and educational programming element of this plan.

Aquatic Plant Management

The aquatic plant management strategy set forth below recognizes the importance of recreational uses of the Waterford Impoundment. Integral to the aquatic plant management strategy is the protection and preservation of fish breeding habitat. In addition, this strategy recognizes the ecosystem values and functions provided within the Waterford Impoundment by a healthy and diverse aquatic plant community, and seeks to maximize these ecosystem level benefits necessary to ensure a balanced lake ecosystem capable of supporting a variety of diverse recreational uses and economic activities.

Alternative Methods for Aquatic Plant Control

Various aquatic plant management techniques—manual, mechanical, and chemical—are potentially applicable on the Waterford Impoundment. A number of these methods have been employed with varying success on the

Waterford Impoundment in the past, although use of chemical herbicides has been the major control measure utilized throughout the Impoundment in recent years.

Chemical Controls

Chemical controls, in the form of herbicides and algicides, have been the primary means of aquatic plant control on Waterford Impoundment. As noted in Chapter V in Volume One of this report, the aquatic herbicides diquat, endothal, sodium arsenite, and 2,4-D have been applied to the Waterford Impoundment to control aquatic macrophyte growth; copper sulfate compounds have been used to control swimmer's itch and algae. Diquat is a nonselective herbicide that will kill many aquatic plants that provide significant habitat value for the fishes and wildlife of the Impoundment, such as the pondweeds, bladderwort, and naiads. Endothall primarily kills pondweeds, but does not control, such nuisance species as Eurasian water milfoil, while 2,4-D is a systemic herbicide that is considered to be more selective and generally used to control Eurasian water milfoil. However, 2,4-D also will kill high-value species, such as water lilies. In addition, in some lakes, the use of chemical control techniques may contribute to an ongoing aquatic plant problem by augmenting the natural rates of accumulation of decayed organic matter in the lake sediments, and releasing the nutrients contained in the plants back into the water column where they can be reused by new plants, inducing further biomass production. The use of chemical control measures may also contribute to the oxygen demand that produces anoxic conditions in a lake, damaging or destroying nontarget plant species that provide needed habitat for fish and other aquatic life.

Selective use of chemical control may be a suitable technique for the control of infestations of Eurasian water milfoil and other nuisance species, especially in areas where other means are not practicable. Chemical applications in early spring have been found to be effective in controlling infestations of Eurasian water milfoil and facilitating the resurgence of growth of native plant species in lakes in Southeastern Wisconsin. Chemical applications should be conducted in accordance with current administrative rules, under the authority of a State permit, and by a licensed applicator working under the supervision of WDNR staff. Records accurately delineating treated areas and the type and amount of herbicide used in each area, should be carefully documented and used as a reference in applying for permits in the following year.

Manual Controls

Manual methods of aquatic plant control, such as raking or hand-pulling, while environmentally sound, are difficult to employ on a large-scale. Although very effective for small-scale application, for example, in and around docks and piers, manual techniques are generally not practical for large-scale plant control methods. Manual means are recommended for use on the Waterford Impoundment to control nearshore plant growths, especially around piers and docks. Within a 30-foot width of the lake shore, manual removal of aquatic plant biomass can be undertaken without a WDNR permit; beyond this frontage, WDNR permits are required for manual harvesting of aquatic plant biomass.

Mechanical Controls

Based on previous experience of the use of mechanical harvester technologies in other lakes in Southeastern Wisconsin, mechanical harvesting of aquatic plants on the Waterford Impoundment could be, in certain areas of the Impoundment, a viable method of controlling plant growth and associated filamentous algae. The most significant impact of mechanical harvesting is the removal of the organic plant biomass, decreasing nutrient inputs to the Impoundment. Potential negative impacts of mechanical harvesting, as outlined by the U.S. Environmental Protection Agency,[14] include: the removal of small fish, limited depths of operation, propagation of plant fragments, and time needed to treat specific areas of a waterbody. Additionally, on a waterbody the size of the Waterford Impoundment, running time from shoreline off-loading locations to areas of treatment may be of such length as to significantly reduce the cost-effectiveness of operating the equipment. However, mechanical

[14]*H. Olem and G. Flock, U.S. Environmental Protection Agency Report No. EPA-440/4-90-006,* The Lake and Reservoir Restoration Guidance Manual, Second Edition*, Washington, D.C., August 1990, p. 146.*

harvesting does offer temporary relief from nuisance aquatic plant growths, especially when conducted in accordance with a management plan designed to optimize benefits and minimize adverse impacts.

In addition to controlling nuisance aquatic plant growth conditions, harvesting has been shown to promote better balance within the in-lake fishery by providing access for larger game fish, such as the largemouth bass, to smaller prey fishes and organisms which can utilize the dense plant beds. Narrow channels harvested to provide navigational access also provide "cruising lanes" for predator fish to migrate into the macrophyte beds to feed on smaller fish.

Shoreline Cleanup Crew
Decomposing, floating vegetation can build up along the shorelines, and, together with terrestrial leaf litter, can limit the use of shoreline areas. Not only is this material unsightly and potentially foul smelling, but it also contributes to the organic and mucky substrates favored by invasive plant species, such as Eurasian water milfoil. Shoreline cleanup is a laborious job that can require substantial amounts of labor and time. Given that a significant number of homeowners are seasonal or elderly, it is not always feasible for the riparian owners to clean their shoreline when needed. To alleviate this problem, the WWMD, in cooperation with shoreline municipalities and riparian owners, could institute a comprehensive program of shoreline cleanup to act in conjunction with harvesting operations to remove as much floating vegetation as possible.

Informational and Educational Programming
In addition to the in-lake rehabilitation methods, an ongoing campaign of community informational programming can support the aquatic plant management program by encouraging the use of shoreland buffer strips, responsible use of household and garden chemicals, and environmentally friendly household and garden practices to minimize the input of nutrients from these riparian areas. In addition, a community information campaign should emphasize the need to clean boats and motors/propellers when removing boats from the Impoundment and upon launching boats into the Impoundment to limit the redistribution of invasive organisms. Plants removed from boats and motors should be retained onboard and/or disposed of by composting at the boat launch or homestead to avoid their being reintroduced into the water. An informational program can also remind riparian residents and others of the habitat and ecological benefits, such as shoreline stabilization, provided by the aquatic flora of the Impoundment, thereby promoting the preservation of a healthy aquatic flora in the Impoundment.

In addition to informational programming, educational programs such as Project WET, Adopt-A-Lake, and other school-based programs can help to build community awareness of the value of lake ecosystems, and the need for vigilance on the part of individual citizens and households within the area tributary to the Impoundment. School groups and other community service organizations also form a cadre of volunteers that can assist in shoreland management programs and in the dissemination and conduct of community informational programs.

The Waterford Impoundment community has consistently supported informational and educational programming within their community. Information is disseminated within the WWMD and beyond through the WWMD Internet website, participation in statewide and regional workshops sponsored by the Wisconsin Lakes Partnership and others, and through targeted meetings and seminars. The WWMD supports educational programming through the conduct of an annual "pontoon classroom" that allows high school students from the Waterford Unified School District to experience lake issues first hand. Additional support for this effort has come from Runzheimer International, with staff support from Racine County, SEWRPC, and the WDNR as well as private consulting corporations based in the Waterford area. Ongoing informational and educational programming is recommended.

Recommended Aquatic Plant Management Measures
It is recommended that continued aquatic macrophyte surveys be conducted at about five-year intervals, depending upon the observed degree of change in the aquatic plant communities. In addition, information on the aquatic plant control program should be recorded and should include descriptions of: major areas of nuisance plant growth; areas chemically treated and/or harvested; and, if harvesting is conducted, species harvested and amounts of plant material removed from the lake, and species and approximate numbers of fish caught in the harvest. It is further recommended that if mechanical harvesting takes place, a daily harvester log, containing this

information, be maintained. This information, in conjunction with the conduct of the recommended aquatic macrophyte surveys, will allow evaluation of the effectiveness of the aquatic plant control program over time and allow adjustments to be made in the program to maximize its benefit.

To enhance the use of the Waterford Impoundment while maintaining the quality and diversity of the biological communities, the following aquatic plant management recommendations are made:

1. It is recommended that the use of chemical herbicides be continued to control nuisance growths of exotic species in shallow water, especially around docks and piers. Maintenance of shoreland areas around docks and piers remains the responsibility of individual property owners.

2. It is recommended that chemical applications, if required, be made by licensed applicators in early spring subject to State permitting requirements to maximize their effectiveness on nonnative plant species, while minimizing impacts on native plant species and acting as a preventative measure to reduce the development of nuisance conditions. Such use should be evaluated annually and the herbicide applied only on an as needed basis. Only herbicides that selectively control milfoil, such as 2,4-D, should be used. Algicides, such as Cutrine Plus, are not recommended because there are few significant, recurring filamentous algal or planktonic algal problems in the Waterford Impoundment and valuable macroscopic algae, such as *Chara* and *Nitella* are killed by this product.

3. The control of rooted vegetation between adjacent piers is recommended to be left to the riparian owners concerned. The WWMD and Village of Waterford may wish to obtain informational brochures regarding shoreline maintenance to inform residents of the control options available.

4. The collection of aquatic plant fragments along shoreline areas is recommended.

5. Mechanical harvesting, in those areas where depth of water, bottom substrate, and running time to shoreline offloading sites make this method of aquatic plant management feasible, is recommended to be considered. Mechanical harvesting can, in the long-term, help to maintain good water quality conditions by removing plant materials which are currently contributing to an accumulation of decomposing vegetation and associated nutrient recycling. The harvesting should be carried out by the WWMD and/or the Village of Waterford utilizing either private contractors or studying the feasibility of purchasing harvesting equipment.

6. If harvesting is employed, surface harvesting is recommended, cutting to a depth necessary to remove the surface canopy of nonnative aquatic plants, such as the Eurasian water milfoil. This should provide a competitive advantage to the low-growing native plants present in the Impoundment. By not disturbing the low-growing species which generally grow within one to two feet of the lake bottom and in relatively low densities, leaving the root stocks and stems of all cut plants in place, the resuspension of sediments in the Waterford Impoundment will be minimized, and some degree of cover will continue to be provided for panfish populations which support the bass population in the Impoundment. Further, cutting should not be broad-based, but focused on boating channels and selected navigation areas.

7. It is further recommended that the WWMD and the Village of Waterford conduct a public informational program on the types of aquatic plants in the Waterford Impoundment; on the value of and the impacts of these plants on water quality, fish, and on wildlife; and on alternative methods for controlling existing nuisance plants including the positive and negative aspects of each method. This program can be incorporated into the comprehensive informational and educational programs that also would include information on related topics, such as water quality, recreational use, fisheries, and onsite sewage disposal systems.

