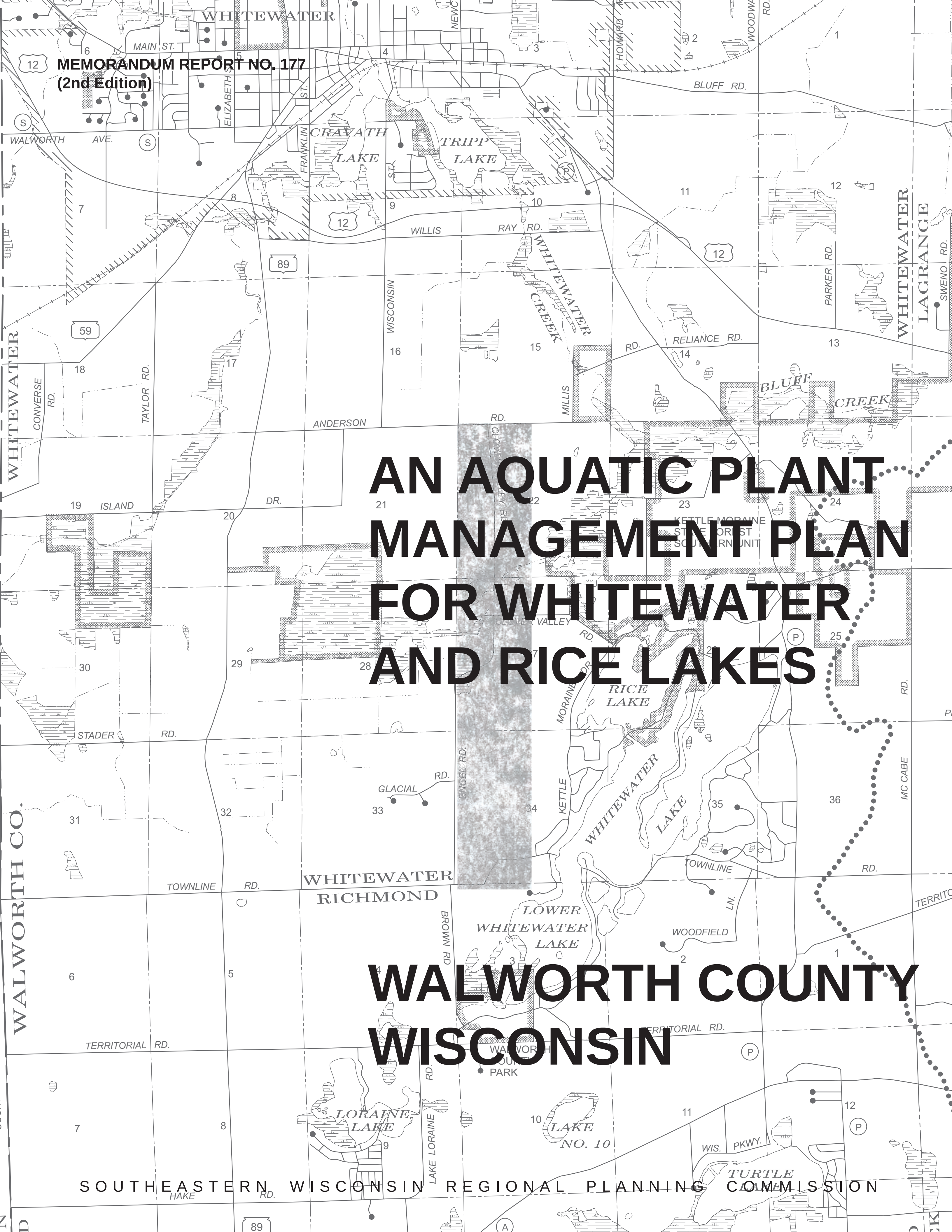
MEMORANDUM REPORT NO. 177
(2nd Edition)

AN AQUATIC PLANT MANAGEMENT PLAN FOR WHITEWATER AND RICE LAKES

WALWORTH COUNTY WISCONSIN



SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

Special acknowledgment is due Tom Ganfield who gathered and reported lake water quality information.

Special acknowledgment is due Dale J. Buser PE, PH, Principal Specialist, Beverly Saunders, Former Senior Specialist, Zofia Noe, Specialist, Megan Beauchaine, Research Analyst, Michael A. Borst, Research Analyst, Anna Cisar, Former Research Analyst, and Laura Fields Sommers, Former Research Analyst, for their contribution to the preparation of this report.

MEMORANDUM REPORT
NUMBER 177, 2nd Edition

A LAKE PROTECTION AND AQUATIC PLANT MANAGEMENT PLAN FOR WHITEWATER AND RICE LAKES, WALWORTH COUNTY, WISCONSIN

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Chapter I

INTRODUCTION

PURPOSE OF PLAN

Water body health and appeal usually directly reflect watershed land use and management. Active intervention is commonly needed to maintain or improve the health and quality of lakes, streams, and wetlands. Located within U.S. Public Land Survey Sections 2 and 3, Township 3 North, Range 15 East, in the Town of Richmond, and U.S. Public Land Survey Sections 25, 26, 27, 34 and 35, Township 4 North, Range 15 East, Town of Whitewater, Walworth County (see Map 1), Whitewater and Rice Lakes, together with their associated watersheds and wetlands, offer quality recreational opportunities (see "Whitewater and Rice Lake Characteristics and Assets" section below). This plan provides a framework to protect and improve the land and water resources of Whitewater and Rice Lakes and their watersheds with a focus on *protecting* these resources from human impacts, *preventing* future degradation, and *enhancing* their ecological value and recreational appeal. This report's recommendations are appropriate and feasible lake management measures which help preserve and enhance Whitewater and Rice Lakes' native plant community and water quality, yet allow the Lakes and their watershed to provide the public with safe, widely popular, and enjoyable recreational opportunities.

This plan complements other existing plans,[1] programs, and ongoing management actions in the Whitewater and Rice Lake watersheds, and it represents the continuing commitments of government agencies, municipalities, and citizens to diligent lake planning and natural resource protection. Additionally, this plans was specifically designed to assist State agencies, local units of government, nongovernmental organizations, businesses, and citizens develop strategies that benefit the natural assets of Whitewater and Rice Lakes. By using the strategies outlined in this plan, the natural environment of the Lakes and their watershed will be preserved and enriched.

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[1] *Walworth County*, 2010 Land and Water Resource Management Plan, *April 6, 2010; SEWRPC Community Assistance Planning Report No. 224*, A Lake Management Plan for Whitewater and Rice Lakes, *1997; and SEWRPC Memorandum Report Report No. 177*, An Aquatic Plant Management Plan for Whitewater and Rice Lakes, Walworth County, Wisconsin, *2010*.

Map 1

LOCATION OF THE WHITEWATER AND RICE LAKES WATERSHED STUDY AREA

Source: SEWRPC.

This planning program was funded in part by the Whitewater-Rice Lakes Management District (WRLMD) and, in part, through a Chapter NR 190 Lake Management Planning grant awarded to the WRLMD and administered by the WDNR. The inventory and aquatic plant management plan elements presented in this report conform to the requirements and standards set forth in relevant *Wisconsin Administrative Codes*.[2]

WHITEWATER AND RICE LAKE CHARACTERISTICS AND ASSETS

Whitewater Lake is a 705-acre drainage lake with a maximum water depth of 40 feet (see Maps 2 and 3 for Whitewater Lake's bathymetry). Despite its 40 foot maximum depth, most of Whitewater Lake is quite shallow with a mean depth of only 8.3 feet. Whitewater Lake intermittently drains into Rice Lake, a 167-acre drainage lake with a maximum water depth of 11 feet (See Map 4 for Rice Lake's bathymetry).[3] Whitewater Lake was created in 1947 by damming the outlet of three smaller, existing lakes: Bass Lake, Kettle or Round Lake, and Whitewater Lake.[4] Rice Lake was created in 1954 by damming Whitewater Creek below Whitewater Lake.[5] See Map 5 for a historical aerial photograph showing the area before construction of the Lakes. Table 1 further details the hydrologic and morphologic characteristics of the Lakes. Chapter II provides more details on the importance of these characteristics.

The water level of Whitewater Lake did not exceed its spillway elevation until 1973.[6] Water flows intermittently from Whitewater Lake to Rice Lake. These waterbodies collectively form the headwaters of Whitewater Creek. Whitewater Creek flows north and enters the Bark River just above its confluence with the Rock River that in turn discharges to the Mississippi River. The Wisconsin Department of Natural Resources (WDNR) has classified the Lakes as drainage lakes meaning that the Lakes have both an inlet and outlet where the main water source is stream drainage (as opposed to groundwater inflows). However, based upon our observations and available data, Whitewater and Rice Lakes may be better described as seepage lakes, having only occasional flow from an outlet (and inlet in the case of Rice Lake) and groundwater as their primary source of water.[7] Furthermore, because Rice Lake owes more than half of its depth to a dam, it can be considered an artificial lake or impoundment.

Whitewater and Rice Lakes and their associated watersheds have a wide range of recreational assets. Prominent features include the Kettle Moraine State Forest-Southern Unit, the Whitewater Lake Recreation Area, and associated campgrounds. Whitewater Lake is able to support a variety of recreational opportunities as is evidenced by boat counts and observations completed by Southeastern Wisconsin Regional Planning Commission

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[2] *This plan has been prepared pursuant to the standards and requirements set forth in the following chapters of the* Wisconsin Administrative Code*: Chapter NR 1, "Public Access Policy for Waterways;" Chapter NR 40, "Invasive Species Identification, Classification and Control;" Chapter NR 103, "Water Quality Standards for Wetlands;" Chapter NR 107, "Aquatic Plant Management;" and Chapter NR 109, "Aquatic Plants Introduction, Manual Removal and Mechanical Control Regulations."*

[3] *Wisconsin Department of Natural Resources Publication No. PUBL-FH-800 2009*, Wisconsin Lakes, *2009*.

[4] *Wisconsin Conservation Department,* Surface Water Resources of Walworth County, 1961*; U.S. Geological Survey Water-Resources Investigations Report 94-4101,* Hydrology and Water Quality of Whitewater and Rice Lakes in Southeastern Wisconsin, 1990-91, *1994.*

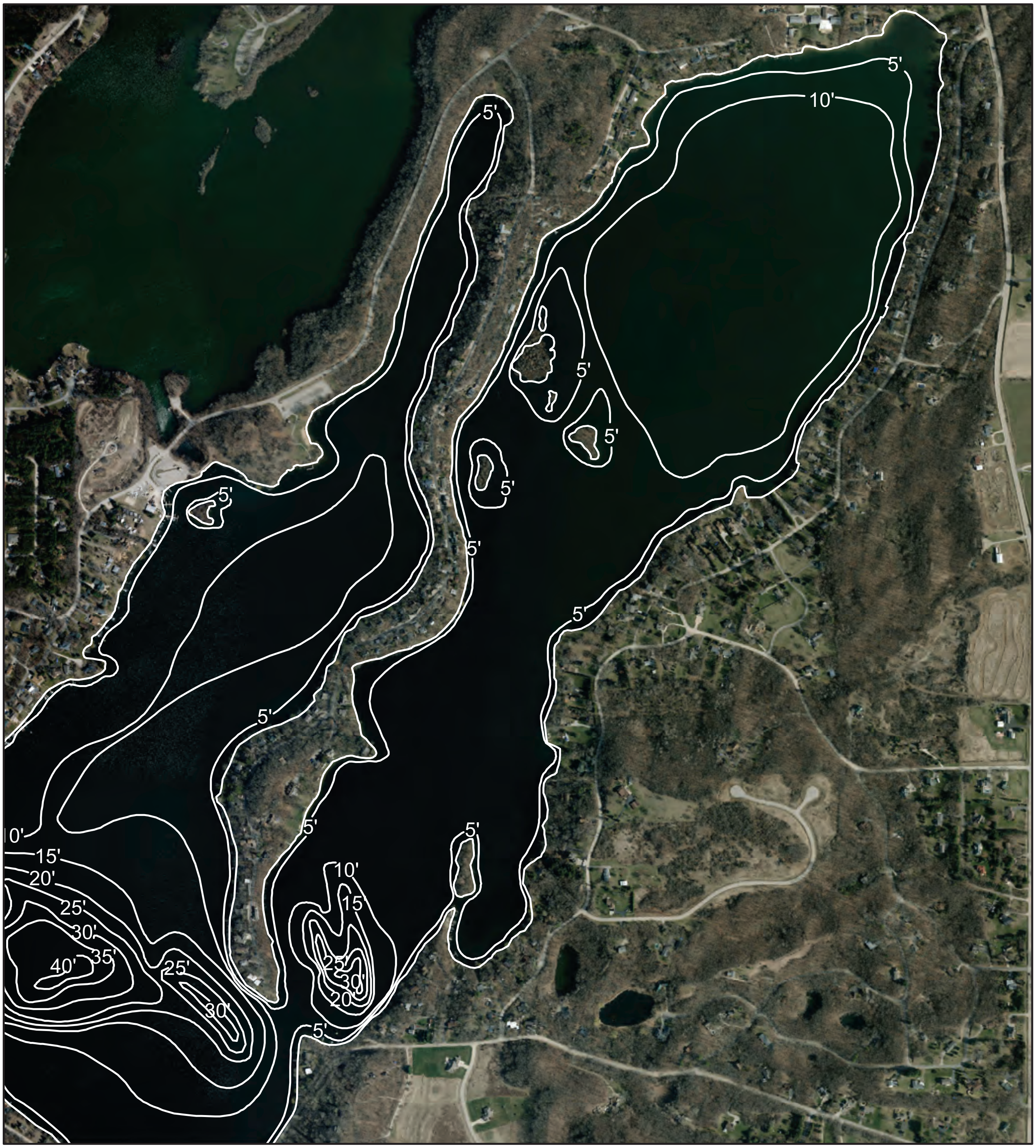
[5] Ibid.

[6] *U.S. Geological Survey Water-Resources Investigations Report 94-4101*, op. cit.

[7] *Wisconsin Department of Natural Resources Publication No. PUBL-FH-800*, op. cit.; Ibid.

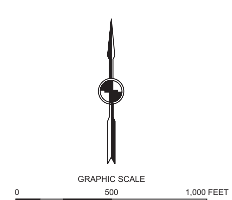
Map 2

WHITEWATER LAKE BATHYMETRIC MAP, NORTH SECTION



DATE OF PHOTOGRAPHY: APRIL 2015

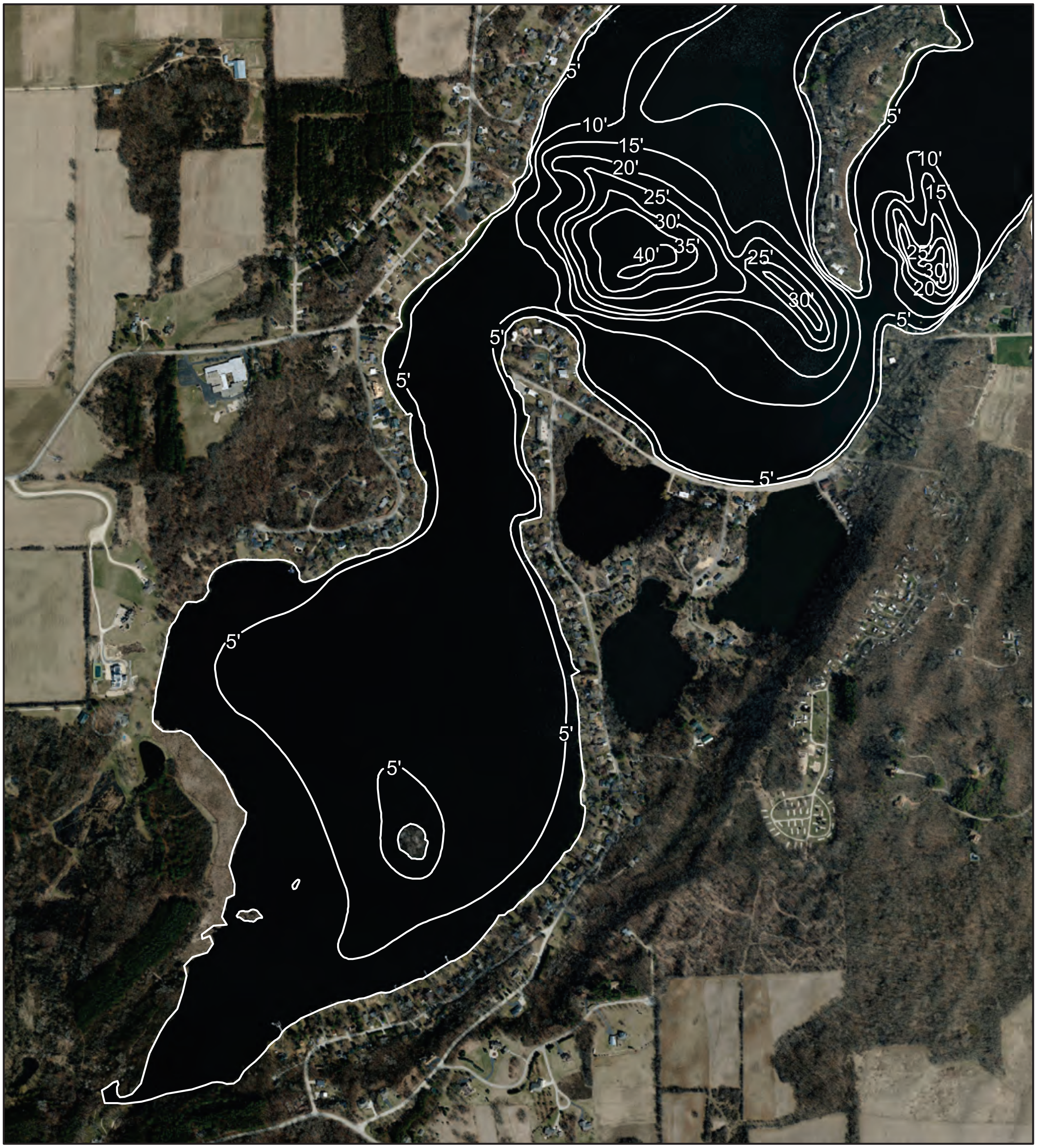
—20'— WATER DEPTH CONTOUR IN FEET



Source: Wisconsin Department of Natural Resources and SEWRPC.

Map 3

WHITEWATER LAKE BATHYMETRIC MAP, SOUTH SECTION



DATE OF PHOTOGRAPHY: APRIL 2015

—20'— WATER DEPTH CONTOUR IN FEET

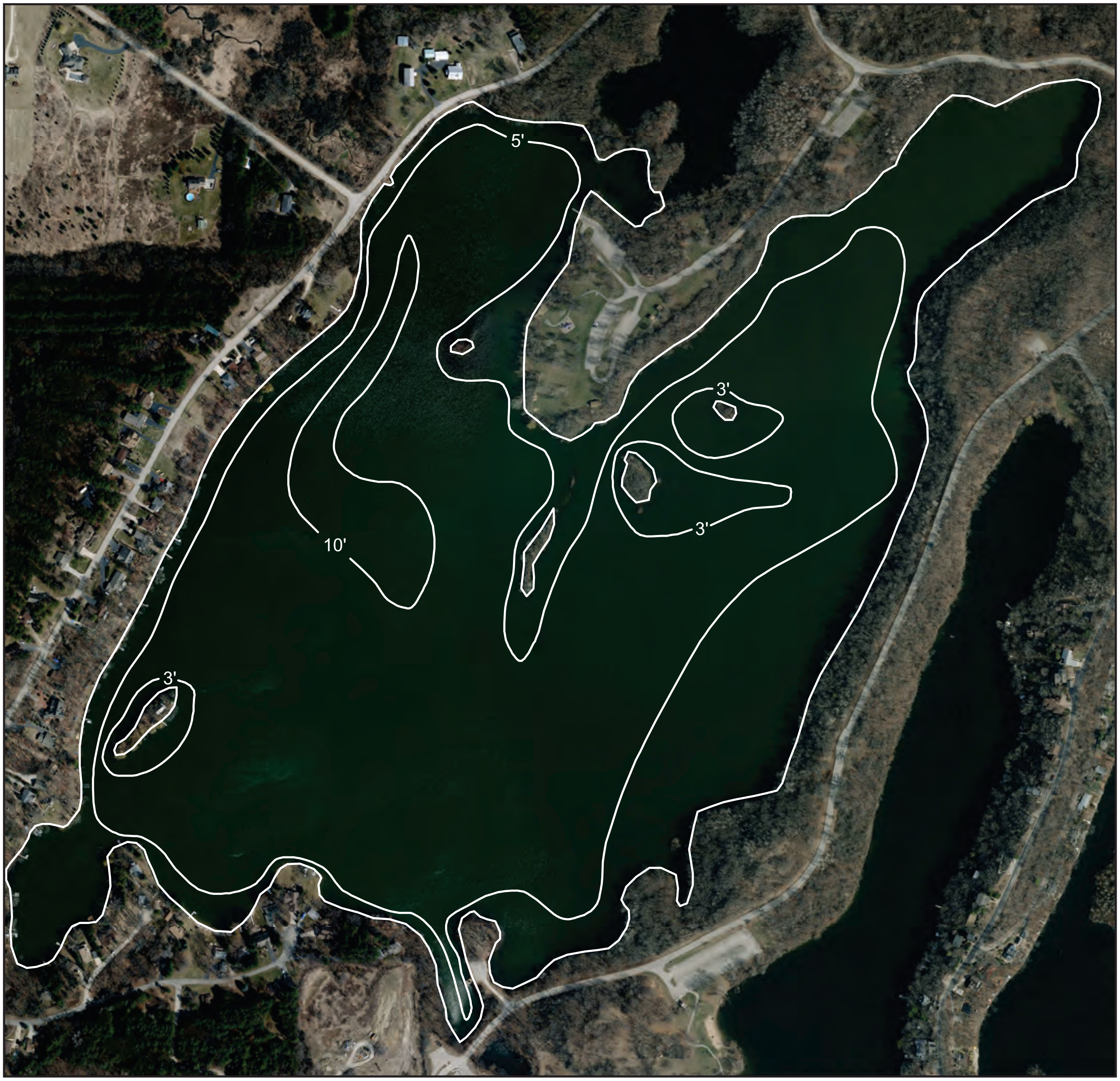
GRAPHIC SCALE

0 500 1,000 FEET

Source: Wisconsin Department of Natural Resources and SEWRPC.

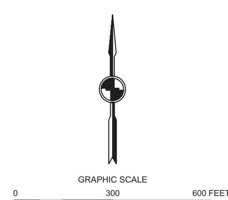
Map 4

RICE LAKE BATHYMETRIC MAP



DATE OF PHOTOGRAPHY: APRIL 2015

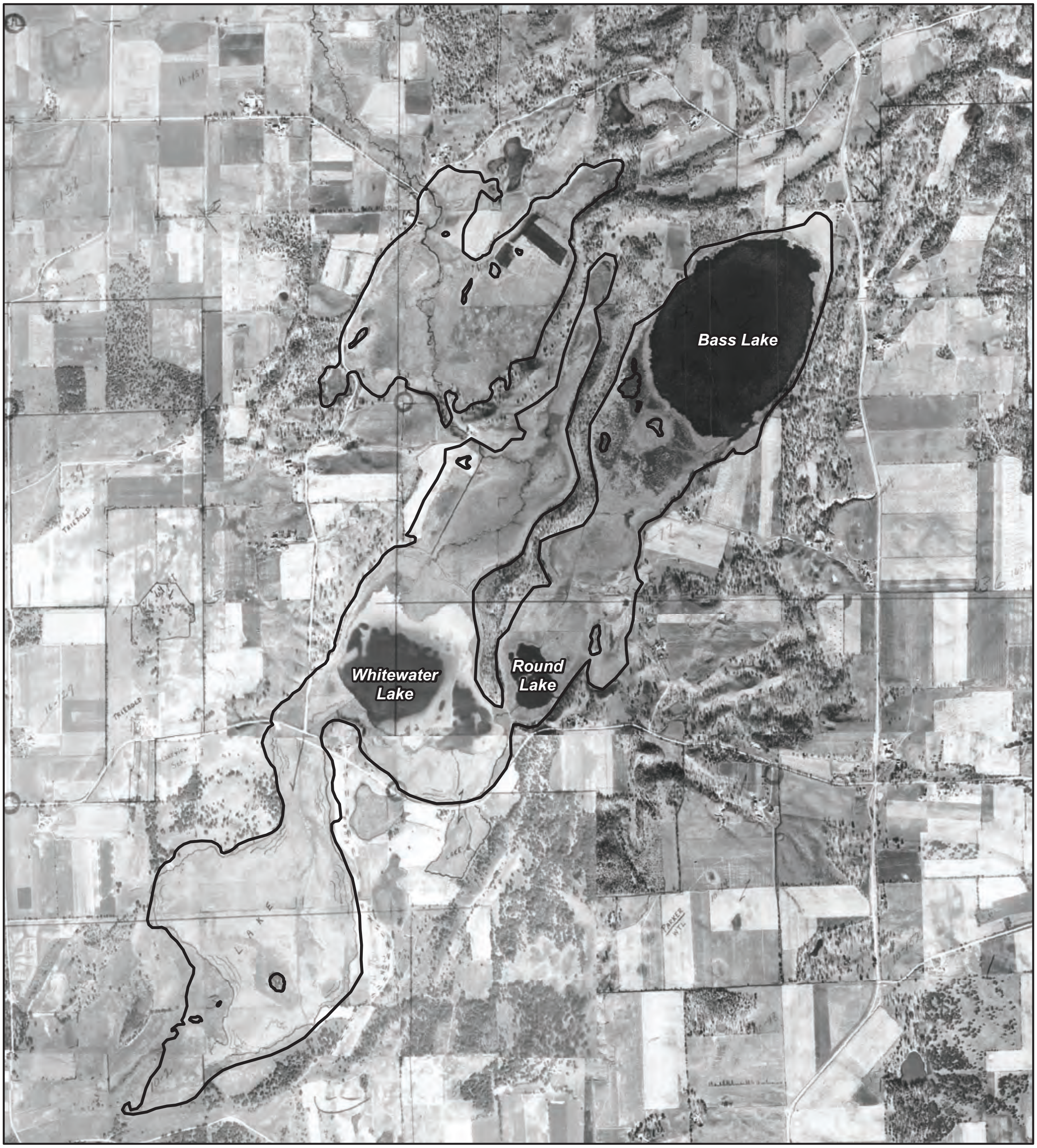
—10'— WATER DEPTH CONTOUR IN FEET



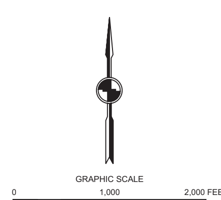
Source: Wisconsin Department of Natural Resources and SEWRPC.

Map 5

HISTORICAL AERIAL PHOTOGRAPH BEFORE CREATION OF WHITEWATER AND RICE LAKES: 1940



CURRENT EXTENT OF WHITEWATER AND RICE LAKES



Source: Walworth County and SEWRPC.

(SEWRPC) staff during summer 2014 (see Chapter II for more details). Lake users engage in full-body contact uses (such as swimming from the beach) as well as high-speed boating and fishing. Both Whitewater and Rice Lakes support a variety of wildlife and fish including gamefish such as largemouth bass, panfish, and northern pike. Additionally, as is also further described in Chapter II, the Lakes' watersheds contain critical species habitat areas and a variety of wetlands, uplands, and woodlands. The Lakes and their watersheds are also expected to support several species of reptiles and amphibians that live in and around the Lakes, small and large mammals, insects, and invertebrates, as well as a number of bird species that inhabit the area during migration.[8]

Table 1

HYDROLOGY AND MORPHOMETRY OF WHITEWATER AND RICE LAKES

Parameter	Whitewater	Rice
Size		
Surface Area of Lake[a]	705 acres	167 acres
Lake Volume	6,212 acre-feet	1,192 acre-feet
Residence Time[b]	1.02 years	7.07 years
Shape[c]		
Length of Lake	2.9 miles	1.0 miles
Width of Lake	0.6 miles	0.5 miles
Length of Shoreline	11.8 miles	3.8 miles
Shoreline Development Factor[d]	3.2	2.1
General Lake Orientation	NE-SW	NE-SW
Depth		
Maximum Depth	40 feet	11 feet[e]
Mean Depth	8.3 feet	5.8 feet

[a] *The areas of Whitewater and Rice Lake were reported as 697 and 162 acres, respectively, in U.S. Geological Survey Water-Resources Investigations Report 94-4101, op.cit. Lake-surface areas of 640 and 137 were reported in WDNR Publication No. PUBL-FH-800 2009 based on measurements made in 1958 when Whitewater and Rice Lakes had not completely filled and lake levels had not exceeded spillway elevations. Lake area values reported in this report are based on measurements made from 2010 orthophotographs using ArcGIS.*

[b] *Residence time is the number of years required for natural water sources under typical weather conditions to fill the lake one time. Natural water sources include runoff from surrounding areas, precipitation falling directly upon a lake, water entering from tributary streams, and water contributed to a lake by groundwater.*

[c] *Lake lengths, widths, shoreline lengths, and development factors reflect larger lake surface areas. Values reported here are based on measurements drawn from 2010 orthophotographs using ArcGIS.*

[d] *Shoreline development factor is the ratio of the shoreline length to the circumference of a circular lake of the same area. It can be used as an indicator of biological activity (i.e., the higher the value, the more likely the lake will be to have a productive biological community).*

[e] *The aquatic plant survey conducted by SEWRPC staff in the summer of 2014 revealed a maximum depth of 13.5 feet in Rice Lake. Lake depth may vary because of year-to-year variation.*

Source: U.S. Geological Survey, Wisconsin Department of Natural Resources, and SEWRPC.

LAKE PROTECTION PROGRAMS AND GOALS

General lake protection goals and objectives for Whitewater and Rice Lakes, aimed at maintaining and enhancing the Lakes' assets, were developed as a part of this planning process. These goals and objectives were developed in consultation with the WRLMD, the Towns of Richmond and Whitewater, and the public. These goals and objectives also directly address goals established in the Walworth County multi-jurisdictional comprehensive plan and include:[9]

1. Documenting the aquatic plant community of Whitewater and Rice Lakes, with emphasis on the occurrence and distribution of non-native species. This report details the aquatic plant survey completed by SEWRPC staff in 2014 and by DNR staff in 2015 for the purpose of understanding the dynamics of the aquatic plant community;

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[8] *These estimates are based on bird, amphibian, and reptile databases for the Region.*

[9] *SEWRPC Community Assistance Planning Report No. 288,* A Multi-Jurisdictional Comprehensive Plan for Walworth County: 2035, *November 2009.*

2. Identifying measures and methods necessary to reduce the extent and abundance of nonnative aquatic plant species in the Lakes to minimize the risk of these species spreading to other waterbodies, including downstream lakes, as noted in the relevant lake protection management plans;[10] and

3. Conducting appropriate in-lake treatments and other possible actions (including public information and education strategies) necessary to address the identified problems and issues of concern.

Implementation of the recommended actions set forth herein should serve as an important step in achieving the lake use/protection objectives over time.

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[10] *SEWRPC Community Assistance Planning Report No. 244* op. cit.; *SEWRPC Memorandum Report No. 177*, op. cit.; *SEWRPC Memorandum Report No. 191*, Lake Protection Plan for Cravath and Trippe Lakes, Walworth County, Wisconsin, *April 2011*.

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Chapter II

ISSUES AND CONCERNS

INTRODUCTION

Despite Whitewater and Rice Lakes being valuable resources, as discussed in Chapter I of this report, both are subject to a number of existing and potential future problems and issues of concern. To better define and understand these issues, and to maintain recreational use and ecological value of the Lakes, the Whitewater-Rice Lakes Management District (WRLMD) and the Southeastern Wisconsin Regional Planning Commission (SEWRPC) executed an agreement to investigate the causes of community concerns and develop a management plan to address these concerns. As a part of this planning program, a list of the issues and concerns to be addressed in the management plan were identified through various means, including:

- Consultation with the Whitewater-Rice Lakes Management District, identifying five general issues of concern.
- Two public meetings, where the issues of concerns were further discussed. These meetings provided further detail on the previously determined issues of concerns.
- Field investigations conducted by SEWRPC staff, revealing three additional issues of concern.

This chapter describes each identified issue of concern (see Table 2) and seeks to answer the questions posed by Whitewater-Rice Lakes Management District and concerned community members. This chapter also presents information used in developing the recommendations provided in Chapter III.

ISSUE 1: AQUATIC PLANT MANAGEMENT

Aquatic plant management is a significant area of concern for the Lakes, and it was the initial and primary purpose of the entire planning effort. This section first discusses the general need for aquatic plant management by quantifying the current state of aquatic plants in Whitewater and Rice Lakes. This section then compares the most recent aquatic plant surveys to past aquatic plant surveys. Lastly, management techniques are discussed that are best suited for these lake ecosystems.

First and foremost, it is important to note that <u>all lakes have plants and that every lake is unique</u>. Aquatic plants are a natural part of most lake communities and serve a number of valuable functions including: improving water quality by using excess nutrients, providing habitat for invertebrates and fish, stabilizing lake bottom sediments, and supplying food and oxygen to the lake through photosynthesis. A lake's water clarity, configuration, depth, nutrient availability, wave action, and the current fish population affect the abundance and distribution of aquatic plants. In nutrient-rich lakes such as Whitewater and Rice Lakes,[1] it is actually normal to have abundant aquatic plant growth in shallow areas.

Table 2

ISSUES OF CONCERN

	Issues and Concerns
1	Aquatic Plant Management
2	Water Quality
3	Cyanobacteria and Floating Algae
4	Bog Removal in Whitewater Lake
5	Groundwater Recharge
6	Recreation
7	Fish and Wildlife
8	Plan Implementation

Source: SEWRPC.

Aquatic Plants in Whitewater Lake

SEWRPC 2014 Aquatic Plant Survey

To determine appropriate aquatic plant management recommendations, SEWRPC staff completed an aquatic plant survey for both Whitewater and Rice Lakes during June and July 2014 using point-intercept methodology.[2] Of the 595 sites shallow enough to be sampled in Whitewater Lake (water depth of 15 feet or less), 323 had vegetation.[3] This survey found five native submergent aquatic plant species in Whitewater Lake. These plants are (listed in descending order of abundance): southern Naiad (*Najas guadalupensis*), elodea (*Elodea canadensis*), muskgrass (*Chara spp.)*, coontail (*Ceratophyllum demersum*), and sago pondweed (*Stuckenia pectinata*). In addition, the survey found two invasive aquatic plant species: Eurasian water milfoil and its hybrid (*Myriophyllum spicatum*) and curly-leaf pondweed (*Potamogeton crispus*). See Table 3 for the list of aquatic plant species that were found in 2014 and for characterization of their abundance and dominance.

With only five different native submerged species of aquatic plants, the 2014 survey concluded that Whitewater Lake has very limited diversity of aquatic species (see Figure 1), especially for a lake of its size. Many lakes in the Region have communities of a dozen or more submergent aquatic plant species. It should be noted that muskgrass (third dominant species) is largely responsible for marl formation. Marl formation reduces lake water phosphorus concentrations through sequestration, which helps improve water quality, demonstrating the valuable ecological service muskgrass provides in Whitewater Lake (See “Issue 2: Water Quality”). Therefore, native plants, such as muskgrass, should be protected to the greatest extent practical.

Studies and surveys conducted on Whitewater Lake reveal that most plant growth is in the shallow Southern Bay of the Lake. In the 2014 survey, of the 323 sites sampled that contained vegetation, 226 locations had southern naiad and 176 sites had elodea (see Appendix A). **Southern naiad and elodea were the most dominant species identified and were primarily located in the South Bay of Whitewater Lake**. Elodea has been identified to grow to a “nuisance” level in Whitewater Lake, which is a concern to Lake residents and Lake users when it comes to management of this species. It is important, however, to note that even though a plant grows to a nuisance level and impedes access to a lake, it should not necessarily be *eliminated* or even significantly reduced because it may serve other beneficial functions. For example, southern naiad, muskgrass, and elodea play

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[1]*Nutrient-rich lakes are very common in the Southeastern Wisconsin Region. Soils in Southeastern Wisconsin soils are rich in phosphorus, a key, and oftentimes limiting, plant nutrient.*

[2]*The point-intercept method uses predetermined points arranged in a grid pattern across the entire lake surface as sampling sites. Each site is located using global positioning system (GPS) technology and a single rake haul is taken at that site. A quantitative assessment of the rake fullness, on a scale of zero to three, is then made for each species identified. Further details on the methodology can be found in Wisconsin Department of Natural Resources, Publication No. PUB-SS-1068,* Recommended Baseline Monitoring of Aquatic Plants in Wisconsin: Sampling Design, Field and Laboratory Procedures, Data Entry and Analysis, and Applications, *2010.*

[3]*SEWRPC conducted the aquatic plant survey during July 2014 following chemical herbicide treatments applied in May 2014. Aquatic plant data results may have differed if no treatments were completed.*

Table 3

ABUNDANCE DATA FOR AQUATIC PLANT SPECIES IN WHITEWATER LAKE: JULY 2014 vs. SEPTEMBER 2015[a]

Aquatic Plant Species	Native or Invasive	Number of Sites Found		Frequency of Occurrence[b]		Relative Density[c]		Dominance Value[d]	
		2014 (Percent)	2015 (Percent)	2014	2015	2014	2015	2014	2015
Submerged Plants									
Najas guadalupensis (Southern naiad)......	Native	226 (40.0)	281 (63.0)	74.59	90.94	1.88	1.58	140.59	144.01
Elodea canadensis (Elodea)..................	Native	176 (29.6)	112 (24.4)	58.09	36.25	1.64	1.06	95.05	38.51
Myriophyllum spicatum (Eurasian water milfoil and hybrid)	**Invasive**	126 (21.2)	89 (19.4)	41.58	28.80	1.20	1.15	49.83	33.01
Chara spp. (Muskgrass)............	Native	37 (6.2)	12 (2.6)	12.21	3.56	1.54	1.18	18.81	4.21
Ceratophyllum demersum (Coontail)................	Native	12 (2.0)	38 (8.3)	3.96	12.30	1.92	1.34	7.59	16.50
Potamogeton crispus (Curly-leaf pondweed)..............	**Invasive**	14 (2.4)	- -	4.62	- -	1.00	- -	4.62	- -
Stuckenia pectinata (Sago pondweed)..............	Native	12 (2.0)	32 (7.0)	3.96	10.36	1.67	1.03	2.64	10.68
Nitella spp. (Nitella)...................	Native	- -	1 (0.2)	- -	0.32	- -	2.00	- -	0.65
Heteranthera dubia (Water stargrass).....	Native	- -	1 (0.2)	- -	0.32	- -	1.00	- -	0.32
Potamogeton pusillus (Small pondweed)..............	Native	- -	1 (0.2)	- -	0.32	- -	1.00	- -	0.32

NOTE: Samples were collected at 595 sites during 2014. Of these 595 sites, 323 (54%) were vegetated. During 2015, samples were collected at 459 sites; 309 of which (67%) were vegetated.

[a]*Approximately 88.8 acres were treated with Endothall and 2,4-D chemical herbicides during 2014. Approximately 153.4 acres were treated with the same chemical during 2015. In addition, 11.9 acres of navigation lanes were treated with the chemical herbicide Reward on June 18, 2015.*

[b]*The **frequency of occurrence** is the number of sampling sites where a species is found divided by the number of sampling sites with vegetation as is expressed as a percentage.*

[c]*The **relative density** is the sum of rake full ratings for a species divided by the number of sampling points with vegetation.*

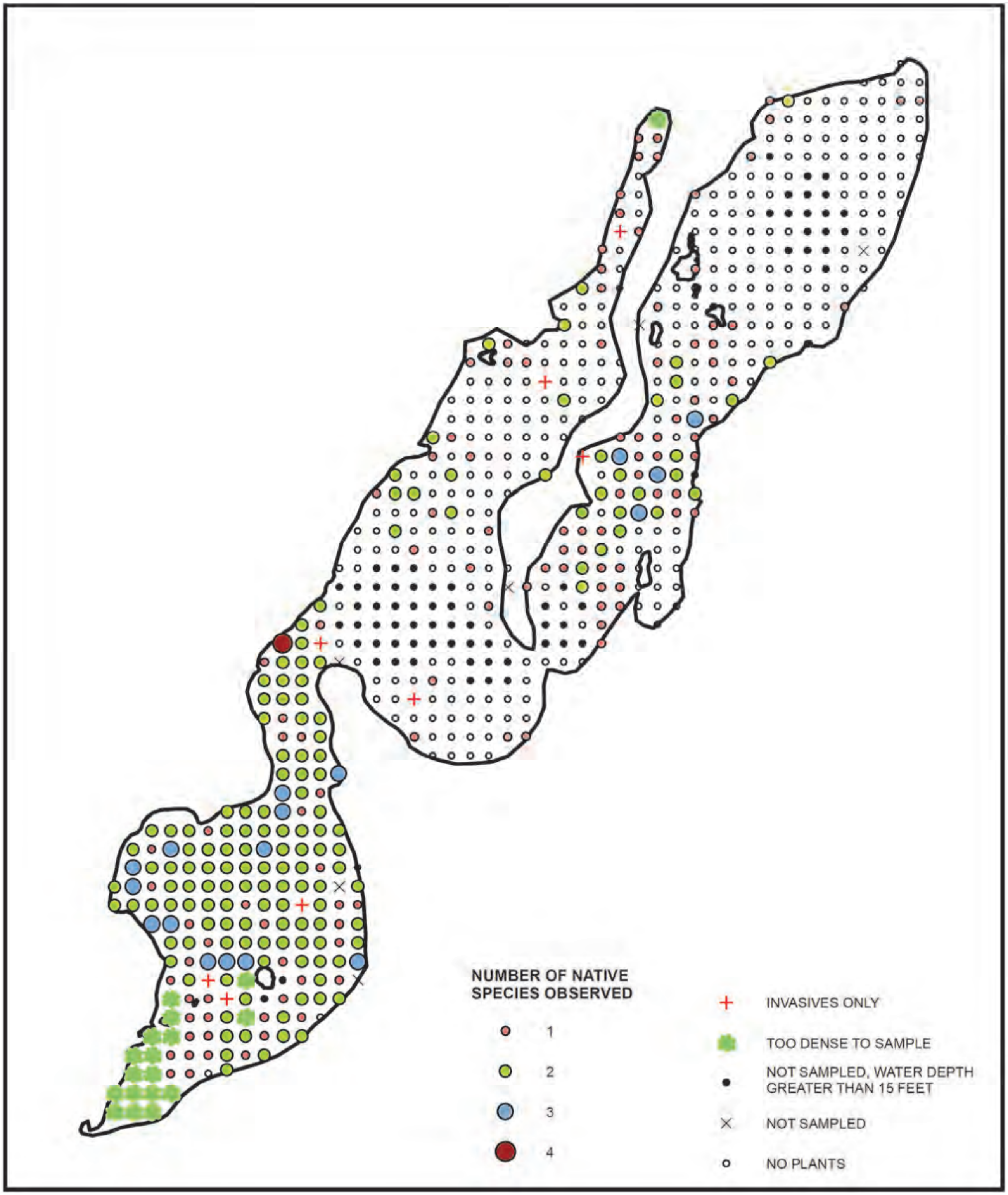
[d]*The **dominance value** of a species is derived from a combination of how often it was observed at sampling sites that had some kind of vegetation present and its relative density at those sites. It provides an indication of the prevalence of a species within an aquatic plant community.*

Source: WDNR and SEWRPC.

a major role in providing shade, habitat, and food for fish and other important aquatic organisms. These plant species also play a significant role in reducing shoreline erosion since they can dampen waves that could otherwise damage shorelines. Additionally, the shade that these plants provide helps reduce growth of undesirable plants such as Eurasian water milfoil and curly-leaf pondweed. Given these benefits, removal of native plants that may be perceived as a nuisance should be avoided when developing plans for aquatic plant management.

Figure 1

AQUATIC PLANT SURVEY SITES AND SPECIES RICHNESS IN WHITEWATER LAKE: JULY 2014



Note: The above diagram presents the number of species observed in Whitewater Lake at each sampling site during the 2014 aquatic plant survey. Sampling occurred at 595 sampling sites, 323 had vegetation. Samples were collected between July 1 and July 11, 2014.

Source: WDNR and SEWRPC.

In addition to native plants, the 2014 survey revealed that **the invasive species Eurasian water milfoil *(Myriophyllum spicatum)* and its hybrid was, overall, the third most dominant aquatic plant species**, and was primarily an issue in the Southern Bay area. Figure 2 shows the distribution and density of the Eurasian water milfoil infestation in Whitewater Lake. Eurasian water milfoil has been known to cause severe recreational use problems in Southeastern Wisconsin Region lakes since it can grow to the water surface and can displace native plant species. These results indicate that the Lake has abundance levels of both native and invasive plants, particularly in the South Bay, that deter recreational use, thereby warranting aquatic plant management.

The *nonnative* aquatic plant **curly-leaf pondweed *(Potamogeton crispus)*** was also identified. Figure 3 shows the distribution and density of curly-leaf pondweed infestation in Whitewater Lake. In the spring, curly-leaf pondweed can interfere with recreational use of a lake by forming dense mats at the water's surface, and it can displace native aquatic plants. By mid-summer, curly-leaf pondweed starts to die off causing plant fragments to accumulate on shorelines.[4] The 2014 plant survey was completed in July, and may not fully represent the abundance of curly-leaf pondweed present earlier in the summer and during spring. As a result, there is likely a need to actively control the curly-leaf pondweed population.

The terms "nonnative" and "invasive" are often confused and incorrectly assumed to be synonymous. Nonnative is an overarching term describing living organisms introduced to new areas beyond their native range with intentional or unintentional human help. Nonnative species may not necessarily harm ecological function or human use values in their new environments. Invasive species are the subset of nonnative species that have damaging impacts on the ecological health of their new environments and/or are considered a nuisance to human use values. In summary, **invasive species are non-native but not all non-native species are invasive**.

Introducing invasive species, either plants or animals, can severely disrupt both terrestrial and aquatic natural systems. **Invasive species reproduce prolifically and often have no natural predators to control their growth, factors that allow them to outcompete native species for space and other necessary resources. This can have devastate on native species that depend on the availability of native plants and animals**.

Wisconsin Department of Natural Resources (WDNR) 2015 Aquatic Plant Survey

The WDNR conducted an aquatic plant survey on Whitewater Lake during September 2015 using the point-intercept method. This survey was conducted to better understand the effectiveness and impacts of the continued use of chemical herbicides Endothall and 2,4-D on exotic aquatic plant species. Both chemical herbicides were used in combination during the previous spring to help control Eurasian and hybrid water milfoil populations. Of the 459 sites sampled in Whitewater Lake in 2015, 309 had vegetation (see Figure 4). Table 3 shows a comparison of SEWRPC's 2014 field survey to WDNR's 2015 field survey data. Both surveys used the point-intercept method, allowing comparison of species dominance values, or relative density. According to the Table 3 data, the dominance of elodea, Eurasian water milfoil (and its hybrid), and muskgrass decreased. Conversely, southern naiad, coontail, and sago pondweed increased in dominance. Furthermore, three additional native plant species were identified in 2015 including nitella (*Nitella spp*.), water stargrass (*Heteranthera dubia*), and small pondweed (*Potamogeton pusillus*).

Most aquatic plants continue to grow throughout the summer which means that rake fullness measurements can increase as summer progresses. Exceptions exist. For example, invasive curly-leaf pondweed grows aggressively during spring and early summer, but senesces (i.e., dies back) by midsummer, a factor that must be considered when comparing plant abundance data from different months. Studies have shown that although certain plant community parameters (e.g. rake fullness and total biomass) may change as the season progresses, the presence of species is

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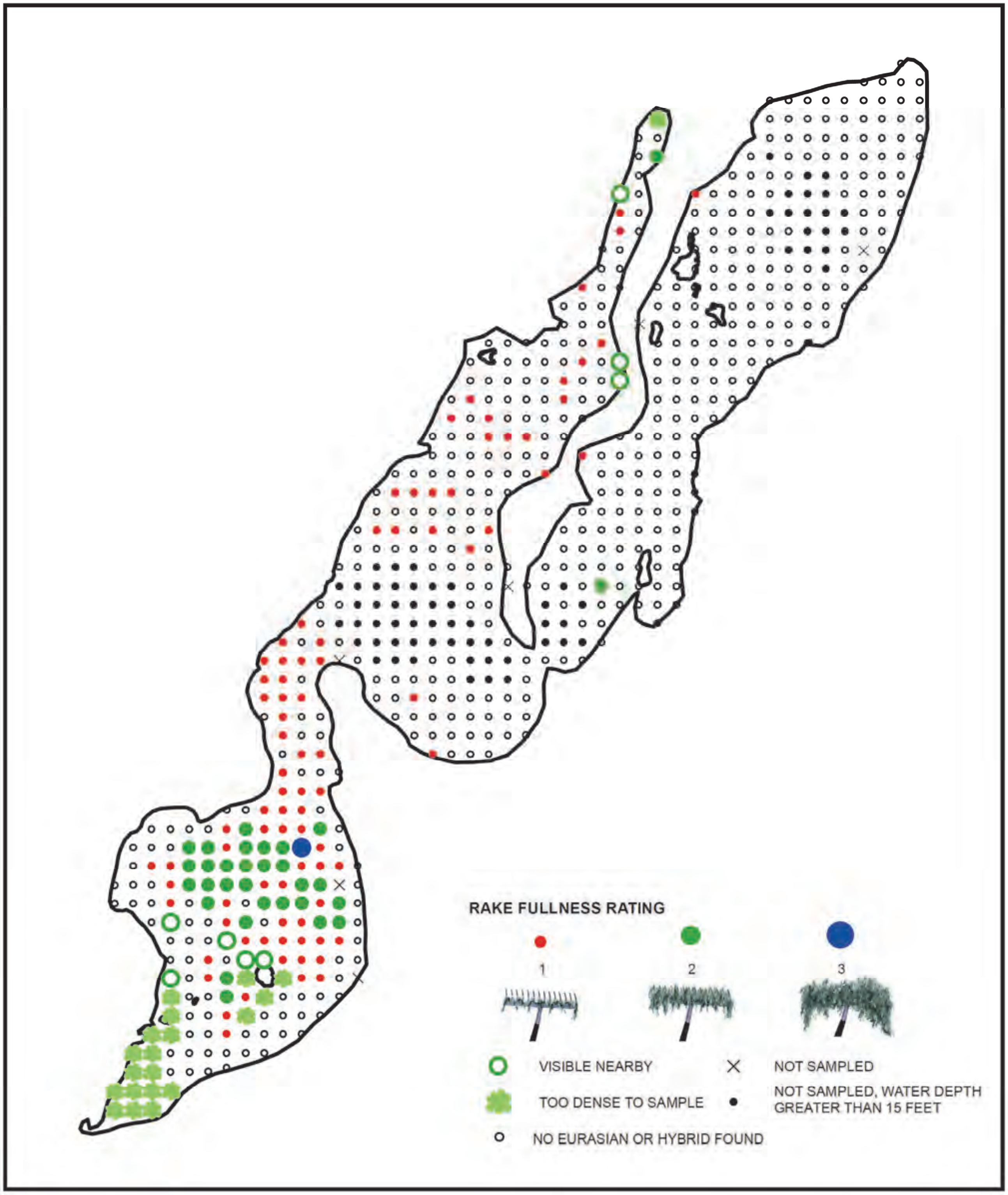
[4]*Curly-leaf pondweed has an early, abbreviated growing season. It usually starts growing in early spring and starts to die by mid-summer.*

Figure 2

EURASIAN AND HYBRID WATER MILFOIL OCCURRENCE IN WHITEWATER LAKE: JULY 2014

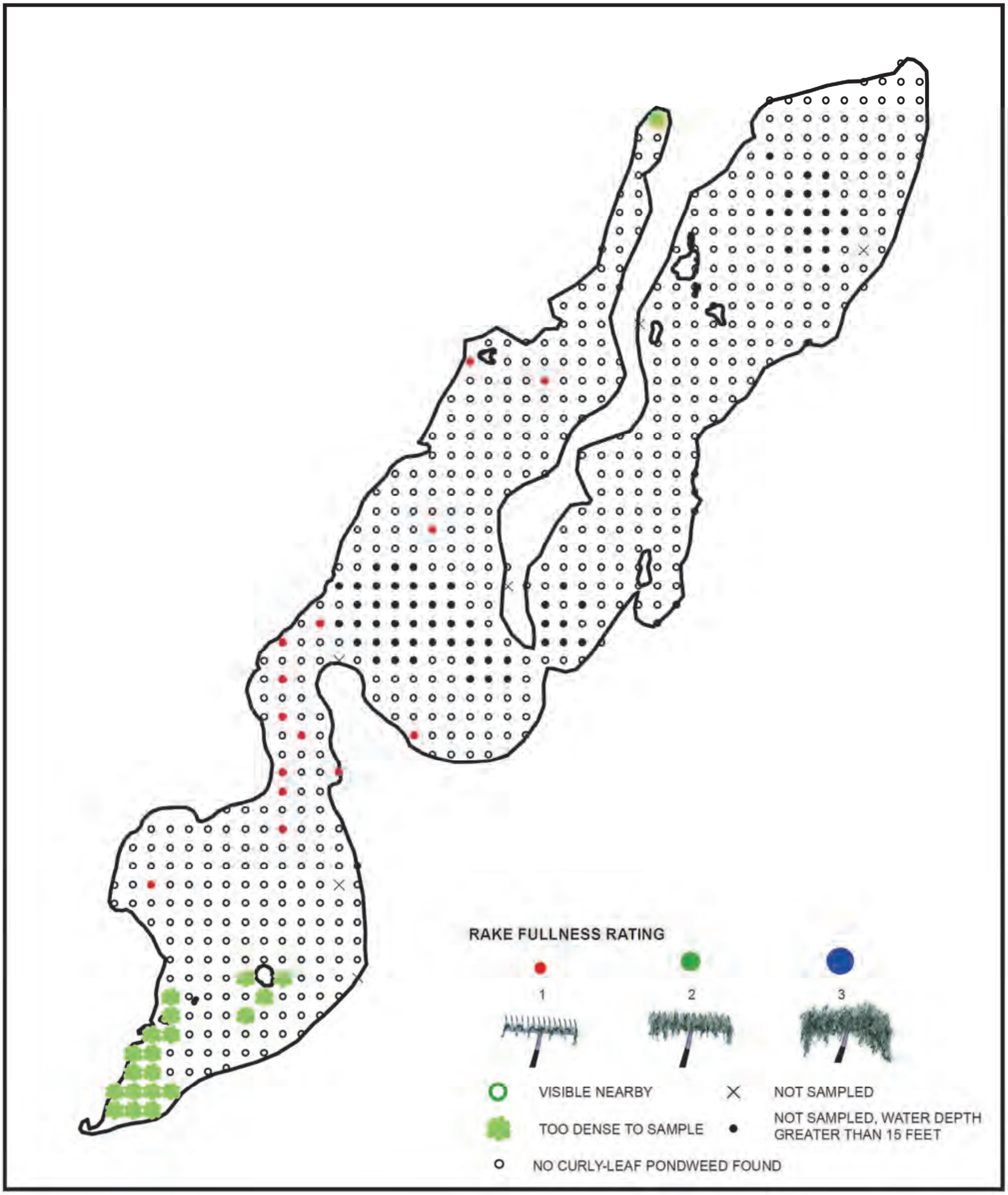


Note: Samples were collected between July 1 and July 11, 2014.

Source: WDNR and SEWRPC.

Figure 3

CURLY-LEAF PONDWEED OCCURRENCE IN WHITEWATER LAKE: JULY 2014

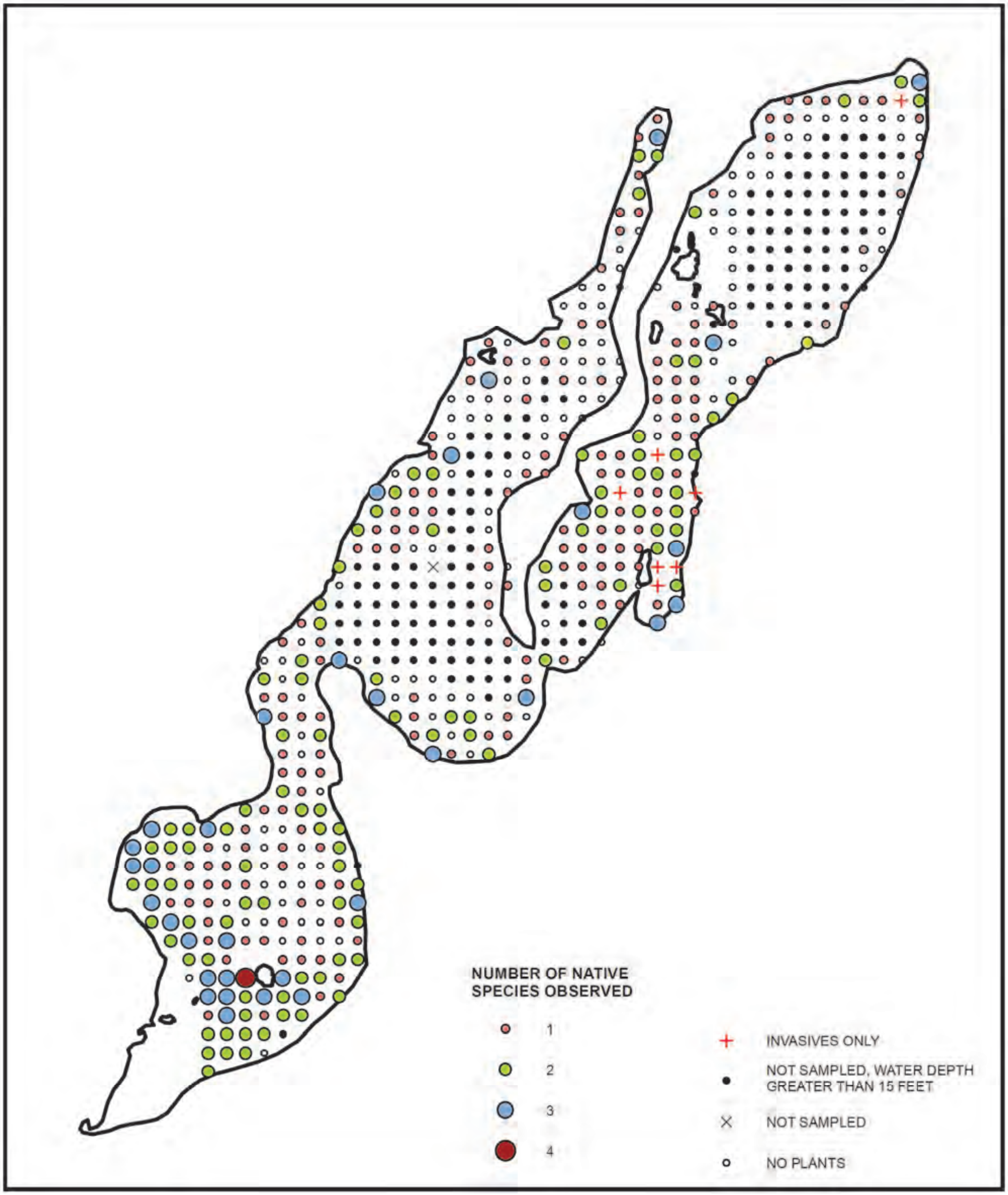


Note: Samples were collected between July 1 and July 11, 2014.

Source: WDNR and SEWRPC.

Figure 4

AQUATIC PLANT SURVEY SITES AND SPECIES RICHNESS IN WHITEWATER LAKE: SEPTEMBER 2015



NOTE: The above diagram presents the data for number of species observed in Whitewater Lake at each sampling site during the 2015 aquatic plant survey; sampling occurred at 459 sampling sites, 309 had vegetation. Samples were collected between September 15 and September 16, 2015.

Source: WDNR and SEWRPC.

generally detectable throughout the growing season.[5] Aquatic plant populations are dynamic and may change year to year. The populations of additional plant species found in the Lakes were small. For this reason, and the documented ability to detect plants during all months, it can be concluded that detection of three additional plant species during 2015 was not related to differing sampling dates, and is instead related to year-to-year variation in plant communities and/or differing herbicide application protocols.

With only a 1.8 percent decrease in Eurasian water milfoil's (and its hybrid) dominance value (see Table 3) it may be implied that chemical herbicides, Endothall and 2,4-D, had little effect on the targeted nonnative aquatic plant species (see Figure 5). However, native plants southern naiad, coontail, and sago pondweed growth did see fluctuate between the 2014 and 2015 growing seasons; this may be due to seasonal fluctuations or the effects of the chemical herbicides used. See Appendix A for comparisons of elodea and muskgrass. Populations of these *native* species were reduced in 2015, especially in the South Bay where a larger area was treated.

WDNR Designated Sensitive Areas

Sensitive Areas, according to WDNR, are identified as sites that have special importance biologically, historically, geologically, ecologically, or even archaeologically.[6] Sensitive Areas of aquatic vegetation offer critical or unique fish and wildlife habitat, including life-cycle critical seasonal or life-stage requirements, or offer water quality or erosion control benefits. Currently, the WDNR designates five Sensitive Areas within Whitewater Lake (see Map 6 and Appendix B) and no Sensitive Areas within Rice Lake. **It is important that WDNR-designated Sensitive Areas are accurately identified and properly managed (WDNR permits required) to preserve ecological value and a healthy aquatic ecosystem**.

Aquatic Plants in Rice Lake

Of the 394 sites shallow enough to be sampled in Rice Lake as part of the SEWRPC July 2014 aquatic plant survey, 105 had vegetation. This survey revealed five *native* submergent aquatic plant species (listed in descending order of abundance): coontail (*Ceratophyllum demersum*), sago pondweed (*Stuckenia pectinata*), elodea (*Elodea canadensis*), white water crowfoot (*Ranunculus longirostris*), and muskgrass (*Chara spp*.), and one *native* emergent aquatic plant species: water smartweed (*Polygonum amphibium*). In addition, the survey found two invasive aquatic plant species: Eurasian water milfoil (*Myriophyllum spicatum*) and curly-leaf pondweed (*Potamogeton crispus*) (see Table 4 for the list of aquatic plant species that were found and for characterization of their abundance and dominance).

The number of types of aquatic plants in Rice Lake, according to the 2014 field survey, was far less than in other lakes in the Southeastern Wisconsin Region. Rice Lake has **limited diversity and abundance of aquatic plant species with only seven submergent plants, two of which are invasive** (see Figure 6). Of the five native plants identified within Rice Lake the two most dominant native species surveyed were coontail and sago pondweed (see Appendix A). <u>The native plants should be protected to the greatest extent practical</u>.

The two *invasive* aquatic plants, **Eurasian water milfoil and curly-leaf pondweed, were among the most dominant plant species** (see Figures 7 and 8, respectively) found in Rice Lake. Eurasian water milfoil and curly-leaf pondweed populations can displace native plant species or drastically alter the habitat that the native plants and animals require, and can interfere with recreational use. However, even with <u>the presence of these two identified invasive species within Rice Lake, the management technique best suited for Rice Lake is to continue to allow these plants to grow to help alleviate internal phosphorus loading through phosphorus sequestration</u>. High phosphorus

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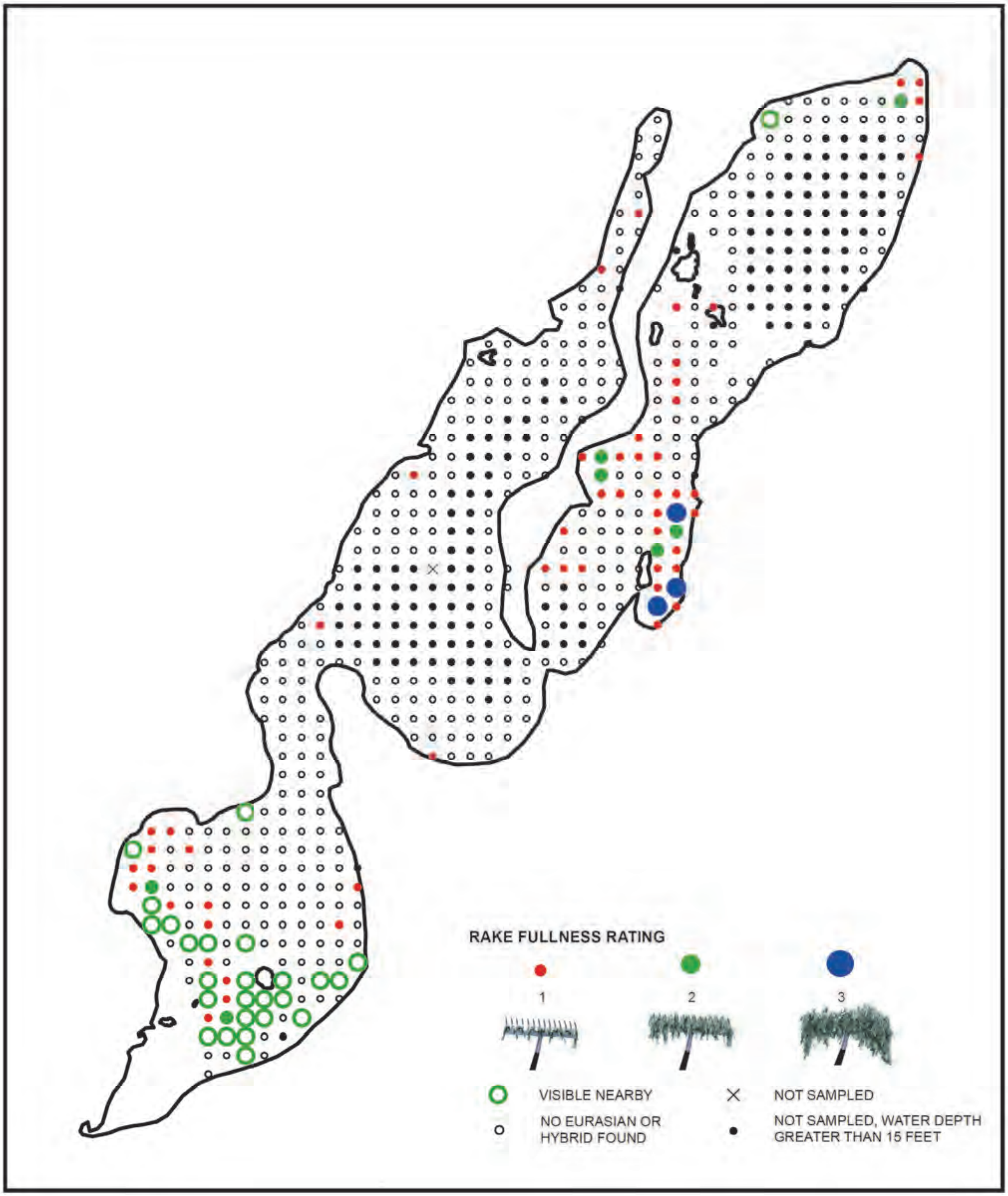
[5]*Madsen, J.D.,* Point intercept and line intercept methods for aquatic plant management. *Aquatic Plant Control* Technical Note MI-02. Army Engineer Waterways Experiment Station, Vicksburg, MS, 1999.

[6]*Areas are identified as Sensitive Areas pursuant to Chapter NR 107 of the* Wisconsin Administrative Code *after a comprehensive examination and study is completed by WDNR staff.*

Figure 5

EURASIAN AND HYBRID WATER MILFOIL OCCURRENCE IN WHITEWATER LAKE: SEPTEMBER 2015

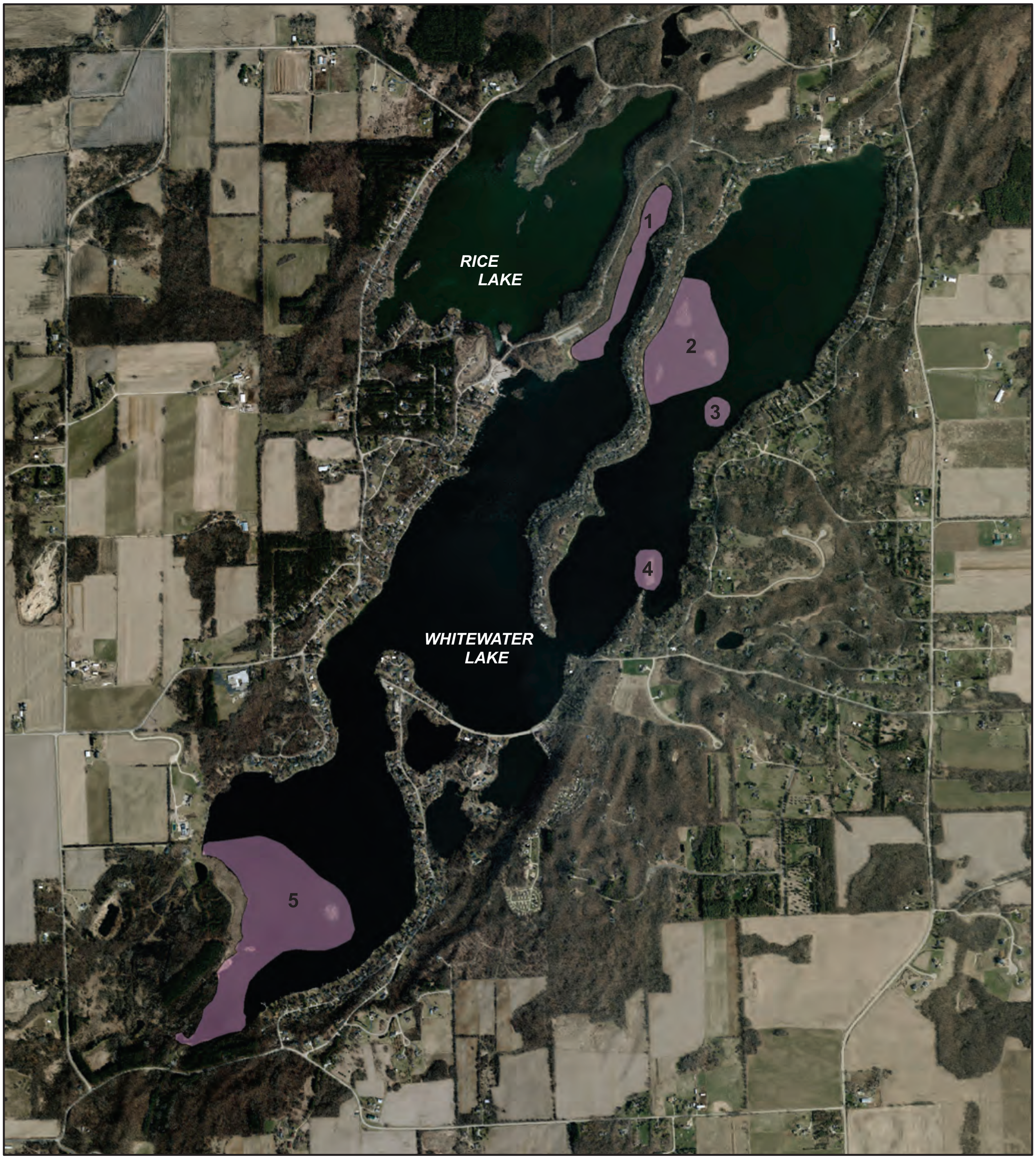


Note: Samples were collected between September 15 and September 16, 2015.

Source: WDNR and SEWRPC.

Map 6

SENSITIVE AREAS WITHIN WHITEWATER LAKE: 2017



5 SENSITIVE AREA AND ID

DATE OF PHOTOGRAPHY: 2015

Source: WDNR and SEWRPC.

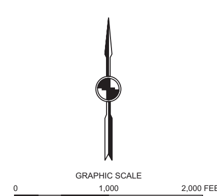


Table 4

ABUNDANCE DATA FOR AQUATIC PLANT SPECIES IN RICE LAKE: JULY 2014

Aquatic Plant Species	Native or Invasive	Number of Sites Found (Percent)	Frequency of Occurence[a]	Relative Density[b]	Dominance Value[c]
Emergent Plants					
Polygonum amphibium (Water smartweed)	Native	7 (1.7)	7.45	1.00	7.45
Submerged Plants					
Myriophyllum spicatum (Eurasian water milfoil)	**Invasive**	62 (15.7)	65.96	2.00	131.91
Ceratophyllum demersum (Coontail)	Native	49 (12.4)	52.13	1.31	68.09
Potamogeton crispus (Curly-leaf pondweed)	**Invasive**	19 (4.8)	20.21	1.11	22.34
Stuckenia pectinata (Sago pondweed)	Native	4 (1.0)	4.26	1.25	5.32
Ranunculus longirostris (White water crowfoot)	Native	2 (0.5)	2.13	2.00	4.26
Elodea canadensis (Elodea)	Native	2 (0.5)	2.13	2.00	4.26
Chara spp. (Muskgrass)	Native	1 (0.2)	1.06	1.00	1.06

NOTE: Sampling occurred at 394 sampling sites; 105 had vegetation.

[a]*The* ***frequency of occurrence*** *is the number of sampling sites where a species is found divided by the number of sampling sites with vegetation as is expressed as a percentage.*

[b]*The* ***relative density*** *is the sum of rake full ratings for a species divided by the number of sampling points with vegetation .*

[c]*The* ***dominance value*** *of a species is derived from a combination of how often it was observed at sampling sites that had some kind of vegetation present and its relative density at those sites. It provides an indication of the prevalence of a species within an aquatic plant community.*

Source: SEWRPC.

concentrations can lead to algal blooms. Rice Lake's internal phosphorus loading and water quality conditions are discussed in more detail in the "Issue 2: Water Quality" section of this chapter.

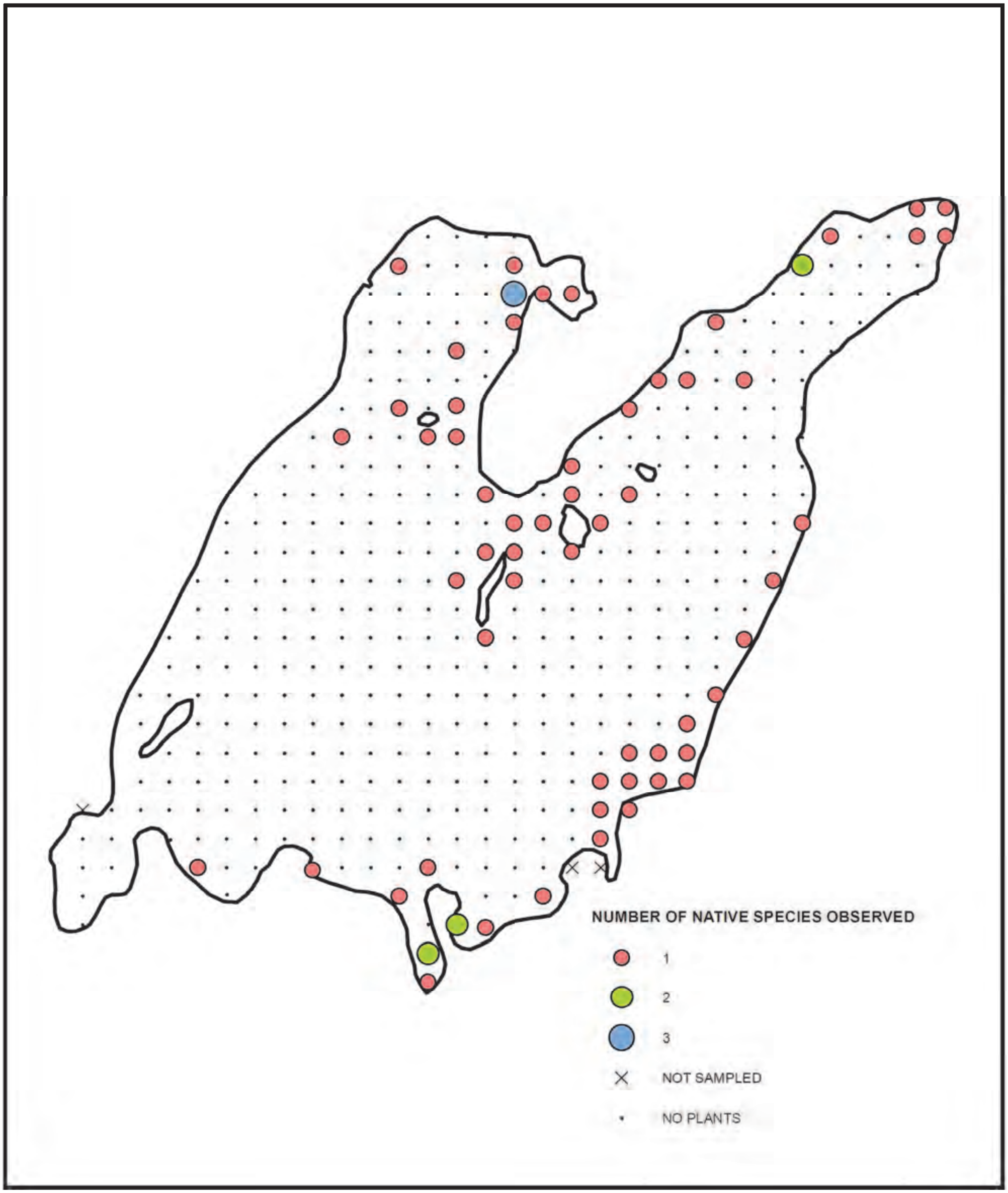
Past and Present Aquatic Plant Inventories

Efforts to manage aquatic plants in Whitewater and Rice Lakes have been ongoing since at least 1950. Prior to 1950, aquatic plant management interventions probably occurred, but the goals and results were not recorded. Aquatic plant surveys for Whitewater Lake were documented by the WDNR in an unknown month in 1973 and July 1988 and by SEWRPC staff in June 1995, July 2008, and July 2014.[7] Aquatic plants in Rice Lake were surveyed by SEWRPC during June 1995, July 2008, and July 2014. Although Rice Lake was not surveyed as part of the WDNR's 1988 survey, field observations by the U.S. Geological Survey (USGS) in 1991 suggest that less than 20

[7]*The 1988 WDNR aquatic plant survey on Whitewater Lake found that ninety-one percent of the Lake was colonized with a nondiverse plant community. About 77 to 96 percent of the plots sampled contained Eurasian water milfoil populations.*

Figure 6

AQUATIC PLANT SURVEY SITES AND SPECIES RICHNESS IN RICE LAKE: JUNE 2014

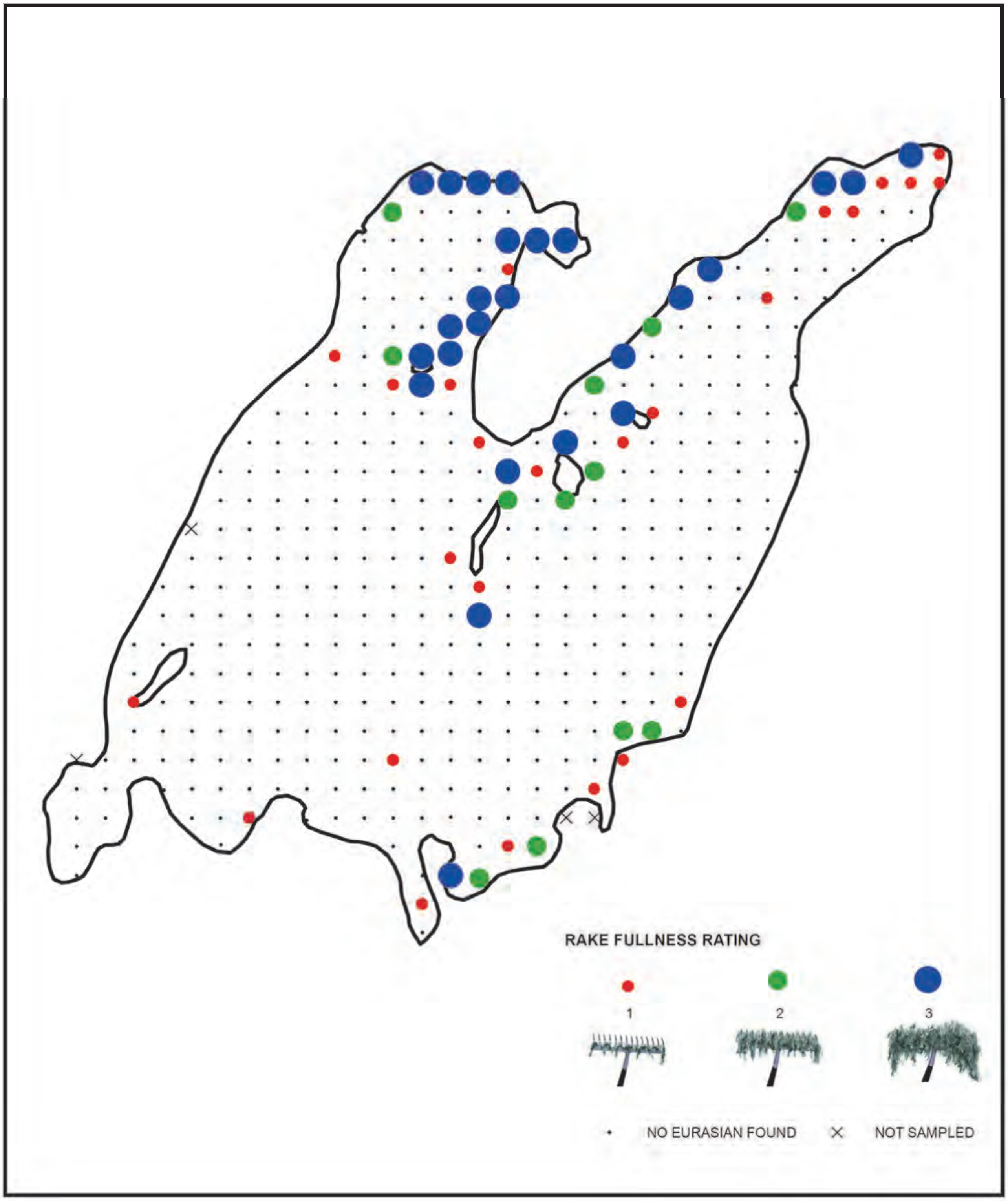


NOTE: The above diagram presents the data for number of species observed in Rice Lake at each sampling site during the 2014 aquatic plant survey; sampling occurred at 394 sampling sites, 105 had vegetation. Note: Samples were collected between June 23 and June 25, 2014.

Source: WDNR and SEWRPC.

Figure 7

EURASIAN WATER MILFOIL OCCURENCE IN RICE LAKE: JUNE 2014

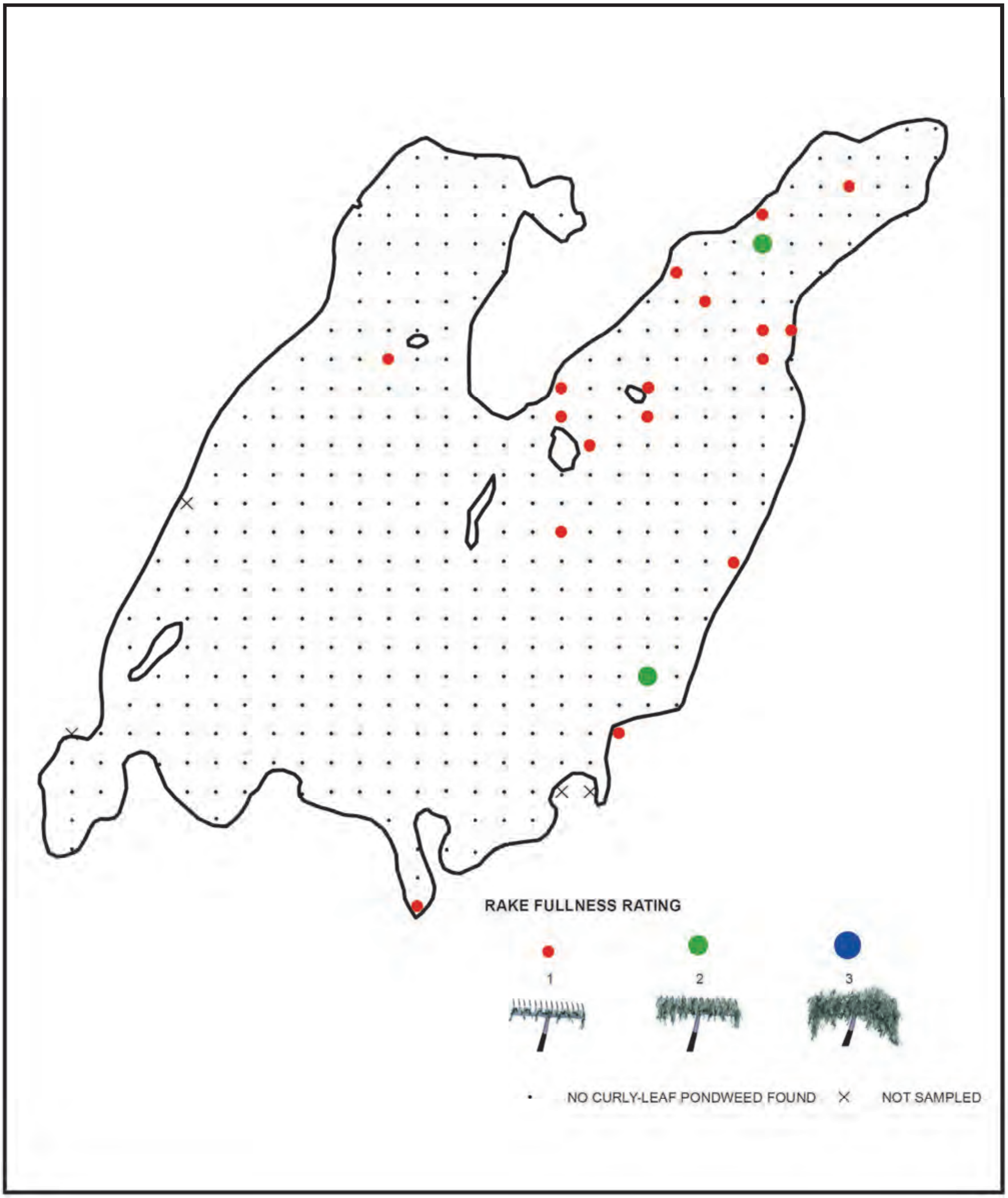


Note: Samples were collected between June 23 and June 25, 2014.

Source: WDNR and SEWRPC.

Figure 8

CURLY-LEAF PONDWEED OCCURENCE IN RICE LAKE: JUNE 2014



Note: Samples were collected between June 23 and June 25, 2014.

Source: WDNR and SEWRPC.

percent of the Lake was colonized with aquatic plants.[8] The aquatic plant surveys conducted on both Lakes prior to 2014 used line-transect methodology,[9] while the 2014 and 2015 field surveys used the point-intercept method. As a result of the use of two different methodologies, a direct comparison of the historical aquatic plant data to the most recent aquatic plant data was not developed. Nevertheless, earlier data does allow comparison of the presence and abundance of particular aquatic plants species observed over time within both Lakes (see Tables 5 and 6). For example, Whitewater Lake, aside from the 1973 field inventory, had similar numbers of species present with an increase in the number observed in 2015. In Rice Lake, the plant community has remained about the same.

Aquatic Plant Management Alternatives for Whitewater and Rice Lake

Several concerns voiced by Lake Residents were discussed during the local consultations including:

1. The general desire for effective Eurasian water milfoil, hybrid water milfoil, and curly-leaf pondweed control;
2. The desire to have navigation lanes through the heavy aquatic plant growth that occurs in the nearshore areas and in the South Bay portion of Whitewater Lake;
3. General questions and concerns about harvesting operations, including: floating, spreading, and transporting plant fragments, plant collection and pickup, and harvesting equipment for future use; and,
4. Overall questions and concerns regarding the efficacy and impacts associated with potential whole-lake chemical herbicide treatment in Whitewater Lake.

Most of these concerns relate to understanding the efficacy of aquatic plant management alternatives and understanding the process behind implementation. Consequently, this section examines each management alternative as it relates to these topics and the risks management alternatives pose to Lake users and native aquatic plant species (which was determined to be a priority, as noted earlier in this chapter). The examination concludes with recommendations for each of the management alternatives.

It is important to note that competing and sometimes conflicting interests and goals commonly occur when it comes to aquatic plant management, because pursuing one particular goal may interfere with accomplishing another important goal. For example, Eurasian water milfoil could be eradicated with heavy chemical treatment. However, since Eurasian water milfoil often *coexists* with native plants, including a very similar looking native milfoil (see Whitewater Lake Figure 9 and Rice Lake Figure 10), this technique would fail to accomplish the goal of preserving native plant populations. Moreover, the presence of hybrid water milfoil is also a factor when trying to eradicate Eurasian water milfoil. Hybrid water milfoil requires a specific chemical concentration to manage it effectively because of its unique genetic make-up. Consequently, all recommendations consider the multiple goals that need to be accomplished under this management plan (e.g., control of hybrid and Eurasian water milfoil, protection of native species, enabling and promoting recreational use of the Lake).

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[8]*U.S. Geological Survey Water-Resources Investigations Report No. 94-410*, Hydrology and Water Quality of Whitewater and Rice Lakes in Southeastern Wisconsin, *1990-1991*.