The recommended aquatic plant control areas are shown on Maps 2, 3, and 4. The control measures in each area are designed to optimize desired recreational opportunities and to protect the aquatic resources.

The recommended aquatic plant management plan represents a continuation of the current aquatic plant management program conducted by the WWMD. Cost-share funding may be available for the acquisition of aquatic plant harvesting equipment, should the WWMD desire to acquire such equipment in the future. Acquisition of such equipment would be required should the area to be managed continue to increase. Cost share funding could be accessed under the Chapter NR 7 Recreational Boating Facilities Grant Program administered by the Wisconsin Waterways Commission. Annual operation and maintenance costs of about $20,000 are estimated to be incurred by the WWMD in the conduct of this program.

OTHER LAKE MANAGEMENT MEASURES

Recreational Use Management

Public Recreational Boating Access

With respect to boating ordinances applicable to the Waterford Impoundment, it is recommended that current levels of enforcement be maintained. In addition, recreational boating access users should be made aware of the presence of exotic invasive species within the Waterford Impoundment, including zebra mussels and Eurasian water milfoil. Appropriate signage should be placed at the public recreational boating sites, and supplemental materials on the control of invasive species should be made available to the public. These materials could be provided to riparian householders by means of mail drops or distribution of informational materials at public buildings, such as municipal buildings and the public library, and to nonriparian users by means of informational materials provided at the entrance to all municipal public recreational boating access sites. In addition, it is recommended that the various municipalities make disposal bins available at their public recreational boating access sites for disposal of plant materials and other refuse removed from watercraft using the public recreational boating access sites.[15]

Recreational Boating Management

The control of recreational boating traffic on the Waterford Impoundment is a significant concern and overlaps issues of public safety, aesthetics and environmental protection. Citizens' concerns associated with recreational boating on the Waterford Impoundment include overcrowding of boat traffic especially in riverine portions of the Impoundment where constriction of the waterway produces significant safety issues. Such overcrowding also poses problems of an environmental nature. Wakes and surface water turbulence created by large power boats and personal water craft, especially operating near shore, can cause damage to ecologically sensitive shoreline areas. In addition, propeller-driven watercraft, when operating in areas where Eurasian water milfoil is abundant, can fragment the surface-floating portions of the plant leading to the spread of this nuisance species as the fragments float to new areas where they eventually take root and establish colonies. The WDNR regulates the operation of power boats and personal watercraft in regards to proximity to shoreline, other boats, and swimming areas.

Identification, through the use of buoys, of swimming areas and slow no-wake zones is a common practice on many Wisconsin waterbodies, including the Waterford Impoundment. Two general types of buoyage exist: *regulatory buoys*, such as those used to demarcate slow-no-wake or exclusionary zones; and *informational buoys*, such as those used to enhance public awareness. Regulatory buoys include buoys used to demarcate restricted areas, prohibit boating or types of boating activity in specific areas, and control the movement of watercraft. Regulatory buoys are enforceable, informational buoys are not.

Buoyage has the advantage of being visible to recreational boaters, and affected areas can be clearly demarcated. Local authorities have jurisdiction over the waters involved, and may place buoys subject to WDNR permitting. Buoys placed in waters of the State of Wisconsin are subject to the requirements set forth in Chapter 30, *Wisconsin Statutes*, and require a WDNR permit prior to placement.

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[15]*The U.S.-Canadian International Joint Commission regularly provides informational materials on this and related subjects.*

In accordance with concerns expressed by the citizenry and in the interests of promoting recreational boating use on the Waterford Impoundment that is consistent with public safety, maintaining the aesthetic integrity of the lake, and encouraging environmentally sound management, the following measures are recommended:

- Minimize boating traffic in areas of the Impoundment where Eurasian water milfoil is prevalent in order to prevent its further spread within the Impoundment.

- Utilize informational buoys to demarcate swimming areas, ecologically valuable areas, and other areas where regulation is deemed necessary. Appropriate signage at the public recreational boating access sites to supplement the buoyage, and inclusion of information on Eurasian water milfoil and zebra mussels, consistent with informational programming measures is also recommended.

- Enforce slow-no-wake ordinances and other ordinances that pertain to use of power boats and personal watercraft on the Impoundment to protect shorelands and enhance public safety.

- Improve demarcation of navigational channels, especially in Conservancy Bay, Buena Lake, and the embayments tributary to the Impoundment along the eastern shoreline.

- Maintain navigational access to the main body of the Impoundment by selective removal of sediment, especially in Conservancy Bay, Buena Lake, and the embayments tributary to the Impoundment along the eastern shoreline, including Elm Island Bay and Island View Bay.

Limited dredging in specific targeted areas, and improved demarcation of navigable channels, especially in Conservancy Bay and in the constricted riverine portions of the Impoundment where constrictions in the riverway pose navigational safety hazards to boat traffic, especially during peak recreational water use periods, is recommended. In particular, removal or relocation of underwater obstructions that pose potential safety hazards in narrow riverine areas as well as the consolidation of emergent vegetation to enhance the cones of visibility for on-water users navigating through constricted areas, such as the area locally known as the "Bend-in-the-River," is recommended. In this regard, widening and maintenance of the navigational channel is recommended to improve visibility at this critical junction within the Impoundment. Numerous accidents and near accidents have been reported by the Town of Waterford Police Department in this area, and frequent damage to motors and stern drives has been noted by residents and local marine business owners, as a result of the narrowness of the riverine portion of the Impoundment and the presence of several large boulders which rise to near surface elevations. The WDNR staff note that these boulders provide valuable fish habitat; hence, proposals to remove these features have not been approved. However, recently, the WWMD has suggested relocating these boulders closer to the shoreline or a widened waterway, which would retain the habitat benefits of these features, while complementing the District's proposals to widen the navigational channel and restore a more diverse shoreland wetland habitat in this area. This proposal is recommended as it balances both ecosystem protection requirements and public safety requirements in a proactive manner, consistent with the goals of both this lake management plan and the community as expressed in the riparian owner survey conducted by the WWMD.

Subject to WDNR permitting requirements, maintenance of navigation access to other areas of the Impoundment through selective deepening of recreational boating access lanes also is recommended. Priority in this regard should be given to ensuring continued access to the Impoundment from the WDNR access site in the vicinity of Bridge Drive, and maintaining navigation traffic lanes within the Impoundment. In addition, navigational access to private properties within Buena Lake and the embayments locally known as Elm Island Bay and Island View Bay should be maintained, subject to WDNR permitting requirements. These measures to improve navigation within the Waterford Impoundment are additional benefits to be achieved from the hydrological management measures recommended above.[16]

[16]*See SEWRPC Memorandum Report No. 102,* op. cit.

Public Informational and Educational Programs
It is recommended that the WWMD assumes the lead in the development of a public informational and educational program. Participation by the Village and Town of Waterford should be encouraged. This program should deal with various lake management-related topics, including onsite sewage disposal system management, water quality management, land management, groundwater protection, aquatic plant management, fishery management, invasive species, and recreational use. Educational and informational brochures and pamphlets, of interest to homeowners and supportive of the recreational use and shoreland zoning regulations, are available from the WDNR and UWEX. These cover topics such as beneficial lawn care practices and household chemical use. Such brochures should be provided to homeowners through local media, direct distribution or targeted library and civic center displays. Such distribution can also be integrated into ongoing, larger-scale activities, such as lakeside litter collections, which can reinforce anti-littering campaigns, recycling drives, and similar environmental protection activities.

Given the extent of public interest in the Waterford Impoundment, it is recommended that the WWMD and the local municipalities consider offering regular informational programs on the Impoundment and issues related thereto. Such programming can provide a mechanism to raise awareness of the Impoundment issues, and provide a focal point from which to distribute the informational materials referred to above.

The WWMD and the municipalities are also encouraged to take an active role in encouraging the local school districts to adopt and utilize lake-related educational programs, such as Adopt-A-Lake and Project WET, as means of more closely linking students to the lake environment.

The cost for conducting this informational and educational program is estimated to be $1,200 per year.

Institutional Development and Attachment of Lands
In the case of the Waterford Impoundment, general oversight of impoundment management activities currently is provided by the WWMD with the advisory input from the Village and Town of Waterford. The WWMD is committed to building and maintaining close working partnerships with other organizations, such as the WDNR, Racine County, the Fox River Committee Against Underwater Sedimentation and Erosion (Fox River CAUSE), U.S. Army Corps of Engineers, the Southeastern Wisconsin Fox River Commission (FRC), the Southeast Wisconsin Fox River Basin Partnership, the Racine County Lakes Association, and other agencies, boards, and commissions to promote the betterment of the Waterford Impoundment.

In order to better manage the Impoundment, the WWMD requested that Commission staff consider the attachment of lands located immediately upstream of the "Iron Bridge" on Bridge Drive at the northern end of the Impoundment, within the area directly tributary to the Waterford Impoundment and lying along the streambanks of the Fox River. In addition, consideration was given to the attachment of lands having preferential lake access, such as subdivisions and areas with deeded lake access. Since the lands directly tributary to the Waterford Impoundment have an immediate and direct impact on lake water quality and ecosystem health and integrity, inclusion of such lands, to the extent possible, would provide the District with the ability to better protect and/or rehabilitate the water quality condition of the Impoundment. Consequently, the attachment of such lands is recommended.

The boundary review was predicated upon consideration of the following criteria:

1. Consistency with Chapter 33, *Wisconsin Statutes*, requirements that properties included within a public inland lake protection and rehabilitation district be benefited by inclusion in the district;

2. Consistency with UWEX guidance set forth in *People of the Lakes: A Guide for Wisconsin Lake Organizations—Lake Associations & Lake Districts,* Eleventh Edition, that recommends that the district, at a minimum, include the entire lakeshore, all riparian property, areas directly affecting the lake and/or which are included in planned service areas, and entire parcels; and

3. Consistency with applicable regional and local plans including the previously referenced lake management plan, county development plan, and other applicable plans.

Implementing these guidelines would attach the properties located along Bridge Drive and Fox River Road within the northeast one-quarter of U.S. Public Land Survey Section 10, and the southeast one-quarter of U.S. Public Land Survey Section 3, Township 4 North, Range 19 East, which are within the current boundaries of the drainage area directly tributary to the Waterford Impoundment, as well as those subdivisions having direct or deeded lake access. This would provide a more substantial operating base for the WWMD and continue to be consistent with applicable guidance set forth in Chapter 33 of the *Wisconsin Statutes*, which suggests that public inland lake protection and rehabilitation districts include those lands which will benefit the lake.