[9]*The line-transect survey was developed from the grid sampling method of Jesson and Lound (1964). Twenty-five transects approximately 1,000 feet apart were established on a Lake map. Each transect (or line) extended from the shoreline to the maximum rooting depth within the Lake. Four sampling points were established on each transect line at 1.5 feet, 5.0 feet, 9.0 feet, and 11.0 feet. Each sampling point was a six-foot diameter circle. Each circle was divided into four quadrants and sampled with a garden rake.*

Table 5

AQUATIC PLANT SPECIES OBSERVED IN WHITEWATER LAKE: 1973 - 2015

Aquatic Plant Species	1973[a]	July 1988	June 1995	July 2008	July 2014	September 2015
Invasive Aquatic Plants						
Potamogeton crispus (Curly-leaf pondweed)	X	X	X	X	X	- -
Myriophyllum spicatum (Eurasian water milfoil)	X	X	X	X	X	X
Native Aquatic Plants						
Ceratophyllum demersum (Coontail)	X	X	X	X	X	X
Chara vulgaris (Muskgrass)	- -	X	X	X	X	X
Elodea canadensis (Elodea)	X	X	X	X	X	X
Heteranthera dubia (Water stargrass)	- -	- -	X	- -	- -	X
Jussisaea repens (Water Primrose)	- -	- -	- -	- -	- -	- -
Najas flexilis (Slender naiad)	- -	X	- -	X	- -	- -
Najas guadalupensis (Southern naiad)	- -	- -	- -	- -	X	X
Nitella spp. (Nitella)	- -	- -	- -	- -	- -	X
Myriophyllum sibiricum (Northern water milfoil)	- -	- -	X	X	- -	- -
Polygonum amphibian (Water smartweed)	X	- -	- -	- -	- -	- -
Potamogeton pusillus (Small pondweed)	- -	- -	- -	- -	- -	X
Potamogeton zosteriformis (Flat-stem pondweed)	- -	X	X	- -	- -	- -
Stuckenia pectinata (Sago pondweed)	X	X	X	X	X	X
Total Native Species	**4**	**6**	**7**	**6**	**5**	**8**

[a]*The 1973 aquatic plant survey was completed during the summer, but the specific month is unknown.*

Source: WDNR and SEWRPC.

Table 6

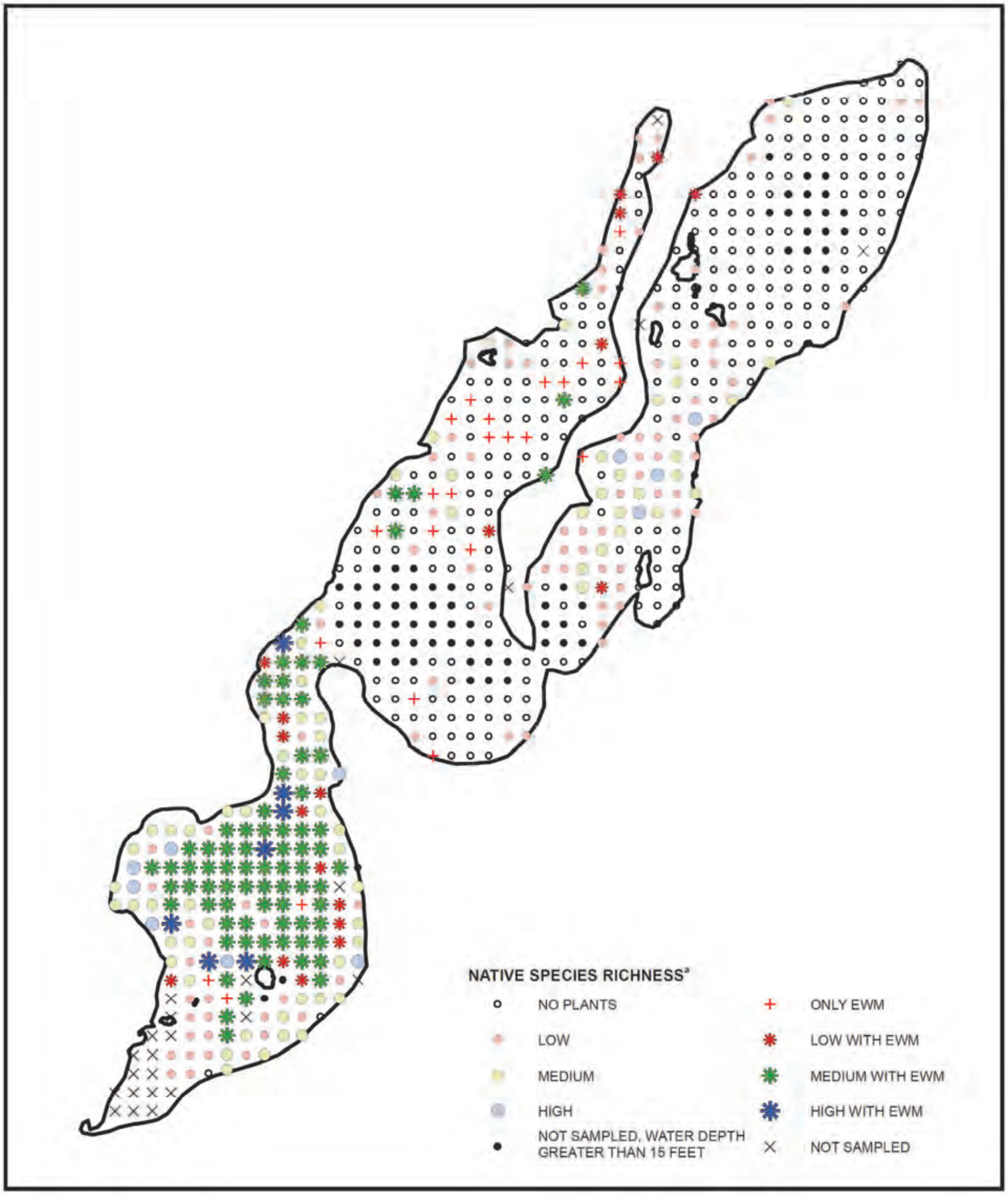
AQUATIC PLANT SPECIES OBSERVED IN RICE LAKE: 1995 – 2014

Aquatic Plant Species	June 1995	July 2008	June 2014
Invasive Aquatic Plants			
Potamogeton crispus (Curly-leaf pondweed)	X	- -	X
Myriophyllum spicatum (Eurasian water milfoil)	X	X	X
Native Aquatic Plants			
Ceratophyllum demersum (Coontail)	X	X	X
Chara vulgaris (Muskgrass)	X	X	X
Elodea canadensis (Elodea)	X	- -	X
Myriophyllum sibiricum (Northern water milfoil)	X	X	- -
Polygonum amphibian (Water smartweed)	- -	X	X
Potamogeton natans (Floating-leaf pondweed)	X	- -	- -
Potamogeton zosteriformis (Flat-stem pondweed)	X	X	- -
Ranunculus longirostris (White water crowfoot)	- -	- -	X
Stuckenia pectinata (Sago pondweed)	X	X	X
Total Native Species	**7**	**6**	**6**

Source: WDNR and SEWRPC.

Figure 9

COINCIDENCE OF EURASIAN WATER MILFOIL WITH NATIVE AQUATIC PLANTS IN WHITEWATER LAKE: JULY 2014

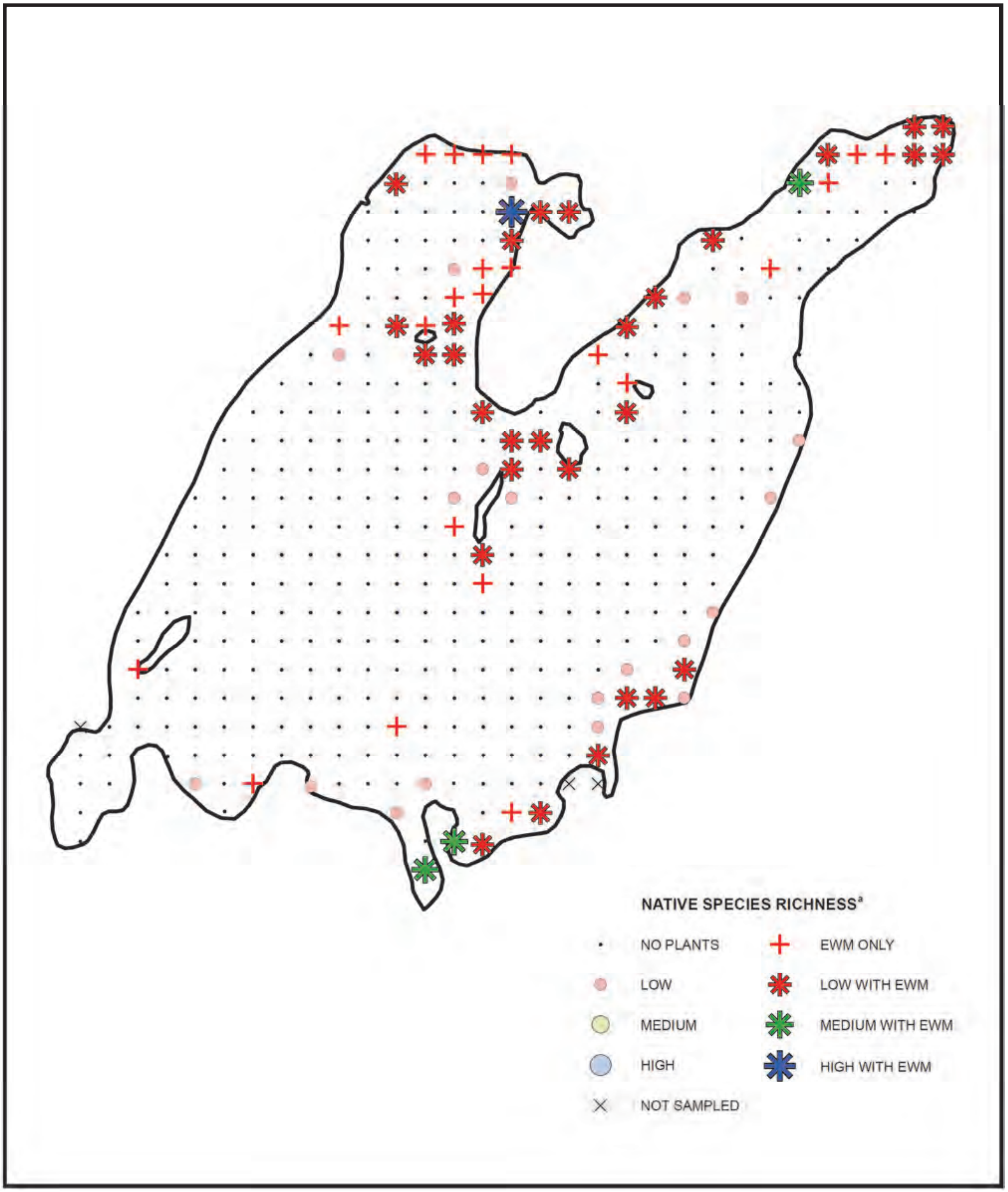


[a]Native species richness refers to the number of native plants present at sampling site: Low=1; Medium=2 or 3; and High=4.
Note: Samples were collected between July 1 and July 11, 2014.

Source: WDNR and SEWRPC.

Figure 10

COINCIDENCE OF EURASIAN WATER MILFOIL WITH NATIVE AQUATIC PLANTS IN RICE LAKE: JUNE 2014



[a]Native species richness refers to the number of native plants present at sampling site: Low=1; Medium=2 or 3; and High=4.
Note: Samples were collected between June 23 and June 25, 2014.

Source: WDNR and SEWRPC.

Aquatic plant management measures can be classified into five groups: 1) ***physical measures***, which include lake bottom coverings; 2) ***biological measures***, which include using organisms, including herbivorous insects; 3) ***manual measures***, which involve the manually removing plants by humans; 4) ***mechanical measures***, which include cutting and removing aquatic plants with a machine known as a harvester or using what is known as suction harvesting; and 5) ***chemical measures***, which include using aquatic herbicides to kill nuisance and nonnative aquatic plants. All of these control measures are stringently regulated. Additionally, most of the alternatives require a State of Wisconsin permit. Chemical controls, for example, require a permit and are regulated under Chapter NR 107 "Aquatic Plant Management," of the *Wisconsin Administrative Code*, while placement of bottom covers, a physical measure, requires a Wisconsin Department of Natural Resources (WDNR) permit under Chapter 30 of the *Wisconsin Statutes*. All other aquatic plant management practices are regulated under Chapter NR 109 "Aquatic Plants: Introduction, Manual Removal and Mechanical Control Regulations," of the *Wisconsin Administrative Code*.

The aquatic plant management elements presented in this section consider alternative management measures consistent with the provisions of Chapters NR 103 "Water Quality Standards for Wetlands," NR 107, and NR 109 of the *Wisconsin Administrative Code*. Further, the alternative aquatic plant management measures are consistent with the requirements of Chapter NR 7 "Recreational Boating Facilities Program," of the *Wisconsin Administrative Code*, and with the public recreational boating access requirements relating to eligibility under the State cost-share grant programs set forth in Chapter NR 1 "Natural Resources Board Policies," of the *Wisconsin Administrative Code*.

Physical Measures

Lake-bottom covers and light screens provide limited control of rooted plants by creating a physical barrier that reduces or eliminates sunlight available to the plants. They are often used to create swimming beaches on muddy shores, to improve the appearance of lakefront property, and to open channels for motor boating. Various materials can be used with varied success rates. For example, pea gravel, which is usually widely available and relatively inexpensive, is often used as a cover material despite the fact that plants readily recolonize areas where it is used. Other options include synthetic materials, such as polyethylene, polypropylene, fiberglass, and nylon, which can provide relief from rooted plants for several years. These materials, known as bottom screens or barriers, generally have to be placed and removed annually, as they are susceptible to disturbance by watercraft propellers and to build-up of gasses from decaying plant biomass trapped under the barriers. In the case of both Whitewater and Rice Lakes, the need to encourage native aquatic plant growth while simultaneously controlling the growth of exotic species, often in the same location, suggests that placing lake bottom covers to control for aquatic plant growth is not viable since it is not consistent with the objective of encouraging native aquatic plant growth.

Biological Measures

Biological controls offer an alternative approach to controlling nuisance plants or exotic plants. Traditional biological control techniques use herbivorous insects that feed upon nuisance plants and have been successful in some southeastern Wisconsin lakes.[10] For instance, a study completed on Whitewater Lake between 1996 until 1997 suggested that the milfoil weevil (*Eurhychiopsis lecontei*) appeared to reduce the abundance of Eurasian water milfoil.[11] According to the study, Eurasian water milfoil declined substantially as the weevil population increased in the study plot areas. However, given that Whitewater Lake has high boat traffic, a highly developed shoreline which limits the existence of leaf-litter habitat (habitat preferred by the weevil), and that this technique is no longer commercially available, using *Eurhychiopsis lecontei* is not considered viable on Whitewater Lake with the possible exception of the southern bay. As for Rice Lake, *Eurhychiopsis lecontei* may be a viable aquatic plant management

[10]*B. Moorman, "A Battle with Purple Loosestrife: A Beginner's Experience with Biological Control,"* Lake Line, *Vol. 17, No. 3, pp. 20-21, 34-37, September 1997; see also, C.B. Huffacker, D.L. Dahlsen, D.H. Janzen, and G.G. Kennedy,* Insect Influences in the Regulation of Plant Population and Communities, *pp. 659-696, 1984; and C.B. Huffacker and R.L. Rabb, editors, Ecological Entomology, John Wiley, New York, New York, USA.*

[11]*Wisconsin Cooperative Fishery Research Unit*, Wisconsin Milfoil Weevil Project, *1999*.

option if the method were to again become commercially available since boating pressure is not as heavy and the presence of leaf-litter habitat is more likely due to the majority of shoreline being undeveloped.

Manual Measures

Manual removal of specific types of vegetation provides a highly selective means of controlling the growth of nuisance aquatic plant species, including hybrid water milfoil, Eurasian water milfoil, and curly-leaf pondweed. There are two common manual removal methods: raking and hand-pulling. Each method is described in the following paragraphs.

Raking is conducted in nearshore areas with specially designed hand tools. This method provides an opportunity to remove nonnative plants in shallow nearshore areas and also provides **a safe and convenient method to control aquatic plants in deeper nearshore waters around piers and docks**. The advantages of raking are that 1) the tools are relatively inexpensive ($100 to $150 each), 2) it is easy to use and generates immediate results, and 3) it immediately remove the plant material (including seeds and plant fragments) from a lake without a waiting period, thereby preventing sedimentation and nutrient release from decomposing plant material and reducing the reproductive ability of target plants. Should Lake residents decide to implement this method of control, an interested party could acquire a number of these specially designed rakes for trail use by the riparian owners. Therefore, to deal with high plant growth in areas where other management efforts are not feasible, raking is considered viable for both Whitewater and Rice Lakes.

The second manual control, hand-pulling of stems where they occur in isolated stands, provides an alternative means of controlling plants such as Eurasian water milfoil and hybrid water milfoil. **This method is particularly helpful when attempting to target nonnative plants in the high growth season, when native and nonnative species often coexist**. This method allows higher selectivity than rakes, mechanical removal, and chemical treatments, and, therefore, results in less loss of native plants. Additionally, physical removal of plant material prevents sedimentation and nutrient release from targeted plants, which can help control water nutrient levels and maintain water depth. Physical removal also reduces the amount of target-plant seeds and plant fragments, reducing the ability of target-plants to reproduce. Given these advantages, manual removal of Eurasian and hybrid water milfoil and curly-leaf pondweed through hand-pulling is considered a viable option in both Whitewater and Rice Lakes where practical. It could be employed by volunteers or homeowners, as long as they are trained to properly identify Eurasian water milfoil, its hybrid, and curly-leaf pondweed. WDNR provides a wealth of guidance materials, including an instructional video on manual plant removal. These guidance materials will be valuable to the residents of the Lakes if this management alternative is implemented.

Pursuant to Chapter NR 109 of the *Wisconsin Administrative Code* (NR 109), **both raking and hand-pulling of aquatic plants are allowed without a permit** under the following conditions:

- Eurasian water milfoil, curly-leaf pondweed, and purple loosestrife may be removed if the native plant community is not harmed in the process.
- Thirty feet or less of shoreline may be cleared, however, this total must include docks, piers, boatlifts, rafts, and areas undergoing other plant control treatment. Vegetation may generally be removed up to 100 feet out from the shoreline.
- Plant materials that drift onto the shoreline may be removed.
- The shoreline is not a designated sensitive area.

Special procedures must be followed if wild rice is present, however, wild rice is not likely to be present in these Lakes. All raked or pulled plant material must be removed from the lake. **An NR 109 harvesting permit is required for manual removal of aquatic plants in WDNR-designated Sensitive Areas. Any other manual removal would require a State permit, unless employed to control designated nonnative/invasive species**, such as Eurasian water milfoil. In general, State permitting requirements for manual aquatic plant removal call for all hand-pulled material to be removed from the lake. **No mechanical equipment may be legally used without a WDNR-issued permit (i.e., dragging equipment such as a rake behind a motorized boat or the use of weed rollers)**.

Mechanical Measures

Though other mechanical harvesting methods exist, the use of a harvester (mechanical harvesting) and suction harvesting are the two methods that are currently permitted and employed in Wisconsin. Consequently, the following paragraphs specifically focus on these two measures.

Traditional Harvesting

Aquatic plants can be harvested mechanically with specialized equipment known as harvesters. This equipment consists of an apparatus that cuts below the water surface and a collection system (e.g., a conveyor and a basket) that picks up the majority of the cut plants. Mechanical harvesting can be a practical and efficient means of controlling sedimentation, as well as plant and algal growth, as it removes the plant biomass, which would otherwise decompose and release nutrients into a lake. Mechanical harvesting is particularly effective for large-scale plant growth.

An advantage of mechanical harvesting is that the harvester, when properly operated, “mows” aquatic plants and, therefore, typically **leaves enough plant material in a lake to provide shelter for aquatic wildlife and to stabilize lake-bottom sediments**. Aquatic plant harvesting also has been shown to facilitate growth of native aquatic plants by allowing more light to penetrate to the lakebed. Finally, harvesting does not kill native plants in the way that other control methods do. Instead, this method simply cuts them back.

A disadvantage of mechanical harvesting is that the **harvesting operations may fragment plants and, thus, unintentionally facilitate spread of Eurasian water milfoil**, a plant that utilizes fragmentation as a means of propagation, particularly in areas where plant roots have been removed. This <u>further emphasizes the need to prevent harvesting that removes the roots of native plants</u>. Harvesting may also disturb bottom sediments in shallow areas, increasing turbidity and resulting in deleterious effects such as smothering of fish breeding habitat and nesting sites. Disrupting bottom sediments also could increase the risk of nonnative species recolonization, as these species tend to thrive on disturbed bottom sediment. To this end, **most WDNR-issued permits do not allow deep-cut harvesting in areas having a water depth of less than three feet**,[12] which limits the utility of this alternative in some littoral areas. Nevertheless, if done correctly and carefully, and employed under suitable conditions, harvesting can benefit navigation lane maintenance and can ultimately reduce regrowth of nuisance plants while maintaining native plant communities.

Another disadvantage of harvesting, and a notable concern for Lake residents, is that some cut **plant fragments fairly frequently escape the harvester’s collection system**. Generally, to compensate for this, most harvesting programs include a plant pickup program in which the harvester gathers floating detached plant material, and lakefront property owners rake plant debris onto their docks for later pick-ups. This kind of program, when completed systematically, can reduce plant propagation from plant fragments and can help alleviate the aesthetic consequences of accumulated plant debris on the lake shore.

Given that mechanical harvesting has been actively employed on both Whitewater and Rice Lakes since 1990; that the WRLMD has invested in its own harvesting equipment since 1992; and the WRLMD’s mechanical harvesting has demonstrated the ability to provide navigation lanes, control nuisance and exotic species, and prevent

[12]*Deep-cut harvesting is harvesting to a distance of only one foot from the lake bottom. This is not allowed in shallow areas because it is challenging to properly ensure that the harvester does not hit the lake bottom in these areas.*

sedimentation with minimal damage to the Lake ecosystems, harvesting is considered viable for Whitewater and Rice Lakes. However, if this program is to be employed, plant collection programs to prevent nuisance amounts of aquatic plant fragment accumulation (i.e., elodea fragments) and a training program for all operators should be continued. [13] In addition, the delineated Sensitive Areas in Whitewater Lake need to be identified and verified by the harvesting operator to ensure proper precautions are observed. Furthermore, it is important that the WRLMD continue to maintain expense records of previous and potential costs for Lake management, such as harvesting and harvesting equipment, which includes: labor, fuel, permits, grading, outside services, supplies, future equipment, and repairs (see Tables 7 and 8). Expense records allow the District to budget resources for future management efforts.

Table 7

RECENT WHITEWATER AND RICE LAKES ANNUAL MECHANICAL AQUATIC PLANT HARVESTING COSTS

2010	$20,525
2011	$7,948
2012	$37,278
2013	$42,687
2014	$53,337
2015	$53,014
2016	$46,795

Source: WRLMD and SEWRPC.

Table 8

WHITEWATER AND RICE LAKES PROJECTED MECHANICAL HARVESTING COSTS

2017	$65,000
2018	$68,000
2019	$72,000

Source: WRLMD and SEWRPC.

Suction Harvesting

An alternative aquatic plant harvesting method has emerged called Diver Assisted Suction Harvesting (DASH). DASH, also known as suction harvesting, is a mechanical process where divers identify and pull select aquatic plants by their roots from the lake bed and then insert the entire plant into a suction hose that transports the plant to the lake surface for collection and disposal. The process is essentially a more efficient method for hand-pulling plants within a lake. This method was first permitted in Wisconsin in 2014. However, such labor-intensive work by skilled professional divers is, at present, a costly undertaking and long-term evaluations will need to take place to determine the efficacy of the technique. Nevertheless, there are many apparent advantages associated with this method, including: 1) **lower potential to fragment plants** when compared to traditional harvesting and hand-pulling, thereby reducing the spread and regrowth of invasive plants like Eurasian water milfoil; 2) **increased selectivity of plant removal** when compared to traditional harvesting, thereby reducing the loss of native plants; and 3) **lower frequency of fish habitat disturbances**. Given these advantages, DASH is considered a viable option for both Whitewater and Rice Lakes, especially for pier areas, and in areas where Eurasian water milfoil (and its hybrid) and curly-leaf pondweed are present among native plants, subject to permit requirement and provisions. The cost of using suction harvesting as a means of management is variable and depends on the range and acreage of the project areas as well as other factors. Additionally, plant density, shoreline access, disposal issues and selectivity by WDNR are all considerations that need to be evaluated to ensure that the potential use of DASH is a feasible management alternative for Whitewater and Rice Lakes.

Both mechanical harvesting and suction harvesting are regulated by WDNR and require a permit. Non-compliance with permit requirements is legally enforceable and may lead to fines and/or complete permit revocation. The information and recommendations provided in this report will help frame permit requirements. Permits can be

[13]*WDNR staff have offered to host this training session to ensure that all harvester operators are aware of the terms of the harvesting permit.*

granted for up to a five-year period.[14] At the end of that period, a new plant management plan will need to be developed to assess the success of completed management techniques and efforts. The updated plan should be based on a new aquatic plant survey and should evaluate the plant management activities that occurred in the Lake since the previous plan was completed.[15] These plans and plan execution are overseen by the WDNR aquatic invasive species coordinator for the region.[16] Recommendations are included in Chapter III.

Chemical Measures

Chemical treatment with herbicides is a short-term method for controlling heavy nuisance aquatic plant growth.[17] Chemicals are applied to growing plants in either liquid or granular form. The advantages of using chemical herbicides to control aquatic plant growth are relatively low cost, as well as the ease, speed, and convenience of application. Disadvantages associated with chemical control include:

1. **Unknown and/or conflicting evidence about long-term harm on fish, fish food sources, and humans**—Chemicals approved by the U.S. Environmental Protection Agency to treat aquatic plants have been studied to rule out short-term (acute) effects on humans and wildlife. Additionally, some studies also evaluate long-term (chronic) effects of the chemical on animals (e.g., the effects of being exposed to these herbicides on an annual basis). However, it is often impossible to conclusively state that there will be no long-term effects due to the constraints of animal testing, time constraints, and other issues. Additionally, long-term studies have not been completed on all potentially affected species,[18] and conflicting studies/opinions exist regarding the role of the chemical 2,4-D as a carcinogen in humans.[19] Appendix C has additional facts on the herbicide 2,4-D. Some lake property owners judge the risk of using chemicals as being too great, despite legality of use. Consequently, the concerns of lakefront owners should be considered whenever chemicals are used. Additionally, if chemicals are used, they should be used as early in the recreational season as practical and possible, which in turn allows time for treatment chemicals to decompose before swimmers and other lake users begin to actively use the Lakes.[20]

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[14]*Five-year permits are granted so that a consistent aquatic plant management plan can be implemented over that time. This process allows the aquatic plant management measures that are undertaken to be evaluated at the end of the permit cycle.*

[15]*Aquatic plant harvesters must report harvesting activities as a part of the permit requirements.*

[16]*Information on the current aquatic invasive species coordinator can be found on the WDNR website.*

[17]*A short-term method is defined in this report as a method that gives quick and immediate results but does not attend to issues that, when addressed, could provide relief over many years, such as reducing overall nutrient input to a lake through the use of best management practices along shoreline properties, thereby reducing overall nuisance growth of plants and algae.*

[18]*U.S. Environmental Protection Agency*, EPA-738-F-05-002, 2,4-D RED Facts, *June 2005*.

[19]*M.A. Ibrahim, et al., "Weight of the Evidence on the Human Carcinogenicity of 2,4-D,"* Environmental Health Perspectives, *Volume 96, pp. 213-222, December 1991.*

[20]*Though the labels allow swimming in 2,4-D-treated lakes after 24 hours, it is possible that some swimmers may want more of a wait time to ensure that they receive less exposure to the chemical. Consequently, allowing for extra time is recommended so that residents and Lake users can feel comfortable that they are not being unduly exposed.*

2. **A risk of increased algal blooms due to nutrient release and suppressed macrophyte competition**—Water borne nutrients promote growth of aquatic plants and algae in lakes. Generally, if plants are not the primary users of nutrients, algae abundance tends to increase. Action must be taken to avoid excessive chemical use and loss of native plants, particularly if fish populations are to be maintained at a healthy level (fish require aquatic plants for food, shelter, and oxygen). Further details on this topic are discussed in the "Issue 3: Cyanobacteria and Floating Algae" section of this chapter.

3. **A potential increase in organic sediments, as well as associated anoxic conditions that can stress aquatic life and cause fish kills**—When chemicals are used on large mats of aquatic plants, the dead plant material generally settles to the bottom of a lake and subsequently decomposes. This process leads to an accumulation of organic-rich sediment. Oxygen can be depleted in the deep areas of a lake as bacteria use oxygen to decompose plant remains. Stratified lakes, such as Whitewater Lake, are particularly vulnerable to oxygen depletion in deep portions of the lake. Resultant low oxygen conditions can trigger processes that release phosphorus from bottom sediment, further increasing lake nutrient levels. Furthermore, extensive loss of oxygen can potentially create conditions that inhibit a lake's ability to support fish, a situation leading to stressed fish or fish kills. These concerns emphasize the need to limit chemical control to early spring, when Eurasian water milfoil has not yet formed dense mats.

4. **Adverse effects on desirable aquatic organisms due to loss of native species**—Native plants, such as pondweeds, provide food and spawning habitat for fish and other wildlife. Consequently, if native plants are unintentionally lost due to chemical application, fish and wildlife populations often suffer. Consequently, if chemical application occurs, only chemicals that preferentially target Eurasian water milfoil (and its hybrid) and curly-leaf pondweed should be used. Such chemicals should be applied in early spring when native plants have not yet emerged.

5. **A need for repeated treatments due to existing seed banks and/or plant fragments**—As mentioned previously, chemical treatment is not a one-time solution. The fact that the plants are not specifically removed from the lake increases the possibility for seeds/fragments to remain in the lake after treatment, thereby allowing for a resurgence of the species the next year. Additionally, leaving large areas void of plants (both native and invasive) creates an unnatural disturbed area (i.e., an area without *any* established plant community). Eurasian water milfoil tends to thrive in such areas. In short, chemically treating large areas can leave opportunities for reinfestation which in turn necessitates repeated herbicide applications.

6. **Hybrid water milfoils resistance to chemical treatments**—Hybrid water milfoil complicates management since research suggests that certain strains may have higher tolerance to commonly utilized aquatic herbicides such as 2,4-D and Endothall. Subsequently, further research on the efficacy and impacts of herbicides on hybrid water milfoil needs to be conducted to better understand the appropriate dosing applied within lakes.

As discussed earlier, other factors complicate chemical application to lakes, namely the intermixed growth of Eurasian water milfoil with native species, the physical similarities between Northern (native) and Eurasian water milfoil, and the presence of hybrid Eurasian water milfoil. However, **due to the tendency for Eurasian water milfoil to grow early in the season, *early spring* chemical application is an effective way to target this plant while minimizing impact to desirable native plants**. Early spring application has the advantage of being more effective due to the colder water temperatures, a condition enhancing herbicidal effects and reducing the dosing needed for effective treatment. As discussed above, early spring treatment reduces human exposure (swimming is not particularly popular in very early spring) and limits the potential for collateral damage to native species.

Another factor to consider is the way Whitewater and Rice Lakes have reacted to **previous chemical treatments**. Aquatic herbicides have been applied to both Whitewater and Rice Lakes for over 50 years, as shown in Tables 9 and 10. Copper sulfate, an algae herbicide, was the main chemical sprayed into Whitewater Lake from 1950 until

Table 9

CHEMICAL CONTROL OF AQUATIC PLANTS IN WHITEWATER LAKE: 1950-2015

		Algae Control			Macrophyte Control					
Year	Total Acres Treated	Copper Sulfate (pounds)	Blue Vitriol (pounds)	Cutrine or Cutrine Plus (pounds)	Sodium Arsenite (pounds)	2,4-D (gallons)	Diquat (gallons)	Glyphosate (gallons)	Endothall/ Aquathol (gallons)	Reward (gallons)
1950-1969	- -	55,920	- -	- -	55,920[a]	- -	- -	- -	- -	- -
1968	- -	- -	- -	- -	- -	- -	- -	- -	64.2	- -
1969	- -	- -	- -	- -	- -	- -	- -	- -	150 lbs.	- -
1970	119.0	1,500	- -	- -	- -	- -	- -	- -	45.0	- -
1971	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
1972	108.0	1,300	- -	- -	- -	- -	- -	- -	- -	- -
1973	137.5	1,895	- -	- -	- -	- -	- -	- -	- -	- -
1974	65.0	1,850	- -	- -	- -	- -	- -	- -	- -	- -
1975	60.0	2,525	- -	- -	- -	- -	- -	- -	- -	- -
1976-1983	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
1984	8.9	- -	- -	- -	- -	42.5	- -	- -	15.0	- -
1985-1986	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
1987	0.9	- -	- -	2.0 gal.	- -	- -	- -	- -	2.0	- -
1988	3.4	- -	- -	2.5 gal.	- -	2.0	0.5	- -	1.0	- -
1989	5.6	- -	- -	- -	- -	17.5	- -	- -	- -	- -
1990	40.3	- -	- -	1.0	- -	139.8 + 30.0 lbs.	1.0	- -	- -	- -
1991	39.5	- -	- -	1.0 gal.	- -	236.0	24.8	- -	- -	- -
1992	38.8	- -	- -	- -	- -	151.6	- -	- -	- -	- -
1993	- -	- -	- -	14.0	- -	5.0	10.0	- -	7.5	- -
1994	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
1995	26.4	- -	- -	- -	- -	100.5	- -	- -	- -	- -
1996	19.5	- -	- -	- -	- -	70.0 + 550 lbs.	- -	- -	- -	- -
1997	24.1	- -	- -	- -	- -	2,405 lbs.	- -	- -	- -	- -
1998	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
1999	41.2	1.2 gal.	- -	- -	- -	2,800 lbs.	1.1	- -	1.1	- -
2000	35.0	- -	- -	- -	- -	3,520 lbs.	- -	- -	- -	- -
2001	29.1	- -	- -	- -	- -	119.0	- -	- -	- -	- -
2002	29.7	12.1 gal.	- -	- -	- -	30.0	12.1	- -	12.1	- -
2003	61.9	28.8 gal.	- -	- -	- -	59.0	28.8	- -	28.8	- -
2004	45.3	7.5 gal.	- -	- -	- -	108.0	7.5	- -	7.5	- -
2005	17.0	- -	- -	- -	- -	1,700 lbs.	- -	- -	- -	- -
2006	48.0	- -	- -	- -	- -	110.0	- -	- -	- -	- -
2007	199.1	- -	- -	- -	- -	698.8 + 3,600 lbs.	- -	- -	- -	- -
2008	164.8	- -	- -	- -	- -	708.3 + 3,600 lbs.	- -	- -	- -	- -
2009	- -	- -	- -	- -	- -	152.7	- -	- -	73.0	- -
2010	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -
2011	51.70	- -	- -	- -	- -	218.5	- -	- -	78.5	- -
2012	67.1	- -	- -	- -	- -	- -	- -	- -	10.75	- -
2013	145.2	- -	- -	- -	- -	415.8	- -	- -	261.4	- -
2014	88.8	- -	- -	- -	- -	590.8	- -	- -	247.6	- -
2015	165.3	- -	- -	- -	- -	543.3	- -	- -	546.6	11.9
Total	- -	64,990 + 49.6 gal.	- -	15.0 + 5.5 gal.	55,920	3,294.0 + 18,205 lbs.	85.8	- -	1144.85 + 150 lbs.	11.9

NOTE: Gallons represent liquid forms of chemical; pounds represent granular forms.

Source: Clean Lakes Inc., WDNR, and SEWRPC.

Table 10

CHEMICAL CONTROL OF AQUATIC PLANTS IN RICE LAKE: 1950-2015

		Algae Control			Macrophyte Control				
Year	Total Acres Treated	Copper Sulfate (pounds)	Blue Vitriol (pounds)	Cutrine or Cutrine Plus (pounds)	Sodium Arsenite (pounds)	2,4-D (gallons)	Diquat (gallons)	Glyphosate (gallons)	Endothall/ Aquathol (gallons)
1950-1967	- -	- -	- -	- -	- -	- -	- -	- -	- -
1968	- -	- -	- -	- -	- -	30.0	- -	- -	- -
1969	- -	- -	- -	- -	- -	40.0	- -	- -	- -
1970-1981	- -	- -	- -	- -	- -	- -	- -	- -	- -
1982	11.3	- -	- -	5.0	- -	- -	5.0	- -	5.0
1983	- -	- -	- -	- -	- -	- -	- -	- -	- -
1984-1990	- -	- -	- -	- -	- -	- -	- -	- -	- -
1991	3.3	- -	- -	- -	- -	8.0	- -	- -	- -
1992	2.7	- -	- -	- -	- -	9.0	- -	- -	- -
1993	- -	- -	- -	- -	- -	- -	- -	- -	- -
1994	- -	- -	- -	- -	- -	- -	- -	- -	- -
1995	3.3	- -	- -	- -	- -	16.5	- -	- -	- -
1996	3.3	5.0 gal.	- -	- -	- -	- -	5.0	- -	5.0
1997	3.3	- -	- -	- -	- -	350 lbs.	- -	- -	- -
1998	- -	- -	- -	- -	- -	- -	- -	- -	- -
1999	9.0	- -	- -	- -	- -	900 lbs.	- -	- -	- -
2000	35.0	- -	- -	- -	- -	3,550 lbs.	- -	- -	- -
2001	1.0	- -	- -	- -	- -	- -	1.0	- -	1.0
2002	6.8	2.0 gal.	- -	- -	- -	16.0	2.0	- -	2.0
2003	5.0	1.3 gal.	- -	- -	- -	9.0	1.3	- -	1.3
2004	7.0	- -	- -	- -	- -	20.0	- -	- -	- -
2005	9.2	- -	- -	- -	- -	27.5	- -	- -	- -
2006	14.0	- -	- -	- -	- -	35.0	- -	- -	- -
2007	16.7	- -	- -	- -	- -	91.8	- -	- -	- -
2008	8.7	- -	- -	- -	- -	48.0	- -	- -	- -
2009	- -	- -	- -	- -	- -	36.7	- -	- -	- -
2010	- -	- -	- -	- -	- -	- -	- -	- -	- -
2011	- -	- -	- -	- -	- -	- -	- -	- -	- -
2012	- -	- -	- -	- -	- -	- -	- -	- -	- -
2013	12.8	- -	- -	- -	- -	73.3	- -	- -	46.1
2014	- -	- -	- -	- -	- -	- -	- -	- -	- -
2015	5.7	- -	- -	- -	- -	12.7	- -	- -	12.7
Total	- -	8.3 gal.	N/A	5.0	N/A	473.5 + 4,800 lbs.	14.3	N/A	73.1

NOTE: Gallons represent liquid forms of chemical; pounds represent granular forms.

Source: Clean Lakes Inc., WDNR, and SEWRPC.

1976, a time when the Lake was algae-dominated.[21] Endothall and 2,4-D have also been applied to Whitewater and Rice Lakes since 1968 to help control nonnative Eurasian water milfoil and curly-leaf pondweed. In 1990, chemical treatments along developed shorelines were supplemented with mechanical harvesting to control nonnative species.

Various sized areas of developed shoreline are subjected to extensive chemical applications in both Lakes (see Figure 11). Management records have shown that chemical treatment, along with mechanical harvesting, has helped reduce nonnative aquatic plant species populations. In addition, shoreline treatments promote better access and

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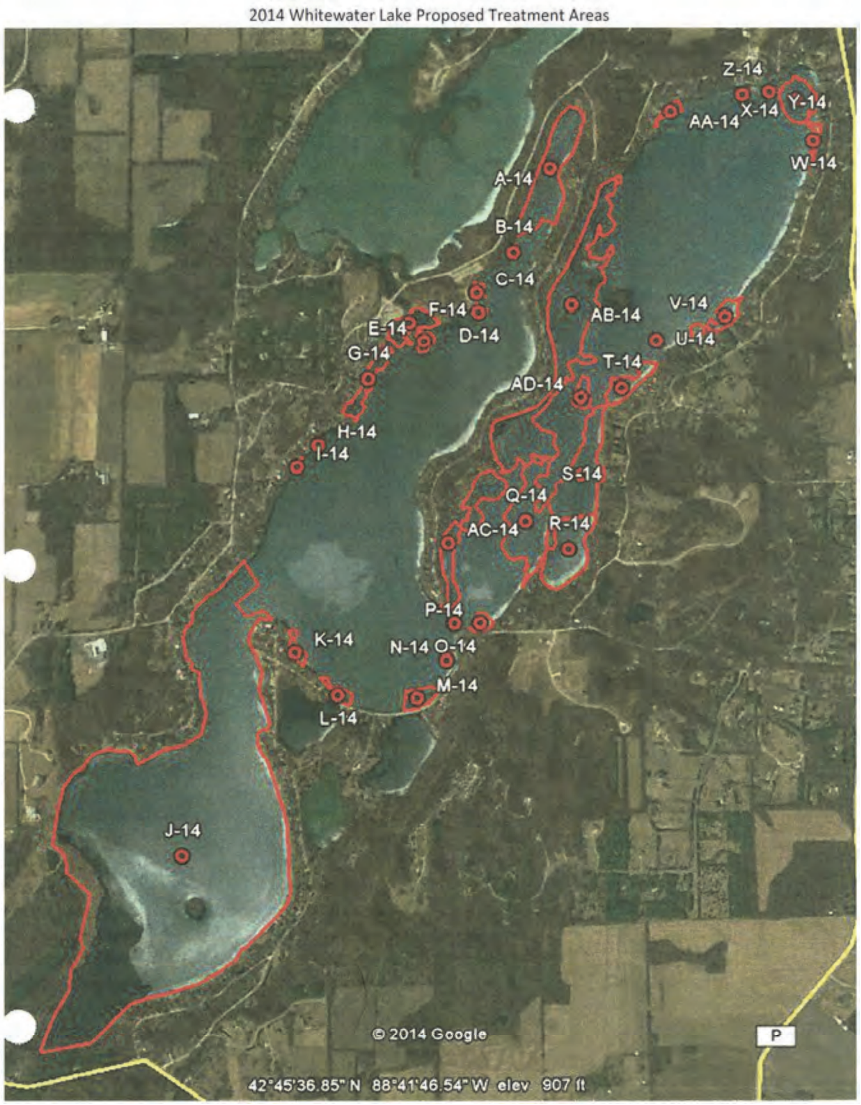
[21]*U.S. Geological Survey Water-Resources Investigations Report No. 94-410*, op cit.

Figure 11

RECENT CHEMICAL APPLICATION AREAS ALONG SHORELINES OF WHITEWATER AND RICE LAKES



Note: Red polygons denote areas that underwent aquatic plant herbicide application in Spring 2014. Letter-number codes are assigned by Clean Lakes Midwest, Incorporated for the purpose of identifying areas to be treated. Letters are assigned counter-clockwise in alphabetical order. The number denotes the year of treatment.

Source: Clean Lakes Midwest, Incorporated and SEWRPC.

navigation throughout the Lakes. Therefore, continued use of shoreline chemical treatments that help reduce and control nonnative aquatic plant species, especially in those shoreline areas where mechanical harvesting would not be deemed feasible, is considered a viable option for Whitewater Lake. As previously mentioned, early spring application and careful dosing is recommended to properly treat Eurasian water milfoil and its hybrid.

As for Rice Lake, the use of chemical treatments for shorelines should be minimized until a healthier aquatic plant community becomes established. This will help reduce the effects of algal blooms as examined in more detail in "Issue 2: Water Quality" and "Issue 3: Cyanobacteria and Floating Algae." Rough fish control is likely an important part of establishing a more healthy and diverse aquatic plant community (see "Issue 7, Fish and Wildlife")

Finally, hybrid water milfoil has been actively evolving and is becoming a concern due to its resistance to commonly used herbicides. With shoreline treatment becoming a short-term solution, or more of a "seasonal control" option, the Whitewater-Rice Lakes Management District would like to explore a chemical treatment method that yields multiple year control to help eliminate, or greatly reduce, nonnative species, and to increase the ecological function of the Lake. Once fully evaluated, whole-lake treatment may be considered a viable management solution for Whitewater Lake (see Chapter III for further detail).

The use of chemical herbicides in aquatic environments is **stringently regulated and requires a WDNR permit and WDNR staff oversight during application**. In order for the WDNR to consider permitting a whole lake treatment, specific conditions need to be met. Specifically, an aquatic plant survey using the point-intercept method must show that the Lake has a minimum of 35 percent frequency of occurrence of Eurasian water milfoil,[22] along with rake fullness density values of two or three over the majority of the sample sites (see Appendix A for schematic of rake fullness). Furthermore, it must be demonstrated whether native aquatic plant species susceptible to the chemicals being applied are present in the treatment area.

ISSUE 2: WATER QUALITY

Actual and perceived water quality conditions continue to be important issues to the Whitewater and Rice Lake communities. Lake residents have expressed concern that specific pollutants could be entering the Lakes from various sources and could be decreasing water quality over time. These sources include general pollution from snowmelt, fertilizer and pesticide runoff from shoreline properties, and fertilizer runoff from agricultural properties within the watershed. Additionally, concern about excessive aquatic plant growth further reinforces water quality as an important issue given that water quality conditions (e.g., phosphorus concentrations) profoundly influence the ability of a lake to support excessive aquatic plant growth.

As part of the discussion regarding the water quality within Whitewater and Rice Lakes, it is important to define what water quality means, since individuals have varying perceptions and levels of understanding. Water quality is commonly described in terms of visual cues. Algal blooms or cloudy water, for example, can lead an observer to conclude that water in a lake is "unclean". However, to actually quantify water quality, lake managers and residents need to collect data and study specific chemical, physical, and biological parameters that influence, or are indicators of, water quality.

The most commonly used metrics for assessing water quality include water clarity, water temperature and the concentrations of chloride, phosphorus, chlorophyll-*a*, and dissolved oxygen (see Table 11 for further information regarding these parameters). These parameters interact with one another in a variety of ways. For example, nutrient pollution from certain fertilizers can cause a lake's phosphorus concentrations to increase, its clarity to decrease

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[22]*Thirty-five percent frequency of occurrence of Eurasian water milfoil means that 35 percent of the sites that were found to contain plants were found to have Eurasian water milfoil.*

Table 11

WATER QUALITY PARAMETER DESCRIPTIONS, TYPICAL VALUES, AND REGULATORY LIMITS/GUIDELINES

Parameter	Description	Southeastern Wisconsin Values[a]		Regulatory Limit or Guideline	Whitewater Lake Values		Rice Lake Values	
		Median	Range		Median	Range	Median	Range
Chloride (mg/L)	Low concentrations (e.g. < 5 mg/L) naturally occur in lakes due to natural weathering of bedrock and soils. Human activities increase concentrations (e.g., road salts, wastewater, water softener regeneration) and can effect certain plants and animals. Chloride remains in solution once in the environment and **can serve as an excellent indicator of other pollutants.**	41	18-126	Acute toxicity [b,c] 757 Chronic toxicity [b,c] 395	5.0[d]	4.0-14.0[d]	- -	- -
Chlorophyll-*a* (µg/L)	The major photosynthetic “green” pigment in algae. The amount of chlorophyll-*a* present in the water is an indicator of the biomass, or amount of algae, in the water. **Chlorophyll-*a* levels above 10 µg/L generally result in a green-colored water** that may be severe enough to impair recreational activities such as swimming or waterskiing and are commonly associated with eutrophic lake conditions	9.9	1.8-706.1	2.6[e]	10.8[f]	1.0-74.2[f]	29.1[f]	3.0-170.0[f]
Dissolved Oxygen (mg/L)	Dissolved oxygen levels are one of the most critical factors affecting the living organisms of a lake ecosystem. Generally, dissolved oxygen levels are higher at the surface of a lake, where there is an interchange between the water and atmosphere, stirring by wind action, and production of oxygen by plant photosynthesis. Dissolved oxygen levels are usually lowest near the bottom of a lake where decomposer organisms and chemical oxidation processes deplete oxygen during the decay process. **A concentration of 5.0 mg/L is considered the minimum level below which many oxygen-consuming organisms, such as fish, become stressed**. Many species of fish are unlikely to survive when dissolved oxygen concentrations drop below 2.0 mg/L.	- -	- -	≥5.0[g]	- -[h]	0-16.6	- -[h]	0.1-14.6
Growing Season Epilimnetic Total Phosphorus (mg/L)	Phosphorus enters a lake from natural and human-derived sources and is a fundamental building block for plant growth. Excessive phosphorus can lead to nuisance levels of plant growth, unsightly algal blooms, decreased water clarity, and oxygen depletion, all of which can stress or kill fish and other aquatic life**. A concentration of less than 0.020 mg/L is the concentration considered necessary in a stratified seepage lake such as Whitewater Lake and less than 0.040 mg/L is necessary in an unstratified seepage lake such as Rice Lake** to limit algal and aquatic plant growth to levels consistent with recreational water use objectives**.** Phosphorus concentration exceeding 30 µg/L are considered to be indicative of eutrophic lake conditions	30	8-720	Whitewater 0.020[g] Rice 0.040[g]	0.028	0.009-0.131	0.063	0.020-0.138
Water Clarity (feet)	Measured with a Secchi disk (a ballasted black-and-white, eight-inch-diameter plate) which is lowered into the water until a depth is reached at which the disk is no longer visible. It can be affected by physical factors, such as suspended particles or water color, and by various biologic factors, including seasonal variations in planktonic algal populations living in a lake. **Measurements less than 5 feet are considered indicative of poor water clarity and eutrophic lake conditions**	4.6	3-12	10.9[h]	4.9	1.5-8.1	2.6	1.0-6.8

Table 11 (continued)

Parameter	Description	Southeastern Wisconsin Values[a]		Regulatory Limit or Guideline	Whitewater Lake Values		Rice Lake Values	
		Median	Range		Median	Range	Median	Range
Water Temperature (°F)	Temperature increases above seasonal ranges are dangerous to fish and other aquatic life. Higher temperatures depress dissolved oxygen concentrations and often correlate with increases of other pollutants.	- -	- -	Ambient[g] 35-77 sub-lethal[g] 49-80 Acute[g] 77-87	- -[h]	33.8-84.0	- -[h]	43.7-80.8

[a]*Wisconsin Department of Natural Resources Technical Bulletin No. 138,* Limnological Characteristics of Wisconsin Lakes, *Richard A. Lillie and John W. Mason,* 1983, except chloride which is based upon SEWRPC 1990-2004 data.

[b]*Wisconsin Administration Code Chapter NR 105, Surface Water Quality Criteria and Secondary Values for Toxic Substances. July, 2010.*

[c]*Pollutants that will kill or adversely affect aquatic organisms after a short-term exposure are termed acutely toxic. Chronic toxicity relates to concentrations of pollutants that will kill or adversely affect aquatic organisms our long time periods (time periods that are a substantial portion of the natural life expectancy of an organism).*

[d]*Chloride concentrations have been consistently increasing across the region, and current chloride concentrations are likely higher.*

[e]*U.S. Environmental Protection Agency,* Ambient Water Quality Criteria Recommendations: Information Supporting the Development of State and Tribal Nutrient Criteria: Lakes and Reservoirs in Nutrient Ecoregion VII, *EPA 822-B-00-009, December 2000.*

[f]*Values collected, during growing season (June 1 through August 31).*

[g]*Wisconsin Administrative Code Chapter NR 102, Water Quality Standards for Wisconsin Surface Waters, November 2010.*

[h]*Oxygen concentrations and temperatures vary with depth and season. Median values provide little insight to understand lake conditions.*

Source: Wisconsin Department of Natural Resources, Wisconsin State Legislature, U.S. Environmental Protection Agency, and SEWRPC.

(due to algal growth in the water column), and chlorophyll-*a* (a measure of algae content) to increase. In addition to water clarity, phosphorus, chlorophyll-*a*, and dissolved oxygen values, a number of other parameters can also help determine the "general health" of a lake. For example, the abundance of the bacteria *Escherichia coli*, commonly known as *E-coli*, is often measured to determine if water is safe for swimming while chloride concentrations are an indicator of overall human-derived pollution entering a lake.[23] To develop a water quality maintenance and improvement program, **key water-quality indices must be regularly measured over extended periods of time**. This allows lake managers to establish baselines and identify trends.

To develop a water quality maintenance and improvement program, the following factors need to be investigated and considered:

1. **The past and current water quality of a lake**—It is important to establish and benchmark current water quality. To do this, concentrations of the aforementioned parameters (phosphorus, water clarity, chlorophyll-*a*, dissolved oxygen, chloride), and potentially other substances, are measured and compared to past levels to determine if water quality has been changing over time. Values that suggest progressively worsening conditions can help reveal which pollutants should be targeted for reduction strategies. This information should be reviewed within the context of general lake characteristics to help determine the extent of water quality concerns and the methods suitable for effectively dealing with these problems.

[23]*Chloride is used as an indicator of human-derived pollution because it is usually only naturally present in low concentrations. Chloride is a "conservative pollutant" meaning that it remains in the environment once released and is not attenuated by natural processes other than dilution. High chloride concentrations may result from road salt, fertilizer application, private onsite wastewater treatment systems that discharge to groundwater which provides baseflow for streams and lakes, and other sources.*

2. **A lake's watershed characteristics, including land use and associated pollutant loadings**—The type and amount of pollutants entering a lake are highly dependent on the ways land surrounding the lake (i.e., its watershed) are used. Different land uses produce different kinds of pollutants (see Figure 12). For example, agricultural land can be a significant contributor of sediment (from eroded soil carried in runoff) and nutrients (e.g., from fertilizers washed off fields), depending on the type of agricultural practices that are used (e.g., tillage can loosen soils and make it easier for pollutants to enter waterways) and the slope of the land. Similarly, urban land uses, such as residential land use, can contribute significant amounts of heavy metals, oils, and nutrients, and other substances. For example, oil leaked from cars onto pavement and lawn fertilizers may drain to a lake during a rain event. The potential for runoff and pollutant transport is influenced by the permeability, degree of cover, and slope of soils. The amount of pollutant actually reaching water bodies may be higher if slopes are steep and ground is bare, paved, or relatively impermeable. Given this connection, it is important to understand past, present, and planned future land use within the watershed. Based on these land use conditions, models can be applied to estimate the amount of pollution that is likely entering the lake. This can help identify areas that are likely to contribute to water quality deterioration and can help focus pollution reduction strategies and efforts.

3. **The filtration ability of a lake's watershed and shorelines**—Various natural or nature-like features can help filter polluted runoff. Features such as wetlands and vegetative buffers,[24] can significantly decrease the amount of pollution entering a lake. Pollutants can either by absorbed and utilized (in the case of nutrients) and/or trapped (such as sediment).

Figure 12

ILLUSTRATIONS OF LAND USE AFFECTING WATERBODIES

NATURAL STREAM ECOSYSTEM

AGRICULTURAL STREAM ECOSYSTEM

URBAN STREAM ECOSYSTEM

Source: Illustration by Frank Ippolito, www.productionpost.com. *Modified from D.M. Carlisle and others.* The quality of our Nation's waters—Ecological health in the Nation's streams, 1993-2005: U.S. Geological Survey Circular 1391*, 120 p.,* http://pubs.usgs.gov/circ/1391/*, 2013, and SEWRPC.*

[24]*Vegetative buffers (e.g., forests, grassed waterways, and vegetative strips) and wetlands have the natural ability to slow runoff. This encourages pollutants to be trapped, stored, and/or consumed before they enter the adjacent lake.*

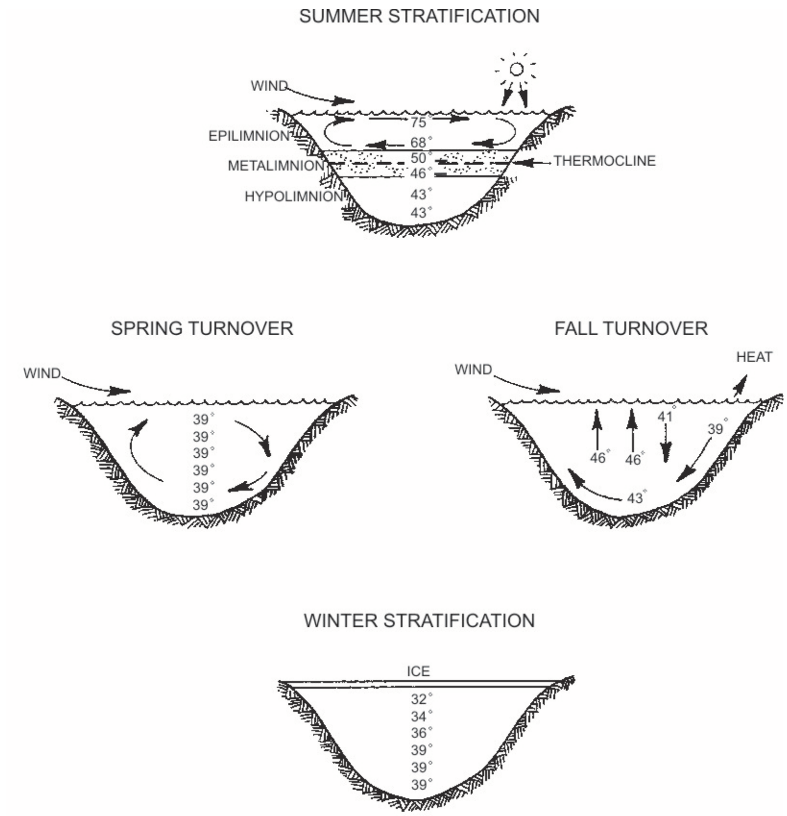
Each of these three factors is further discussed below.

Water Quality and Lake Characteristics Evaluation

Water quality fluctuates over short- and long-term time periods. Therefore, thorough evaluation of lake water quality relies on periodically monitoring various chemical and physical properties (ideally at the same depths and locations over protracted time periods). Monitoring data is used to determine the level and nature of pollution within a lake, the risks associated with that pollution, the lake's ability to support various fish and recreational uses, and the overall health of the lake. When evaluating water quality, it is important to document certain lake characteristics that provide context for evaluation. These lake characteristics include:

Figure 13

THERMAL STRATIFICATION OF LAKES



Source: University of Wisconsin-Extension and SEWRPC.

1. **Whether the lake stratifies, and, if it does, when the lake mixes**—Stratification refers to a state in which the temperature difference (and associated density difference) between the surface waters of a lake (i.e., the epilimnion) and the deep waters of the lake (i.e. the hypolimnion) is great enough to prevent gases and pollutants from mixing between the two layers (see Figure 13). If a lake stratifies, oxygen-rich surface water in contact with the atmosphere does not freely mix with water in deeper portions of the lake. Therefore, the deeper hypolimnetic water cannot exchange gases with the atmosphere. Metabolic processes continue to consume oxygen in the hypolimnion. If oxygen demands are high (such as in an enriched lake), or if the volume of deep isolated hypolimnetic water is small (limiting oxygen storage potential), water in deep portions of lakes can become extremely low in, or even completely devoid of, oxygen for a period of time. Water with extremely low oxygen concentrations is termed anoxic. While some lakes remain permanently stratified, stratification in most Wisconsin lakes breaks down at least twice per year (once in spring and once in fall) in response to changing seasons and ambient weather conditions.

   A lake must be relatively deep to create sufficient temperature differences between surface and bottom waters for the lake to stratify. In general, lakes in Southeastern Wisconsin less than 15 feet deep are unlikely to stratify, whereas lakes with depths greater than 20 feet are likely to stratify. A lake's propensity to stratify is heavily influenced by the lake's shape, size, orientation, landscape position, surrounding vegetation, through flow, water sources, and a host of other factors. Depth to the thermocline (the transition layer between the epilimnion and hypolimnion, sometimes also called the metalimnion) can range from less than 10 feet to well over 20 feet in typical Southeastern Wisconsin lakes.

   For most stratifying lakes in the Region, the pattern is for the lake to become stratified sometime during summer, with a short (usually less than a week) period of whole-lake water circulation and mixing (turnover) that takes place once during the spring and once again in the fall (see Figure 13). At turnover, the lake's temperature is uniform from the surface to the bottom. Lakes that stratify and turn over in the spring and fall are termed "dimictic." Mixing can also occur in response to windy conditions in some lakes. Lakes can also weakly stratify in winter when warmer, denser water is found in the deeper portions of the lake. It is important to determine if stratification and subsequent turnovers occur because nutrients, low-oxygen water, and in some cases pollutants and sediment that have accumulated in the isolated bottom waters can suddenly mix into the entire water column during the turnover period, causing management problems. For example, excess nutrients mixed into the water column can fuel nuisance-level algae and plant growth in the lake.

2. **Whether internal loading is occurring**—Internal loading refers to release of phosphorus stored in a lake's bottom sediment that occurs under water quality conditions associated with stratification. Phosphorus is typically not particularly soluble and often adheres to particles that settle to the lake bottom. When organic detritus and sediment settle to the lake bottom, decomposer bacteria break down the organic substances, a process that consumes oxygen. If lake-bottom waters become devoid of oxygen, the activity of certain decomposer bacteria, together with certain geochemical reactions that occur only in the absence of oxygen, can allow phosphorus from plant remains and lake-bottom sediment to dissolve into the water column. This allows phosphorus that is otherwise trapped in deep lake-bottom sediment to be released into lake water. This released phosphorus can mix into the water column during the next turnover period fueling plant and algae growth. In most lakes, phosphorus is the nutrient controlling overall plant and algal growth so additional phosphorus loading can lead to increased plant and algal growth. If this is occurring, a water quality management plan may focus on in-lake phosphorus management efforts in addition to pollution prevention.

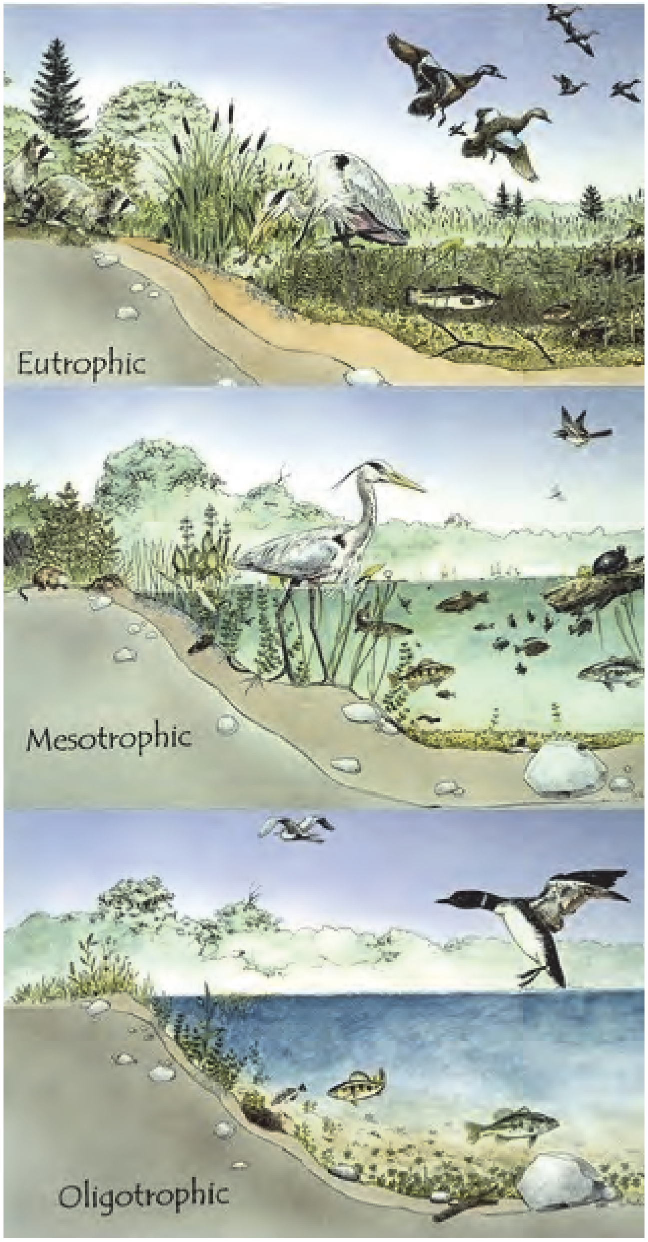
3. **A lake's current and past trophic statuses**—Lakes are commonly classified according to their degree of nutrient enrichment, or trophic status. The ability of lakes to support a variety of recreational activities and healthy fish and other aquatic life communities is often correlated with the lake's degree of nutrient enrichment. Three terms are generally used to describe the trophic status of a lake: oligotrophic (nutrient poor), mesotrophic (moderately fertile), and eutrophic (nutrient rich) (see Figure 14). Each of these states can happen naturally, and do shift to a more nutrient-rich condition as part of the natural lake aging process (see Figure 15). However, if a lake rapidly shifts to a more eutrophic state, this can be an indication of human-induced pollution. Under severe pollution and highly enriched conditions, a lake enters the "hyper-eutrophic" level (see Figure 16). Hyper-eutrophic conditions do not commonly occur naturally, and are nearly always related to human pollution sources.

4. **A lake's hydraulic residence time**—Hydraulic residence time refers to the average length of time needed to replace the lake's entire water volume.[25] Residence time is significant because it can help determine how quickly pollution problems can be resolved. For example, if retention times are short, pollutants are flushed out of the lake fairly quickly. In such cases, management efforts can likely focus on pollutant and nutrient loads contributed to the lake from the watershed. In contrast, lakes with long retention times tend to accumulate nutrients and pollutants. These can eventually become concentrated in bottom sediments. In this case, in addition to preventing external pollution, it also may be necessary to employ in-lake water quality management efforts.

[25]*The term "flushing rate" is also commonly used to describe the amount of time runoff takes to replace one lake volume. Flushing rate is the mathematic reciprocal of hydraulic residence time. Therefore, while retention time is expressed in years and has units of time, flushing rate is typically expressed as the number of times lake water is completely replaced by runoff in one year, and is therefore a rate (units/time).*

Figure 14

ILLUSTRATION OF TROPHIC STATES



Source: DH Environmental Consulting, 1995.

To determine the preceding characteristics for Whitewater and Rice Lakes, SEWRPC staff completed a water quality data inventory. Water quality data have been collected since the early 1970s. Citizen Lake Monitoring volunteers collected data on Whitewater Lake from 1987 to the present and on Rice Lake from 1986 to 2006. In addition, the USGS conducted a comprehensive study and collected data in 1990 and 1991.[26] Available data were utilized to establish existing conditions, identify trends, and evaluate the need for management efforts. By analyzing oxygen/temperature profiles, phosphorus concentrations, chlorophyll-a concentrations, and secchi depth measurements, it was determined that **Whitewater Lake thermally stratifies during the summer, is prone to internal loading of phosphorus, and is eutrophic. Rice Lake does not thermally stratify during the summer and is hypereutrophic**.[27] These characteristics are examined and discussed in more detail in the following sections.

Whitewater Lake

Temperature, Oxygen, and Stratification

When a lake is stratified, shallow depths are considerably warmer, support abundant algae, and contain abundant oxygen. The thermocline is generally found somewhere between 10 and 20 feet below the surface, with the depth varying month-to-month and year-to-year. Water within the thermocline rapidly becomes colder with depth and contains less oxygen than the epilimnion. Water below the thermocline (the hypolimnion) is much colder than water at the Lake's surface and may not mix with the epilimnion until fall. Little sunlight penetrates past the thermocline, therefore, the deeper portions of the Lake do not host significant photosynthetic activity and hence do not receive oxygen from plants. However, oxygen continues to be consumed by decomposition and other processes in the deeper portions of the Lake. As a result, oxygen concentrations in the hypolimnion decline after the Lake stratifies and cannot be replenished until the Lake fully mixes.

Temperature and oxygen concentration profiles were assembled from data spanning over 40 years. Temperature and oxygen concentration profiles suggest that **Whitewater Lake stratifies every year and remains stratified throughout the summer** (Figures 17 and 18). The depth to the thermocline varies month-to-month and year-by-

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[26]*U.S. Geological Survey Water-Resources Investigations Report 94-410,* op cit.

[27]*The trophic status of Whitewater and Rice Lakes was determined using the Wisconsin Trophic State Index value formula with Secchi-disk measurements, total phosphorus levels, and chlorophyll-*a *levels.*

Figure 15

LAKE AGING'S EFFECT ON TROPHIC STATUS

Source: WDNR.

Figure 16

EXAMPLE OF A HYPER-EUTROPHIC LAKE

Source: University of Minnesota, College of Natural Resources, 2003.

year, however, it commonly is found somewhere between 10 and 20 feet below the Lake's surface. **Whitewater Lake also appears to occasionally weakly stratify in winter under the ice**. Water achieves its maximum density in its liquid form at approximately four degrees Celsius, or 39 degrees Fahrenheit. Denser, warmer water occasionally accumulates in the deepest areas of the Lake. Temperature profiles taken throughout the years have often been more precise than oxygen profile data, with temperature data collected every 5 feet or less in the water column and oxygen profile data commonly only being taken at three depths in the water column. The coarse nature of oxygen profile data skews the resultant curves and make it appear to show anoxic conditions below 10 feet in the water column, while temperature profiles consistently show the thermocline forming at 15 to 20 feet in the water column. Therefore, all discussion of thermocline development and anoxic conditions within the hypolimnion in this report relied on temperature profile data.

Based upon the available profiles, **Whitewater Lake is usually fully mixed by sometime in April, with oxygen concentrations capable of supporting aquatic life present at essentially all depths**. During April 1989, water temperatures were warmer and surface waters were warmer than deeper portions of the Lake, possibly suggesting initial stratification, and possibly causing deep water oxygen concentrations to fall below the 5.0 mg/L standard set by the WDNR to support warmwater aquatic life.[28] It is possible that mixing may have occurred in March of 1989 but no dissolved oxygen data were available for that month. A similar, but less pronounced, trend appears to have occurred during spring 1991.

During summer, water in Whitewater Lake's hypolimnion contains little to no oxygen. Approximately half of Wisconsin lakes containing similar phosphorus concentrations develop anoxia in their hypolimnia during the summer.[29] By early to mid-May, just as the Lake stratifies, only the deepest portions of the Lake (e.g., waters below 20 feet) contain less than 5 mg/L during most years. That accounts for only 31 acres of the Lake. However, by early summer, all water deeper than 15 to 20 feet contains less than 5.0 mg/L during most years. By midsummer, essentially the entire Lake volume below 15 feet contains little to no oxygen during most years (Figures 18 and 19). This is equivalent to roughly 50 acres of the Lake total bottom area or 470 acre-feet of the lake volume (Figures 20 and 21). During some years, notably in 2002, waters below as little as 10 feet were devoid of oxygen by July, however, a limited data set was available for profile analysis. **Approximately 90 percent of Whitewater Lake is less than 15 feet deep (Figure 19). Shallow areas such as these experience mixing from wind action and are less susceptible to stratification and anoxic conditions**. Whitewater Lake has a relatively narrow and shallow basin. February data reveal that the oxygen concentrations are also depressed in deeper portions of the Lake in winter. **During mid- to late-winter, water found below roughly 20 to 30 feet contains less than the 5.0 mg/L standard supportive of the Lake's fish population and desirable aquatic life**. In 1994, the entire water column contained less than 5.0 mg/L. Water temperatures were colder than usual that year.

As opposed to concentration, oxygen saturation relates the concentration of oxygen actually measured in water to a concentration in equilibrium with the atmosphere at a given temperature. Values between 90 and 110 percent saturation are generally considered desirable for aquatic life. Higher and lower levels of oxygen saturation are injurious to aquatic life. Oxygen saturation profiles (Figure 20) reveal that the near-surface waters of Whitewater Lake have in the past been supersaturated with oxygen during portions of July,[30] a result of abundant photosynthetic

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[28]Wisconsin Administrative Code *Chapter NR 102, Water Quality Standards for Wisconsin Surface Waters, November 2010.*

[29]*Wisconsin Department of Natural Resources Technical Bulletin No. 138*, op. cit.

[30]*Supersaturation refers to a condition when the amount of dissolved substance exceeds the substance's maximum solubility in the solvent under normal circumstances. Such conditions are typically unstable. Dissolved gas comes out of water as bubbles. Fish exposed to oxygen saturations greater than 115 percent can develop bubbles in their tissues (a condition similar to "the bends" experienced by deepwater divers).*

Figure 17

TEMPERATURE PROFILES FOR WHITEWATER LAKE BY MONTH

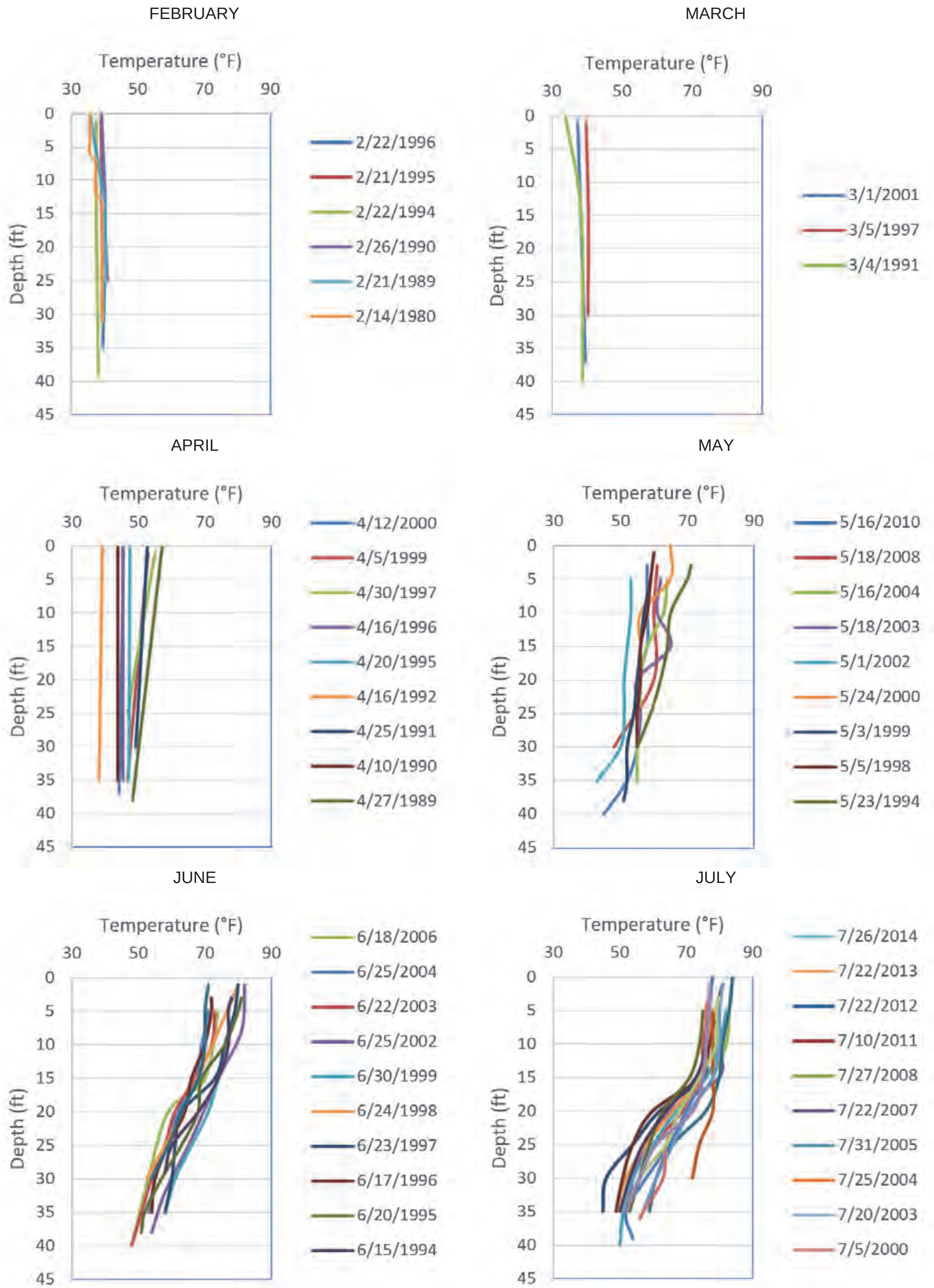
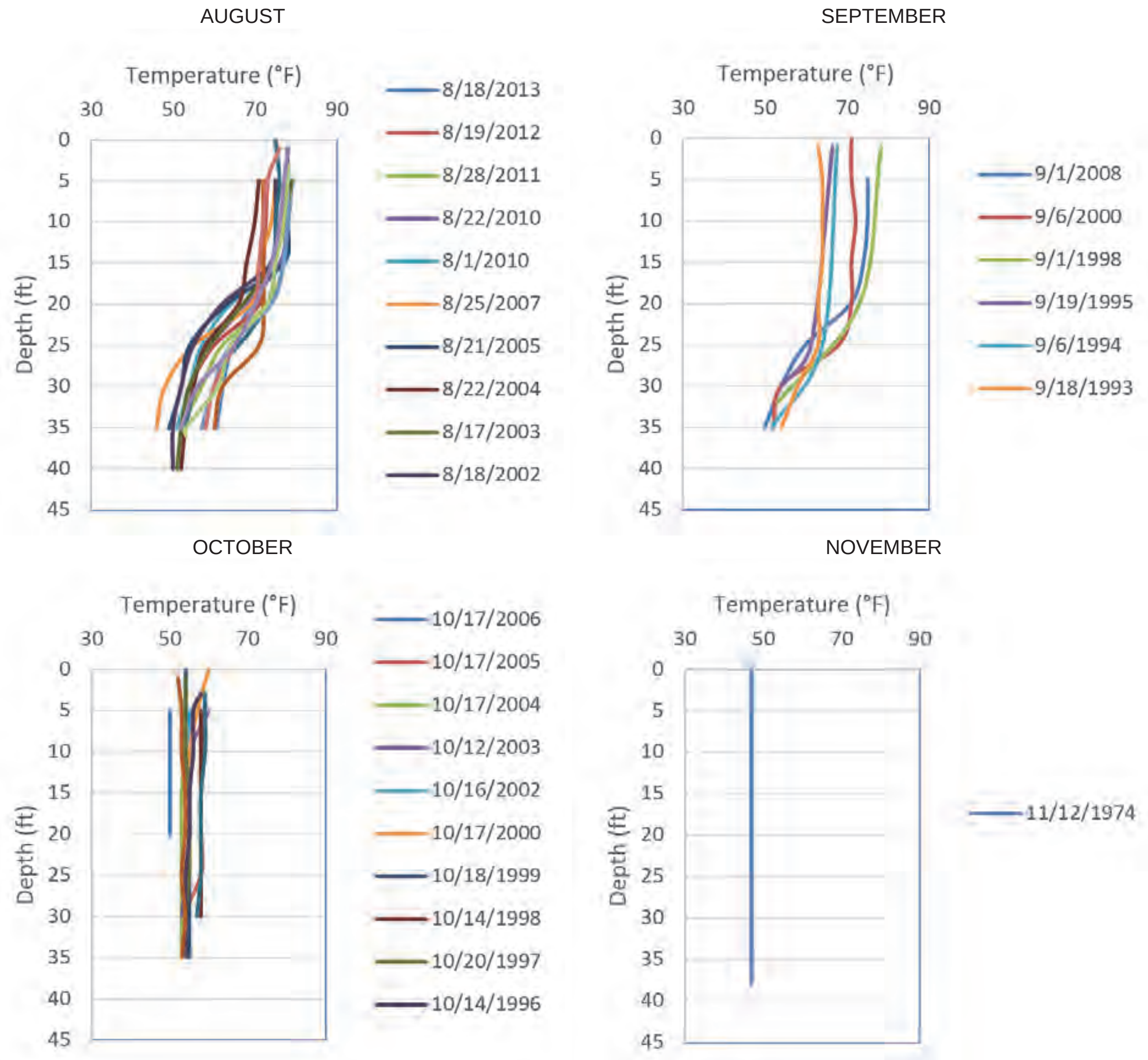


Figure 17 (continued)



Source: WDNR and SEWRPC.

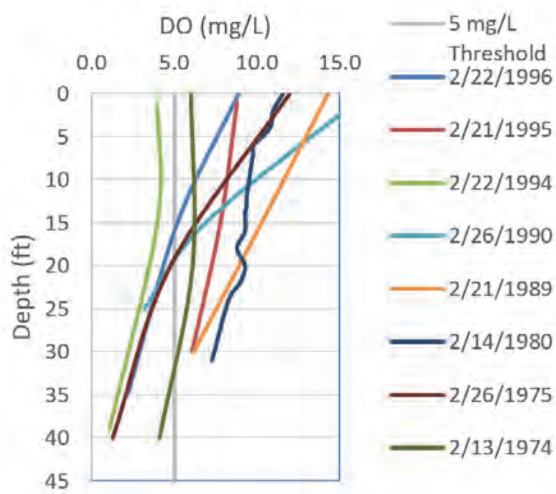
activity, and a factor likely related to human-induced nutrient enrichment. Fortunately, measured oxygen supersaturation values have not exceeded 110 percent in Whitewater Lake since the early 1990s. Oxygen saturation has been observed to peak near the thermocline, a condition suggestive of nutrient enrichment sourced in the hypolimnion.

Although no information is available for nighttime conditions, many **water bodies exhibiting oxygen supersaturation during the day experience unacceptably low oxygen saturation levels at night**, a condition related to respiration and decomposition continuing to occur while photosynthesis is lacking. Such conditions are stressful to aquatic organisms and can lead to fish stress and fish kills in summer. However, fish kills have never been observed in this lake. The available data is rather limited, and more detailed vertical profiles may need to be measured for this phenomenon to be seen in the Lake. Oxygen concentrations have great influence on the Lake's biota and chemistry. For this reason, detailed <u>oxygen concentration profiles should be regularly measured, including profiles collected at night during the summer</u>. More details of this recommendation may be found in Chapter III.

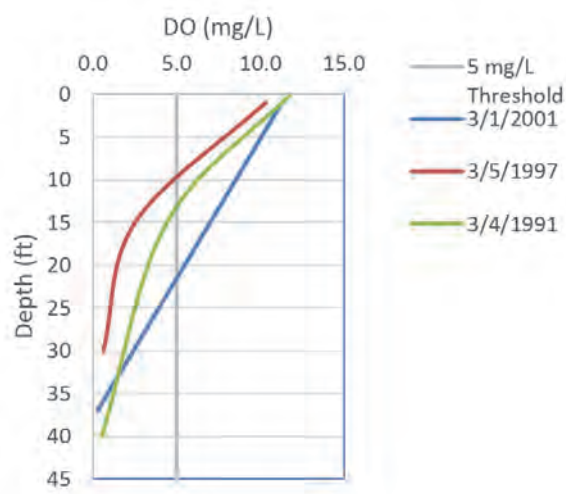
Figure 18

DISSOLVED OXYGEN PROFILES FOR WHITEWATER LAKE BY MONTH

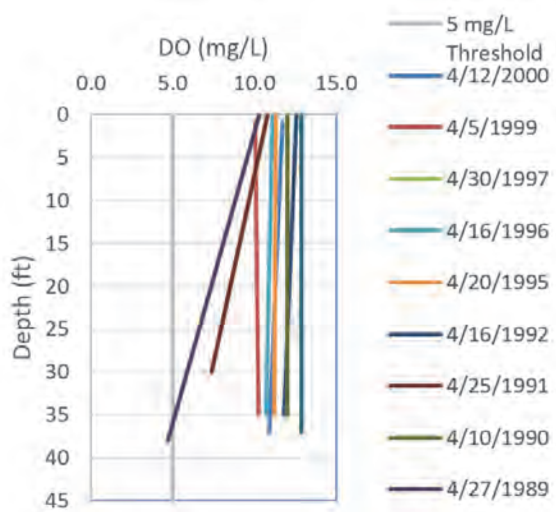
FEBRUARY



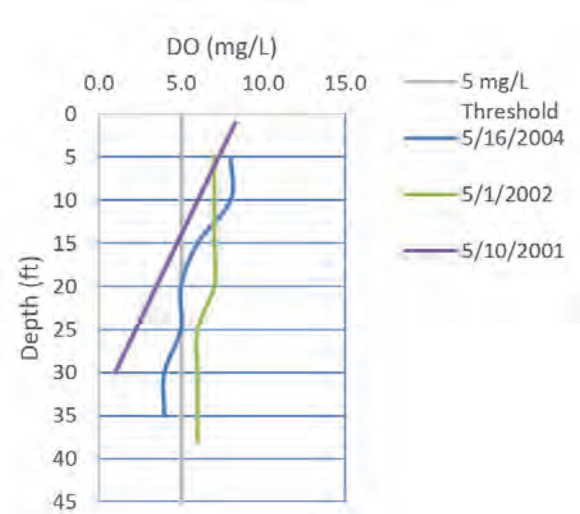
MARCH



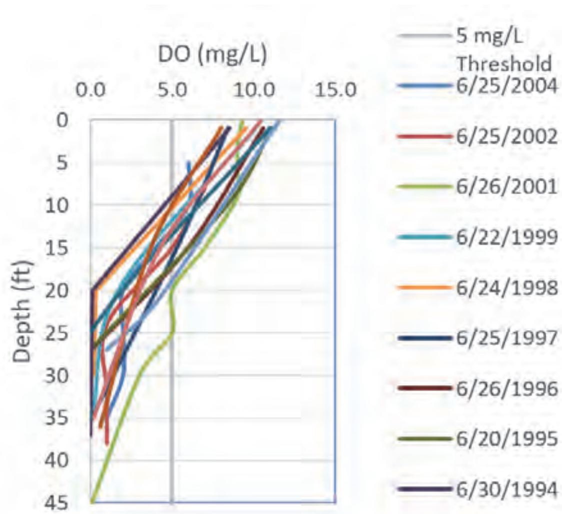
APRIL



MAY



JUNE



JULY

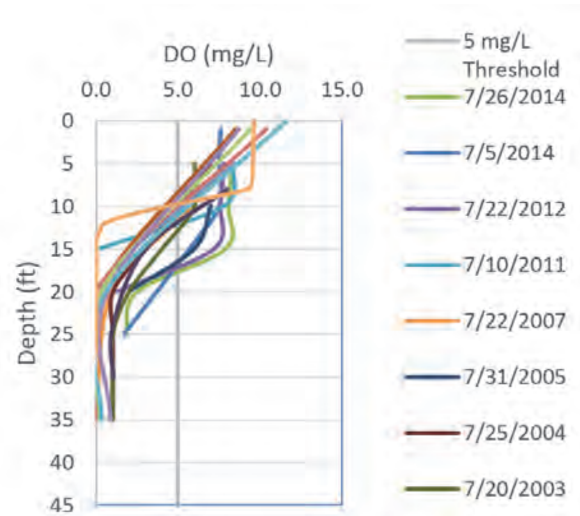
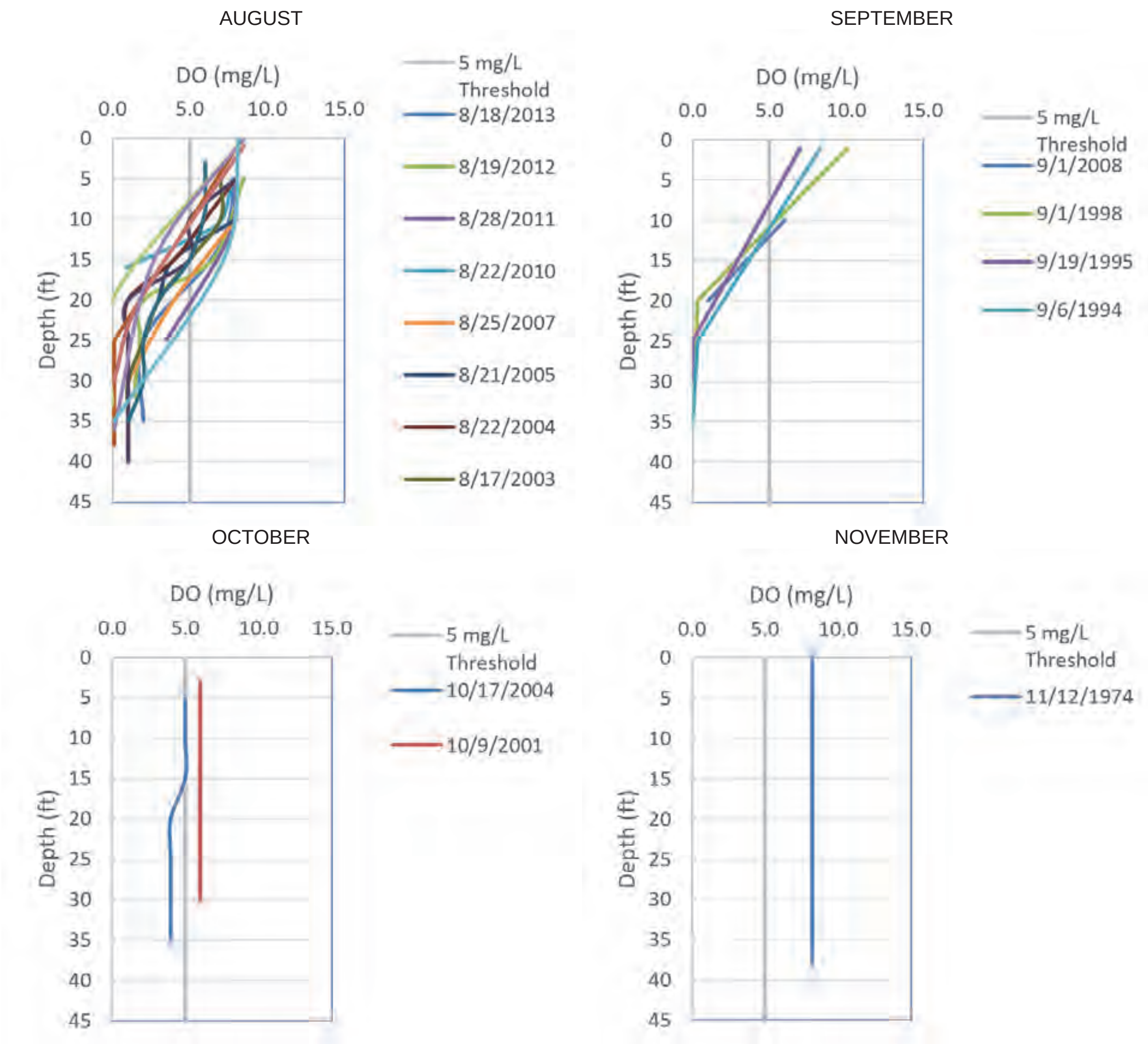


Figure II-18 (continued)



Source: WDNR and SEWRPC.