Lands may be attached to an existing lake management district pursuant to requirements set forth in Section 33.33(2), *Wisconsin Statutes*. Attachment may be initiated either by petition of the affected landowners within the district, or by motion of the district commissioners to attach lands to the district. In both cases, the district commissioners must make a finding that the lands to be attached are benefited by inclusion within the district. This finding can be appealed to the circuit court for judicial review. While bound by the specific process and requirements of Section 33.33(2) the district commissioners have full discretion regarding the granting of a petition for attachment. If attaching lands to a District by motion of the board of commissioners, the governmental unit initially creating the District must hold a hearing on the attachment pursuant to Section 33.26 insofar as it may be applicable. In this latter case, Racine County would have to consider the request for attachment of the designated lands to the WWMD. In any event, attachment of lands to a district should not create a "hole' within the district.

PLAN IMPLEMENTATION AND COSTS

The actions recommended in this plan largely represent an extension of ongoing actions being carried out by the WWMD and the Village and Town of Waterford, in cooperation with neighboring municipalities and county and State agencies. The recommended plan introduces few new elements, although some of the plan recommendations represent refinements of current programs. This is particularly true in the case of the fisheries and aquatic plant management programs, where the field surveys recommended in this plan will permit more efficient management of these resources.

Generally, aquatic plant and fisheries management practices and public awareness campaigns currently implemented by the WWMD and local municipalities, are recommended to continue with refinements as proposed herein. Some aspects of these programs lend themselves to citizen involvement through participation in the WDNR Self-Help Monitoring Program, and identification with environmentally sound owner-based land management activities. It is recommended that the WWMD, in cooperation with the local municipalities, assume the lead in the promotion of such citizen actions, with a view toward building community commitment and involvement. Assistance is generally available from agencies such as the WDNR, the County UWEX office, and SEWRPC.

The suggested lead agency or agencies for initiating program-related activities, by plan element, are set forth in Table 2, and the estimated costs of these elements, linked to possible funding sources where such are available, are summarized in Table 3. In general, it is recommended that the WWMD continue to provide a coordinating role for community-based lake management actions, in cooperation with the appropriate local government units.

The Waterford Impoundment is a valuable natural resource in the Southeastern Wisconsin Region. Increases in population, urbanization, income, leisure time, and individual mobility forecast for the Region may be expected to result in additional pressure for development in the area tributary to the Impoundment and for water-based recreation on the Impoundment. Adoption and administration of an effective lake management program for the Waterford Impoundment, based upon the recommendations set forth herein, will provide the water quality protection needed to maintain conditions in the Waterford Impoundment suitable for recreational use and for fish and other aquatic life.

Table 3

ESTIMATED COSTS OF RECOMMENDED LAKE MANAGEMENT MEASURES FOR WATERFORD IMPOUNDMENT

Plan Element	Management Measure	Estimated Cost 2000-2020[a]		Potential Funding Sources[b]
		Capital	Annual Operation and Maintenance	
Land Use	Observe regional and county land use plan guidelines	- -	- -	County, Town, Village
	Density management in the shoreland zone	- -	- -	
	Stormwater management plan development	- -	- -	
	Protection of environmentally significant lands and environmental corridors	- -	- -	WDNR Lake Protection Grant and Stewardship Grant Programs, WWMD
Pollution Abatement	Implement regional and county land and water resource management plans	- -[c]	- -[c]	County, USDA EQIP, WDNR/WDATCP Runoff Management Program
	Promote sound rural land management practices	- -[c]	- -[c]	County, WDNR/WDATCP Runoff Management Program
	Promote urban good housekeeping and yard care practices	- -[c]	- -c	
	Use integrated nutrient and pest management at Rivermore Country Club and Edgewood Golf Course	- -[c]	- -c	
	Implement various urban nonpoint controls, including stormwater management	- -[c]	- -c	
	Develop and enforce construction site erosion controls and storm water management ordinances	- -[c]	$250-$500/acre[c]	Municipalities, county, private firms, individuals
	Public sanitary sewer system management	- -	- -	County, Towns, City, Village, local sanitary districts
	Onsite sewage system management	- -[c]	$100-$200[c]	County, Towns, City, Village, local sanitary districts
Water Quality	Continue participation in WDNR Self-Help Monitoring Program; consider participation in WDNR Expanded Self-help program, USGS Water Quality Monitoring Program or University of Wisconsin-Stevens Point Environmental Task Force TSI monitoring program	- -	$16,000[d]	WWMD, USGS, WDNR
Water Quantity	Periodically inspect Waterford Dam	- -	- -	WDNR
	Install lake stage gages and Monitor lake levels	$6,000	- -	WWMD, USGS
Aquatic Biota	Protect fish habitat	- -	- -	WDNR, WWMD, private sports organizations, individuals
	Maintain shoreline and littoral zone fish habitat	- -	- -	County, municipalities, private sports organizations, WWMD, individuals, WDNR
	Trout stream restoration	- -	- -	WDNR, WWMD, FRC, private sports organizations
	Continue stocking of selected game fish	- -	- -	WDNR, private sports organizations
	Enforce size and catch limit regulations	- -	- -	WDNR
	Habitat restoration in constricted riverine portion of Impoundment	- -	- -	WDNR, WWMD

Table 3 (continued)

Plan Element	Management Measure	Estimated Cost 2000-2020[a]		Potential Funding Sources[b]
		Capital	Annual Operation and Maintenance	
Aquatic Biota (continued)	Conduct periodic reconnaissance surveys of aquatic plant communities	- -	$1,500[e]	WDNR Lake Management Planning Grant Program, WWMD
	Update aquatic plant management plan every three to five years	- -	$1,500[e]	WDNR Lake Management Planning Grant Program, WWMD
	Provide and conduct programming on aquatic plants and various management measures	- -	- -	WDNR Lake Management Planning Grant Program, WWMD
	Use (limited) aquatic herbicides for control of nuisance plants such as Eurasian water milfoil and purple and yellow loosestrife	- -	$1,000/acre[g]	WWMD, individuals
	Conduct mechanical harvesting of aquatic macrophytes to provide navigational channels and fish lanes, control nuisance plants and to promote growth of native plants if warranted	$303,000[f]	$16,000	WDNR Lake Management Planning Grant Program, WWMD
	Manually harvest aquatic plants from around docks and piers where feasible	$100	$100	WWMD, individuals
	Collect floating plant fragments from shoreland areas to minimize rooting of Eurasian water milfoil	- -	- -	WWMD, individuals
	Continue to monitor invasive species populations; continue current control of purple and yellow loosestrife	- -	$1,200	WWMD, WDNR
Water Use	Enforce regulations governing the operation of watercraft; improve signage and materials at public recreational access site to aid in the identification and control of exotic species	$500	$100	Town, Village, WWMD, WDNR
	Surface use zoning, sediment removal and relocation of underwater boulders in constricted riverine portion	- -	- -	WDNR, WWMD, FRC
	Maintain navigability	- -	- -	WDNR, WWMD, FRC
	Improve demarcation and removal of sediment in Conservancy Bay	- -	- -	U.S. Army Corps of Engineers, WDNR,
Ancillary Management Measures	Public informational and educational programming: seminars, programs, Project WET, Adopt-A-Lake	- -	$1,200	WWMD, UWEX/ WDNR/WAL Lakes Partnership, school districts
	Attachment of lands at northern extent of direct tributary area to WWMD	- -	- -	WWMD, Racine County
Total	- -	$309,600	$37,600	- -

Table 3 Footnotes

[a]*All costs expressed in January 2002 dollars.*

[b]*Unless otherwise specified, USDA is the U.S. Department of Agriculture, USGS is the U.S. Geological Survey, WDNR is the Wisconsin Department of Natural Resources, WDATCP is the Wisconsin Department of Agriculture, Trade and Consumer Protection, County is Racine County, Village is the Village of Waterford, Town is the Town of Waterford, UWEX is the University of Wisconsin-Extension, WAL is the Wisconsin Association of Lakes, WWMD is the Waterford Waterways Management District, and WSP is the Water Safety Patrol.*

[c]*Costs vary with the level of activity and effort during any given year.*

[d]*The WDNR Self-Help Monitoring Program involves no cost but does entail a time commitment from the volunteer; monitoring by the USGS can be cost-shared between the Federal agency and local cooperators.*

[e]*Cost-share assistance may be available for lake management planning studies under the NR 190 Lake Management Planning Grant Program.*

[f]*Costs are based on the assumption that harvester and ancillary equipment may eventually need replacement; cost-share assistance for harvester purchase may be available from the Wisconsin Waterways Commission Recreational Boating Facilities Grant Program. Planning costs assume that plan revisions will be completed at a cost of $6,000 every four years.*

[g]*Cost-share assistance may be available from the Wisconsin Waterways Commission Recreational Boating Facilities Grant Program.*

Source: SEWRPC.

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APPENDICES

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Appendix A

NONPOINT SOURCE POLLUTION CONTROL MEASURES

Nonpoint, or diffuse, sources of water pollution include urban sources such as runoff from residential, commercial, industrial, transportation, and recreational land uses; construction activities; and onsite sewage disposal systems and rural sources such as runoff from cropland, pasture, and woodland, atmospheric contributions, and livestock wastes. These sources of pollutants discharge to surface waters by direct overland drainage, by drainage through natural channels, by drainage through engineered stormwater drainage systems, and by deep percolation into the ground and subsequent return flow to the surface waters.

A summary of the methods and estimated effectiveness of nonpoint source water pollution control measures is set forth in Table A-1. These measures have been grouped for planning purposes into two categories: basic practices and additional. Application of the basic practices will have a variable effectiveness in terms of control level of pollution control depending upon the subwatershed area characteristics and the pollutant considered. The additional category of nonpoint source control measures has been subdivided into four subcategories based upon the relative effectiveness and costs of the measures. The first subcategory of practices can be expected to generally result in about a 25 percent reduction in pollutant runoff. The second and third subcategory of practices, when applied in combination with the minimum and additional practices, can be expected to generally result in up to a 75 percent reduction in pollutant runoff, respectively. The fourth subcategory would consist of all of the preceding practices, plus those additional practices that would be required to achieve a reduction in ultimate runoff of more than 75 percent.

Table A-1 sets forth the diffuse source control measures applicable to general land uses and diffuse source activities, along with the estimated maximum level of pollution reduction which may be expected upon implementation of the applicable measures. The table also includes information pertaining to the costs of developing the alternatives set forth in this appendix.[1] These various individual nonpoint source control practices are summarized by group in Table A-2.

[1]*Costs are presented in more detail in the following SEWRPC Technical Reports: No. 18,* State of the Art of Water Pollution Control in Southeastern Wisconsin*, Volume Three,* Urban Storm Water Runoff*, July 1977, and Volume Four,* Rural Storm Water Runoff*, December 1976; and No. 31,* Costs of Urban Nonpoint Source Water Pollution Control Measures*, June 1991.*

Table A-1

GENERALIZED SUMMARY OF METHODS AND EFFECTIVENESS OF NONPOINT SOURCE WATER POLLUTION ABATEMENT

Applicable Land Use	Control Measures[a]	Summary Description	Approximate Percent Reduction of Released Pollutants[b]	Assumptions for Costing Purposes
Urban	Litter and pet waste control ordinance	Prevent the accumulation of litter and pet wastes on streets and residential, commercial, industrial, and recreational areas	2 to 5	Ordinance administration and enforcement costs are expected to be funded by violation penalties and related revenues
	Improved timing and efficiency of street sweeping, leaf collection and disposal, and catch basin cleaning	Improve the scheduling of these public works activities, modify work habits of personnel, and select equipment to maximize the effectiveness of these existing pollution control measures	2 to 5	No significant increase in current expenditures is expected
	Management of onsite sewage treatment systems	Regulate septic system installation, monitoring, location, and performance; replace failing systems with new septic systems or alternative treatment facilities; develop alternatives to septic systems; eliminate direct connections to drain tiles or ditches; dispose of septage at sewage treatment facility	10 to 30	Replace one-half of estimated existing failing septic systems with properly located and installed systems and replace one-half with alternative systems, such as mound systems or holding tanks; all existing and proposed onsite sewage treatment systems are assumed to be properly maintained; assume system life of 25 years. The estimated cost of a septic tank system is $5,000 to $6,000 and the cost of an alternative system is $10,000. The annual maintenance cost of a disposal system is $250. An in-ground pressure system is estimated to cost $6,000 to $10,000 with an annual operation and maintenance cost of $250. A holding tank would cost $5,500 to $6,500, with an annual operation and maintenance cost of $1,800
	Increased street sweeping	On the average, sweep all streets in urban areas an equivalent of once or twice a week with vacuum street sweepers; require parking restrictions to permit access to curb areas; sweep all streets at least eight months per year; sweep commercial and industrial areas with greater frequency than residential areas	30 to 50	Estimate curb-miles based on land use, estimated street acreage, and Commission transportation planning standards; assume one street sweeper can sweep 2,000 curb-miles per year; assume sweeper life of 10 years; assume residential areas swept once weekly, commercial and industrial areas swept twice weekly. The cost of a vacuum street sweeper is approximately $120,000. The cost of the operation and maintenance of a sweeper is about $25 per curb-mile swept
	Increased leaf and clippings collection and disposal	Increase the frequency and efficiency of leaf collection procedures in fall; use vacuum cleaners to collect leaves; implement ordinances for leaves, clippings. and other organic debris to be mulched, composted, or bagged for pickup	2 to 5	Assume one equivalent mature tree per residence, plus five trees per acre in recreational areas; 75 pounds of leaves per tree; 20 percent of leaves in urban areas not currently disposed of properly. The cost of the collection of leaves in a vacuum sweeper and disposal is estimated at $180 to $200 per ton of leaves
	Increased catch basin cleaning	Increase frequency and efficiency of catch basin cleaning; clean at least twice per year using vacuum cleaners; catch basin installation in new urban development not recommended as a cost-effective practice for water quality improvement	2 to 5	Determine curb-miles for street sweeping; vary percent of urban areas served by catch basins by watershed from Commission inventory data; assume density of 10 catch basins per curb-mile; clean each basin twice annually by vacuum cleaner. The cost of cleaning a catch basin is approximately $10
	Reduced use of deicing salt	Reduce use of deicing salt on streets; salt only intersections and problem areas; prevent excessive use of sand and other abrasives	Negligible for pollutants addressed in this plan, but helpful for reducing chlorides and associated damage to vegetation	Increased costs, such as for slower transportation movement, are expected to be offset by benefits, such as reduced automobile corrosion and damage to vegetation

Table A-1 (continued)

Applicable Land Use	Control Measures[a]	Summary Description	Approximate Percent Reduction of Released Pollutants[b]	Assumptions for Costing Purposes
Urban (continued)	Improved street maintenance and refuse collection and disposal	Increase street maintenance and repairs; increase provision of trash receptacles in public areas; improve trash collection schedules; increase cleanup of parks and commercial centers	2 to 5	Increase current expenditures by approximately 15 percent
	Parking lot stormwater temporary storage and treatment measures	Construct gravel-filled trenches, sediment basins, or similar measures to store temporarily the runoff from parking lots, rooftops, and other large impervious areas; if treatment is necessary, use a physical-chemical treatment measure, such as screens, dissolved air flotation, or a swirl concentrator	5 to 10	Design gravel-filled trenches for 24-hour, five-year recurrence interval storm; apply to off-street parking acreages. For treatment, assume four-hour detention time. The capital cost of stormwater detention and treatment facilities is estimated at $40,000 to $80,000 per acre of parking lot area, with an annual operation and maintenance cost of about $200 per acre
	Onsite storage—residential	Remove connections to sewer systems; construct onsite stormwater storage measures for subdivisions	5 to 10	Remove roof drains and other connections from sewer system wherever needed; use lawn aeration, if applicable; apply dutch drain storage facilities to 15 percent of residences. The capital cost would approximate $500 per house, with an annual operation and maintenance cost of about $25
	Stormwater Infiltration—urban	Construct gravel-filled trenches for areas of less than 10 acres or basins to collect and store temporarily stormwater runoff to reduce volume, provide groundwater recharge and augment low stream flows	45 to 90	Design gravel-filled trenches or basins to store the first 0.5 inch of runoff; provide at least a 25-foot grass buffer strip to reduce sediment loadings. The capital cost of stormwater infiltration is estimated at $12,000 for a six-foot-deep, 10-foot-wide trench, and at $70,000 for a one-acre basin, with an annual maintenance cost of about $10 to $350 for the trench and about $2,500 for the basin
	Stormwater storage—urban	Store stormwater runoff from urban land in surface storage basins or, where necessary, subsurface storage basins	10 to 35	Design all storage facilities for a 1.5-inch runoff event, which corresponds approximately to a five-year recurrence interval event, with a storm event being defined as a period of precipitation with a minimum antecedent and subsequent dry period of from 12 to 24 hours; apply subsurface storage tanks to intensively developed existing urban areas where suitable open land for surface storage is unavailable; design surface storage basins for proposed new urban land, existing urban land not storm sewered, and existing urban land where adequate open space is available at the storm sewer discharge site. The capital cost for stormwater storage would range from $35,000 to $110,000 per acre of basin, with an annual operation and maintenance cost of about $40 to $60 per acre
	Stormwater treatment	Provide physical-chemical treatment which includes screens, microstrainers, dissolved air flotation, swirl concentrator, or high-rate filtration, and/or disinfection, which may include chlorination, high-rate disinfection, or ozonation to stormwater following storage	10 to 50	To be applied only in combination with stormwater storage facilities above; general cost estimates for microstrainer treatment and ozonation were used; some costs were applied to existing urban land and proposed new urban development. Stormwater treatment has an estimated capital cost of from $900 to $7,000 per acre of tributary drainage area, with an average annual operation and maintenance cost of about $35 to $100 per acre

Table A-1 (continued)

Applicable Land Use	Control Measures[a]	Summary Description	Approximate Percent Reduction of Released Pollutants[b]	Assumptions for Costing Purposes
Rural	Conservation practices	Includes such practices as strip cropping, contour plowing, crop rotation, pasture management, critical area protection, grading and terracing, grassed waterways, diversions, woodlot management, fertilization and pesticide management, and chisel tillage	Up to 50	Cost for Natural Resources Conservation Service (NRCS) recommended practices are applied to agricultural and related rural land; the distribution and extent of the various practices were determined from an examination of 56 existing farm plan designs within the Region. The capital cost of conservation practices ranges from $3,000 to $5,000 per acre of rural land, with an average annual operation and maintenance cost of from $5.00 to $10 per rural acre
	Animal waste control system	Construct streambank fencing and crossovers to prevent access of all livestock to waterways; construct a runoff control system or a manure storage facility, as needed, for major livestock operations; prevent improper applications of manure on frozen ground, near surface drainageways, and on steep slopes; incorporate manure into soil	50 to 75	Cost estimated per animal unit; animal waste storage (liquid and slurry tank for costing purposes) facilities are recommended for all major animal operations within 500 feet of surface water and located in areas identified as having relatively high potential for severe pollution problems. Runoff control systems recommended for all other major animal operations. It is recognized that dry manure stacking facilities are significantly less expensive than liquid and slurry storage tanks and may be adequate waste storage systems in many instances. The estimated capital cost and average operation and maintenance cost of a runoff control system is $100 per animal unit and $25 per animal unit, respectively. The capital cost of a liquid and slurry storage facility is about $1,000 per animal unit, with an annual operation and maintenance cost of about $75 per unit. An animal unit is the weight equivalent of a 1,000-pound cow
	Base-of-slope detention storage	Store runoff from agricultural land to allow solids to settle out and reduce peak runoff rates. Berms could be constructed parallel to streams	50 to 75	Construct a low earthen berm at the base of agricultural fields, along the edge of a floodplain, wetland, or other sensitive area, design for 24-hour, 10-year recurrence interval storm; berm height about four feet. Apply where needed in addition to basic conservation practices; repair berm every 10 years and remove sediment and spread on land. The estimated capital cost of base-of-slope detention storage would be $500 per tributary acre, with an annual operation and maintenance cost of $25 per acre
	Bench terraces	Construct bench terraces, thereby reducing the need for many other conservation practices on sloping agricultural land	75 to 90	Apply to all appropriate agricultural lands for a maximum level of pollution control. Utilization of this practice would exclude installation of many basic conservation practices and base-of-slope detention storage. The capital cost of bench terraces is estimated at $1,500 per acre, with an annual operation and maintenance cost of $100 per acre
Urban and Rural	Public education programs	Conduct regional and county-level public education programs to inform the public and provide technical information on the need for proper land management practices on private land, the recommendations for management programs, and the effects of implemented measures; develop local awareness programs for citizens and public works officials; develop local contract and education efforts	Indeterminate	For first 10 years, includes cost of one person, materials, and support for each 25,000 population. Thereafter, the same cost can be applied for every 50,000 population. The cost of one person, materials, and support is estimated at $55,000 per year

Table A-1 (continued)