Phosphorus

When Whitewater Lake is fully mixed in the spring, phosphorus concentrations are similar throughout the Lake, with phosphorus concentrations averaging 0.027 mg/L over the period of record. The data set includes one extreme value (0.060 mg/L) from April 1974 that exceeds the average. The significance of the 1974 value is difficult to estimate as it could represent a typographical, sampling, or laboratory procedural error, but also could reveal extreme conditions that existed before implementation of many modern water pollution control practices and regulations. Aside from the 1974 value, spring turnover total phosphorus concentrations range from 0.009 to 0.048 mg/L. Spring phosphorus concentration have fluctuated but have not significantly changed since at least 1990 (Figure 21).

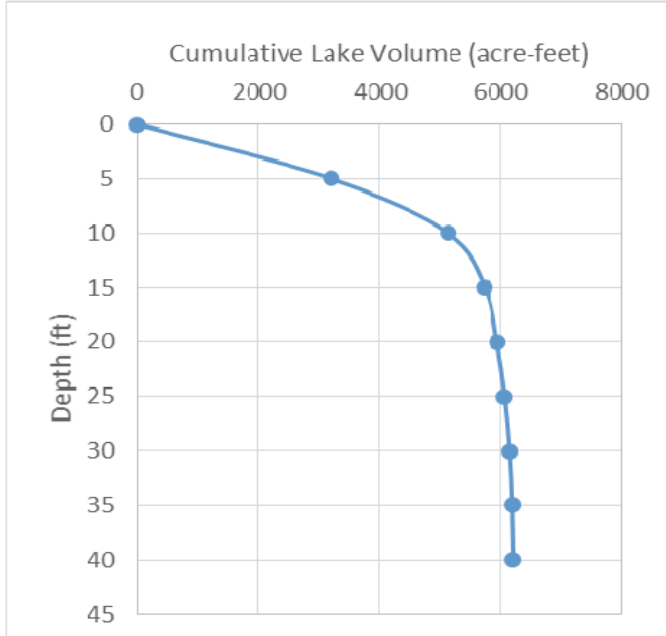
Phosphorus concentrations vary widely within Whitewater Lake when the Lake is stratified (Figure 22). Samples collected near the surface during the growing season commonly have the lowest phosphorus concentrations, averaging 0.032 mg/L, a value well below the aquatic life impairment threshold of 0.060 mg/L for deep seepage lakes

(Figure 23). However, this value is well above the substantially lower recreational impairment threshold of 0.020 mg/L for such lakes mandated by the *Wisconsin Administrative Code*.[31, 32, 33]

Phosphorus concentrations reach their highest values in the deeper waters of Whitewater Lake during warm season stratification (Figure 24). Samples drawn from the Lake's hypolimnion during the summer months commonly contain phosphorus concentrations many times higher than near-surface lake water, with values averaging 0.156 mg/L, and values ranging from 0.025 mg/L to 0.430 mg/L over the period of available record. Phosphorus concentrations rapidly increase immediately after the Lake stratifies, commonly reaching their maxima during July. This is a common occurrence on many lakes since biological productivity and attendant organic loading to deep portions of lakes declines after peaking in late spring.

Figure 19

LAKE DEPTH VERSUS VOLUME, WHITEWATER LAKE



Note: This is a cumulative plot of the total volume of the Lake contained in depths less than or equal to the depicted values. For example, roughly 5,100 acre-feet of the Lake's total volume is contained in the upper 10 feet of the Lake's water column.

Source: WDNR and SEWRPC

PHOSPHORUS SEQUESTRATION

In areas of mineral-rich calcareous groundwater ("hardwater"), marl deposits often exist on the beds of lakes fed by groundwater seeps and springs. Marl is composed chiefly of calcium carbonate, clays and silts, and some organic detritus. The formation of marl can co-precipitate dissolved phosphorus which helps reduce phosphorus concentrations in the water of some lakes. In such instances, co-precipitated phosphorus is deposited as a stable mineral upon the lake bed. Over fifty percent of a lake's external phosphorus loading is typically retained in lake-bottom sediment. The actual amount retained in a lake varies widely with watershed and lake characteristics, but up to ninety percent can be retained in some instances.[34] Studies of Nagawicka Lake in Waukesha County have shown that 87 percent of the

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[31]*Wisconsin Department of Natural Resources*, Wisconsin 2014 Consolidated Assessment and Listing Methodology (WisCALM) Clean Water Act Section 305(b), 314, and 303(d) Integrated Reporting, *September 2013*.

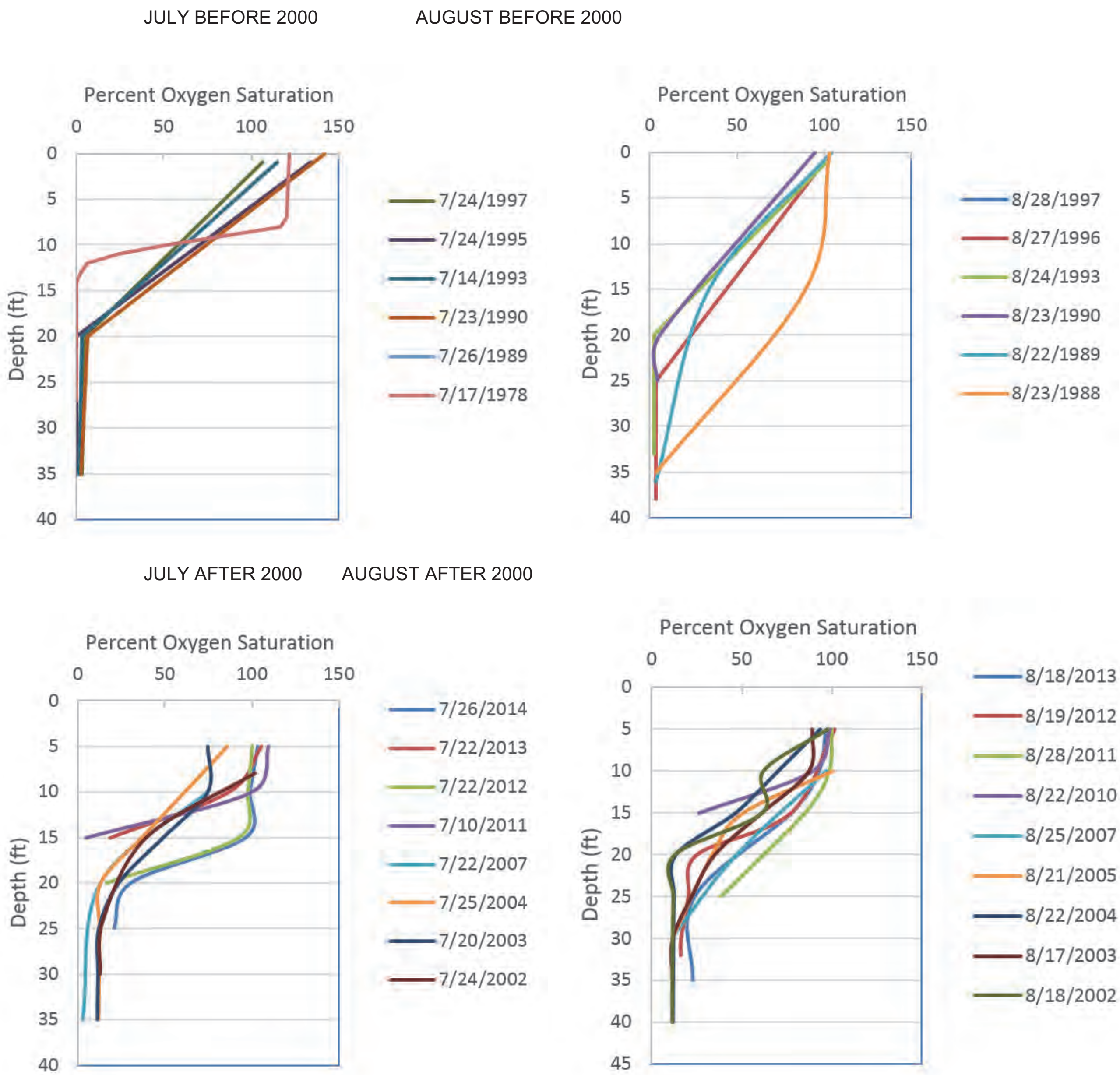
[32]*Whitewater Lake is currently classified as a drainage lake by the WDNR, which is a lake type with fairly liberal phosphorus standards. However, Whitewater Lake does not have a perennial outlet, has a small watershed with few tributaries, and is fed primarily by precipitation, groundwater, and runoff. This condition and the Lake's depth better fit the characteristics of a deep seepage lake. Therefore, the lower phosphorus standards associated with deep seepage lakes are more in keeping with Whitewater Lake's actual conditions.*

[33]Wisconsin Administrative Code *Chapter NR 102*, op. cit.

[34]*Lijklema L., "Phosphorus accumulation in sediments and internal loading,"* Hydrological Bulletin, *Volume 20, Issue 1, pp. 213-224, November 1986.*

Figure 20

SUMMER OXYGEN SATURATION PROFILES FOR WHITEWATER LAKE BY MONTH



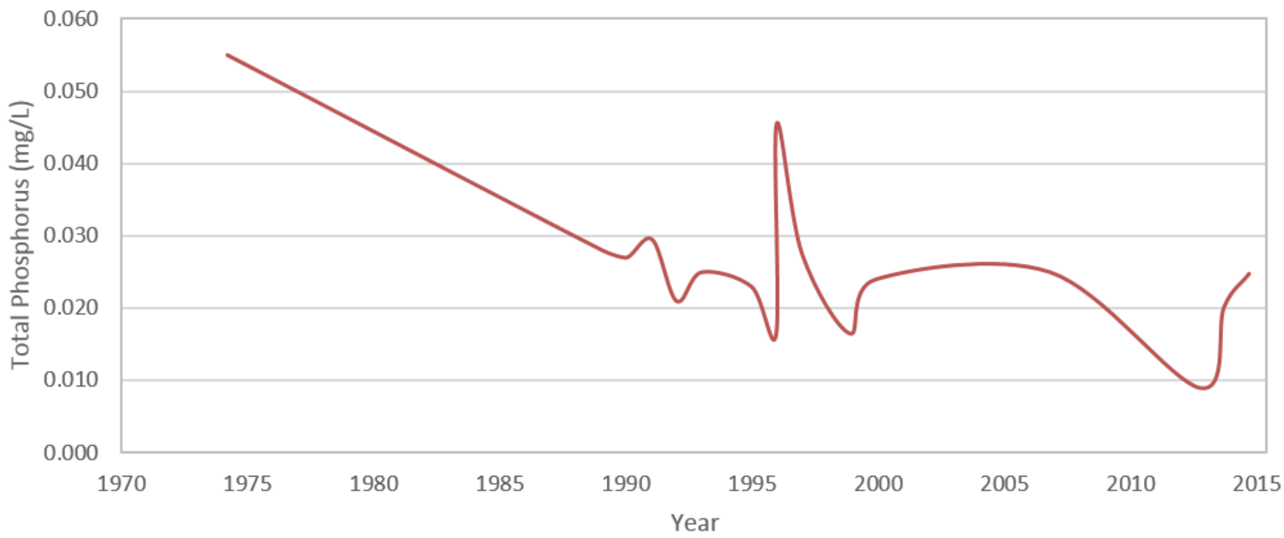
Source: WDNR and SEWRPC.

phosphorus contributed to the Lake is retained in lake-bottom sediment.[35] Surveys of Whitewater Lake's bottom sediment do not denote marl deposits in parts of the Lake shallower than 15 feet, which is not surprising given that much of the Lake area was uplands before construction of the dam. It is possible that marl is present in deeper portions of the Lake that were the natural groundwater-fed lakes before impoundment and creation of the larger

[35]*U.S. Department of the Interior, Geological Survey Scientific Investigations Report 2006-5273*, Water Quality, Hydrology, and Response to Changes in Phosphorus Loading of Nagawicka Lake, a Calcareous Lake in Waukesha County, Wisconsin, *2006*.

Figure 21

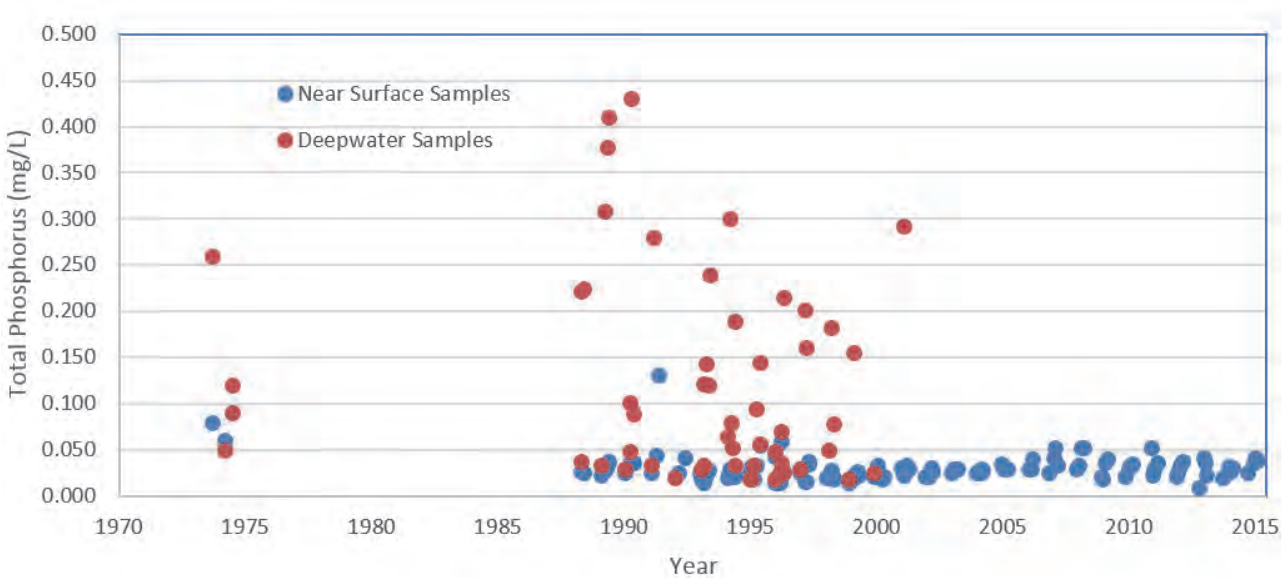
SPRING (FULLY MIXED) PHOSPHORUS TREND, WHITEWATER LAKE: 1974-2015



Source: WDNR and SEWRPC

Figure 22

SUMMER PHOSPHORUS CONCENTRATIONS, WHITEWATER LAKE: 1974-2015

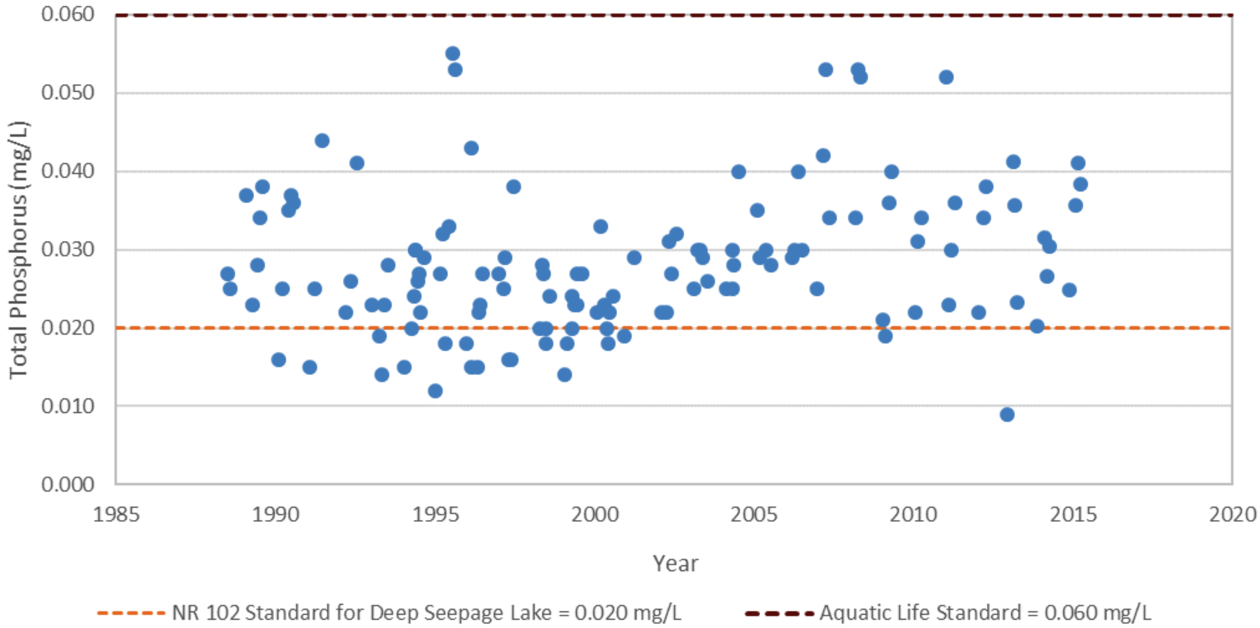


Source: WDNR and SEWRPC.

impounded Lake (See Map 4). Marl is now likely being deposited in new, suitable areas of the new Lake. Current marl deposition areas would likely occur at water depths that support aquatic plant growth and any deepwater marl deposits are likely a relic condition predating dam construction. If marl is being formed in the modern Lakes, it likely forms at depths allowing sufficient light penetration to support aquatic plant growth. A rough rule of thumb is that plant growth can extend to twice the depth of average Secchi water clarity measurement, which means that aquatic plants may be able to grow in waters up to six to ten feet deep. Given the large proportion of shallow water in both Lakes, aquatic plants could likely grow over broad areas, a situation which helps attenuate phosphorus by co-precipitation with calcium carbonate.

Figure 23

NEAR-SURFACE TOTAL PHOSPHORUS CONCENTRATIONS, WHITEWATER LAKE: 1988-2015



Source: WDNR and SEWRPC.

Marl is commonly formed as a byproduct of growth of certain algae species (e.g., muskgrass), accumulates on plant stems and leaves, and ultimately falls to the lake-bottom as the algae grows and dies. Photosynthesis increases water pH in the immediate vicinity of the plant, enhancing precipitation of calcite. Since enriched lakes generally support more algae, enriched lakes can have a self-reinforcing feedback loop to sequester more phosphorus. However, calcite/phosphorus minerals may become less stable at high pH ranges, potentially reducing the effect of this feedback loop. Unfortunately, muskgrass was not found to be a dominant species in the Lakes. Hence, muskgrass may currently only have a limited ability to sequester phosphorus in either Whitewater or Rice Lake.

Research in Europe has found that although marl lakes are resistant to phosphorus enrichment and eutrophication, the bottom-dwelling species of algae that promote marl production can be sensitive to long-term phosphorus enrichment. Decreased water clarity associated with higher phosphorus concentrations can decrease the depth to which bottom dwelling algae can grow, in turn decreasing the extent of marl-precipitating algae near the lake bottom. Less marl precipitation increases overall dissolved phosphorus in the lake which in turn fosters higher abundance of free-floating algal species. This further decreases water clarity, forming a self-reinforcing loop that eventually destabilizes the beneficial marl formation process. Some formerly clear European marl lakes that had successfully buffered heavy, long-term external phosphorus loads went through rapid change after the lake's buffering capacity was exceeded and are now eutrophic lakes with low water clarity.[36] This illustrates how the algae-based phosphorus sequestration process is vulnerable to excessive long-term high phosphorus loads, demonstrating the importance of reducing external phosphorus loads to lakes. Phosphorus sequestration may be able to be enhanced if water clarity improves, reinforcing this beneficial process.

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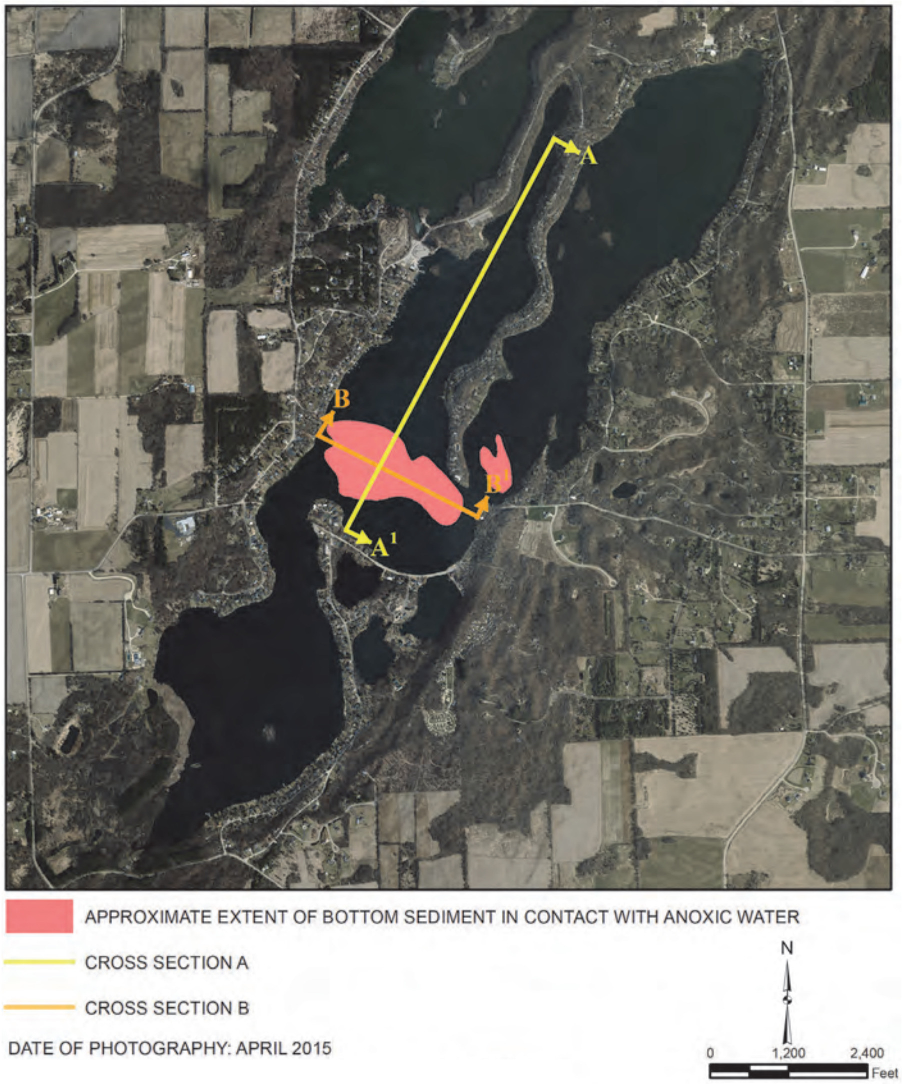
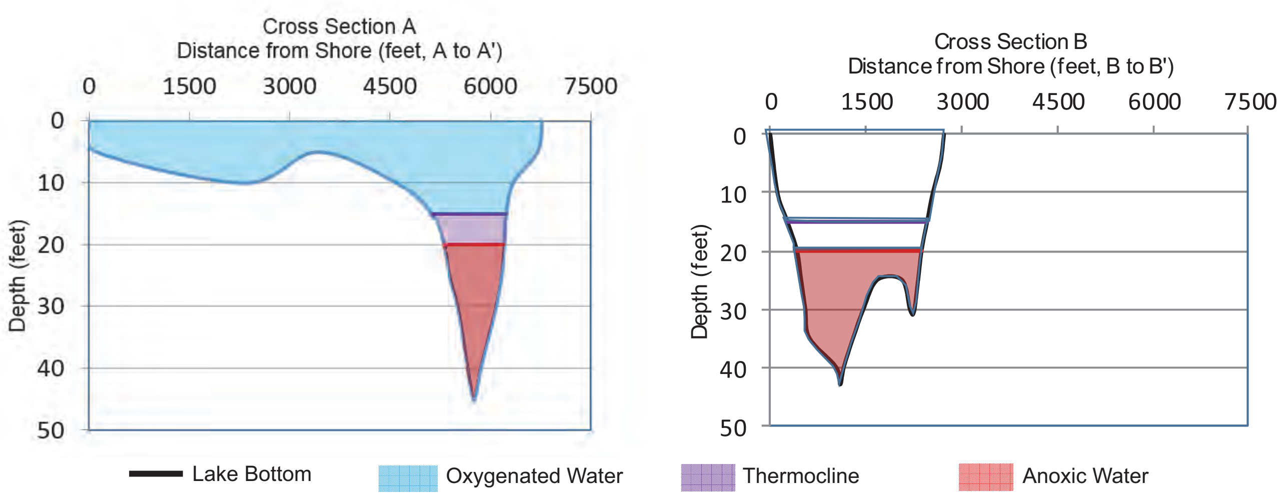
[36]*Wiik, Emma, Helen Bennion, Carl D. Sayer, Thomas A. Davidson, Suzanne McGowan, Ian R. Patmore, and Stewart J. Clarke, "Ecological sensitivity of marl lakes to nutrient enrichment: Evidence from Hawes Water,* UK", Freshwater Biology, *Volume 60, Issue 11, pp. 2226-2247, November 2015.*

Figure 24

TYPICAL MIDSUMMER EXTENT OF ANOXIC WATER IN WHITEWATER LAKE

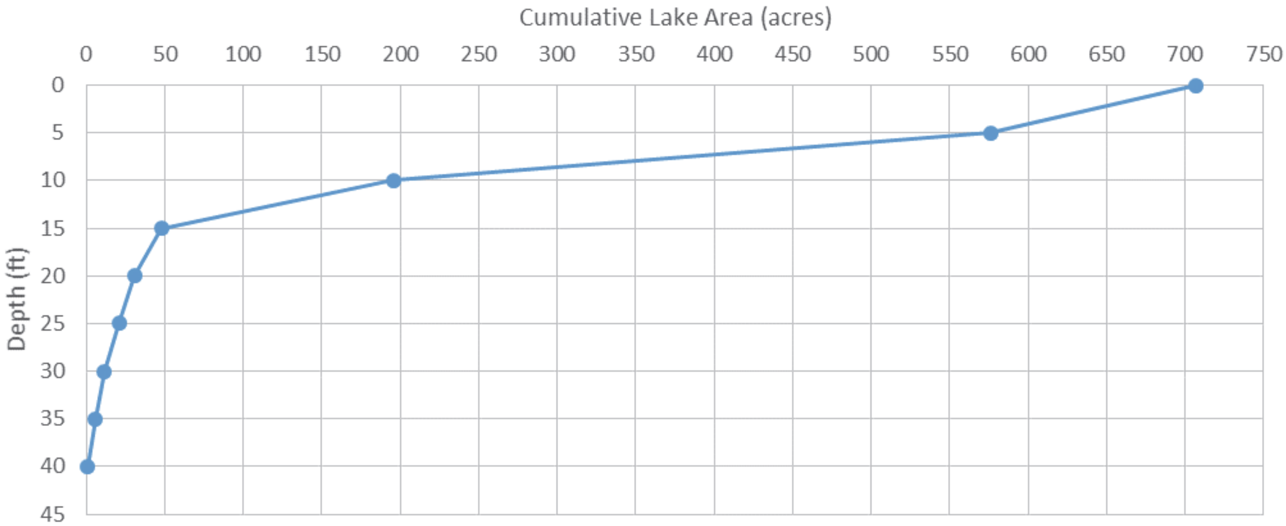




Source: Wisconsin Department of Natural Resources and SEWRPC.

Figure 25

LAKE DEPTH VERSUS SURFACE AREA, WHITEWATER LAKE



Note: This is a cumulative plot of the total surface area of the Lake with depths greater than or equal to depicted values. For example, roughly 200 acres of the Lake has water depths greater than 10 feet.

Source: WDNR and SEWRPC

Marl formation/phosphorus co-precipitation depends upon continued discharge of mineral-rich groundwater to springs and seeps on the lake bottom. If the supply of groundwater is reduced, the vigor of hardwater algae is reduced, compromising the phosphorus sequestration cycle. Therefore, the Lake's groundwater supply must be protected to ensure that phosphorus sequestration remains active if sequestration is, in fact, occurring.

In Wisconsin, phosphorus is sequestered in lake-bottom sediment with calcite (as described above) or with iron. Unlike calcium minerals, iron-bound phosphorus is sensitive to the concentration of oxygen in adjacent water. Under low oxygen conditions, iron-bound phosphorus minerals dissolve and release plant-available phosphorus to the water column. This source of phosphorus, an important component of what is commonly referred to as internal loading, can be a significant contributor to the total phosphorus available to algae in lakes, especially in lakes that have fewer sources of external phosphorus during the growing season. For this reason, the presence of anoxic water can profoundly influence the nutrient dynamics of certain lakes.

INTERNAL LOADING

As mentioned earlier in this report, lake productivity is controlled by available phosphorus. Phosphorus, under oxygenated conditions, is tightly bound to solids and large amounts of phosphorus are commonly found in lake-bottom sediment. However, when oxygen is absent, geochemical reactions occur that release phosphorus from the bottom sediment into the water column. The amount of sediment exposed to anoxic water is controlled by the shape of the lake basin. For example, even though two lakes may have equivalent maximum depths, a lake that has broad shallow areas and a small deep hole has less deep water bottom sediment area than an equal depth lake that is uniformly deep. Since sediment exposed to anoxic water can release phosphorus into the water column, lakes with more deep water sediment area are more susceptible to significant phosphorus internal loading. Moderate depth/size stratified lakes are among the most prone to internal phosphorus loading. Such lakes lack large water volumes, and, hence, have comparatively little stored oxygen in the hypolimnion, making them prone to anoxia.

Water chemistry, lake type, and bathymetry information yield crosslinking evidence that **Whitewater Lake supports conditions that favor internal phosphorus loading**. Waters below about 20 feet contain little to no oxygen during much of the summer, meaning that a portion of the lake-bottom is prone to phosphorus dissolution from bottom sediment (Figure 24). Approximately 48 acres of lake-bottom sediment are covered with anoxic water during a typical summer (Figure 25). The composition of lake-bottom sediments in deeper portions of the Lake is currently unknown. If the bottom is covered primarily with muck, a fine grained organic-rich sediment, such sediment commonly contains significant concentrations of phosphorus that could be released to the water column. Given that the deepest portions of Whitewater Lake were natural lakes surrounded by wetlands, the sediments in contact in anoxic water are likely muck.

Internal phosphorus mass loading attributable to dissolution from seasonally anoxic bottom sediment can be estimated using whole lake total phosphorus water concentrations determined during the fully mixed conditions occurring during or shortly after spring turnover (Figure 21), from lake water samples collected from the hypolimnion during the stratified conditions occurring in summer (Figure 22), and assuming that little mixing between the epilimnion and hypolimnion occurs after the Lake stratifies. Reviewing the available data, the median mid-summer phosphorus concentration in the hypolimnion of Whitewater Lake is 0.132 mg/L, varying from 0.036 mg/L to 0.430 mg/L. Whitewater Lake's hypolimnion typically occupies approximately 470 acre feet of the Lake's total water volume. Although values vary significantly between years, internal loading likely contributes on average about 133 pounds of phosphorus to the water column between late spring and midsummer during most years. Internal loading appears to contribute 512 pounds of phosphorus during extreme years. Since anoxic water covers about 48 acres of the lake-bottom during an average year, each acre of lake-bottom exposed to anoxic water contributes approximately 2.8 pounds of phosphorus to the water column during a typical late spring and summer, and 10.7 pounds per acre during years of high loading.

During most years, internal phosphorus loading appeared to level off during late summer. This is consistent with observations in other Midwestern lakes. However, on some occasions, Whitewater Lake's hypolimnetic phosphorus concentrations continued to climb through September. The highest late summer phosphorus concentrations documented by the available data set occurred during mid-September 1993 (0.240 mg/L), yielding a warm season internal phosphorus loading of nearly 273 pounds. A deep water total phosphorus concentration of 1.140 mg/L was recorded in mid-September of 1973 (the concentration at the surface was 0.080 mg/L), but because the value is so much higher than other recorded numbers, it may be due to clerical error or equipment malfunction. A phosphorus concentration of 1.140 mg/L would yield a warm season internal loading of nearly 1,348 pounds.

Assuming that most phosphorus is contributed to the water column during the first 60 days of stratification, a unit area phosphorus flux rate from anoxic bottom sediment can be computed.[37] Whitewater Lake's computed unit area phosphorus flux rate is 5.2 milligrams per square meter per day (roughly five one hundredths of a pound per acre per day) during typical years, and 20.0 milligrams per square meter per day during years of high internal loading. The value during typical years is on the lower end of the range of values determined as part of a State of Michigan lake sediment column study. The Michigan study reports unit-area phosphorus flux rates ranging from 1.6 to 29.5 milligrams per square meter per day.[38] Extreme years in Whitewater Lake match more closely to the high end of the range. The Whitewater Lake value also agrees well with studies completed in Minnesota. Minnesota lakes that were eventually treated to reduce internal phosphorus loading exhibited unit area phosphorus flux rates ranging from 9.3 to 14.1 milligrams per square meter per day.[39] These comparisons add credibility to the phosphorus flux rates calculated for Whitewater Lake and point to limited contributions from internal loading in the overall nutrient balance of the Lake during most years.

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[37]*Unit area flux rate refers to the mass of a substance moving past a threshold over a set area during a unit of time.*

[38]*Steinman, Alan, Rick Rediske and K. Ramesh Reddy, "The Reduction of Internal Phosphorus Loading Using Alum in Spring Lake, Michigan,"* Journal of Environmental Quality, *Volume 33, pp. 2040-2048, 2004.*

[39]*Bassett Creek Watershed Management Commission,* Twin Lake Phosphorus Internal Loading Investigation, *March 2011.*

It should be noted that phosphorus released to the hypolimnion is not directly available to most algae growing in the lake since little sunlight penetrates to these depths. Even though the thermocline is a barrier to circulation, it is imperfect and some phosphorus can migrate to shallower areas. For this reason, the highest levels of algal productivity are often found just above the thermocline in lakes with phosphorus internal loading. Mixing caused by wind and/or seasonal turnover can cause large concentrations of phosphorus from the hypolimnion to suddenly mix with surface water. This can lead to algal blooms.

The United States Geological Survey completed a detailed examination of Whitewater and Rice Lakes during the early 1990s.[40] In addition to the anoxia-driven process described above, the USGS report examined other ways sediment-bound phosphorus can enter the water column. For example, rooted aquatic plants can draw phosphorus from lake-bottom sediment and release the phosphorus to the water column when the plant dies. This is an example of phosphorus recycling. As a case in point, Lake Wingra near Madison, Wisconsin receives almost half of it phosphorus input from the lake bottom through growth and decomposition of Eurasian milfoil. Other factors include sediment resuspended by wind, motorboats, benthic invertebrates, and fish. The USGS study reported that **51 percent of Whitewater Lake's and 82 percent of Rice Lake's phosphorus loads were attributable to internal loading and recycling processes and the value of removing plant mass from the Lakes. This finding underscores the significance of in-lake processes to the nutrient supply to the Lakes, and the reduced likelihood of controlling lake nutrient enrichment problems using watershed management practices alone.**

WHITEWATER LAKE MANAGEMENT IMPLICATIONS AND RECOMMENDATIONS

As a stratified, deep seepage lake,[41] Whitewater Lake does not receive abundant runoff or stream inflow, limiting the delivery of externally-sourced phosphorus to the Lake. During the growing season, weather conditions can be dry, further reducing the already limited surface water delivery of phosphorus to the Lake. Available information suggests that **internal phosphorus loading and/or phosphorus recycling may be the primary contributor to high summer phosphorus concentrations**. These findings make phosphorus internal loading and recycling an issue of great importance for lake management. Phosphorus internal loading and recycling is a problem in many lakes. Many approaches have been developed to help mitigate its effects on water quality.

To be truly effective and long lasting, **efforts to reduce phosphorus internal loading must be predicated by or accompanied with efforts that permanently reduce and control external phosphorus loading**. If a lake receives heavy phosphorus inputs from its watershed or point sources, any improvement in lake health from internal load/recycling reduction efforts will be short lived. However, Whitewater Lake, a seepage lake with a small watershed and modest external phosphorus loading, is a good candidate for internal phosphorus load/recycling reduction measures. Nevertheless, activities that help incrementally reduce external loading will increase the relative success and longevity of internal load control efforts. Efforts to reduce internal loading and recycling of phosphorus must not supplant aggressive action to identify and minimizes external phosphorus loading. Phosphorus concentrations appear to be decreasing over time as the Lake flushes phosphorus downstream when the spillway operates and as phosphorus is removed by macrophyte harvesting. If current trends continue, phosphorus concentrations may decline to more acceptable levels in the future and may no longer warrant active efforts to reduce internal loading/recycling. A continued effort to monitor surface and deepwater phosphorus concentrations is recommended to assist with such future management decisions.

A wide variety of methods have been used in other lakes to attempt to reduce phosphorus internal loading and recycling. The applicability of each method is highly dependent on lake-basin morphology, hydrology, water chemistry, cost, and other factors. Some of these methods are listed below along with a judgement of practicality for employment in Whitewater Lake.

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[40]*U.S. Geological Survey, 1994,* op. cit.

[41]*Wisconsin Department of Natural Resources,* Wisconsin 2014 Consolidated Assessment and Listing Methodology (WisCALM) Clean Water Act Section 305(b), 314, and 303(d) Integrated Reporting, op cit.

Dredging

Internal loading and recycling depend upon the presence of phosphorus-rich bottom sediment. **Dredging physically removes phosphorus rich sediment from the water body** in question. Dredging is generally very costly and

can negatively affect lake ecology. Furthermore, it is most effective on small, shallow lakes with limited sediment depth. Since Whitewater Lake has a significant area of deep water, and since both lakes likely have thick deposits of nutrient rich sediment, dredging is impractical from logistical and cost standpoints. Dredging is not recommended for further evaluation.

Chemical Inactivation

Internal phosphorus loading results when low oxygen water destabilizes and dissolves minerals trapped in bottom sediment allowing phosphorus to dissolve into overlying water. Substances can be added to the lake to suppress this process. **In the Midwest, chemical inactivation generally uses alum (aluminum sulfate), a compound used to clarify drinking water**. Alum works in two ways. First, a solid is formed immediately upon contact with lake water. The solid captures particles, clears the water, and settles on the lake bottom. The alum forms a layer that is not affected by low oxygen levels, and it therefore isolates the lake bottom from anoxic lake water, hindering phosphorus release from bottom sediment during all seasons. Alum treatments are reasonably priced, can be applied to lakes of essentially all depths and sizes, and have provided long-term improvement in the right application. Given Whitewater Lake's size and depth, alum treatment is considered a marginally feasible alternative and is discussed in more detail in Chapter III.

Hypolimnetic Discharge

The goal of hypolimnetic discharge is to reduce the volume and, relatedly, the extent of a lake's anoxic hypolimnion. This is done by modifying the lake's outlet to pull water from deeper areas, decreasing the volume of cool deep water and preserving the volume of warm water in the epilimnion. Although the lake may still develop anoxia in its deepest areas, the volume of the hypolimnion will be reduced. As a result of this, the proportion of the lake's bottom in contact with anoxic water will be reduced, and the flux of phosphorus from bottom sediment will also be reduced. Whitewater Lake is highly dependent on groundwater influx and exhibits only intermittent outflow, and therefore could not use a gravity discharge. In addition, the outlet of Whitewater Lake is located almost over a half mile from the deep portions of the Lake, requiring long conveyance piping routes. For ths reason, hypolimnetic discharge is not feasible for Whitewater Lake and is not considered further.

Hypolimnetic Withdrawal and On-shore Treatment

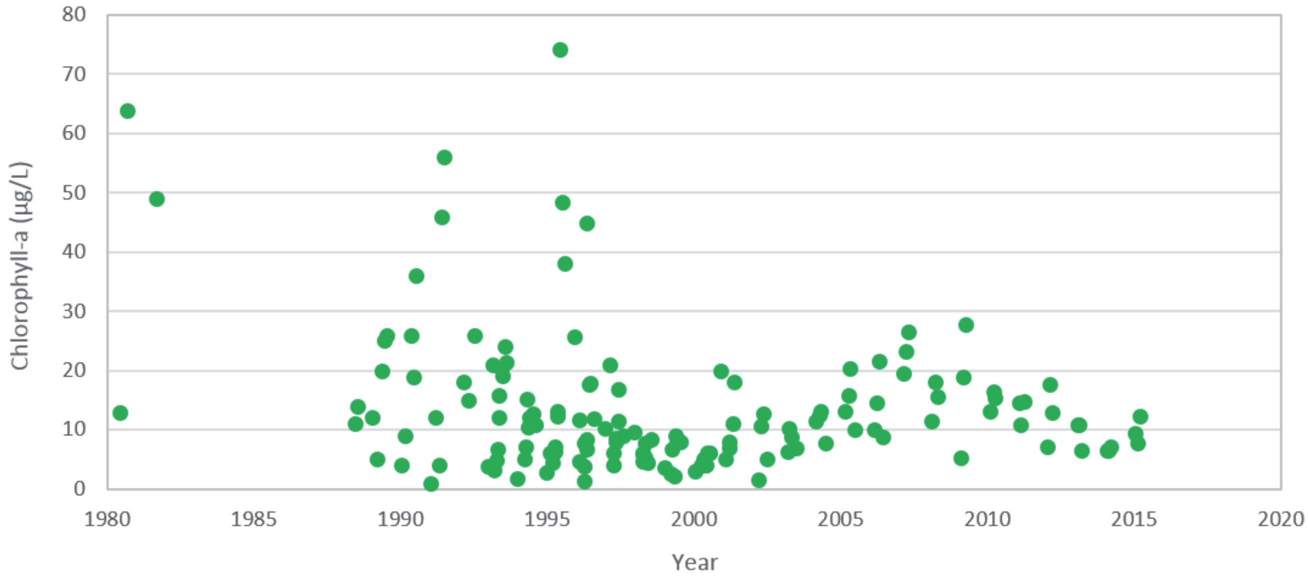
This process uses standard water treatment or natural processes to remove phosphorus from water drawn from the hypolimnion. The purified water is then returned to the lake. This technique has been used in modest sized lakes, but the long-term success of the technique is not well documented. Whitewater Lake's hypolimnion can exhibit very high phosphorus concentrations, and the total mass of phosphorus contributed by internal loading appears to be a significant component of the overall phosphorus budget for the Lake. Implementing this alternative would require long piping runs, pumps, and equipment and/or land for treating the water, all of which require significant up-front investment as well as perennial costs associated with operating and maintaining equipment. Other strategies such as aquatic plant harvesting are likely more economical methods for removing nutrients from the Lake. For this reason, while on-shore treatment is considered feasible, it is assigned a low priority.

Aeration/Circulation

The goal of aeration/circulation is to supplement oxygen levels in the hypolimnion and circulate lake water, hindering or preventing thermal stratification. Air is pumped to the lake bottom and is discharged through diffusers that create columns of air bubbles that rise to the surface. On their way to the surface, the air bubbles contribute oxygen to the water and form upwelling currents that mix the lake. Aeration/circulation is feasible, but requires careful design, maintenance, and operation to be effective. Furthermore, if poorly designed or operated, **aeration/circulation may not provide sufficient oxygen or mixing to prevent internal loading and phosphorus may be transported to the surface during the growing season**. This can increase algal abundance, worsening lake conditions. In addition to this concern, **a lake as large as Whitewater Lake would require an extensive (and therefore expensive) system to assure success**. For these reasons, aeration/circulation for Whitewater Lake, is not recommended and is not considered any further in this report.

Figure 26

CHLOROPHYLL-*A* CONCENTRATION, WHITEWATER LAKE: 1980-2015



Source: WDNR and SEWRPC.

Plant Harvesting

A considerable mass of phosphorus can be removed from a lake by aquatic plant harvesting. The two-year USGS study found that aquatic plant harvesting removed on average over 2,000 pounds of phosphorus from Whitewater Lake per year. Therefore, at a minimum, aquatic plant harvesting appeared to completely offset watershed phosphorus contributions. Plant harvesting is already underway in the Lakes for navigation purposes. **The WRLMD should consider continued or expanded aquatic plant harvesting to be a high priority water quality issue. Furthermore, the WRLMD should record estimates of the volume or weight of aquatic plants removed from each Lake to allow nutrient mass removed with harvested plants to be estimated**.