Applicable Land Use	Control Measures[a]	Summary Description	Approximate Percent Reduction of Released Pollutants[b]	Assumptions for Costing Purposes
Urban and Rural (continued)	Construction erosion control practices	Construct temporary sediment basins; install straw bale dikes; use fiber mats, mulching, and seeding; install slope drains to stabilize steep slopes; construct temporary diversion swales or berms upslope from the project	20 to 40	Assume acreage under construction is the average annual incremental increase in urban acreage; apply costs for a typical erosion control program for a construction site. The estimated capital cost and operation and maintenance cost for construction erosion control is $250 to $5,500 and $250 to $1,500 per acre under construction, respectively
	Materials storage and runoff control facilities	Enclose industrial storage sites with diversion; divert runoff to acceptable outlet or storage facility; enclose salt piles and other large storage sites in crib and dome structures	5 to 10	Assume 40 percent of industrial areas are used for storage and to be enclosed by diversions; assume existing salt storage piles enclosed by cribs and dome structures. The estimated capital cost of industrial runoff control is $2,500 per acre of industrial land. Material storage control costs are estimated at $75 per ton of material
	Stream protection measures	Provide vegetative buffer zones along streams to filter direct pollutant runoff to the stream; construct streambank protection measures, such as rock riprap, brush mats, tree revetment, jacks, and jetted willow poles, where needed	5 to 10	Apply a 50-foot-wide vegetative buffer zone on each side of 15 percent of the stream length; apply streambank protection measures to 5 percent of the stream length. Vegetative buffer zones are estimated to cost $21,200 per mile of stream and streambank protection measures cost about $37,000 per stream mile
	Pesticide and fertilizer application restrictions	Match application rate to need; eliminate excessive applications and applications near or into surface water drainageways	0 to 3	Cost included in public education program
	Critical area protection	Emphasize control of areas bordering lakes and streams; correct obvious erosion and other pollution source problems	Indeterminate	Indeterminate

[a] *Not all control measures are required for each subwatershed. The characteristics of the watershed, the estimated required level of pollution reduction needed to meet the applicable water quality standards, and other factors will influence the selection and estimation of costs of specific practices for any one subwatershed. Although the control measures costed represent the recommended practices developed at the regional level on the basis of the best available information, the local implementation process should provide more detailed data and identify more efficient and effective sets of practices to apply to local conditions.*

[b] *The approximate effectiveness refers to the estimated amount of pollution produced by the contributing category (urban or rural) that could be expected to be reduced by the implementation of the practice. The effectiveness rates would vary greatly depending on the characteristics of the watershed and individual diffuse sources. It should be further noted that practices can have only a "sequential" effect, since the percent pollution reduction of a second practice can only be applied against the residual pollutant load which is not controlled by the first practice. For example. two practices of 50 percent effectiveness in series would achieve a theoretical total effectiveness of only 75 percent control of the initial load. Further, the general levels of effectiveness reported in the table are not necessarily the same for all pollutants associated with each source. Some pollutants are transported by dissolving in water and others by attaching to solids in the water; the methods summarized here reflect typical pollutant removal levels.*

[c] *For highly urbanized areas which require retrofitting of facilities into developed areas, the costs can range from $400,000 to $1,000,000 per acre of storage.*

Source: SEWRPC.

Of the sets of practices recommended for various levels of diffuse source pollution control presented in Table A-2, not all practices are needed, applicable, or cost-effective for all watersheds, due to variations in pollutant loadings and land use and natural conditions among the watersheds. Therefore, it is recommended that the practices indicated as needed for nonpoint source pollutant control be refined by local level nonpoint source control practices planning, which would be analogous to sewerage facilities planning for point source pollution abatement. A locally prepared plan for nonpoint abatement measures should be better able to blend knowledge of current problems and practices with a quickly evolving technology to achieve a suitable, site-specific approach to pollution abatement.

Table A-2

ALTERNATIVE GROUPS OF DIFFUSE SOURCE WATER POLLUTION CONTROL MEASURES PROPOSED FOR STREAMS AND LAKE WATER QUALITY MANAGEMENT

Pollution Control Category	Level of Pollution[a] Control	Practices to Control Diffuse Source Pollution from Urban Areas[b]	Practices to Control Diffuse Source Pollution from Rural Areas[a]
Basic Practices	Variable	Construction erosion control; onsite sewage disposal system management; streambank erosion control	Streambank erosion control
	25 percent	Public education programs; litter and pet waste control; restricted use of fertilizers and pesticides; construction erosion control; critical areas protection; improved timing and efficiency of street sweeping, leaf collection, and catch basin cleaning; material storage facilities and runoff control	Public education programs; fertilizer and pesticide management; critical area protection; crop residue management; chisel tillage; pasture management; contour plowing; livestock waste control
Additional Diffuse Source Control Practices[c]	50 percent	Above, plus: Increased street sweeping; improved street maintenance and refuse collection and disposal; increased catch basin cleaning; stream protection; increased leaf and vegetation debris collection and disposal; stormwater storage; stormwater infiltration	Above, plus: crop rotation; contour strip-cropping; grass waterways; diversions; wind erosion controls; terraces; stream protection
	75 percent	Above, plus: An additional increase in street sweeping, stormwater storage and infiltration; additional parking lot stormwater runoff storage and treatment	Above, plus: Base-of-slope detention storage
	More than 75 percent	Above, plus: Urban stormwater treatment with physical-chemical and/or disinfection treatment measures	Bench terraces[b]

[a]*Groups of practices are presented here for general analysis purposes only. Not all practices are applicable to, or recommended for, all lake and stream tributary watersheds. For costing purposes, construction erosion control practices, public education programs, and material storage facilities and runoff controls are considered urban control measures and stream protection is considered a rural control measure.*

[b]*The provision of bench terraces would exclude most basic conservation practices and base-of-slope detention storage facilities.*

[c]*In addition to diffuse source control measures, lake rehabilitation techniques may be required to satisfy lake water quality standards.*

Source: SEWRPC.

Appendix B

PRIORITY SUBBASINS FOR APPLICATION OF NONPOINT SOURCE POLLUTION CONTROLS WITHIN THE DRAINAGE AREA DIRECTLY TRIBUTARY TO THE WATERFORD IMPOUNDMENT

POLLUTION LOADINGS AND SOURCES

As set forth in Chapter IV of Volume One of this plan, pollutant loads are generated by various natural processes and human activities that take place in the area tributary to a lake.[1] These loads are transported to the lake through the atmosphere, across the land surface, and by way of inflowing streams. Pollutants transported by the atmosphere are deposited onto the surface of the lake as dry fallout and direct precipitation. Pollutants transported across the land surface enter the lake as direct runoff and, indirectly, as groundwater inflows, including drainage from onsite wastewater treatment systems. Pollutants transported by streams enter a lake as surface water inflows. In through-flow waterbodies, like the Waterford Impoundment, pollutant loadings transported across the land surface directly tributary to a lake, in the absence of identifiable or point source discharges from industries or wastewater treatment facilities, often comprise the principal route by which contaminants enter a waterbody. Such nonpoint sources of water pollution include urban sources, such as runoff from residential, commercial, transportation, construction, and recreational activities; and rural sources, such as runoff from agricultural lands and onsite sewage disposal systems. The Waterford Impoundment, as a result of its downstream location from several large communities located along the Fox River and its major tributaries, is subject to both nonpoint sources, as well as point sources of pollutants. Control of point sources of water pollutants is currently being effected through the application of public wastewater treatment technologies in urban centers upstream of the Waterford Impoundment, and through the implementation of onsite sewage disposal system inspection programs in other areas, as noted in Chapter III of Volume Two. For this reason, emphasis has been placed on the control of nonpoint source pollutants, which, while being addressed in part through actions recommended in the adopted

[1] *Sven-Olof Ryding and Walter Rast,* The Control of Eutrophication of Lakes and Reservoirs*, Unesco Man and the Biosphere Series, Volume 1, Parthenon Press, Carnforth, 1989; Jeffrey A. Thornton, Walter Rast, Marjorie M. Holland, Geza Jolankai, and Sven-Olof Ryding,* The Assessment and Control of Nonpoint Source Pollution of Aquatic Ecosystems*, Unesco Man and the Biosphere Series, Volume 23, Parthenon Press, Carnforth, 1999.*

regional water quality management, priority watershed, and County land and water resource management plans,[2] remain a major source of contaminants entering the Impoundment. Specifically, those areas directly tributary to the Impoundment can be considered to exert a more direct influence on lake water quality than the upstream watershed. These areas also lie within or immediately adjacent to the lands that comprise the Waterford Waterway Management District (WWMD). Consequently, the WWMD should initiate actions to manage these nonpoint source contaminants. This Appendix provides a basis for prioritizing actions by the District based upon an evaluation of the relative contaminant loads being delivered from specific subbasins draining to the Waterford Impoundment. Six subbasins have been identified as source areas for nonpoint source pollutants; namely, Subbasin MF-35, and Subbasins MF-37 through MF-41, as shown on Map B-1.

Nonpoint sources of water pollution include both urban and rural sources, such as runoff from residential, commercial, transportation, construction, and agricultural lands. The inputs to the Waterford Impoundment of representative nonpoint source contaminant loads were estimated using unit area loading (UAL) based models for suspended solids, phosphorus, and urban-derived metals developed for use within the Southeastern Wisconsin Region and applied to year 2000 land use conditions observed in each of the six subbasins draining directly to the Impoundment.

Phosphorus Loadings

Phosphorus has been identified as the factor generally limiting aquatic plant growth in the Waterford Impoundment. Thus, excessive levels of phosphorus in the Impoundment are likely to result in conditions that interfere with the desired use of the waterbody. Tables B-1 through B-6 set forth the estimated phosphorus loads to the Waterford Impoundment from the six subbasins directly tributary to the Impoundment, under existing year 2000 conditions.

It was estimated, that, under the year 2000 conditions, the total phosphorus load to the Impoundment from Subbasin MF-35, which drains the largely agricultural area located northwest of the portion of the Impoundment locally known as Conservancy Bay, as shown on Map B-1, was 3,500 pounds. Of this total, 3,200 pounds, or 90 percent, were estimated to be contributed by runoff from agricultural lands. The remaining land uses in the subbasin—urban land uses and direct deposition onto the surface of the waterbody, as well as other rural sources, such as woodlands and wetlands—were estimated to contribute the balance of the phosphorus loading, or 300 pounds, or 10 percent of the phosphorus load to the Impoundment. Given the large area of wetland and woodland located adjacent to the Impoundment, at the point of entry of the nutrient load to the Impoundment, it can be anticipated that the impact of phosphorus loads generated within Subbasin MF-35 would be substantially moderated, with the phosphorus delivered from the agricultural lands being utilized by the wetland vegetation within this nearshore area during the summer growing season. This would suggest that the impact of these loads is limited.[3] Hence, this subbasin would be considered to be of relatively low priority from the point of view of application of nonpoint source pollution control measures to control phosphorus loading to the Impoundment.