Carp Control

Carp feeding habits resuspend sediment and can change aquatic vegetation growth patterns. Controlling carp populations may be an element in a strategy to reduce phosphorus recycling in the Lakes. This is discussed later in this Chapter as part of Issue 7: Fish and Wildlife. Relevant management recommendations are discussed in Chapter III. Carp control should be given a medium priority in Whitewater Lake.

Chlorophyll-a

Chlorophyll-*a* is the major photosynthetic ("green") pigment in algae. The amount of chlorophyll-*a* present in water is an indication of the biomass, or amount, of algae in the water. The median chlorophyll-*a* concentration for lakes in Southeastern Wisconsin is approximately 9.9 µg/L but can range from 1.8 to 706.1 µg/L.[42] Chlorophyll-*a* concentrations have been measured in Whitewater Lake since the 1980s and indicate that historic spikes in chlorophyll-a levels appear to have subsided (Figure 26). Concentrations as high as 74 µg/L occurred during the 1990s, often in August and September. The last measured high concentration was 44.9 µg/L in July of 1996. Since then, chlorophyll-a averages 10.4 µg/L, comparable to the regional median, indicating that algal blooms have become less dense. This coincides with decreasing phosphorus concentrations in Whitewater Lake.

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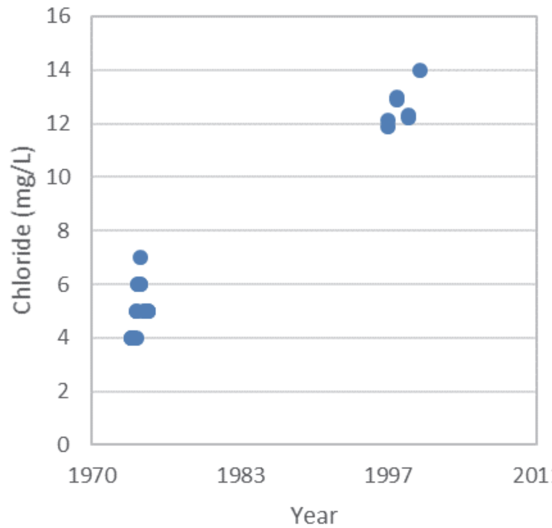
[42]*Wisconsin Department of Natural Resources Technical Bulletin No. 138*, op. cit.

Chloride

Under natural conditions, surface water in Southeastern Wisconsin contains very low chloride concentrations. Studies completed in Waukesha County lakes during the early 1900s report three to four mg/L of chloride. Most Wisconsin lakes saw little increase in chloride concentrations until the 1960s, but a rapid increase thereafter.[43] Chloride concentrations in Whitewater Lake were first recorded from September 1973 to February 1975, at which time concentrations averaged 5.0 mg/L. Chloride concentrations were again recorded from April 1997 to April 2000. During that period chloride concentrations averaged 12.6 mg/L (Figure 27). The Lake's lower-than-typical-for-the-Region chloride concentrations are probably related to the significant amount of groundwater entering and leaving the Lake. Groundwater commonly contains less chloride when compared to surface water. No current data is available for chloride concentrations, but it would be beneficial to make comparisons to historical levels and determine more definitively if human-produced pollutants are entering the Lake at high levels.

Figure 27

HISTORICAL CHLORIDE CONCENTRATIONS FOR WHITEWATER LAKE



Source: WDNR and SEWRPC.

Chloride is considered a conservative pollutant, meaning that natural processes other than evaporation typically do not detain or remove it from water. Humans use chloride bearing materials for a multitude of purposes (e.g., road salt, water softening, industrial processes), and chloride concentrations are normally positively correlated with human-derived pollutant concentrations. Chloride is indicative of a suite of human-sourced and human enriched chemicals. These chemicals include agricultural nutrients and pesticides, pharmaceuticals, petroleum products, and a host of other substances in common use by modern society. For this reason, chloride concentrations are a good indicator of the overall level of human activity, potential impact, and possibly the overall health of a water body. Increasing chloride concentrations may suggest that Whitewater Lake is subject to significant cultural pressure and the Lake has a propensity to accumulate human-introduced substances, a condition that could reduce water quality and overall ecosystem function over time.

While the most recently recorded concentrations of chloride in Whitewater Lake did not exceed guidelines, plant and animal species have varying abilities to survive or thrive in saltier environments. For example, reed canary grass, a common invasive species of wetland and riparian settings, is well-adapted to salty water environments.[44] Similarly, Eurasian water milfoil can survive levels of industrial and salt pollution that eliminates native aquatic plants.[45] At least a few invasive animal species are also more tolerant of saltier water than native fish species. For example, invasive round go by (*Neogobius melanostomus*), a fish introduced from brackish water areas of Eurasia,

[43]Ibid.

[44]*Prasser, Nick and Joy Zedler, Salt Tolerance of Invasive Phalaris arundinacea Exceeds That of Native Carex Stricta (Wisconsin)*, Ecological Restoration *28(3): 238-240, August 2010*.

[45]*Schuyler, A. E., S. B. Anderson, and V. J. Kolaga, Plant Zonation Changes in the Tidal Portion of the Delaware River*, Proceedings of the Academy of Sciences of Philadelphia, *144: 263-266, 1993*.

grows better in higher salt environments and tolerates salt concentrations that are lethal to native fish species.[46] Therefore, **progressively higher chloride concentration may increasingly favor undesirable changes to the flora and fauna of the Lakes and their watershed**.

Management efforts to reduce chloride loading to Whitewater Lake and other waterbodies throughout the Region are an important issue of concern. Winter road deicing practices are one issue related to this issue. Chloride concentrations provide an excellent low-cost mechanism to monitor overall human influence on the Lake. Therefore, chloride concentrations should be determined as part of regular water quality monitoring work and chloride reduction best management practices should be implemented. More details are provided in Chapter III.

Secchi Depth and Trophic Status

Secchi depth, a measure of water clarity, is often used as an indication of water quality. Water transparency can be affected by physical factors, such as water color and suspended particles, and by various biological factors, including seasonal variations in planktonic algal populations living in the lake. Secchi depth is often highest during winter months, indicating high water clarity, and lowest during summer months, when biological activity is highest and water clarity is lowest. Secchi depths are being collected at four locations in Whitewater Lake: the Deep Hole, or deepest area of the Lake (Figure 28); the South Bay (Figure 29); the Northwest Bay (Figure 30); and the Northeast Bay (Figure 31). Measurements have been taken at the Deep Hole since 1974 and have been taken at the three additional locations since 1986.

While all portions of the Lake tend to have secchi depths indicating poor to fair water quality, the South Bay tends to have the lowest secchi measurements, with summer values averaging 3.2 feet. This could potentially be caused by heavy summer plant growth which might obstruct the secchi disk or by sediment resuspending by carp feeding. The Northeast and Northwest Bays tend to have the highest overall secchi measurements in the summer, with values averaging 5.0 feet and 4.9 feet, respectively. It is important to note that although only summer secchi measurements are shown, low secchi measurements can continue well into September in all portions of the Lake.

Figure 32 shows water clarity across the whole Lake derived from satellite data. The figure supports secchi depth measurements collected across Whitewater Lake, with the lowest water clarity, approximately five feet, found in the South Bay, and the highest clarity, upwards of 16 feet, being found in the Northeast Bay. The higher clarity suggests that the Northeast Bay may be receiving less nutrients and could be a prime groundwater discharge area (groundwater typically has low concentrations of phosphorus). This is further supported by the fact that the Northeast Bay is the location of one of the original three lakes present before the creation of the dam to fill Whitewater Lake (see Map 4). In addition, the imagery data were collected on September 23, 2014 and higher clarity may be explained by lower biological activity (e.g., algal blooms) so late in the growing season.

The zebra mussel (*Dreissena polymorpha*) has been shown to affect water clarity. This nonnative species of shellfish rapidly colonizes nearly any clean, stable, flat underwater surface, artificial or natural. Massive colonies have become a significant nuisance in some lakes. The WDNR sampled Whitewater Lake for veligers (zebra mussel larvae) three times between 2002 and 2008. No evidence of adults or larvae were found through 2008. The WDNR verified the presence of zebra mussels in Whitewater Lake during 2010. Zebra mussels remove particulate matter from the water column and have the tendency to improve water clarity. Water clarity appears to have improved throughout the Lake since 2010 (see Figures 28 to 31). During the 2014 Aquatic Plant Survey conducted by SEWRPC staff, zebra mussels were found primarily throughout the South Bay, where aquatic plant growth was the densest. (See "Section 1: Aquatic Plant Management").

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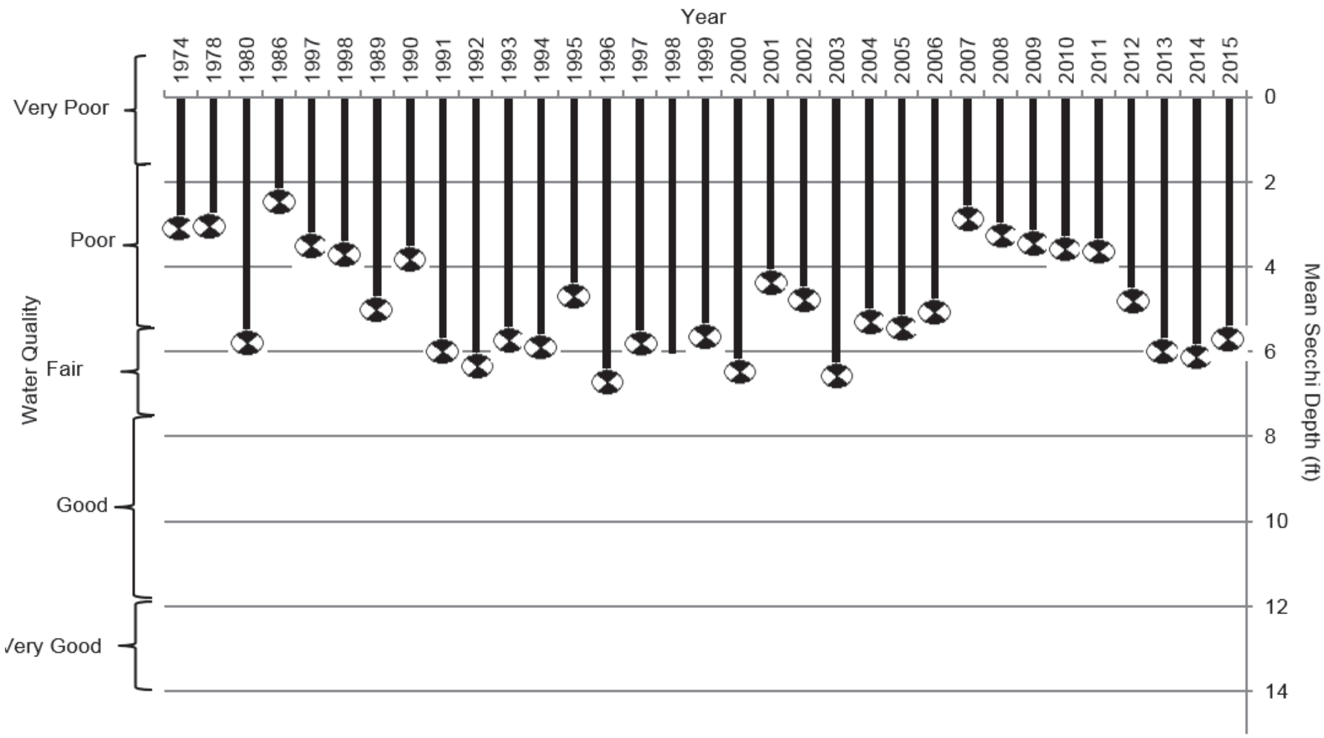
[46] *Karsiotis, Susanne, Lindsey Pierce, Joshua Brown, and Carol Stepien, Salinity Tolerance of the Invasive Round Goby: Experimental Implications for Seawater Ballast Exchange and Spread to North American Estuaries,* Journal of Great Lakes Research, *Volume 38, Issue 1, pp 121-128, March 2012.*

Figure 28

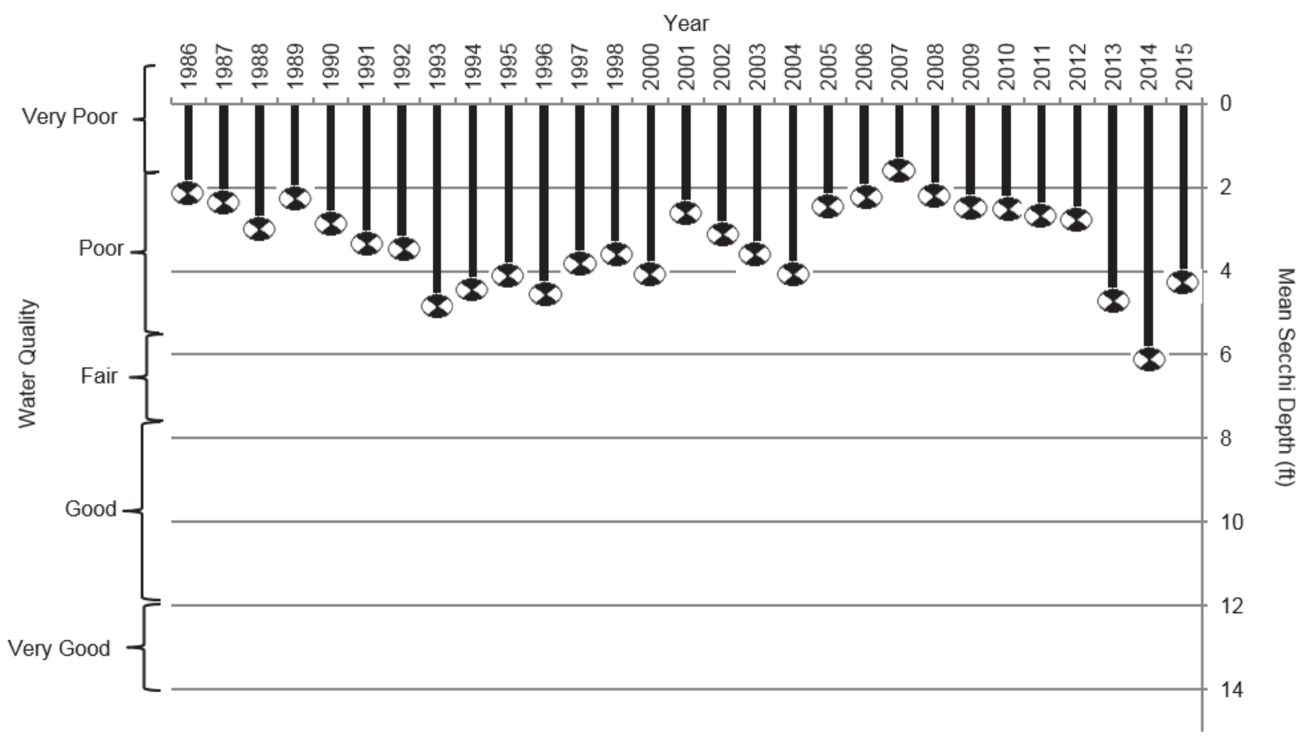
MEAN SECCHI DISK DEPTHS IN WHITEWATER LAKE FOR JUNE TO AUGUST ONLY: DEEP HOLE



Source: WDNR and SEWRPC.

Figure 29

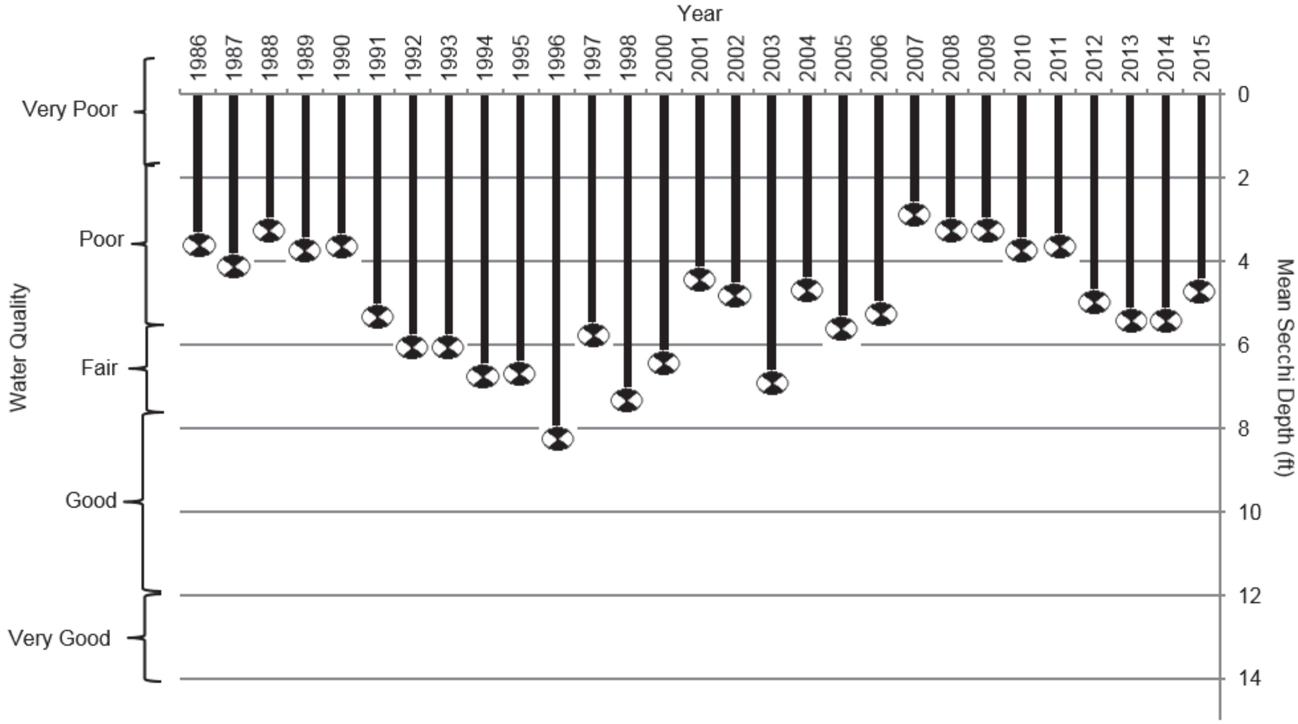
MEAN SECCHI DISK DEPTHS IN WHITEWATER LAKE FOR JUNE TO AUGUST ONLY: SOUTH BAY



Source: WDNR and SEWRPC.

Figure 30

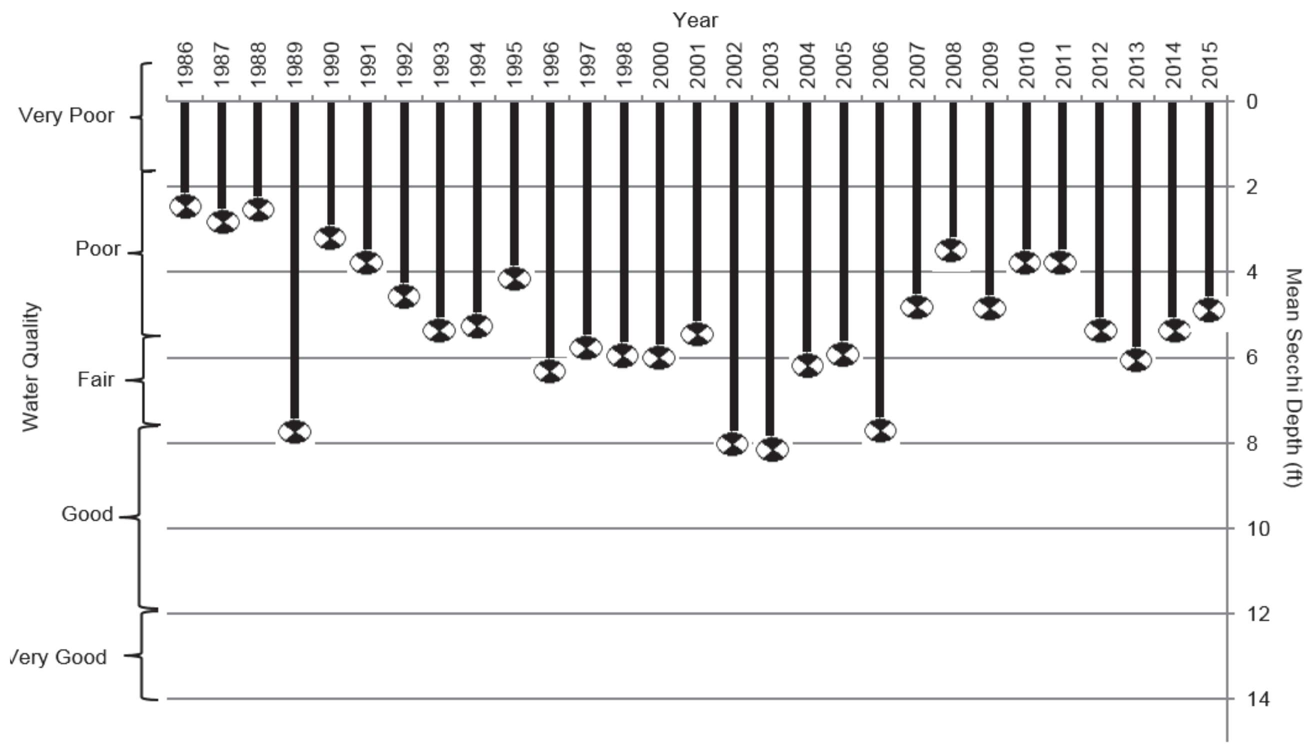
MEAN SECCHI DISK DEPTHS IN WHITEWATER LAKE FOR JUNE TO AUGUST ONLY: NORTHWEST BAY



Source: WDNR and SEWRPC.

Figure 31

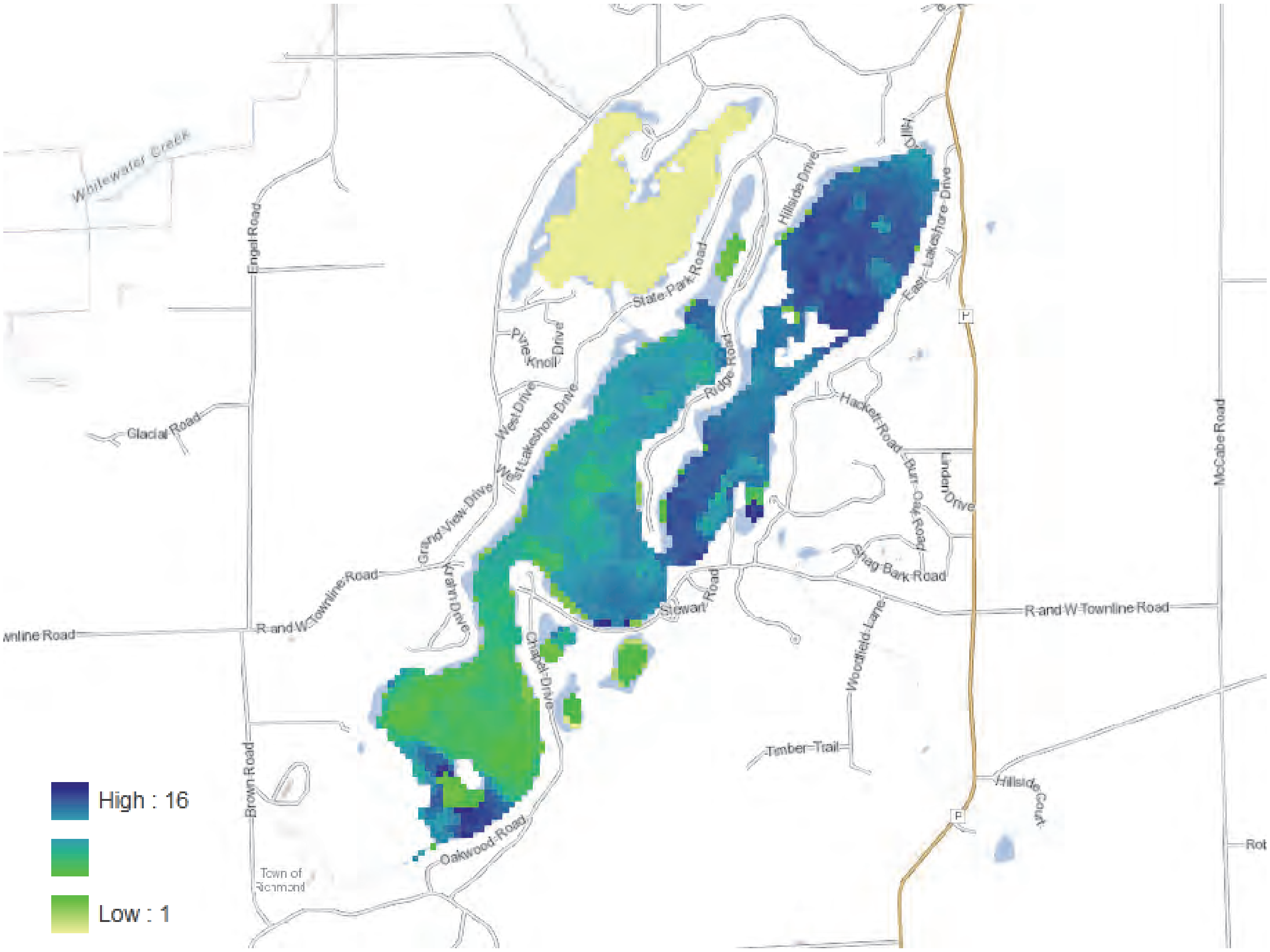
MEAN SECCHI DISK DEPTHS IN WHITEWATER LAKE FOR JUNE TO AUGUST ONLY: NORTHEAST BAY



Source: WDNR and SEWRPC.

Figure 32

SATELLITE DERIVED WATER CLARITY FOR WHITEWATER AND RICE LAKES: 2014



Date of Image: September 23, 2014.

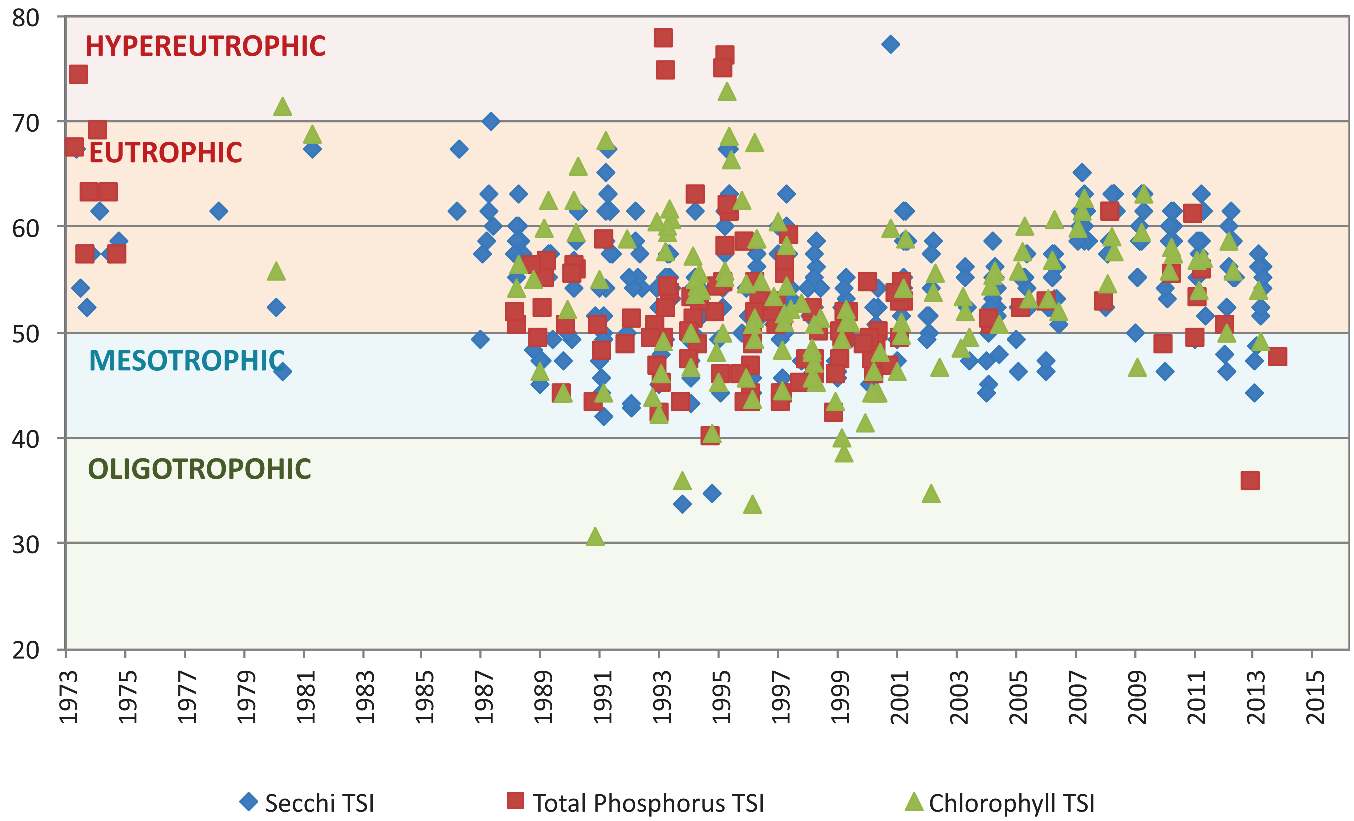
Source: WDNR.

Based on recent water chemistry and other data, **Whitewater Lake appears to be a eutrophic lake** with an average TSI over the past five years of 54 (Figure 33) which, for a deep seepage lake, is considered **a "fair" lake condition**.[47] Historically, TSI values were sometimes as high as 77, which is considered hypereutrophic and a poor lake condition. As seen with total phosphorus and chlorophyll-*a* concentrations, overall conditions within Whitewater Lake have been improving since creation of the Lake. As the Lake continues to age and becomes more dominated by rooted aquatic plants, more phosphorus may be removed through macrophyte harvesting, a situation that could further improve Whitewater Lake's water quality. Furthermore, watershed land use changes and implementation of best management practices both have the potential to reduce the mass of phosphorus delivered to the Lake, which also could improve water quality.

[47] *Wisconsin Department of Natural Resources*, Wisconsin 2014 Consolidated Assessment and Listing Methodology (WisCALM) Clean Water Act Section 305(b), 314, and 303(d) Integrated Reporting, op cit.

Figure 33

TROPHIC STATUS INDEX MEASUREMENTS FOR WHITEWATER LAKE: 1973-2014



Source: WDNR and SEWRPC.

Rice Lake

Available data for Rice Lake are very limited and collection of most parameters was sporadic between 1978 and 2006. Volunteer data collection concluded in 2006. The most thorough analysis of water quality conditions was conducted by the USGS in 1990 to 1991, data which has been analyzed thoroughly in that report and in previous Lake Management and Aquatic Plant Management Plans prepared by SEWRPC.[48,49] Therefore, only a brief summary of known water quality conditions is presented in the following sections.

Temperature, Oxygen, and Stratification

Unlike Whitewater Lake, Rice Lake can be classified as a shallow, unstratified seepage lake.[50] Very little temperature and dissolved oxygen data is available for Rice Lake. Historical data from July 1978 show that, although the Lake did not stratify during the summer, dissolved oxygen levels were below the 5.0 mg/L standard set by the WDNR to

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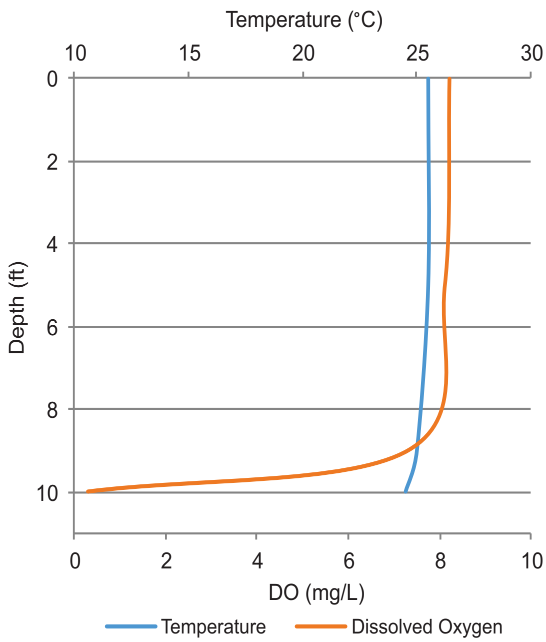
[48]*U.S. Geological Survey Water-Resources Investigations Report 94-410*, op cit.

[49]*SEWRPC Community Assistance Planning Report No. 224*, op cit., *SEWRPC Memorandum Report No. 177*, op cit.

[50]*Wisconsin Department of Natural Resources*, Wisconsin 2014 Consolidated Assessment and Listing Methodology (WisCALM) Clean Water Act Section 305(b), 314, and 303(d) Integrated Reporting, op cit.

Figure 34

HISTORICAL SUMMER DISSOLVED OXYGEN-TEMERATURE PROFILE FOR RICE LAKE: 1978



Source: WDNR and SEWRPC.

support warmwater aquatic life at the very bottom of the Lake (Figure 34).[51] Data from 1991 provided by USGS indicate that, **although thermal stratification does not occur in Rice Lake during the summer months, anoxic conditions develop in bottom waters in June and in August, at between 4 and 8 feet, and water column mixing occurs in April, July and September.**[52] **This means that as much as 60 percent of the Lake bottom could experience anoxia during a typical summer**. The anoxic conditions are created by dense algal blooms that exhibit respiration (use of oxygen) during the night and that die and sink to the bottom to be consumed by bacteria, another process which uses oxygen. Anoxic conditions suggest that phosphorus trapped in bottom sediment can be released into the deep waters and mixed into the water column during mixing periods.[53] No data are available to determine if anoxic conditions occur during winter months. It is recommended that regular water quality monitoring be reinstated in Rice Lake to collect data to determine if anoxic bottom water conditions are continuing to occur and, if so, to what extent.

Oxygen saturation data in surface and deep water, from March to November 1991, are shown in Figure 35. Near-surface waters of Rice Lake were supersaturated with oxygen during portions of the summer, with values reaching as high as 180 percent, while waters below approximately eight feet became anoxic, with saturation values as low as 1.2 percent. The extremely high saturation values are a result of abundant photosynthetic activity during algal blooms. No data is available for nighttime conditions. **Such conditions create a highly stressful environment for aquatic organisms**. Oxygen concentrations have great influence on the Lake's biota and chemistry. For this reason, oxygen concentration profiles should be regularly and consistently measured, including profiles collected at night during the summer. More details of this recommendation may be found in Chapter III.

Phosphorus

Near-surface water quality samples have been sporadically collected in Rice Lake. Rice Lake's spring and summer total phosphorus concentrations ranged from 0.020 to 0.047 mg/L between 1994 and 2005, with an overall average of 0.030 mg/L (Figure 36). Late summer and deeper water samples have not been recently collected. Data from the 1991 USGS study indicate that surface total phosphorus levels ranged between 0.022 mg/L in April and 0.138 mg/L in July. During that same time period, bottom water total phosphorus concentrations ranged from 0.022 mg/L in April to 0.125 mg/L in September (Figure 33).[54] The overall average phosphorus concentration during 1991 was 0.076 mg/L. During summer months these values were often higher than both the aquatic life impairment threshold of 0.100 mg/L for shallow (see Figure 37), headwater drainage lakes and the recreational impairment threshold

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[51]Wisconsin Administrative Code *Chapter NR 102*, Water Quality Standards for Wisconsin Surface Waters, *November 2010*.

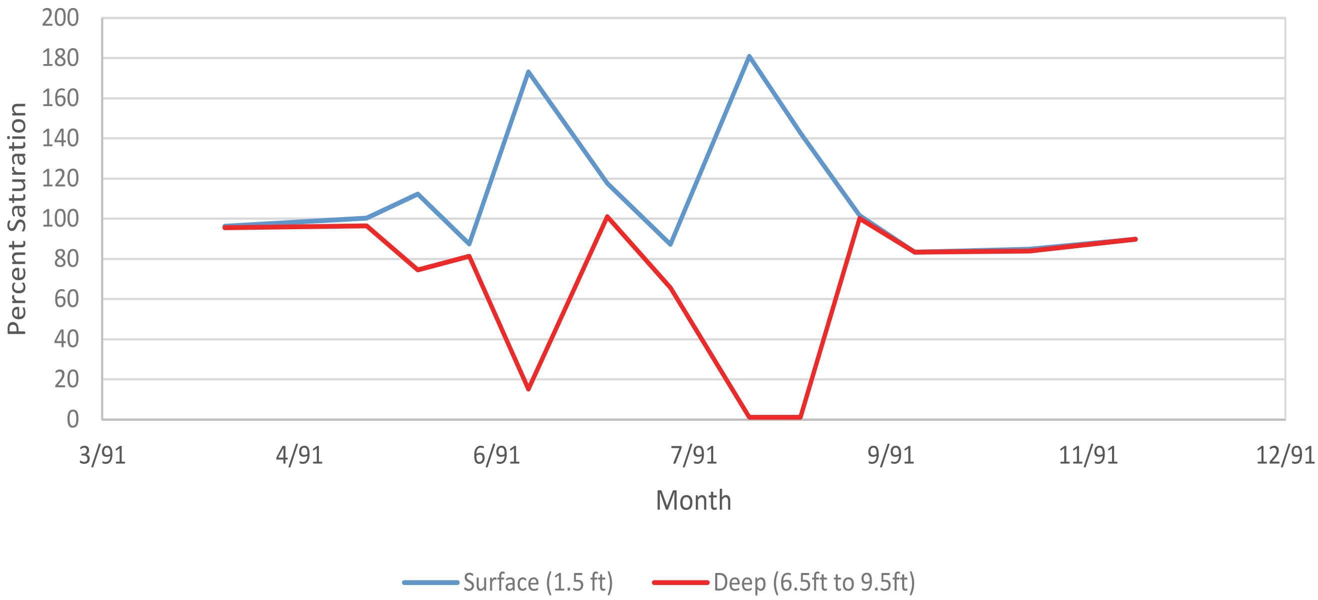
[52]*U.S. Geological Survey Water-Data Report WI 91-1*, Water Resources Data, Wisconsin, *Water Year 1991, 1992*.

[53]*U.S. Geological Survey Water-Resources Investigations Report 94-410*, op cit.

[54]*U.S. Geological Survey Water-Data Report WI 91-1*, op cit.

Figure 35

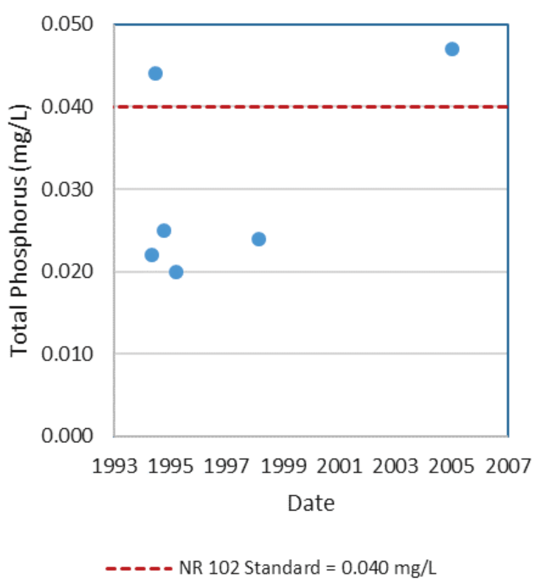
OXYGEN SATURATION AT SURFACE AND IN DEEP WATER IN RICE LAKE: 1991



Source: USGS and SEWRPC.

Figure 36

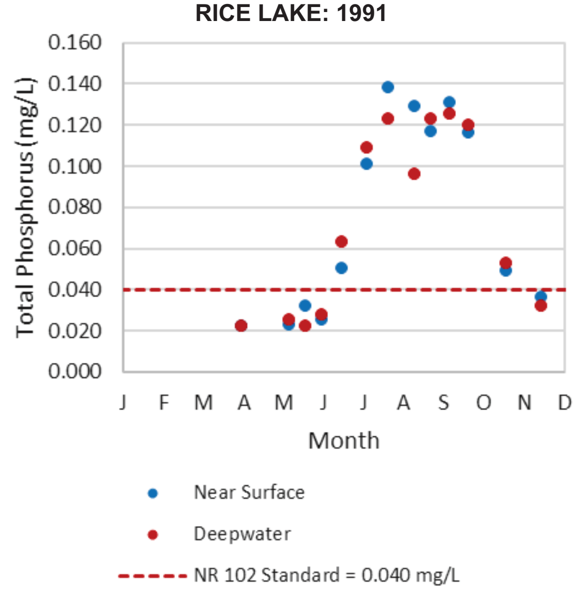
HISTORICAL TOTAL PHOSPHORUS CONCENTRATIONS IN RICE LAKE SURFACE WATERS: 1994



Source: WDNR and SEWRPC.

Figure 37

TOTAL PHOSPHORUS CONCENTRATIONS IN RICE LAKE: 1991



Source: WDNR and SEWRPC.

of 0.040 mg/L for such lakes mandated by the *Wisconsin Administrative Code*.[55,56] High phosphorus concentrations during summer months suggest significant internal phosphorus loading or recycling. The contribution of total phosphorus from internal loading and recycling was estimated to be 295 pounds and was determined to represent 82 percent of the combined internal and external total phosphorus input to Rice Lake.[57] Given the observed water quality of Rice Lake, phosphorus recycling likely continues to be the dominant reason for degraded water quality, underscoring the need for a water quality monitoring program and in-lake phosphorus management. Obtaining this data will provide a baseline for comparison to determine if, over time, management efforts improve conditions within the Lake.

RICE LAKE MANAGEMENT IMPLICATIONS AND RECOMMENDATIONS

Once these data are collected, possible methods to reduce phosphorus internal loading can be better conceptualized. The methods, discussed previously for Whitewater Lake, are listed below along with a judgement of practicality for employment in Rice Lake.

Dredging

Internal loading depends upon the presence of phosphorus-rich bottom sediment. **Dredging physically removes phosphorus rich sediment from the water body** in question. Dredging is generally very costly and can negatively affect lake ecology. Furthermore, it is most effective on small, shallow lakes with limited sediment depth. The dominance of thick muck sediment present from the drowning of wetlands would require extensive dredging, causing this method to be impractical from logistical and cost standpoints. Dredging is not recommended for further evaluation.

Chemical Inactivation

Internal phosphorus loading results when low oxygen water destabilizes and dissolves minerals trapped in bottom sediment allowing phosphorus to dissolve into overlying water. Substances can be added to the lake to suppress this process. **In the Midwest, chemical inactivation generally uses alum (aluminum sulfate), a compound used to clarify drinking water**. Alum works in two ways. First, a solid is formed immediately upon contact with lake water. The solid captures particles, clears the water, and settles on the lake bottom. The alum forms a layer that is not affected by low oxygen levels, and it therefore isolates the lake bottom from anoxic lake water, hindering phosphorus release from bottom sediment during all seasons. Alum treatments are reasonably priced, can be applied to lakes of essentially all depths and sizes, and have provided long-term improvement in the right application. Although Rice Lake may temporarily benefit from an alum treatment, the Lake's shallow depth and abundant carp make long-term effectiveness doubtful. Therefore, alum treatment is not considered a feasible option for Rice Lake.

Hypolimnetic Discharge

The goal of hypolimnetic discharge is to reduce the volume and, relatedly, the extent of a lake's anoxic hypolimnion. Since Rice Lake does not thermally stratify, hypolimnetic discharge is not feasible for Rice Lake and is not considered further.

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[55]*Wisconsin Department of Natural Resources*, Wisconsin 2014 Consolidated Assessment and Listing Methodology (WisCALM) Clean Water Act Section 305(b), 314, and 303(d) Integrated Reporting, op cit.

[56]Wisconsin Administrative Code *Chapter NR 102*, op. cit.

[57]*U.S. Geological Survey Water-Resources Investigations Report 94-410*, op cit.

Hypolimnetic Withdrawal and On-shore Treatment

This process uses standard water treatment processes to remove phosphorus from water drawn from the hypolimnion. Since Rice Lake does not thermally stratify, a hypolimnion with high dissolved phosphorus concentrations fails to form. Although waters with lower phosphorus concentration can be treated, excessive volumes of water need to be processed to remove significant amounts of phosphorus, making hypolimnetic withdrawal and on-shore treatment approach impractical for Rice Lake. Therefore, this method is assigned a low priority for Rice Lake.

Aeration/Circulation

The goal of aeration/circulation is to supplement oxygen levels in the hypolimnion and circulate lake water hindering or preventing thermal stratification. Since Rice Lake does not thermally stratify, this method is not feasible for Rice Lake and is not considered further.

Plant Harvesting

A considerable mass of phosphorus can be removed from a lake by aquatic plant harvesting. The two-year USGS study found that aquatic plant harvesting removed on average 37 pounds from Rice Lake per year. Therefore, at a minimum, aquatic plant harvesting appears to completely offset watershed phosphorus contributions. Plant harvesting is already underway in the Lakes for navigation purposes. The WRLMD should consider continued aquatic plant harvesting to be a high priority water quality issue. Furthermore, the WRLMD should record estimates of the volume or weight of aquatic plants removed from each Lake to allow nutrient mass removed with harvested plants to be estimated.

Carp Control

Carp feeding habits resuspend sediment and can change aquatic vegetation growth patterns. Controlling carp populations may be an important element in a strategy to reduce phosphorus recycling in the Lakes. This is discussed later in this Chapter as part of Issue 7: Fish and Wildlife. Relevant management recommendations are discussed in Chapter III. Carp control should be given a high priority in Rice Lake.

Chlorophyll-a

Chlorophyll-*a* data are only available from 1980 to 1998 and suggest that chlorophyll-*a* concentrations have decreased from levels as high as 170 μg/L (Figure 38). However, in the late 1990s, chlorophyll concentrations were still measured to be as high as 35 μg/L, indicating poor water quality and algal blooms. **Data from 1991 provided by USGS also indicate dense algal blooms, particularly in the summer months, in conjunction with internal phosphorus loads mixing into the water column**.[58] Spring turnover chlorophyll-*a* concentrations were only 6 μg/L, while July concentrations reached 147 μg/L (Figure 39), well above the regional mean of 9.9 μg/L.[59] Currently, frequent and dense algal blooms continue to be an issue of concern on Rice Lake, hence, it is recommended a monitoring program for chlorophyll-*a* be reinstated to determine current trends and measure effectiveness of future management efforts. Algae are discussed further in "Issue 3: Cyanobacteria and Floating Algae."

Secchi Depth and Trophic Status

Historic summer secchi depth data collected in Rice Lake (Figure 40) suggest poor water quality, with an average measurement of three feet. Secchi depths have not been collected by Citizen Lake Monitoring volunteers since 2006, but would be beneficial to future lake management. TSI values have averaged 59 over the time of monitoring, but have risen as high as 80 historically and indicate that Rice Lake is commonly eutrophic to hypereutrophic

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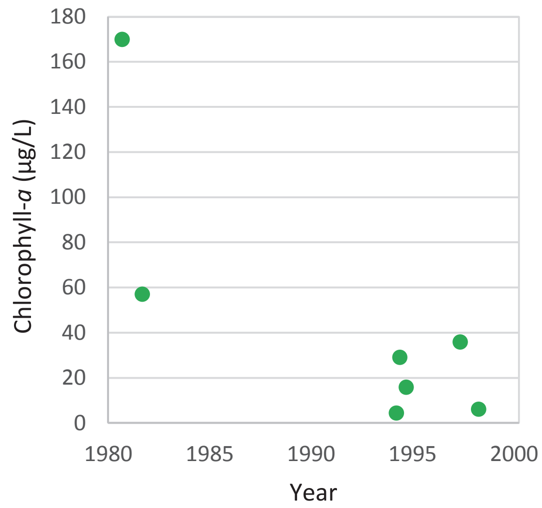
[58] *U.S. Geological Survey Water-Data Report WI 91-1*, op cit.

[59] *Wisconsin Department of Natural Resources Technical Bulletin No. 138*, op. cit.

Figure 38

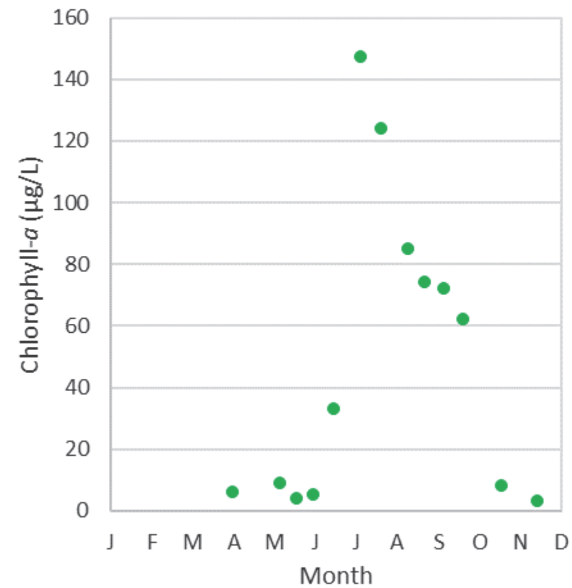
CHLOROPHYLL-*A* CONCENTRATION, RICE LAKE: 1980-1998



Source: WDNR and SEWRPC.

Figure 39

CHLOROPHYLL-*A* CONCENTRATION, RICE LAKE: 1991



Source: USGS and SEWRPC

(Figure 41). The WDNR has been collecting satellite water clarity observations for the last five years, giving an average trophic state of 73, which, for a shallow unstratified seepage lake, is considered **a "poor" lake condition**.[60] Figure 32 shows that satellite derived water clarity within Rice Lake tends to be extremely low, with a depth of one foot. No other water quality parameters have been studied in Rice Lake.

Retention Times of Whitewater and Rice Lakes

The USGS thoroughly studied surface flow, groundwater flow, evaporation, and precipitation rates to determine retention times for both Whitewater and Rice Lakes.[61] **Retention time was estimated to be 1.02 years for Whitewater Lake. Rice Lake was found to have a retention time of 7.07 years**. The degree of nutrient inflow is very important in managing water quality conditions within the Lakes (since pollutants accumulate in the Lakes). Additionally, in-lake measures to control phosphorus will be needed since internal loading of phosphorus is an issue and excess phosphorus is not being flushed out of the Lakes quickly by surface water, fueling algal blooms and nuisance plant growth.

Based upon typical watershed yield within the Rock River basin, WiLMS modeling estimated **the long-term hydraulic detention time of 0.98 years for Whitewater Lake, and 3.95 years for Rice Lake**.[62] The Whitewater Lake value is comparable to that reported in the USGS report. However, the detention time for Rice Lake is three years shorter according to the WiLMS model. The differences may reflect the great influence of groundwater flow in the local area. During periods of heavy precipitation, the instantaneous hydraulic detention time may be much

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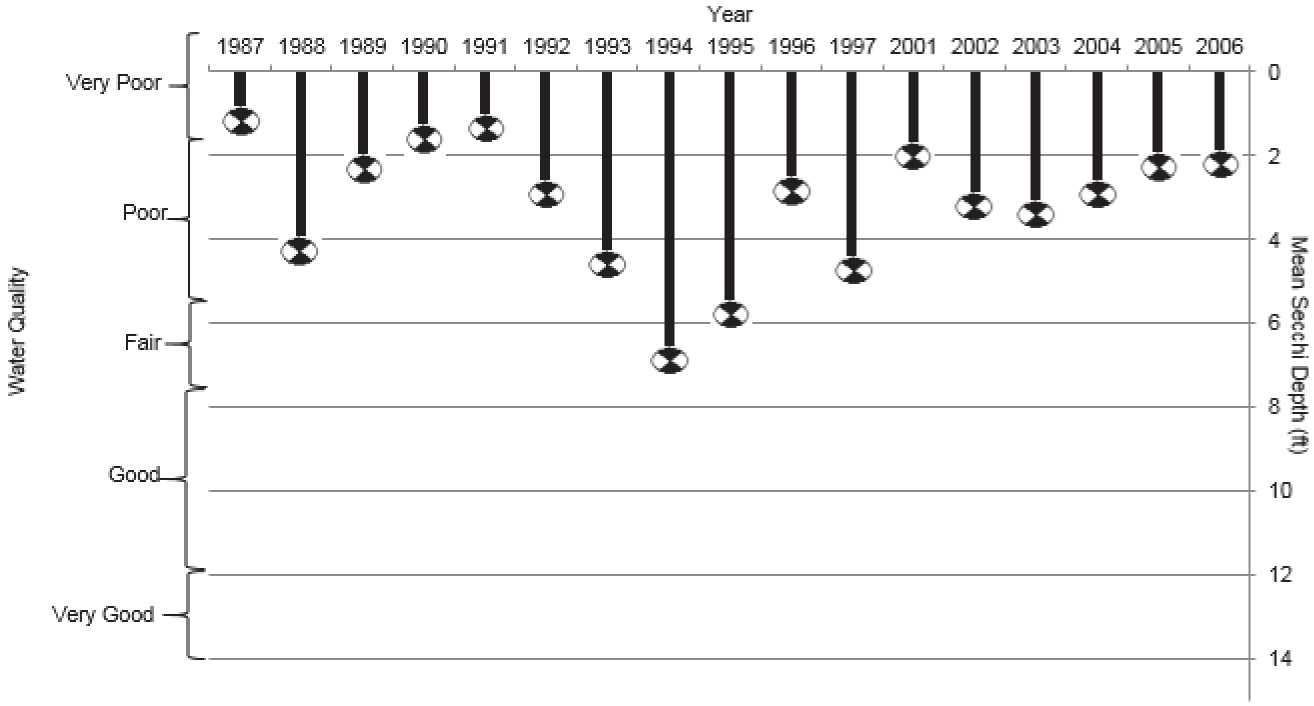
[60]*Wisconsin Department of Natural Resources*, Wisconsin 2014 Consolidated Assessment and Listing Methodology (WisCALM) Clean Water Act Section 305(b), 314, and 303(d) Integrated Reporting, op cit.

[61]*U.S. Geological Survey Water-Resources Investigations Report 94-410*, op cit.

[62]*Wisconsin Lake Model Spreadsheet (WiLMS version 3.3.18).*

Figure 40

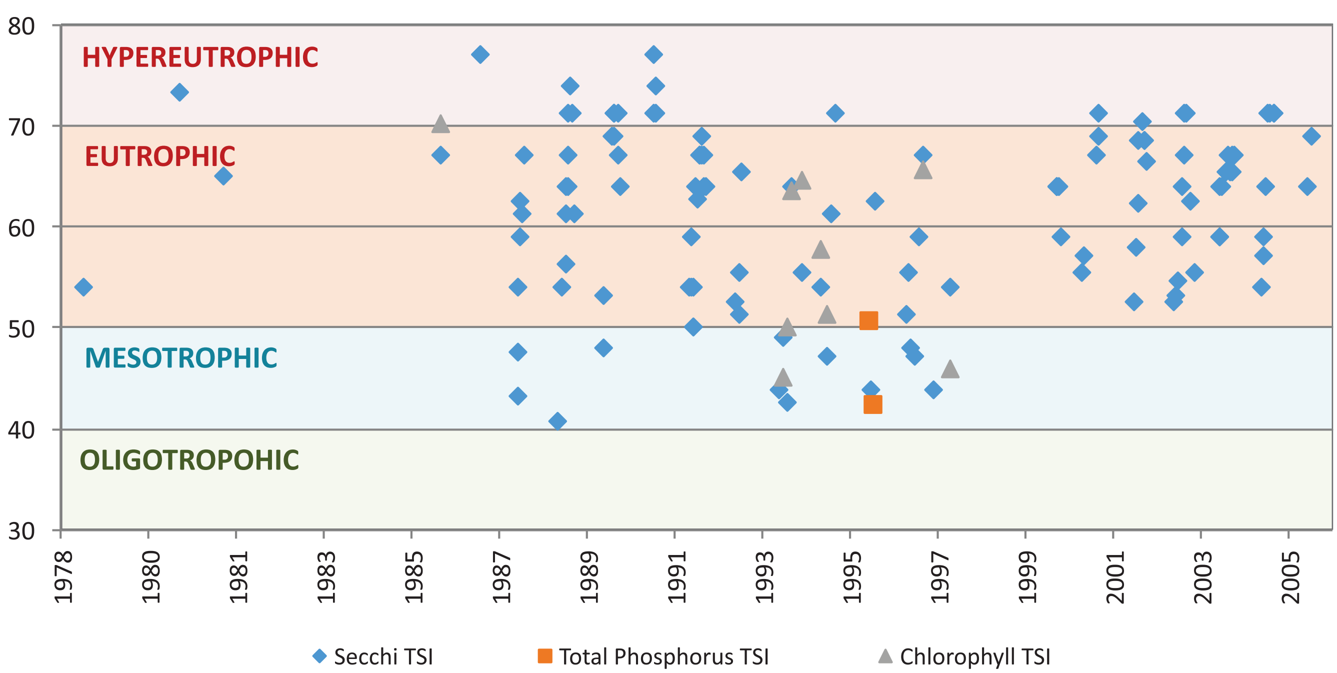
MEAN SECCHI DISK DEPTHS IN RICE LAKE FOR JUNE TO AUGUST ONLY



Source: WDNR and SEWRPC.

Figure 41

TROPHIC STATUS INDEX MEASUREMENTS FOR RICE LAKE: 1978-2006



Source: WDNR and SEWRPC.

lower, while during drought, the instantaneous hydraulic detention time may be much higher. The average hydraulic retention time for other stratified seepage lakes in Wisconsin is 2.63 years, which means that Whitewater Lake has a faster than average flushing rate.[63] Based upon available data, Whitewater Lake likely receives copious volumes of groundwater, a condition that likely contributes to its faster than average flushing rate. The average hydraulic retention time for other unstratified seepage lakes in Wisconsin is 1.24 years, which means that Rice Lake has a much slower than average flushing rate. Rice Lake water levels are highly dependent on precipitation, a condition that likely contributes to its slower than average flushing rate. See Issue 5: "Groundwater Recharge" for more detailed information.

Ultimately, more data on Lake conditions will need to be collected to confirm water quality trends and interpretations and to better forecast the effectiveness of future management efforts. Whatever the case, **preventing pollution from entering the Lakes will aid in-lake management efforts**. Consequently, recommendations related to both monitoring and management are discussed in Chapter III of this report to help promote better water quality.

Watershed Characteristics and Pollutant Loadings

Different land uses can contribute different types of pollution to a lake. Though it is normal for some sediment and nutrients to enter a lake from the surrounding lands (contributing to the natural lake aging process), it becomes an issue of concern when people introduce pollutants (such as heavy metals, fertilizers, and oils) which would not have otherwise entered the system. Sedment and nutrient loads can greatly increase when land is disturbed through tilling and construction, which causes soils to loosen, erode, and eventually enter streams and lakes.

Given these connections between the practices around a lake and lake water quality, it is important to characterize the area that drains to a lake—its watershed—to determine potential pollution sources and risks to the lake's water quality. Several items need to be examined in order to complete this characterization, including:

1. **The location and extent of a lake's watershed**—Before beginning to characterize a watershed, it is first necessary to delineate that watershed. The process of delineation essentially involves analyzing land surface elevation data surrounding a lake to determine the area draining towards the lake. This analysis provides the basis for determining whether potential pollutant sources threaten the lake. If a pollution source is near to a lake but outside of the watershed, for example, surface runoff from that source would not reach the lake, and, therefore, is not an issue of concern in terms of water quality.

2. **The type and location of existing land use within the watershed**—The extent and location of current land use within the watershed can help determine potential causes of pollution to a lake. Land use conditions can be represented in models to estimate total pollutant loads entering a lake, evaluate the relative contribution of certain land uses or areas, and predict consequences of land use changes. Once these loads are determined, it is then possible to determine where to focus management efforts (e.g., if agriculture is the primary source of phosphorus, this may be an effective place to begin pollution reduction efforts).

3. **The type and location of past land use changes within the watershed**—Being aware of past land use changes can provide a context for understanding what caused past issues within a lake, particularly when considered with contemporaneous water quality monitoring data or well-known historical issues. If a long-term lake property owner, for example, remembers or has record of years of heavy aquatic plant growth, large algal blooms, or low or high lake levels, those conditions can be correlated in terms of the historical land use changes to determine if something changed within the watershed to cause an issue (such as an increase in agricultural land use or development). This information can help planning because it is offers insight into how a lake might react to similar situations.

[63] *Wisconsin Department of Natural Resources Technical Bulletin No. 138*, op. cit.

4. **The nature and location of planned land use within the watershed**—In addition to current land use in the watershed, it is also possible to estimate future planned land use changes. This information helps target areas that may need management efforts in the future, as well as the potential extent of future pollution issues.

5. **The location of septic systems in the watershed (if applicable)**—Private onsite wastewater treatment systems (POWTS), or septic systems, can be a significant source of phosphorus pollution when not properly maintained, and are usually a source of chloride. Consequently, it is important to investigate whether they exist within the watershed.

The Whitewater and Rice Lake watershed boundaries were delineated using two-foot interval ground elevation contours developed from a year 2003 digital terrain model. The watersheds of Whitewater and Rice Lakes are situated within the Towns of Whitewater and Richmond, Walworth County (Map 7). The **total areas draining to Whitewater and Rice Lakes is approximately 4300 and 4670 acres**, respectively, or about 6.7 and 7.3 square miles.[64] However, the USGS study conducted in 1990 to 1991 indicated that much of the watershed did not contribute surface flow to the lakes because of terrain and soils.[65] Therefore, SEWRPC staff re-evaluated the extent of the watersheds that contribute surface flow. Much of the watershed area was found to be internally drained, meaning that water drains to closed depressions soaking into the soil and becoming part of the groundwater flow system.

SEWRPC quantified the location and extent of internally drained areas by examining the hills and depressions of the Whitewater and Rice Lake watersheds. Internally drained areas were reviewed using Walworth County 2010 aerial photography and 2003 two-foot topographic contour maps. Much of the land surrounding these lakes is characterized by kettles and other depressions without obvious drainage outlets. When these depressions are deep enough, they prevent surface water runoff from flowing to one of the lakes and instead allow the water to infiltrate to groundwater. In this analysis it was assumed that during most storm events a land depression would not allow any water to flow towards a lake if the depression would need to fill withmore than ten feet of water. Some exceptions to the 10 foot rule were made for depressions that have a large contributing drainage area. Boundaries were drawn around the depressions that were assumed to not overflow, and these boundaries define the internally drained areas for the Whitewater and Rice Lake watersheds (see Map 8).

Nine internally drained areas were delineated within the Whitewater Lake watershed. These areas ranged between six and 2270 acres in size and totaled 2994 acres. Three internally drained areas were delineated within the Rice Lake watershed. They ranged between 3 and 71 acres in size and totaled 106 acres. **Revising the watershed to remove these internally drained areas reduces the extent of the watershed contributing surface flow to each Lake, resulting in drainage areas of 1307 acres (2.0 square miles) for Whitewater Lake and 262 acres (0.4 square miles) for Rice Lake**. On rare occasions, the water elevation of Whitewater Lake reaches the lake-level control dam elevation, and water spills to Rice Lake. This highly intermittent flow briefly adds another 2012 acres to Rice Lake's watershed.

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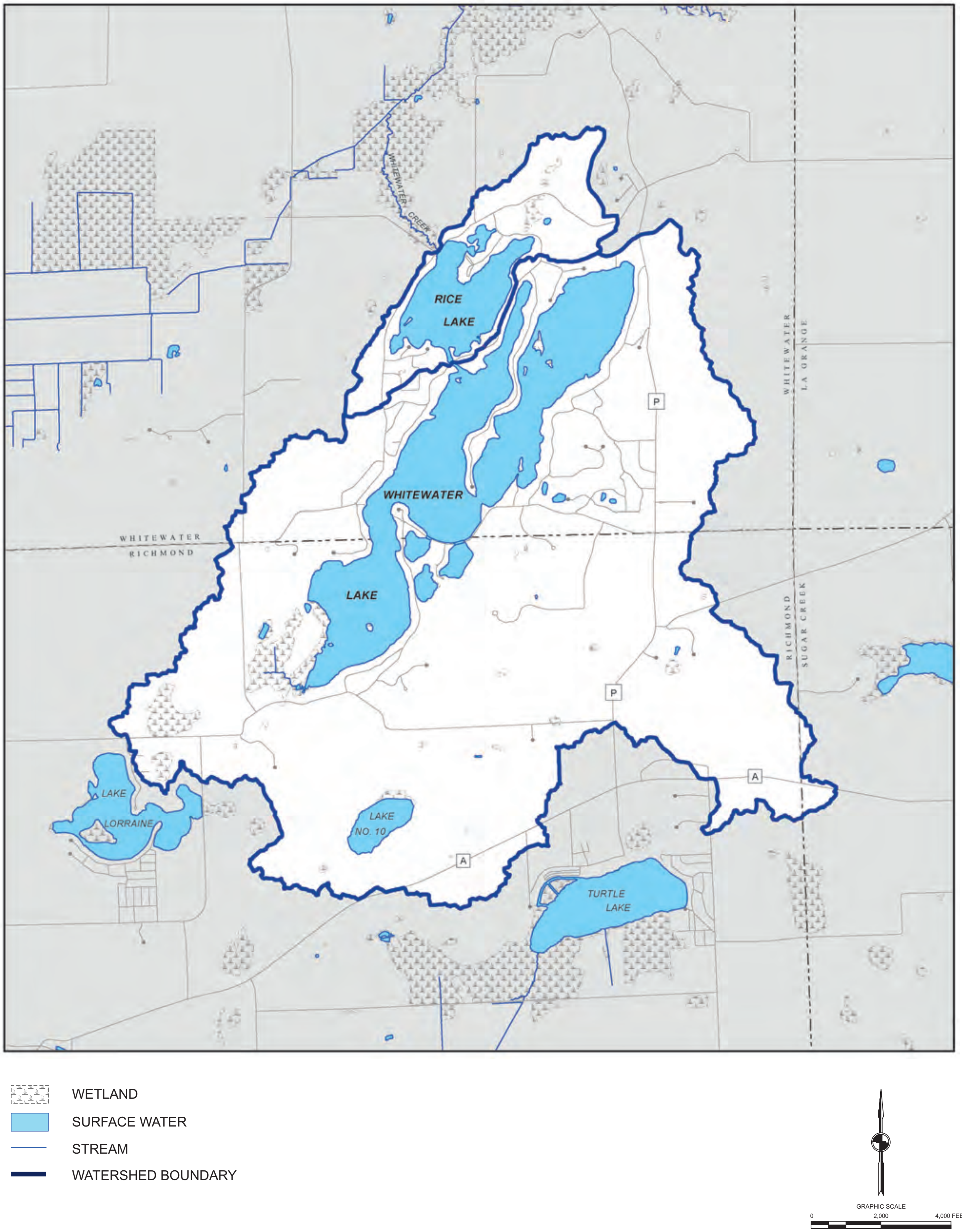
[64]*Watershed areas reported here differ from previous reports because the surface areas of the Lakes were subtracted from the total watershed areas.*

[65]*U.S. Geological Survey Water-Resources Investigations Report 94-410*, op cit.

Map 7

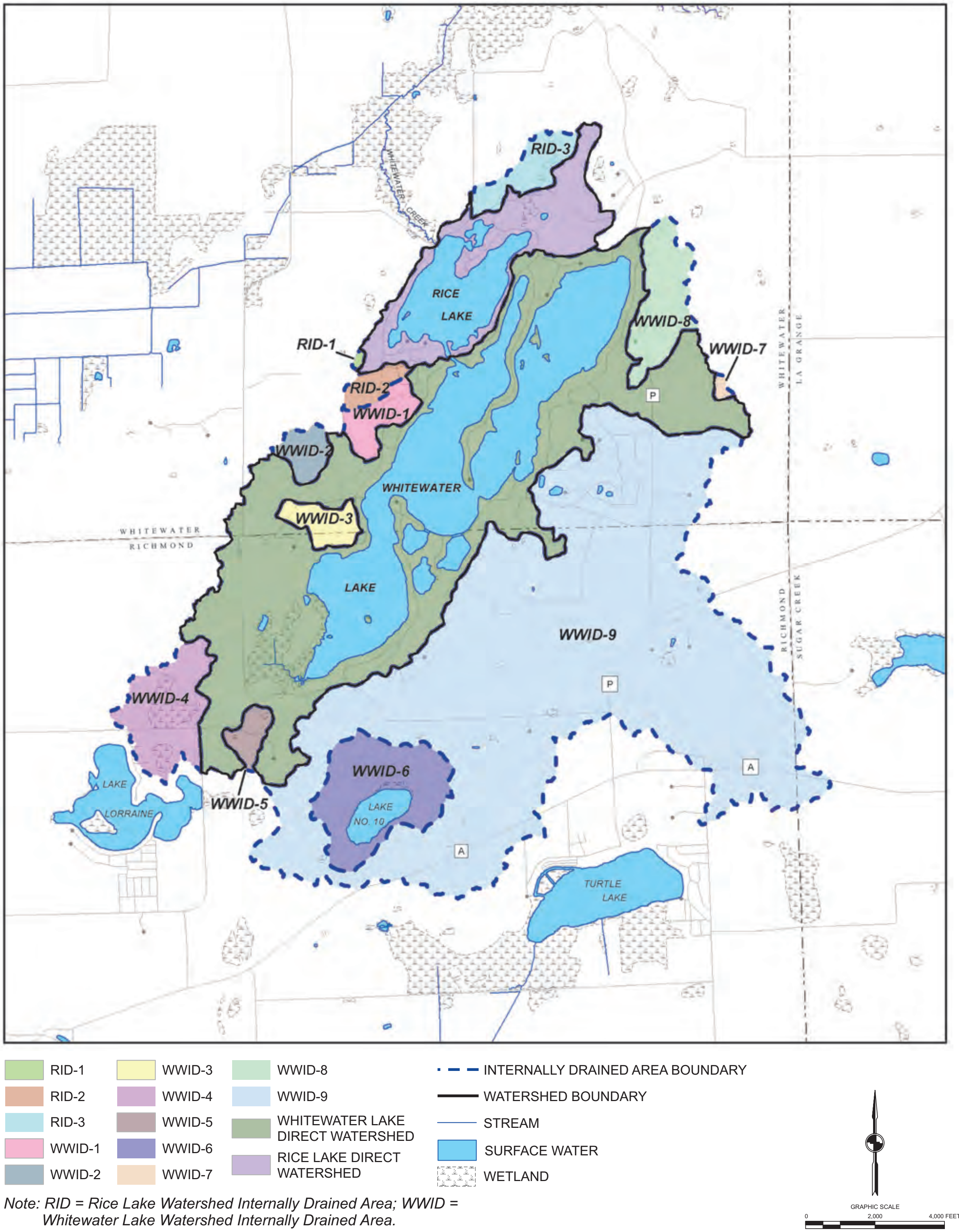
WHITEWATER AND RICE LAKE WATERSHEDS



Source: SEWRPC.

Map 8

INTERNALLY DRAINED AREAS WITHIN THE WHITEWATER AND RICE LAKE WATERSHEDS



Note: RID = Rice Lake Watershed Internally Drained Area; WWID = Whitewater Lake Watershed Internally Drained Area.

Source: SEWRPC.

Table 12

EXISTING AND PLANNED LAND USE WITHIN THE DIRECT DRAINAGE AREA TO WHITEWATER LAKE: 2010 AND 2035

Land Use Categories[a]	2010 Acres	2010 Percent of Total Tributary Drainage Area	2035 Acres	2035 Percent of Total Tributary Drainage Area
Urban				
Residential				
Single-Family, Suburban Density	16	1.2	29	2.2
Single-Family, Low Density	233	17.8	291	22.3
Single-Family, Medium Density	39	3.0	39	3.0
Single-Family, High Density	- -	- -	- -	- -
Multi-Family	- -	- -	- -	- -
Commercial	10	0.8	10	0.8
Industrial	1	0.1	- -	- -
Governmental and Institutional	6	0.5	6	0.5
Transportation, Communication, and Utilities	100	7.6	121	9.2
Recreational	13	1.0	16	1.2
Subtotal	418	32.0	512	39.2
Rural				
Agricultural	408	31.2	369	28.2
Other Open Lands	89	6.8	34	2.6
Wetlands	60	4.6	60	4.6
Woodlands	287	21.9	287	21.9
Water	39[b]	3.0	39[b]	3.0
Extractive	6	0.5	6	0.5
Landfill	- -	- -	- -	- -
Subtotal	889	68.0	795	60.8
Total	1307	100.0	1307	100.0

[a]*Parking included in associated use.*

[b]*Thirty-nine acres of open water exist within the upland area draining to Whitewater Lake. Whitewater Lake occupies an additional 705 acres.*

Source: SEWRPC.

Existing year 2010 land use and planned year 2035 land use within the adjusted watersheds were quantified by urban and rural categories, and that land use information was used with two models that calculate pollutant loadings.[66] Pollutant loading characteristics are described below.

2010 Land Use within the Whitewater and Rice Lake Watersheds

Year 2010 land uses in Whitewater Lake's watershed, as shown on Map 9, are comprised of about 32 percent urban uses and 68 percent rural uses (see Table 12). Approximately five percent of the total watershed area is wetland (located around the South Bay of the Lake), 6.8 percent is open lands other than agricultural, 3 percent is water, 21.9 percent is woodlands, and 31.2 percent is agricultural.

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[66]*The calculations for nonpoint source phosphorus, suspended solids, and urban-derived metal inputs to Whitewater and Rice Lakes were estimated using either the Wisconsin Lake Model Spreadsheet (WiLMS version 3.3.18), or the unit area load-based (UAL) model developed for use within the Southeastern Wisconsin Region. These two models operate on the general principal that a given land use will produce a typical mass of pollutants on an annual basis.*

Table 13

EXISTING AND PLANNED LAND USE WITHIN THE DIRECT DRAINAGE AREA TO RICE LAKE: 2010 AND 2035

Land Use Categories[a]	2010 Acres	2010 Percent of Total Tributary Drainage Area	2035 Acres	2035 Percent of Total Tributary Drainage Area
Urban				
Residential				
Single-Family, Suburban Density	- -	- -	- -	- -
Single-Family, Low Density	31	11.8	65	24.8
Single-Family, Medium Density	- -	- -	- -	- -
Single-Family, High Density	- -	- -	- -	- -
Multi-Family	- -	- -	- -	- -
Commercial	- -	- -	- -	- -
Industrial	1	0.4	1	0.4
Governmental and Institutional	- -	- -	- -	- -
Transportation, Communication, and Utilities	24	9.2	32	12.2
Recreational	28	10.7	29	11.1
Subtotal	84	32.1	127	48.5
Rural				
Agricultural	34	13.0	- -	- -
Other Open Lands	15	5.7	6	2.3
Wetlands	10	3.8	10	3.8
Woodlands	119	45.4	119	45.4
Water	- -[b]	- -	- -[b]	- -
Extractive	- -	- -	- -	- -
Landfill	- -	- -	- -	- -
Subtotal	178	67.9	135	51.5
Total	262	100.0	262	100.0

[a]*Parking included in associated use.*

[b]*No areas of open water exist within the upland area draining to Rice Lake. Rice Lake occupies an additional 167 acres.*

Source: SEWRPC.

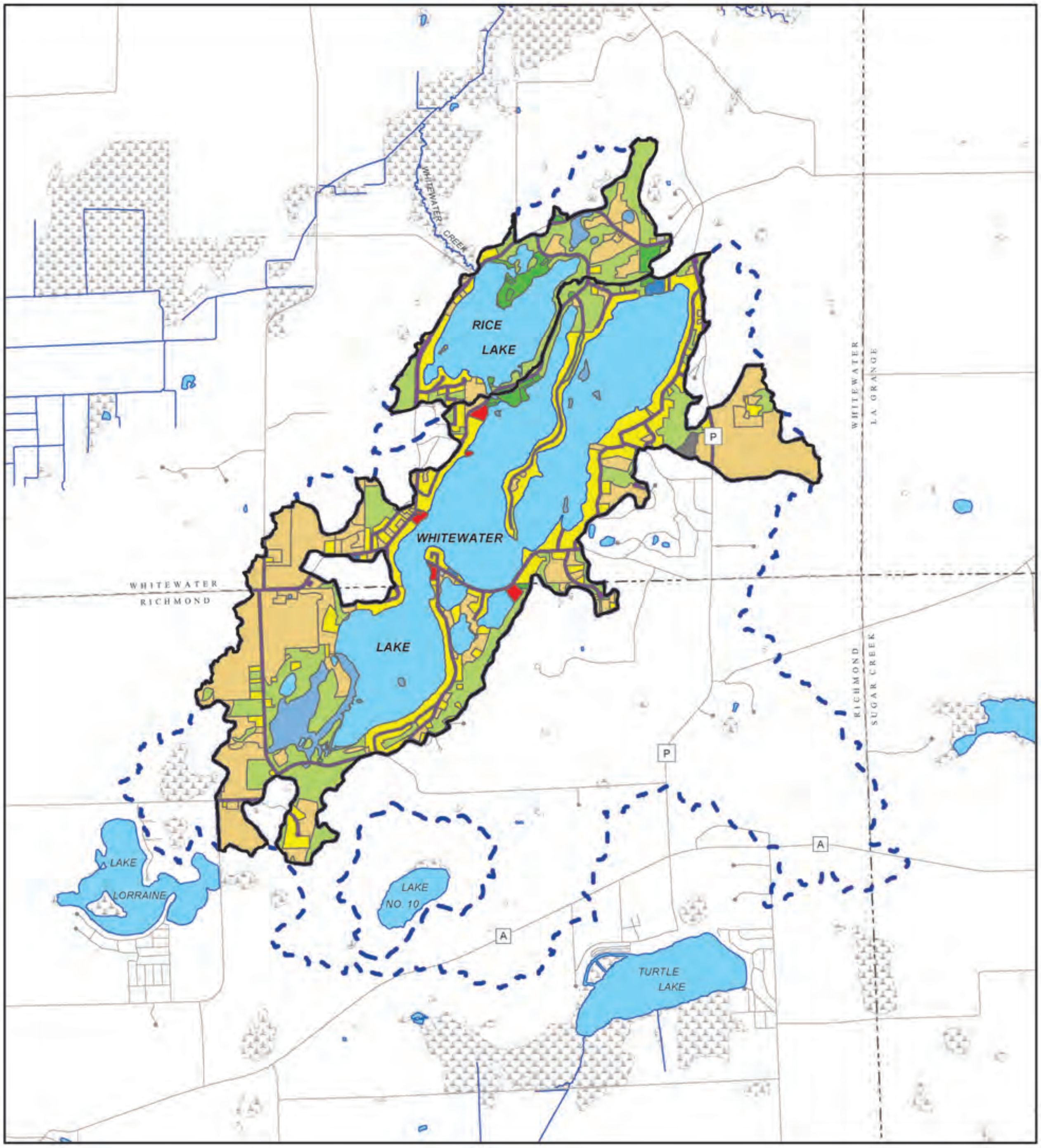
The year 2010 land uses in Rice Lake's watershed, as shown on Map 9, are comprised of approximately 32.1 percent urban uses and 67.9 percent rural uses (see Table 13). Almost four percent of the total watershed area is wetland (located north of the Lake), 5.7 percent is open lands other than agricultural, 0 percent is water, 45.4 percent is woodlands, and 13.0 percent is agricultural.

Land use data was used within a unit area load-based (UAL) model to estimate pollutant loadings (sediment, phosphorus, copper, and zinc) which could potentially be entering the Lakes,[67] as summarized in Tables 14 and 15. These calculations assume that urban land use is the only significant source of heavy metals. Heavy metals monitoring has not occurred within the Lakes. However, urban areas should be targeted if heavy metals become an issue within the Lakes in the future. The planned conversion of agricultural land to urban use may increase copper and zinc runoff load to Whitewater Lake by about 18 and 16 percent, respectively, and to Rice Lake by 32 and 33 percent. The UAL model also suggests that, under year 2010 land use conditions, agricultural land uses contribute about 81 percent of

[67]Ibid.

Map 9

2010 LAND USE FOR THE DIRECT DRAINAGE AREA TO WHITEWATER AND RICE LAKES



SINGLE-FAMILY RESIDENTIAL	RECREATION	INTERNALLY DRAINED AREA BOUNDARY
MULTI-FAMILY RESIDENTIAL	WETLANDS	WATERSHED BOUNDARY
COMMERCIAL	WOODLANDS	STREAM
INDUSTRIAL	SURFACE WATER	WETLAND
TRANSPORTATION, COMMUNICATIONS, AND UTILITIES	AGRICULTURAL, UNUSED, AND OTHER OPEN LANDS	
GOVERNMENT AND INSTITUTIONAL	EXTRACTIVE AND LANDFILL	

Note: A property on the central western shore of Whitewater Lake currently identified as commercial land is actually used for residential purposes and will be corrected in soon-to-be-released SEWRPC 2015 Land Use Maps.

GRAPHIC SCALE
0 2,000 4,000 FEET

Source: SEWRPC.

Table 14

ESTIMATED ANNUAL POLLUTANT LOADINGS BY LAND USE CATEGORY WITHIN THE DIRECT DRAINAGE AREA TO WHITEWATER LAKE: 2010 AND 2035

Land Use Category	Pollutant Loads: 2010			
	Sediment (tons)	Phosphorus (pounds)	Copper (pounds)	Zinc (pounds)
Urban				
Residential	5.0	61.5	1.1	10.0
Commercial	3.9	12.0	2.2	14.9
Industrial	0.4	1.2	0.2	1.5
Governmental	1.5	8.1	0.4	4.8
Transportation	5.5	11.0	24.0	86.0
Recreational	0.2	3.5	0.0	0.0
Subtotal	16.5	97.3	27.9	117.2
Rural				
Agricultural	91.8	350.9	0.0	0.0
Wetlands	0.1	2.4	0.0	0.0
Woodlands	0.5	11.5	0.0	0.0
Water	3.7	5.1	0.0	0.0
Subtotal	96.1	369.9	0.0	0.0
Total	112.6	467.2	27.9	117.2

Land Use Category	Pollutant Loads: 2035			
	Sediment (tons)	Phosphorus (pounds)	Copper (pounds)	Zinc (pounds)
Urban				
Residential	6.2	76.6	1.4	12.4
Commercial	3.9	12.0	2.2	14.9
Industrial	0.0	0.0	0.0	0.0
Governmental	1.5	8.1	0.4	4.8
Transportation	6.7	13.3	29.0	104.1
Recreational	0.2	4.3	0.0	0.0
Subtotal	18.5	114.3	33.0	136.2
Rural				
Agricultural	83.0	317.3	0.0	0.0
Wetlands	0.1	2.4	0.0	0.0
Woodlands	0.5	11.5	0.0	0.0
Water	3.7	5.1	0.0	0.0
Subtotal	87.3	336.3	0.0	0.0
Total	105.8	450.6	33.0	136.2

Source: SEWRPC.

Table 15

ESTIMATED ANNUAL POLLUTANT LOADINGS BY LAND USE CATEGORY WITHIN THE DIRECT DRAINAGE AREA TO RICE LAKE: 2010 AND 2035

Land Use Category	Pollutant Loads: 2010			
	Sediment (tons)	Phosphorus (pounds)	Copper (pounds)	Zinc (pounds)
Urban				
Residential	0.3	6.2	0.0	0.3
Commercial	0.0	0.0	0.0	0.0
Industrial	0.4	1.2	0.2	1.5
Governmental	0.0	0.0	0.0	0.0
Transportation	1.3	2.6	5.8	20.6
Recreational	0.3	7.6	0.0	0.0
Subtotal	2.3	17.6	6.0	22.4
Rural				
Agricultural	7.7	29.2	0.0	0.0
Wetlands	0.0	0.4	0.0	0.0
Woodlands	0.2	4.8	0.0	0.0
Water	0.0	0.0	0.0	0.0
Subtotal	7.9	34.4	0.0	0.0
Total	10.2	52.0	6.0	22.4

Land Use Category	Pollutant Loads: 2035			
	Sediment (tons)	Phosphorus (pounds)	Copper (pounds)	Zinc (pounds)
Urban				
Residential	0.6	13.0	0.0	0.7
Commercial	0.0	0.0	0.0	0.0
Industrial	0.4	1.2	0.2	1.5
Governmental	0.0	0.0	0.0	0.0
Transportation	1.8	3.5	7.7	27.5
Recreational	0.3	7.8	0.0	0.0
Subtotal	3.1	25.5	7.9	29.7
Rural				
Agricultural	0.0	0.0	0.0	0.0
Wetlands	0.0	0.4	0.0	0.0
Woodlands	0.2	4.8	0.0	0.0
Water	0.0	0.0	0.0	0.0
Subtotal	0.2	5.2	0.0	0.0
Total	3.3	30.7	7.9	29.7

Source: SEWRPC.

the sediment and about 75 percent of the phosphorus reaching Whitewater Lake and 19 percent of the sediment and 56 percent of the phosphorus reaching Rice Lake in surface water runoff. Under planned 2035 conditions, agricultural lands will be converted to urban land use, and the overall mass of sediment and phosphorus from agricultural land that is delivered to Whitewater Lake will decrease by about 10 percent each. Agricultural sourced sediment and phosphorus delivered to Rice Lake will both decrease by 100 percent because all remaining agricultural lands within the Rice Lake watershed are planned for development. With proactive and aggressive pursuit of runoff water quality measures, sediment and phosphorus loading can be further reduced to both Lakes. Practices to reduce urban loading are addressed in more detail in Chapter III.

The Wisconsin Lake Model Suite (WiLMS) can also be used to estimate phosphorus loading to lakes. Similar to the approach employed by the UAL model, land use, hydrologic, and watershed area information are used to estimate the total flux of phosphorus to a lake during a typical year.[68] The WiLMS model produces a range of probable phosphorus load values (low, most likely, and high). Load estimates are then used to predict water quality in the receiving lakes using several regression equations. The regression equations have been designed to fit a variety of lake types. For example, some are designed for reservoirs, some for deep lakes, while others are general lake models.

Given 2010 land use estimates, the WiLMS model predicts between 334 and 1543 pounds of phosphorus could be delivered to Whitewater Lake per year, and between 58 and 282 pound of phosphorus could be delivered to Rice Lake per year. The low-range values predicted by the WiLMS model essentially match those estimated by the UAL model, suggesting that the lower range loading values may better portray conditions in the watershed. Therefore, the lower range values were also used to predict present and future water quality of both lakes.

Using the low-range loading estimates for the reason discussed above, two regression-based models (the Walker Reservoir Model and the Larsen-Mercier Model) best fit observed conditions in Whitewater Lake.[69,70] Both models predict growing season mean phosphorus values of 30 μg/L, a value within 6 percent of average observed value of 32 μg/L. For Rice Lake, the Walker general model appears to best predict observed values.[71] The Walker General Model estimated growing season mean phosphorus values of 31 μg/L, a value within 6 percent of average observed value of 33 μg/L.

The regression models that best predicted observed growing season mean phosphorus values were next used to predict water quality of both Lakes under planned 2035 land use conditions. Both the Walker Reservoir Model and the Larsen-Mercier Model predict a slight increase (1 μg/L) in Whitewater Lake's growing season mean phosphorus concentrations under 2035 planned land use. Rice Lake's growing season mean phosphorus concentrations under planned 2035 land use conditions are actually predicted to decrease 1 μg/L. These estimates suggest that planned

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[68]*These models do not account for groundwater influx and exit from the lake. Models can be manipulated to include this variable if sufficient interest is expressed by lake users and managers as part of a future study. Groundwater is a very important component of the water budget of Whitewater Lake and to a lesser degree Rice Lake. Including groundwater in future models may not necessarily improve the accuracy of the models, but will account for and potentially eliminate a currently untested variable from the simulation process.*

[69]*Walker, W. W., Jr.,* Statistical Bases from Mean Chlorophyll-*a* Criteria, In Lake and Reservoir Management: Practical Applications, *North American Lake Management Society, pages 57-62, 1985.*

[70]*Larsen, D. P and H. T. Mercier*, Phosphorus Retention Capacity of Lakes, *Journal of the Fisheries Research Board of Canada, Volume 33, pages 1742-1750, 1976.*

[71]*Walker, W. W., Jr.,* Some Analytical Methods Applied to Lake Water Quality Problems, *PhD Dissertation, Harvard University, 1977.*

Table 16

INCREMENTAL HISTORICAL URBAN GROWTH IN THE WHITEWATER AND RICE LAKE WATERSHEDS

Time Period	Whitewater: Land Developed During Time Period (acres)	Whitewater: Annual Increase in Land in Urban Use (percent of watershed land area per year)	Rice: Land Developed During Time Period (acres)	Rice: Annual Increase in Land in Urban Use (percent of watershed land area per year)
1940-1950	0.4	- -	0.0	0.0
1950-1963	182.2	0.3	0.0	0.0
1963-1970	90.8	0.3	20.9	0.8
1970-1975	25.9	0.1	12.7	0.7
1975-1980	177.1	0.8	0.5	0.0
1980-1985	0.0	0.0	0.0	0.0
1985-1990	9.6	0.0	9.6	0.5
1990-2000	24.1	0.1	5.3	0.1
2000-2010	0.0	0.0	0.0	0.0

Source: SEWRPC.