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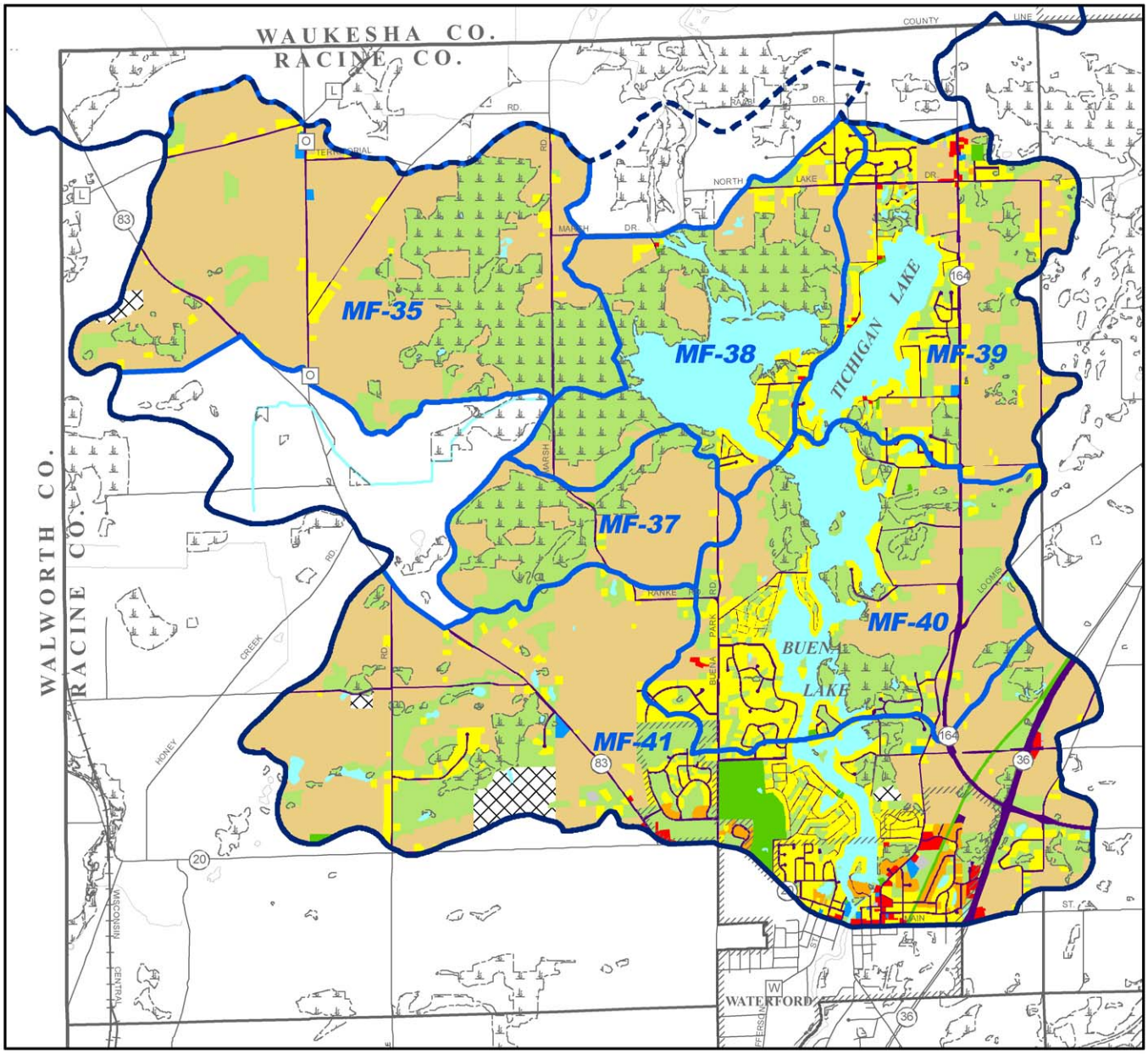
[2]*SEWRPC Planning Report No. 30,* A Regional Water Quality Management Plan for Southeastern Wisconsin: 2000*, Volume Three,* Recommended Plan*, June 1979; as refined in SEWRPC Memorandum Report No. 93,* A Regional Water Quality Management Plan for Southeastern Wisconsin: An Update and Status Report*, March 1995; Wisconsin Department of Natural Resources Publication PUBL-WR-366-94,* Nonpoint Source Control Plan for the Upper Fox River Priority Watershed Project*, June 1994; SEWRPC Community Assistance Planning Report No. 259,* A Land and Water Resource Management Plan for Racine County: 2000-2004, *September 2000; and, Waukesha County Department of Parks & Land Use, Land Resources Division,* Waukesha County Land and Water Resource Management Plan: 2006-2010*, March 2006.*

[3]*See D.M. Robertson, S.J. Field, J.F. Elder, G.L. Goddard and W.F. James*, Phosphorus Dynamics in Delavan Lake Inlet, Southeastern Wisconsin, 1994*, U. S. Geological Survey Water-Resources Report 96-4160, 1996*; and *W.F. James, C.S. Smith, J.W. Barko, and S.J. Field,* Direct and Indirect Influences of Aquatic Macrophyte Communities on Phosphorus Mobilization from Littoral Sediments of an Inlet Region in Lake Delavan, Wisconsin*, U. S. Army Corps of Engineers, Technical Report W-95-2, September 1995.*

Map B-1

EXISTING LAND USE WITHIN THE SUBBASINS DIRECTLY TRIBUTARY TO THE WATERFORD IMPOUNDMENT AND TICHIGAN LAKE: 2000



- Single-Family Residential
- Multi-Family Residential
- Commercial
- Industrial
- Transportation, Communications, and Utilities
- Governmental and Institutional
- Recreation
- Surface Water
- Wetlands and Woodlands
- Agricultural, Unused, and Other Open Lands
- Extractive and Landfill
- Total Tributary Boundary
- Direct Tributary Boundary
- Subbasin Boundary

N

GRAPHIC SCALE

0 0.5 1 1.5 Miles

Source: SEWRPC.

Table B-1

ESTIMATED CONTAMINANT LOADS FROM SUBBASIN MF-35 TRIBUTARY TO THE WATERFORD IMPOUNDMENT: 2000

Land Use	2000					
	Area (acres)	Sediment (pounds)	Phosphorus (pounds)	Copper (pounds)	Zinc (pounds)	Cadmium (pounds)
Residential	94	1,833	18.8	0.0	0.9	0.0
Commercial	- -	- -	- -	- -	- -	- -
Industrial	- -	- -	- -	- -	- -	- -
Communications, Transportation, and Utilities	457	4,341	50.3	0.0	0.0	0.0
Governmental	5	2,555	6.8	0.3	4.0	0.0
Recreational	2	48	0.5	0.0	0.0	0.0
Agricultural	3,740	1,683,000	3,216.4	0.0	0.0	0.0
Wetlands and Woodlands	1,282	4,743	51.3	0.0	0.0	0.0
Landfill	31	13,950	26.6	0.0	0.0	0.0
Water	1,178	221,464	153.1	0.0	0.0	0.0
Total	6,789	1,931,935	3,523.8	0.3	4.9	0.0

Source: SEWRPC.

Table B-2

ESTIMATED CONTAMINANT LOADS FROM SUBBASIN MF-37 TRIBUTARY TO THE WATERFORD IMPOUNDMENT: 2000

Land Use	2000					
	Area (acres)	Sediment (pounds)	Phosphorus (pounds)	Copper (pounds)	Zinc (pounds)	Cadmium (pounds)
Residential	16	312	3.2	0.0	0.2	0.0
Commercial	- -	- -	- -	- -	- -	- -
Industrial	- -	- -	- -	- -	- -	- -
Communications, Transportation, and Utilities	58	551	6.4	0.0	0.0	0.0
Governmental	- -	- -	- -	- -	- -	- -
Recreational	1	24	0.3	0.0	0.0	0.0
Agricultural	1,826	821,700	1,570.3	0.0	0.0	0.0
Wetlands and Woodlands	872	3,226	34.9	0.0	0.0	0.0
Landfill	- -	- -	- -	- -	- -	- -
Water	- -	- -	- -	- -	- -	- -
Total	2,773	825,813	1,615.1	0.0	0.2	0.0

Source: SEWRPC.

It was estimated, that, under the year 2000 conditions, the total phosphorus load to the Impoundment from Subbasin MF-37, shown on Map B-1, was 1,615 pounds. Of this total, 1,570 pounds, or 97 percent, were estimated to be contributed by runoff from agricultural lands. The remaining land uses in the subbasin—urban land uses and direct deposition onto the surface of the waterbody, as well as other rural sources, such as woodlands and wetlands—were estimated to contribute the balance of the phosphorus loading, or 45 pounds, or 3 percent of the phosphorus load to the Impoundment. While an area of wetland and woodland is located adjacent to the Impoundment at the point of entry of the nutrient load to the Impoundment, the recent conversion of portions of the agricultural lands to urban land uses would be expected to alter the magnitude of the phosphorus loads generated within Subbasin MF-37. Typically, the unit area load model would forecast a reduction in phosphorus load generated from urban residential lands when compared to the phosphorus load generated agricultural lands.

Table B-3

ESTIMATED CONTAMINANT LOADS FROM SUBBASIN MF-38 TRIBUTARY TO THE WATERFORD IMPOUNDMENT: 2000

Land Use	2000					
	Area (acres)	Sediment (pounds)	Phosphorus (pounds)	Copper (pounds)	Zinc (pounds)	Cadmium (pounds)
Residential	247	4,816	49.4	0.0	2.5	0.00
Commercial	2	1,568	2.4	0.4	3.0	0.02
Industrial	- -	- -	- -	- -	- -	- -
Communications, Transportation, and Utilities	150	1,425	16.5	0.0	0.0	0.00
Governmental	- -	- -	- -	- -	- -	- -
Recreational	1	24	0.3	0.0	0.0	0.00
Agricultural	1,542	693,900	1,326.1	0.0	0.0	0.00
Wetlands and Woodlands	1,457	5,391	58.3	0.0	0.0	0.00
Landfill	- -	- -	- -	- -	- -	- -
Water	1,175	220,900	152.7	0.0	0.0	0.00
Total	4,574	928,024	1,605.7	0.4	5.5	0.02

Source: SEWRPC.

Table B-4

ESTIMATED CONTAMINANT LOADS FROM SUBBASIN MF-39 TRIBUTARY TO THE WATERFORD IMPOUNDMENT: 2000

Land Use	2000					
	Area (acres)	Sediment (pounds)	Phosphorus (pounds)	Copper (pounds)	Zinc (pounds)	Cadmium (pounds)
Residential	413	8,214	82.7	0.04	4.4	0.00
Commercial	9	7,056	10.8	2.00	13.4	0.09
Industrial	1	752	1.2	0.20	1.5	0.01
Communications, Transportation, and Utilities	530	5,035	58.3	0.00	0.0	0.00
Governmental	3	1,533	4.0	0.20	2.4	0.00
Recreational	20	480	5.4	0.00	0.0	0.00
Agricultural	815	366,750	700.9	0.00	0.0	0.00
Wetlands and Woodlands	510	1,887	20.4	0.00	0.0	0.00
Landfill	- -	- -	- -	- -	- -	- -
Water	1,179	221,652	153.3	0.00	0.0	0.00
Total	3,480	613,359	1,037.0	2.50	21.7	0.10

Source: SEWRPC.

However, the increasing use of lawn care chemicals in urban residential environments has been shown to result in higher levels of phosphorus in runoff than have been traditionally used in the modeling.[4] It is for this reason that the Town of Waterford has adopted a no-phosphorus ordinance applicable to residential lands within its jurisdiction. In addition, the application of stormwater management measures within the urban lands within this subbasin, as required pursuant to Chapter NR 151 of the *Wisconsin Administrative Code*, could be expected to contain a portion of the phosphorus load on site. Hence, Subbasin MF-37 also would be considered to be of relatively low priority from the point of view of application of nonpoint source pollution control measures to control phosphorus loading to the Impoundment.

[4]*See U.S. Geological Survey Water-Resources Investigations Report No. 02-4130,* Effects of Lawn Fertilizer on Nutrient Concentration in Runoff from Lakeshore Lawns, Lauderdale Lakes, Wisconsin*, July 2002.*

Table B-5

ESTIMATED CONTAMINANT LOADS FROM SUBBASIN MF-40 TRIBUTARY TO THE WATERFORD IMPOUNDMENT: 2000

Land Use	2000					
	Area (acres)	Sediment (pounds)	Phosphorus (pounds)	Copper (pounds)	Zinc (pounds)	Cadmium (pounds)
Residential	505	9,847	101.0	0.0	5.0	0.00
Commercial	2	1,568	2.4	0.4	3.0	0.02
Industrial	- -	- -	- -	- -	- -	- -
Communications, Transportation, and Utilities	710	6,745	78.1	0.0	0.0	0.00
Governmental	- -	- -	- -	- -	- -	- -
Recreational	2	48	0.5	0.0	0.0	0.00
Agricultural	1,404	631,800	1,207.4	0.0	0.0	0.00
Wetlands and Woodlands	792	2,930	31.7	0.0	0.0	0.00
Landfill	- -	- -	- -	- -	- -	- -
Water	1,180	221,840	153.4	0.0	0.0	0.00
Total	4,595	874,778	1,574.5	0.4	8.0	0.02

Source: SEWRPC.

Table B-6

ESTIMATED CONTAMINANT LOADS FROM SUBBASIN MF-41 TRIBUTARY TO THE WATERFORD IMPOUNDMENT: 2000

Land Use	2000					
	Area (acres)	Sediment (pounds)	Phosphorus (pounds)	Copper (pounds)	Zinc (pounds)	Cadmium (pounds)
Residential	630	17,920	130.9	1.4	15.4	0.00
Commercial	41	32,144	49.2	9.0	61.1	0.41
Industrial	7	5,264	8.2	1.5	10.4	0.07
Communications, Transportation, and Utilities	1,008	9,576	110.8	0.0	0.0	0.00
Governmental	18	9,198	24.3	1.3	14.4	0.00
Recreational	157	3,768	42.3	0.0	0.0	0.00
Agricultural	5,355	2,409,750	4,605.3	0.0	0.0	0.00
Wetlands and Woodlands	1,067	3,948	42.6	0.0	0.0	0.00
Landfill	18	9,198	24.3	0.0	0.0	0.00
Water	1,218	228,984	158.3	0.0	0.0	0.00
Total	9,651	2,788,052	5,301.2	13.2	101.3	0.48

Source: SEWRPC.

It was estimated, that, under the year 2000 conditions, the total phosphorus load to the Impoundment from Subbasin MF-38, which drains the largely agricultural area located northwest of the portion of the Impoundment locally known as Conservancy Bay, as shown on Map B-1, was 1,600 pounds. Of this total, 1,300 pounds, or 80 percent, were estimated to be contributed by runoff from agricultural lands. The remaining land uses in the subbasin—urban land uses and direct deposition onto the surface of the waterbody, as well as other rural sources, such as woodlands and wetlands—were estimated to contribute the balance of the phosphorus loading, or 300 pounds, or 20 percent of the phosphorus load to the Impoundment. Given the large area of wetland and woodland located adjacent to the Impoundment, at the point of entry of the nutrient load to the Impoundment, it can be anticipated that the impact of phosphorus loads generated within Subbasin MF-38 would be substantially moderated, with the phosphorus delivered from the agricultural lands being utilized by the wetland vegetation

within this nearshore area during the summer growing season.[5] Hence, this subbasin would be considered of relatively low priority from the point of view of application of nonpoint source pollution control measures to control phosphorus loading to the Impoundment.

It was estimated, that, under the year 2000 conditions, the total phosphorus load to the Impoundment from Subbasin MF-39, which drains the residential and agricultural area located north and east of Tichigan Lake, as shown on Map B-1, was 1,030 pounds. Of this total, 700 pounds, or 70 percent, were estimated to be contributed by runoff from agricultural lands. Urban lands were estimated to contribute 160 pounds of phosphorus, or 15 percent of the phosphorus load generated from within this subbasin. The remaining land uses in the subbasin—direct deposition onto the surface of the waterbody and other rural sources, such as woodlands and wetlands—were estimated to contribute the balance of the phosphorus loading, or 170 pounds, or a further 15 percent of the phosphorus load to the Impoundment. Mitigation measures, including the construction and recent maintenance of stormwater management basins within the Golden Bay subdivision in the Town of Waterford, as well as the application of stormwater management practices on lands draining the agricultural lands located east of STH 164, are expected to control a significant portion of the phosphorus loads generated from within the subbasin. Hence, besides ongoing maintenance actions, the external phosphorus loads generated from within this subbasin may be expected to have been controlled to the extent feasible.[6]

It was estimated, that, under the year 2000 conditions, the total phosphorus load to the Impoundment from Subbasin MF-40, which includes the lands adjacent to both shores of the central portion of the Waterford Impoundment, as shown on Map B-1, was 1,570 pounds. Of this total, 1,210 pounds, or 80 percent, were estimated to be contributed by runoff from agricultural lands. These lands are located primarily along the eastern shores of the Impoundment. About 180 pounds of phosphorus, or approximately 10 percent of the total phosphorus load, are contributed from urban lands, primarily consisting of urban density residential lands located along the western shoreline of the Impoundment, adjacent to the Buena Lake subbasin. The remaining land uses in the subbasin—direct deposition onto the surface of the waterbody, as well as other rural sources, such as woodlands and wetlands—were estimated to contribute the balance of the phosphorus loading, or 180 pounds, or 10 percent of the phosphorus load to the Impoundment. Recent surveillance during late 2007 indicated that there was a large subdivision being constructed east of Buena Park Road in the northeastern portion of this subbasin located on the western shores of the Impoundment. Likewise, on the eastern shores, similar recent subdivision development has been observed on agricultural lands located to the west of STH 164 on Loomis Road in the central portions of Subbasin MF-40. Pursuant to the stormwater management requirements imposed by the Town of Waterford, both developments will be served by stormwater management practices that are consistent with Chapter NR 151 requirements. Consequently, relative to the existing agricultural condition, completion of these subdivisions may be expected to result in no net increase in phosphorus loading to the Impoundment and should reduce the estimated phosphorus load as a result of the application of the stormwater management practices on these sites. Ongoing maintenance of these basins would be required to ensure their continuing effectivity. A considerable area of agricultural and open lands east of STH 164 drains to the eastern shores of the Impoundment, and remains a potential source of phosphorus loading. While the wetlands and woodlands that exist along the eastern shorelands of the Impoundment within this subbasin can be anticipated to moderate the impacts of phosphorus loads generated within the eastern portions of Subbasin MF-40, the presence of high value natural

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[5]*See D.M. Robertson, S.J. Field, J.F. Elder, G.L. Goddard and W.F. James*, op. cit.; and *W.F. James, C.S. Smith, J.W. Barko, and S.J. Field,* op. cit.

[6]*Recent surveillance during late 2007 indicated that there was a large subdivision being constructed southwest of the intersection of STH 164 and N. Lake Drive. Pursuant to the stormwater management requirements imposed by the Town of Waterford, this development will be served by three stormwater basins that are consistent with Chapter NR 151 requirements. Consequently, relative to the existing agricultural condition, completion of this subdivision may be expected to result in no net increase in phosphorus loading to the Impoundment and should reduce the estimated phosphorus load as a result of the application of the stormwater management practices on this site. Ongoing maintenance of these basins would be required to ensure their continuing effectivity in phosphorus load reduction to the Tichigan Lake subbasin of the Waterford Impoundment.*

resource features, such as Elm Island Bog and Island Oak Woods noted in Chapter V of Volume One would indicate that this subbasin be considered to be of relatively high priority from the point of view of application of nonpoint source pollution control measures to control phosphorus loading to the Impoundment.[7]

It was estimated, that, under the year 2000 conditions, the total phosphorus load to the Impoundment from Subbasin MF-41, which includes a substantial portion of the lands within the Village of Waterford that drain to the southern portion of the Waterford Impoundment, as shown on Map B-1, was 5,300 pounds. Of this total, 4,600 pounds, or 85 percent, were estimated to be contributed by runoff from agricultural lands. The majority of these lands are located west of the Impoundment, to the west of the western boundary of the Village of Waterford. The majority of the lakeshore lands within Subbasin MF-41 are comprised of urban density lands, as shown on Map B-1. About 350 pounds of phosphorus, or approximately 10 percent of the total phosphorus load, are contributed from these urban lands. Consequently, this subbasin should be considered to be of relatively high priority from the point of view of application of nonpoint source pollution control measures to control phosphorus loading to the Impoundment.

Sediment Loadings

Sediment enters the aquatic environment both in the form of suspended materials eroded from the land surface by stormwater runoff and in the form of wind-blown dust. Consequently, sediment loads to the Impoundment include both water-borne particulates carried into the Impoundment through the influent rivers and direct overland flows, as well as particulates that settle directly on to the Lake surface from the atmosphere. These latter masses of sediment are shown in Tables B-1 through B-6 as sediment of "water" origin. Fortunately, sediment is amenable to removal through settling, allowing a significant level of nonpoint source pollution control to be exercised through the placement of stormwater management measures in strategic areas of the watershed, prior to stormwater being discharged to the Impoundment. Such measures are best suited for use in urban areas, although maintenance of ground cover in agricultural areas—through the use of conservation tillage techniques, for example—and on construction sites also provides an effective mechanism to minimize sediment transport from the land to the water.

It was estimated, that, under the year 2000 conditions, the sediment load to the Waterford Impoundment from Subbasin MF-35, tabulated in Table B-1, was two million pounds, with 90 percent estimated to be contributed by runoff from agricultural lands. The remaining land uses in the subbasin—urban land uses and direct deposition onto the surface of the waterbody, as well as other rural sources, such as woodlands and wetlands—were estimated to contribute the balance of the sediment loading, or 250,000 pounds, or 10 percent of the sediment load to the Impoundment. The large area of wetland and woodland located adjacent to the point of entry of this sediment load to the Impoundment can be anticipated to substantially moderate the impact of this load. Hence, this subbasin would be considered to be of relatively low priority from the point of view of application of nonpoint source pollution control measures to control sediment loading to the Impoundment.

It was estimated, that, under the year 2000 conditions, the sediment load to the Impoundment from Subbasin MF-37, tabulated in Table B-2, was 825,000 pounds. Of this total, 820,000 pounds, or 99 percent, were estimated to be contributed by runoff from agricultural lands. The remaining land uses in the subbasin—urban land uses and direct deposition onto the surface of the waterbody, as well as other rural sources, such as woodlands and wetlands—were estimated to contribute the balance of the sediment loading, or 5,000 pounds of sediment. The recent conversion of portions of the agricultural lands to urban land uses would be expected to reduce the mass of sediment generated from within this subbasin. The application of stormwater management measures within the urban lands within this subbasin, as required pursuant to Chapter NR 151 of the *Wisconsin Administrative Code*, could be expected to contain a large portion of the sediment load on site. Hence, Subbasin MF-37 should be

[7] *The Waterford Waterway Management District and the Town of Waterford, in recognition of the sensitive nature of the natural resource features in the area, have cooperated in the design and placement of stormwater management facilities within the Fowler Bay subdivision to enhance protection of the environmentally valuable lands.*

considered to be of low to moderate priority from the point of view of application of nonpoint source pollution control measures to control sediment loading to the Impoundment.

It was estimated, that, under the year 2000 conditions, the sediment load to the Impoundment from Subbasin MF-38, tabulated in Table B-3, was 930,000 pounds. Of this total, 690,000 pounds, or 75 percent, were estimated to be contributed by runoff from agricultural lands. The remaining land uses in the subbasin—urban land uses and direct deposition onto the surface of the waterbody, as well as other rural sources, such as woodlands and wetlands—were estimated to contribute the balance of the sediment loading, or 240,000 pounds of sediment to the Impoundment. Given the large area of wetland and woodland located adjacent to the Impoundment, it can be anticipated that the impact of sediment loads generated within Subbasin MF-38 would be substantially moderated. Hence, this subbasin would be considered to be of relatively low priority from the point of view of application of nonpoint source pollution control measures.

It was estimated, that, under the year 2000 conditions, the sediment load to the Impoundment from Subbasin MF-39, tabulated in Table B-4, was 610,000 pounds. Of this total, 360,000 pounds, or 60 percent of the sediment load, were estimated to be contributed by runoff from agricultural lands. Urban lands were estimated to contribute 25,000 pounds of sediment. The remaining land uses in the subbasin—direct deposition onto the surface of the waterbody and other rural sources, such as woodlands and wetlands—were estimated to contribute the balance of the sediment loading, or 225,000 pounds of sediment. Mitigation measures, including the construction and recent maintenance of stormwater management basins within the Golden Bay subdivision in the Town of Waterford, as well as the application of stormwater management practices on lands draining the agricultural lands located east of STH 164, are expected to control a significant portion of the sediment loads generated from within the subbasin. For this reason, only ongoing maintenance actions to ensure continued control of the external sediment loads generated from within this subbasin are likely to be required.

It was estimated, that, under the year 2000 conditions, the sediment load to the Impoundment from Subbasin MF-40, tabulated in Table B-5, was 875,000 pounds. Of this total, 630,000 pounds, or 70 percent, were estimated to be contributed by runoff from the agricultural lands located primarily along the eastern shores of the Impoundment. Twenty thousand pounds of sediment were estimated to be contributed from urban lands, primarily located adjacent to the Buena Lake subbasin. The remaining land uses in the subbasin—direct deposition onto the surface of the waterbody, as well as other rural sources, such as woodlands and wetlands—were estimated to contribute the balance of the sediment loading, or 225,000 pounds of sediment. Stormwater management practices, consistent with Chapter NR 151 requirements, would be expected to moderate the impacts of the sediment loads generated within this subbasin. Consequently, this subbasin should be considered to be of relatively high priority from the point of view of application of nonpoint source pollution control measures.

It was estimated, that, under the year 2000 conditions, the sediment load to the Impoundment from Subbasin MF-41, tabulated in Table B-6, was 2.8 million pounds. Of this total, 2.4 million pounds of sediment, or 85 percent of the load, were estimated to be contributed by runoff from agricultural lands. The majority of these lands are located to the west of the Village of Waterford. Seventy-eight thousand pounds of sediment are estimated to be contributed from urban lands. Consequently, this subbasin should be considered to be of relatively high priority from the point of view of application of nonpoint source pollution control measures to control sediment loading to the Impoundment.

Urban Heavy Metals Loadings

Urbanization brings with it increased use of metals and other materials that contribute pollutants to aquatic systems. Tables B-1 through B-6 set forth the estimated loadings of copper, zinc, and cadmium likely to be contributed to the Waterford Impoundment from urban development draining to and surrounding the waterbody. The majority of these contaminants become associated with sediment particles and is likely to be encapsulated into the bottom sediments of the Impoundment. Nevertheless, these loads are of concern since such metals can bio-accumulate and their effects can be bio-magnified through the actions of aquatic fauna, with potentially significant impacts on human populations that harvest fishes from the Impoundment.

It was estimated, that, under the year 2000 conditions, the heavy metals loads to the Waterford Impoundment from urban lands within Subbasin MF-35 were 0.3 pound of copper and five pounds of zinc—no appreciable

cadmium load was estimated to be generated from the urban lands within this subbasin. This subbasin would be considered to be of moderate priority from the point of view of application of nonpoint source pollution control measures to control heavy metals loadings to the Impoundment.

It was estimated, that, under the year 2000 conditions, the heavy metals loads to the Impoundment from Subbasin MF-37 were limited to one-quarter pound of zinc—no appreciable copper or cadmium loads were estimated to be generated from the urban lands within this subbasin. Consequently, Subbasin MF-37 should be considered to be of low priority from the point of view of application of nonpoint source pollution control measures to control heavy metals loadings to the Impoundment.

It was estimated, that, under the year 2000 conditions, the heavy metals loads to the Impoundment from Subbasin MF-38 were 0.4 pound of copper, five pounds of zinc, and 0.02 pound of cadmium. Given the large wetland and woodland area located adjacent to the Impoundment, it can be anticipated that the impact of the heavy metals loads generated within Subbasin MF-38 would be considered to be of relatively low priority from the point of view of application of nonpoint source pollution control measures.

It was estimated, that, under the year 2000 conditions, the heavy metals loads to the Impoundment from Subbasin MF-39 were 2.5 pounds of copper, 20 pounds of zinc, and 0.1 pound of cadmium. Consequently, this subbasin would be considered to be of relatively high priority from the point of view of application of nonpoint source pollution control measures to control heavy metals loadings to the Impoundment.

It was estimated, that, under the year 2000 conditions, the heavy metals loads to the Impoundment from Subbasin MF-40 were one-half pound of copper, eight pounds of zinc, and 0.02 pound of cadmium. The urbanized and urbanizing nature of this subbasin would suggest that this subbasin should be considered to be of moderate to high priority from the point of view of application of nonpoint source pollution control measures to control heavy metals loadings to the Impoundment.

It was estimated, that, under the year 2000 conditions, the heavy metals loads to the Impoundment from Subbasin MF-41 were 13 pounds of copper and 100 pounds of zinc, and one-half pound of cadmium. Consequently, this subbasin should be considered to be of high priority from the point of view of application of nonpoint source pollution control measures to control heavy metals loadings to the Impoundment.

PRIORITY AREAS FOR INTERVENTION

The foregoing analysis is summarized in Table B-7. This analysis would suggest that the lower portions of the Waterford Impoundment—Subbasins MF-40 and MF-41, which are more highly urbanized than the upper reaches of the Impoundment—Subbasins MF-35, and MF-37 through MF-39, should be considered priority areas for the application of nonpoint source pollution abatement practices. These practices are tabulated in Appendix A, and focus on the control of potential contaminants on the land surface, using a variety of techniques. In urban settings, the use of stormwater management practices is the primary mechanism for reducing nonpoint source pollutant loads that have the potential to degrade water quality and aquatic habitat. In rural areas, the application of agricultural management practices that minimize soil loss provide the principle means of moderating nonpoint source pollutant inputs. These practices form the basis for the recommendations set forth in this management plan for the Waterford Waterway.

With respect to those areas indicated to be of moderate priority for the application of nonpoint source pollution control measures—Subbasins MF-35 and MF-37, the areas to be managed—are those areas proposed for urban residential development or those areas currently being developed for urban density residential use. The majority of these areas is currently subject to stormwater management requirements promulgated pursuant to Chapter NR 151 of the *Wisconsin Administrative Code*. Nevertheless, ongoing oversight of development activities as required through the building inspection programs being executed by the Town and Village of Waterford is recommended to be continued.

Table B-7

RELATIVE PRIORITIES FOR NONPOINT SOURCE POLLUTION CONTROL INTERVENTIONS IN SUBBASINS DRAINING DIRECTLY TO THE WATERFORD IMPOUNDMENT

Subbasin	Phosphorus	Sediment	Heavy Metals[a]
MF-35	Low	Low	Moderate
MF-37	Low	Moderate	Low
MF-38	Low	Low	Low
MF-39	- -[b]	- -[b]	- -[b]
MF-40	High	High	High
MF-41	High	High	High

[a]*Heavy metals evaluated were copper, zinc, and cadmium, assumed to be generated from urban sources.*

[b]*Nonpoint source pollution control measures have been implemented within this subbasin by the Waterford Waterway Management District and the Southeastern Wisconsin Fox River Commission, in partnership with local government and individual property owners. Future interventions are limited to ongoing maintenance of installed management practices.*

Source: SEWRPC.