Table 17

POPULATION AND HOUSEHOLDS IN THE WHITEWATER AND RICE LAKE WATERSHEDS: 1960-2035

Year	Population	Change from Previous Decade		Households	Change from Previous Decade	
		Number	Percent		Number	Percent
1960	195	- -	- -	62	- -	- -
1970	889	694	356	237	175	282
1980	861	-28	-3	307	70	30
1990	921	60	7	355	48	16
2000	1,185	264	29	475	120	34
2010	1,159	-26	-2	480	5	1
Planned 2035	1,343	184	16	556	76	16

NOTE: Planned 2035 data based on 2000 census data and does not reflect change which may have occurred between 2000 and 2010.

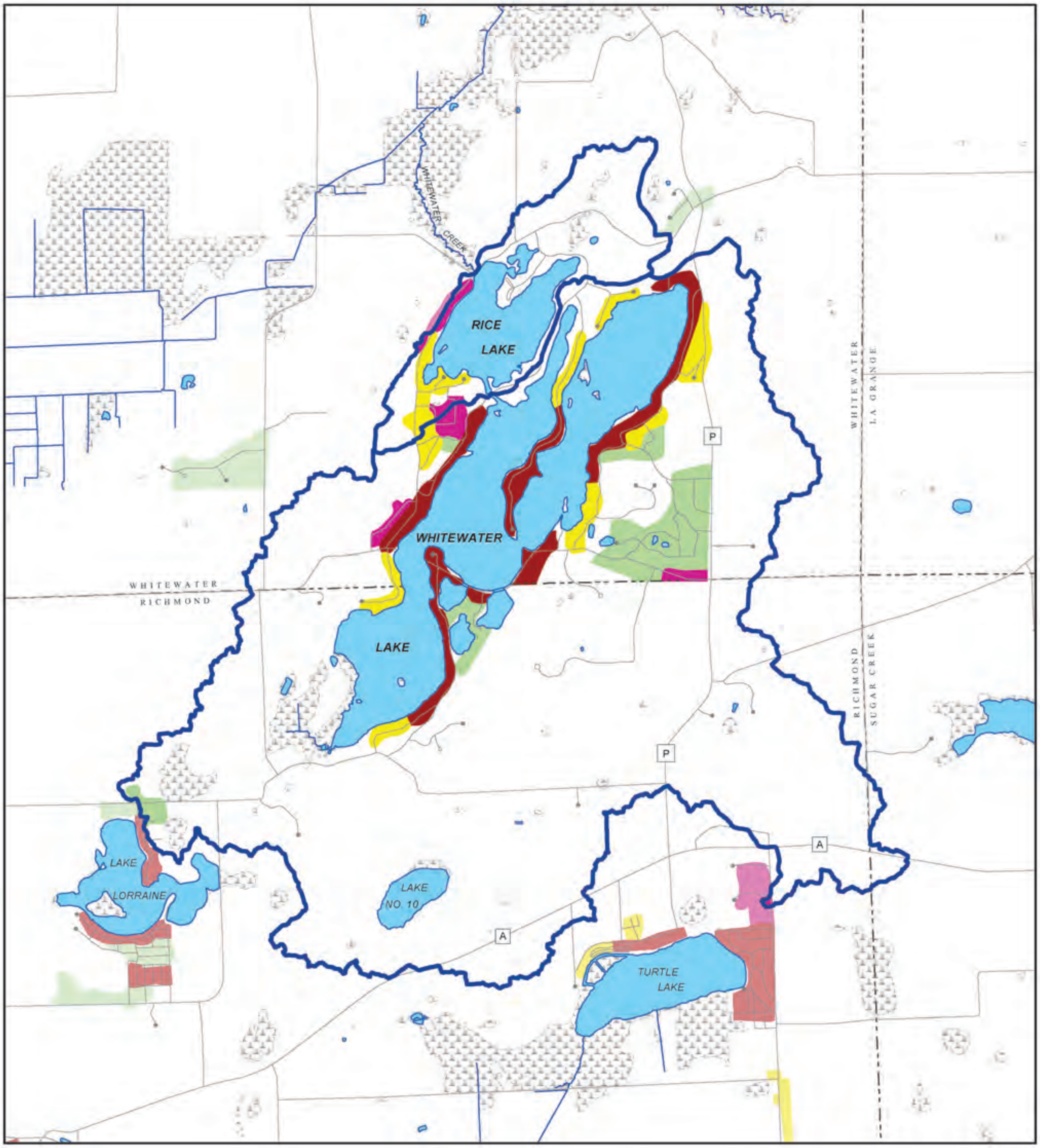
Source: U.S. Bureau of Census and SEWRPC.

2035 land use conditions will not significantly change summer phosphorus concentrations in the Lakes on their own. It must be noted that these predictions are based solely on watershed conditions, and do not include factors (e.g., changes to rough fish control, revised shoreline and agricultural practices, aquatic plant harvesting, and other management tools). If development is required to follow a stringent set of stormwater water quality practices, there is a real chance to decrease phosphorus loading to the lakes, even with additional development. This can be further reinforced through widespread use of residential, agricultural, and open land best management practices.

Historical urban development within the Whitewater and Rice Lake watersheds is shown on Map 10 and represented in Table 16. Changes in population and households over time are shown in Table 17. These changes can also be seen by comparing aerial photographs representing conditions in 1956 (Map 11), soon after the creation of the Lakes,

Map 10

HISTORICAL URBAN GROWTH WITHIN AND NEAR THE WHITEWATER AND RICE LAKE WATERSHEDS



1950 - 1970
1970 - 1980
1980 - 1990
1990 - 2000

SURFACE WATER
STREAM
WATERSHED BOUNDARY
WETLAND

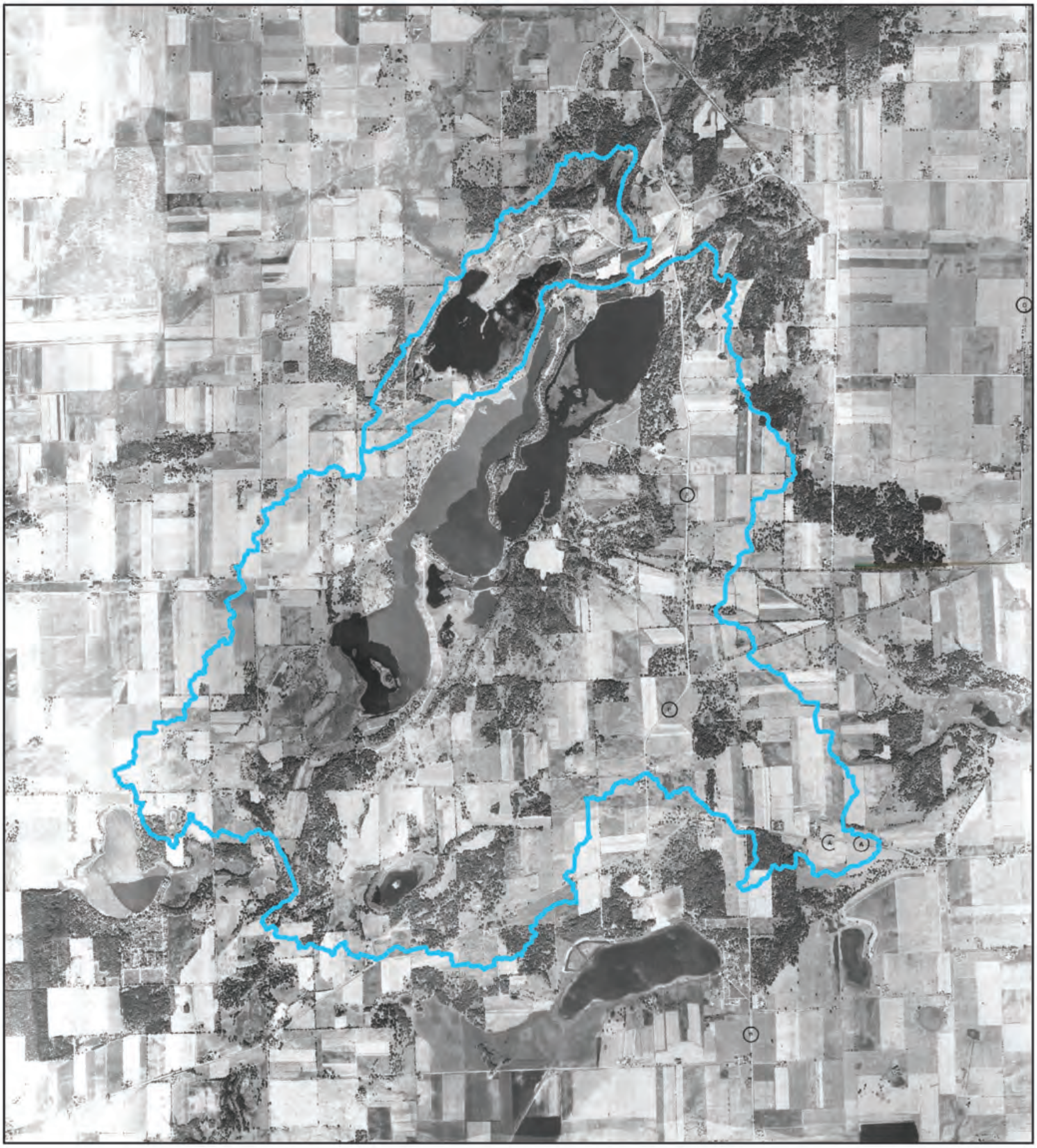
Note: No significant urban growth occurred between 2000 and 2010. Colors outside the watershed boundary are reduced in intensity to show the adjacent extent and distribution of each legend category.

GRAPHIC SCALE
0 2,000 4,000 FEET

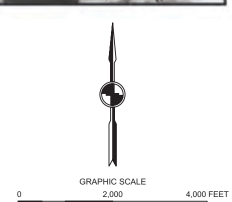
Source: SEWRPC.

Map 11

HISTORICAL AERIAL PHOTOGRAPH OF WHITEWATER AND RICE LAKES: 1956



WATERSHED BOUNDARY



Source: SEWRPC.

and 2015, the most recent date for which regionwide digital orthophotography is available (Map 12). Most of the area has remained agricultural, with the most intense urban growth occurring between the 1950s and early 1970s.

Water Quality data from the 1950s are not available, but data from the 1970s indicate highly enriched conditions within the Lakes. Although agricultural land was a higher percentage of the watershed in the 1970s, initially high nutrient concentrations may be related to inundation of nutrient-rich wetlands and agricultural lands during creation of the Lakes.

2035 Land Use within the Whitewater and Rice Lake Watersheds

Year 2035 planned land uses for Whitewater and Rice Lakes' adjusted watersheds are shown on Map 13.[72] A moderate portion of agricultural land is planned to be developed around both Whitewater and Rice Lakes. As summarized in Table 12, **agricultural land uses within the adjusted Whitewater Lake watershed are expected to decrease from about 31 percent of the land area in 2010, to about 28 percent of the land area in 2035**. As summarized in Table 13, **agricultural land uses within the Rice Lake watershed are expected to decrease from about 13 percent of the land area in 2010, to 0 percent of the land area in 2035**. The anticipated land use changes would involve conversion of agricultural and open lands to residential use. Tables 14 and 15 indicate the possibility of modest reductions in annual sediment and phosphorus loads due primarily to planned land use changes between 2010 and 2035, and moderate increases in heavy metals contributed by urban land uses. Thus, there is a potential for increased heavy metals delivered to the Lakes and for transient increased sediment pollution related to erosion during construction associated with the conversion of land from agricultural to residential uses. <u>Consequently, recommendations to mitigate these risks and ensure the health of the Lakes are included in Chapter III</u>.

Finally, **none of the watershed areas are within the City of Whitewater planned sewer service area**. Without proper maintenance, septic systems can malfunction possibly causing bacterial contamination and increased phosphorus loadings to the Lakes and the groundwater. <u>Therefore, management of current systems and any new systems is discussed in Chapter III of this report</u>.

Pollution Mitigation Abilities

Many infrastructure and land management features can filter or remove pollutant-loaded stormwater before it enters a lake system. Identifying the type and location of such features can help determine if pollution sources potentially enter the Lakes directly (without any filtration) or pass through treatment features. A few examples of treatment features follow:

1. **Stormwater detention or retention ponds**—Stormwater management ponds, when properly maintained, can detain water during and after rainfall events, slowing runoff, and allowing many pollutants (e.g., sediments, nutrients, heavy metals) to settle out before reaching downstream water bodies. Since phosphorus is tightly bound to sediment, trapping sediment reduces phosphorus loads passed downstream. These ponds need to be periodically dredged and may require other maintenance to ensure proper function properly. **Stormwater detention or retention ponds in a lake's watershed are a useful means of protecting or improving lake water quality by significantly reducing sediment and nutrient loads to the lake**. Stormwater ponds are normally designed to decrease peak flows by storing water during the heaviest runoff period and releasing stored water at a controlled rate over an extended period of time. Some ponds are designed to infiltrate a portion of the stormwater, recharging groundwater supplies. On account of this, stormwater management ponds may also help mitigate downstream bed and bank erosion problems, extend the period when intermittent streams actively flow, and contribute to the value of riparian and in-stream habitat. However, they may also warm the water stored within them, can sometimes attract nuisance species, and can be barriers to aquatic organism migration.

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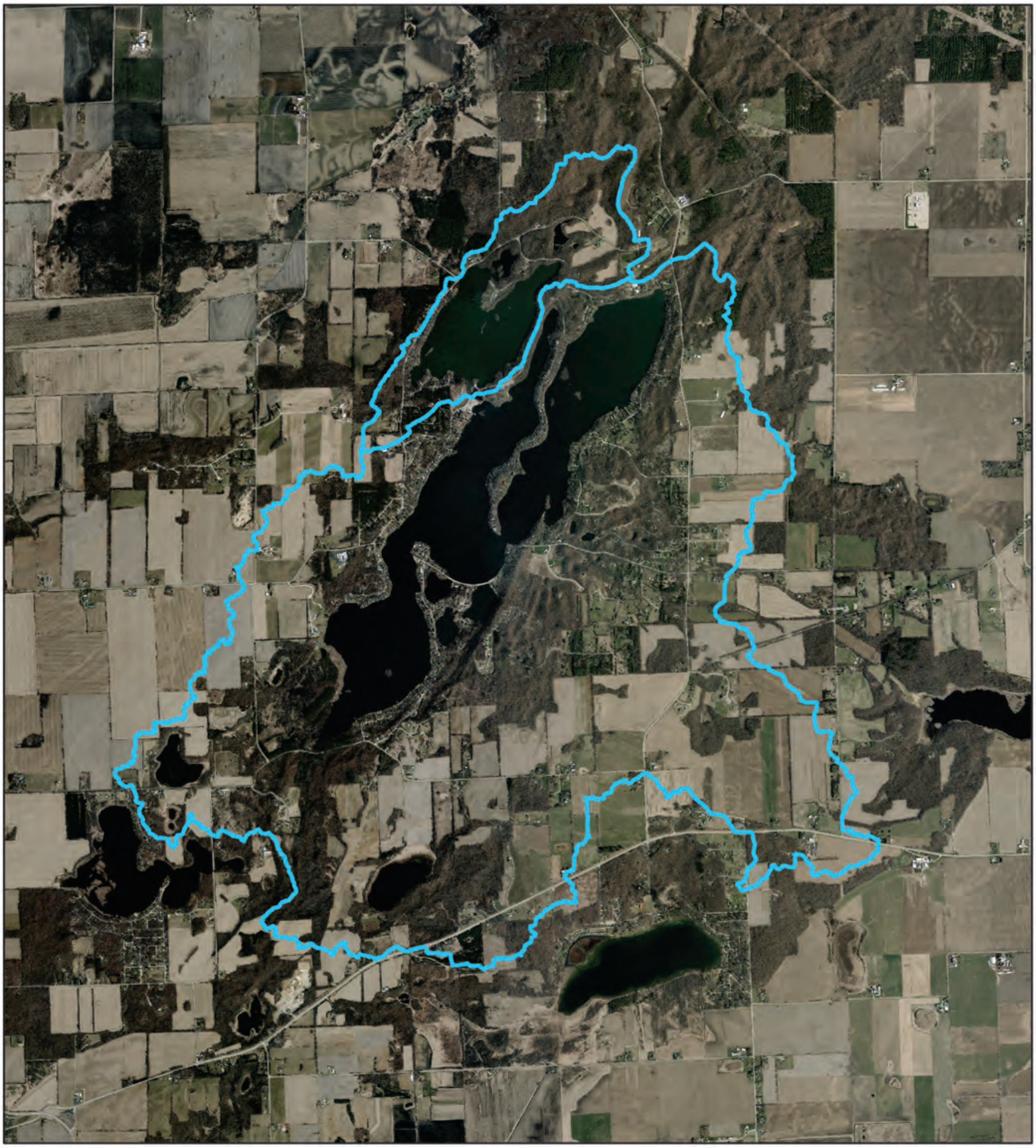
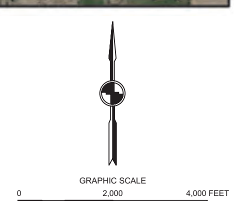
[72]*See SEWRPC Planning Report No. 48*, A Regional Land Use Plan for Southeastern Wisconsin: 2035, *June 2006.*

Map 12

HISTORICAL AERIAL PHOTOGRAPH OF WHITEWATER AND RICE LAKES: 2015



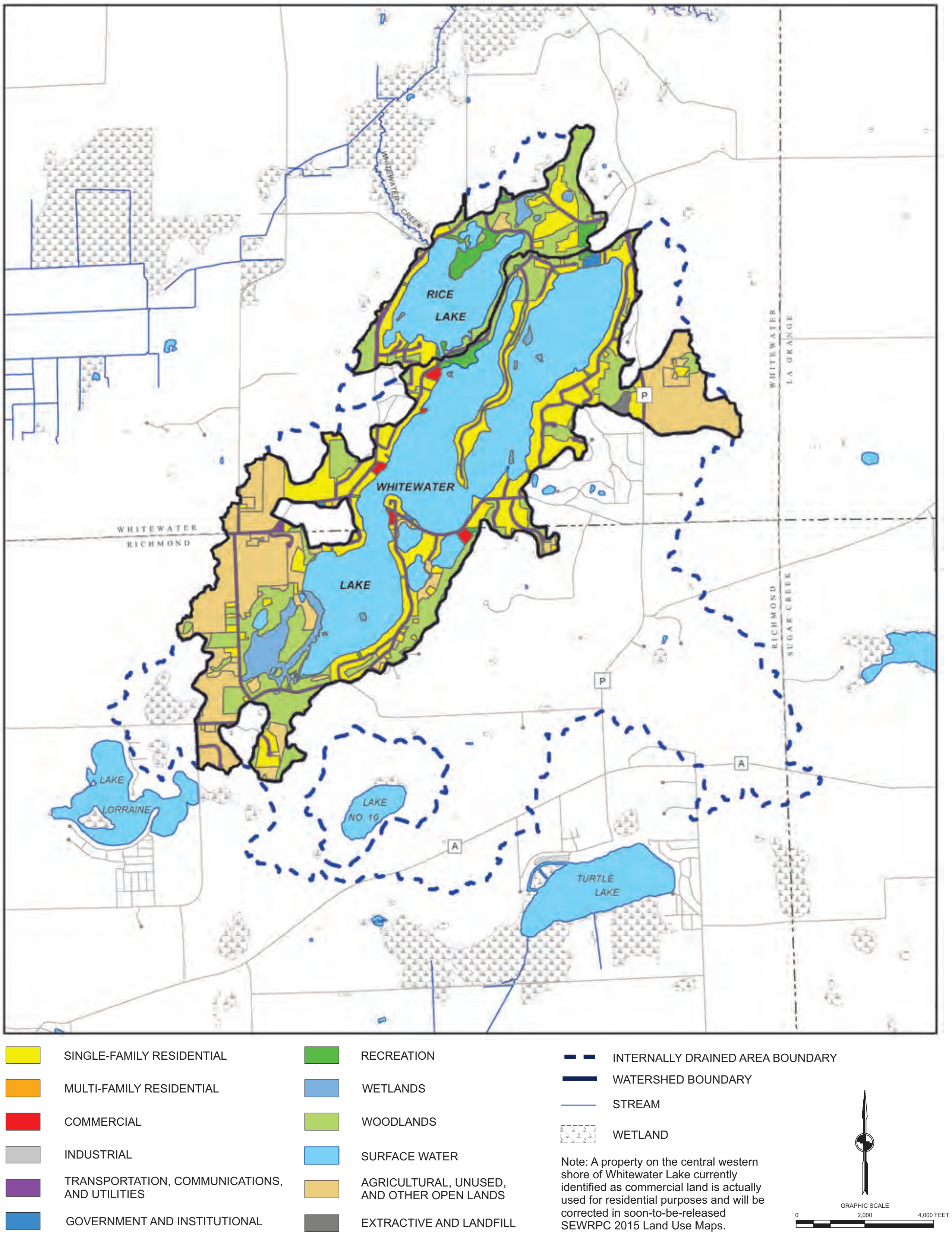
WATERSHED BOUNDARY



Source: SEWRPC.

Map 13

2035 LAND USE FOR THE DIRECT DRAINAGE AREA TO WHITEWATER AND RICE LAKES



Note: A property on the central western shore of Whitewater Lake currently identified as commercial land is actually used for residential purposes and will be corrected in soon-to-be-released SEWRPC 2015 Land Use Maps.

Source: SEWRPC.

2. **Wetlands**—Wetlands, which are generally identifiable by saturated soils and water-loving plants, are beneficial to the health of a lake, particularly when located at or along the lake's shoreline, within the floodplain, and along the shores of tributary streams. Wetlands slow runoff moving toward a lake which reduces flood peaks and allows sediment and affiliated pollutants to settle in a similar fashion to stormwater management ponds. Additionally, plant life located in wetlands assimilates and processes pollutants such as phosphorus, incorporating them into biomass, thereby preventing the pollutant from entering a lake. These natural features are well known as "nature's pollution filtration system" and are key to the life histories of a large number of fish, amphibians, birds, and other animals. Without wetlands, familiar species such as northern pike may not be able to naturally reproduce. Knowing where wetlands are located can help determine if a pollution source is a high risk to downstream waters, since wetlands can detain or retain certain pollutants.

3. **Natural terrestrial buffers**—Natural buffers primarily refer to vegetative features such as woodlands or prairies. When these areas, like wetlands, are densely vegetated, they can slow stormwater runoff and incorporate pollutants into biomass. Consequently, **buffer, when located in an area intercepting water flowing toward the Lake, can help lower pollution risks to a lake**. Moreover, enhancing these features, particularly in areas adjacent to a waterbody, can decrease the amount of pollution entering that waterbody. Like wetlands, such areas are critical to the life cycle of many herptiles (amphibians and reptiles) and birds.

4. **Floodplains**—Floodplains are areas inundated during periods of heavy runoff. The portions of floodplains that actively conveys floodwater are referred to as floodways. Flood fringe areas, which are located adjacent to, and beyond, the floodway on either side of a stream are lower velocity, shallower depth areas where the energy of the flowing water is spread out over a broader area and floodwaters are temporarily stored. Flood fringe lands help reduce downstream flood elevations by storing floodwater and can reducing stream power, thereby reducing erosion and pollutant mobilization/transport. Additionally, flood fringe areas can trap sediment, nutrient, and pollutant and provide refuge to aquatic life, affording similar ecological services as wetland habitat. Floodplains provide the broadest value in their natural state but can still provide valuable service when developed in compatible open space uses. Floodplains can be restored along manipulated drainage ways as part of projects that help stabilize eroding beds and banks

5. **Artificial terrestrial buffers (e.g., grassed waterways, vegetative strips)**—Artificial buffers take a number of forms. A few examples include grassed waterways, vegetative strips, and rain gardens located along shorelines. Such buffers are generally constructed to intercept runoff shortly before it enters a river or lake. They function in a similar way to natural buffers (i.e., slowing runoff); however, they need to be carefully designed and should use native plants to ensure that they function well in the longer term. **Artificial buffers can enhance lake water quality without significant adverse effects to residential and agricultural land uses**. Further details regarding artificial buffers and their efficacy are included in Appendix D.

6. **Nearshore Aquatic Vegetative Buffers**—In-lake vegetation (e.g., bulrush and cattails) in shallow nearshore areas can filter and assimilate nutrients and sediments to some degree before runoff reaches the main body of a lake. Such areas also help protect shorelines from erosion and provide valuable aquatic habitat to a wide range of animals. Consequently, encouraging survival and enhancement of nearshore vegetation can help improve lake water quality.

It should be noted that these features can overlap and may provide multiple benefits. To locate each of the features described above, SEWRPC staff completed an inventory of the detention basins, wetlands, and natural features such as woodlands within the watershed using existing databases, mapping software, and aerial imagery. Additionally, to identify the extent of shoreline buffers, SEWRPC staff completed a field assessment of the Whitewater and Rice Lake shorelines during summer of 2014. These inventories are discussed below.

No large stormwater basins are located within the portion of the Whitewater and Rice Lake watershed that contribute surface flow to the Lakes. If such basins are created in the contributing watershed area in the future, they will need to be properly maintained, and will help limit or reduce the amount of urban nonpoint source pollution entering the Lakes from the land areas draining to these basins. Where feasible, constructing such basins to collect runoff from areas of existing development would decrease already existing pollutant loads.

Approximately five percent of the Whitewater Lake watershed is comprised of wetlands in an area located primarily at the southern end of Whitewater Lake (see Map 9). **Almost four percent of the Rice Lake watershed is comprised of wetlands** in an area located primarily north of Rice Lake (see Map 9). These wetlands provide the Lakes with a degree of pollution and sediment reduction from surface water runoff entering the Lakes from the southern and northern portions of the watersheds. The potential to naturally remove pollutants, in combination with the many other benefits provided by wetlands, illustrates how crucial protecting these wetlands is for Whitewater and Rice Lakes. Consequently, recommendations related to maintaining and enhancing wetland functions are also included in Chapter III of this report.

Woodlands, uplands, and other "natural areas," as mentioned above, buffer water-bodies. About 22 percent of the Whitewater Lake watershed and 45 percent of the Rice Lake watershed is composed of woodlands. Woodlands and other "natural areas" are particularly valuable when located in areas adjacent to the Lake or its tributaries (see Map 9). Consequently, woodlands and other upland natural areas should be protected to the greatest extent practical to protect the water quality of the Lakes (see Chapter III for recommendations).

Mapped floodplains are not present within the Whitewater and Rice Lake watersheds. The lakes compose the headwaters of Whitewater Creek, which is downstream of the watershed and has floodplains along its banks. Never the less, the areas that convey or store water along any stream entering the lake should be protected.

Artificial terrestrial buffers and other shoreline protection measures (e.g., riprap) along the shorelines of Whitewater and Rice Lakes are shown on Maps 14, 15, and 16. Figure 42 illustrates common shoreline protection techniques. The majority of the Whitewater Lake shoreline is covered with riprap. The Lake also has undeveloped woodland around the northwestern lobe of the Lake and undeveloped wetland around the southwestern portion of the Lake, creating a natural shoreline in these areas. The majority of the Rice Lake shoreline has vegetative buffers and riprap. Rice Lake also has a significant amount of undeveloped woodland along the eastern side of the Lake creating a natural shoreline for that area. "Soft" shoreline protection, referred to as "vegetative shore protection" (see Figures 43 and 44) is increasingly popular with riparian owners. Such shoreline protection not only protects the shoreline but improves the viewshed and provides natural wildlife habitat. These and other vegetative buffers also provide the Lake with some protection from pollution which could otherwise enter the Lake (e.g., lawn clippings, fertilizers, oils from cars). However, **portions of the shoreline are mowed up to the water line**. Since the immediate shoreline of both Lakes is the primary contributor of surface runoff, and these areas pose risks to the Lakes, enhancing shoreline buffers along the shorelines should be considered a high priority. Recommendations related to this topic are further discussed in Chapter III of this report.

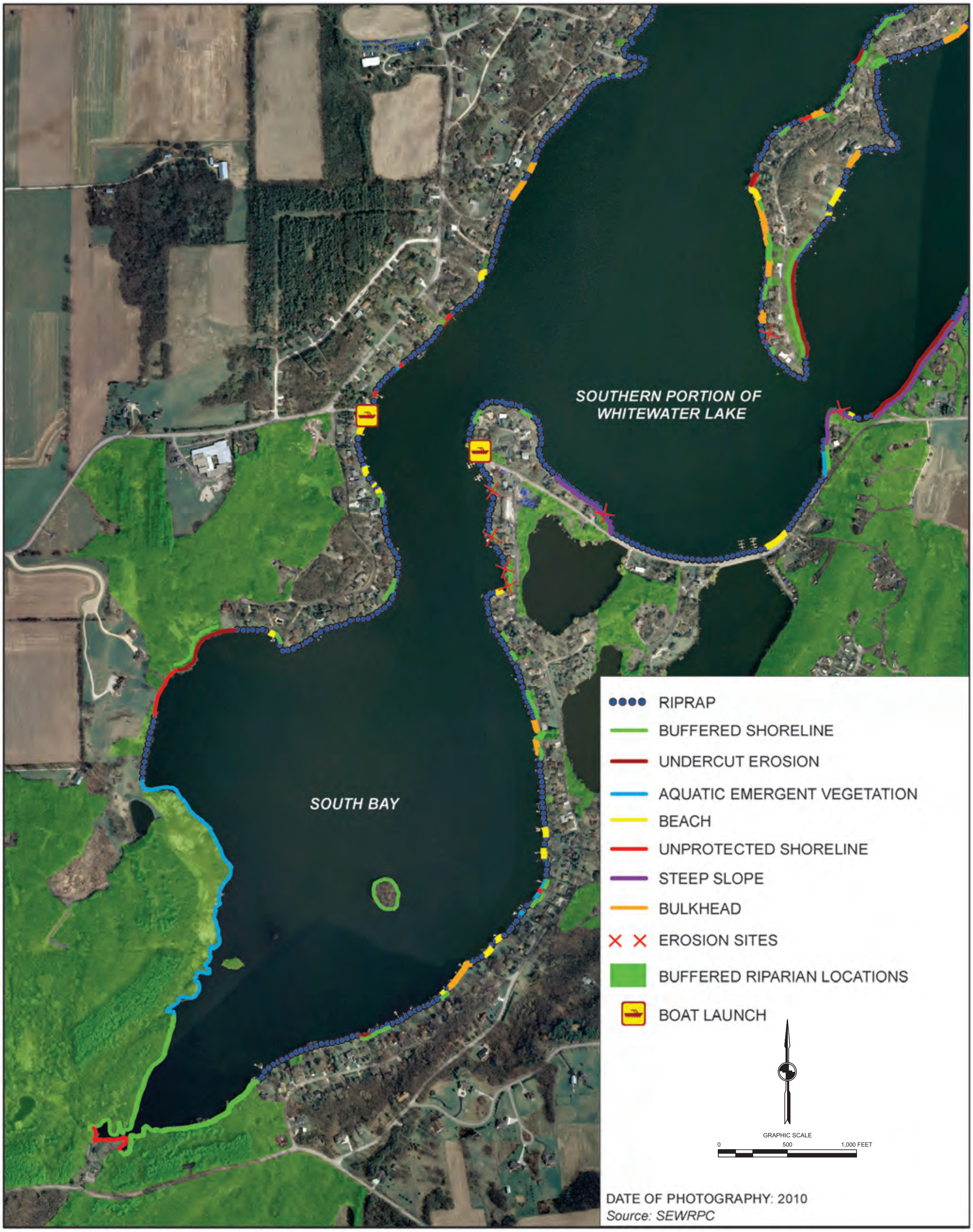
Creating artificial buffers and enhancing of existing buffers and wetlands should be foundational aspects to protecting the water quality of Whitewater and Rice Lakes. This reflects the goals of the *Wisconsin's Healthy Lakes Implementation Plan*, which focuses on habitat restoration, runoff, and erosion control projects to improve and protect the health of our lakes through shoreline owner participation (see Appendix E). Buffer and wetland maintenance and development should likely be strategically targeted at areas of the watershed producing runoff which does not currently filter through an existing buffer or wetland system prior to entering the Lakes. Recommendations related to water quality enhancement within Chapter III focus primarily on such opportunities.

Map 14

SHORELINE CHARACTERISTICS AND EXISTING BUFFERS ALONG UPPER WHITEWATER LAKE: 2014

Map 15

SHORELINE CHARACTERISTICS AND EXISTING BUFFERS ALONG LOWER WHITEWATER LAKE: 2014



Map 16

SHORELINE CHARACTERISTICS AND EXISTING BUFFERS ALONG RICE LAKE: 2014

Figure 42

TYPICAL SHORELINE PROTECTION TECHNIQUES

RIPRAP

NATURAL VEGETATION

BULKHEAD

REVETMENT

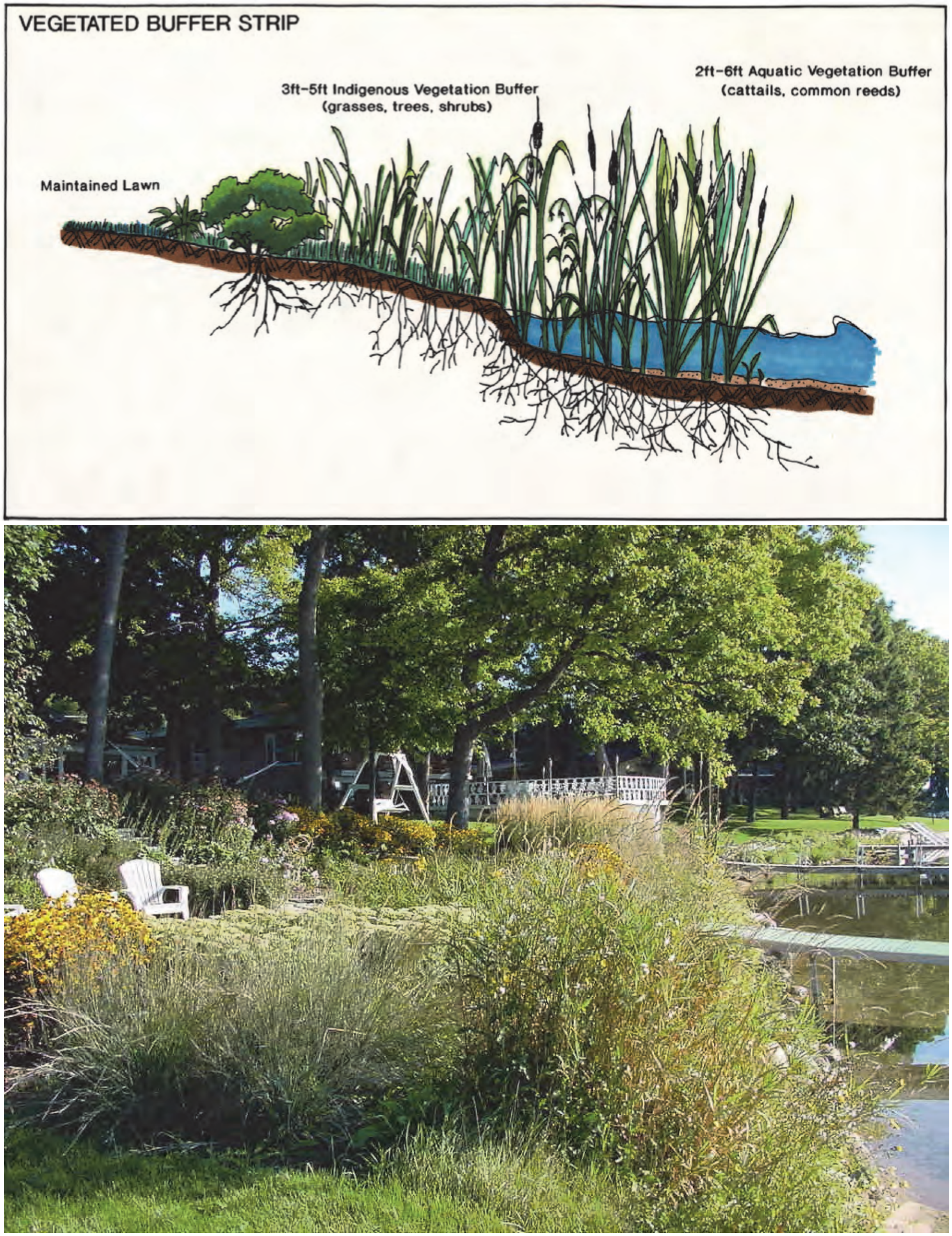
Source: SEWRPC.

ISSUE 3: CYANOBACTERIA AND FLOATING ALGAE

Cyanobacteria, formerly known as blue-green algae, and floating algae are ongoing issues of concern for Whitewater and Rice Lake residents and users, as the Lakes have experienced algal blooms throughout the spring and summer (see Figure 45). However, before discussing excessive algae growth and management, it is important to note that **algae is an important and healthy part of lake ecosystems**. Algae is a foundational component of lake food chains and produces oxygen in the same way as rooted plants. Many kinds of algae exist, from filamentous algae to cyanobacteria (see Figure 46). Most algae strains are beneficial to lakes when present in moderate levels. However, the presence of toxic strains (see Figure 47), as well as excessive growth patterns, should be considered issues of concern. As with aquatic plants, algae grows faster in the presence of abundant phosphorus (particularly in stagnant areas). Consequently, when toxic or high volumes of algae begin to grow in a lake, it often is a sign of phosphorus enrichment or pollution.

Figure 43

NATURAL SHORELINE BUFFER SCHEMATIC AND EXAMPLE



Source: Washington County Planning and Parks Department and SEWRPC.

Figure 44

EXAMPLE OF “SOFT” SHORELINE STRUCTURES

Natural Shoreline

Bio-logs

Buffers (Vegetative Strips)

Cattails

Source: Native Lakescapes and SEWRPC.

Algae populations are quantified by abundance and composition. Suspended Algal abundance is estimated by measuring chlorophyll-*a* concentrations. High concentrations are often associated with green-colored water. Samples are also examined to determine if the algae is toxic or nontoxic. There is public concern regarding algal blooms and the potential presence of toxic strains, implementing an algal collection and identification program is recommended. Chlorophyll-*a* measurements have been taken in the Lakes, as discussed in the “Issue 2: Water Quality” section of this report. Chlorophyll-*a* levels have been decreasing since creation of the Lakes, but are still considered high, suggesting frequent and dense algal blooms, particularly in Rice Lake. As chlorophyll-*a* levels are affected by nutrient levels, recommendations for water quality measurements are discussed in Chapter III of this report.

Figure 45

ALGAL BLOOMS IN WHITEWATER AND RICE LAKES

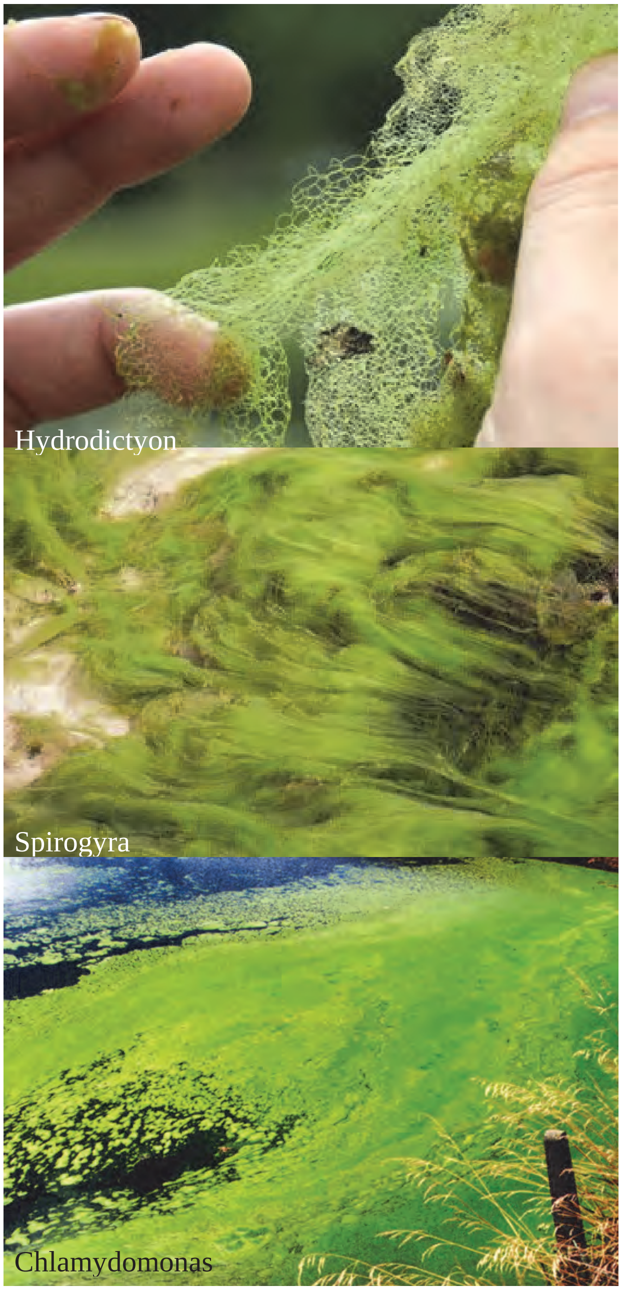
PHYTOPLANKTON ALGAL BLOOM IN RICE LAKE

FILAMENTOUS ALGAL BLOOM IN WHITEWATER LAKE

Source: SEWRPC.

Figure 46

DIFFERENT TYPES OF NON-TOXIC ALGAE



Source: Lewis Lab, University of New Mexico, Landcare Research.

Figure 47

EXAMPLES OF TOXIC ALGAE

Source: National Oceanic and Atmospheric Administration and St. John's River Water Management District.

In general, **the most permanent methods for preventing excessive and toxic algae growth are:**

1. **Manage water quality with a focus on phosphorus reduction**—Phosphorus pollution is often the root cause of excessive algal growth. Consequently, the water quality recommendations discussed in Chapter III should be implemented.

2. **Maintain a healthy and active native plant community**—As mentioned in the "Chemical Measures" subsection of this chapter, maintaining a healthy, robust native plant community helps prevent excessive algal blooms since the native aquatic plants directly compete with algae for nutrients. Particular attention should be directed at fostering the extent and health of the bottom dwelling algae species responsible for the natural phosphorus sequestration process (i.e., muskgrass). Consequently, carefully implementing the aquatic plant management recommendations provided in Chapter III and communicating this nutrient-growth relationship to residents (to encourage land owners to employ conservative hand-pulling of vegetation and phosphorus-reducing landscaping and land use) should be a priority.

Furthermore, high carp populations can negatively affect native plant communities. The bottom-feeding activity of carp can uproot native plant populations and stir-up sediment into the water column. This can release nutrients into the water column and shade native plant populations, further reducing aquatic rooted plant growth and increasing algal growth. Therefore, attention should be directed at reducing carp populations as discussed below in "Issue 7: Fish and Wildlife" and in subsequent recommendations provided in Chapter III.

In addition to these approaches, in-lake measures and manual removal methods which could also be implemented include:

1. **In-lake treatments**—Floating algae use dissolved or suspended nutrients to fuel growth. If water-column nutrient levels are reduced, the abundance of algae can be controlled. Water quality enhancement recommendations were discussed earlier in this chapter under "Issue 2: Water Quality." Alternatives presented as feasible under this section could be considered to help control algae. Additional information regarding this alternative can be found in the Water Quality sections of Chapters II and III. Supplemental activities not highly recommended for general water quality but, which may be considered for severe algae problems are discribed below.

   a. **Alum treatments**—Alum treatment involves spreading a chemical (alum: hydrated potassium aluminum sulfate) over the surface of a lake. This chemical forms a solid that sinks, carrying algae and other solids to the bottom of the lake allowing water to clear and rooted aquatic plants to grow at greater depth. Additional rooted aquatic plants compete with algae for nutrients, and can help clear lake water in the long term.[73] Alum-bound phosphorus precipitated to the lake bottom does not become soluble under anoxic water conditions and can help form a cap to reduce internal phosphorus loading. These effects can lower lake water phosphorus concentrations, and, therefore, reduce algal blooms. An alum treatment is a possible alternative to treat problematic algae blooms for Whitewater Lake, and is discussed further in Chapter III of this report.

   b. **Hypolimnetic withdrawal and on-shore treatment**—Much of the phosphorus available to fuel warm-season algal growth is released from Lake bottom sediment during summer, is available to fuel algal growth when conditions are right, and is returned to the Lake bottom where it remains available to fuel algal growth in the future. At least some of this stored phosphorus is likely a legacy from the creation of the Lakes during which time marsh and agricultural lands rich in nutrients were flooded. Since the Lakes have a relatively low capacity to flush pollutants downstream, actions to actively and permanently remove phosphorus from the Lake can help decrease future nutrient levels. Hypolimnetic withdrawal and on-shore treatment would use pumps or gravity to remove nutrient-rich waters from within the Lake, treat the water on shore, and then allow the treated water to pass downstream or re-enter the Lake. This approach can be designed at a variety of scales, with the most intensive approaches yielding the quickest results. Less costly low-intensity approaches can operate essentially indefinitely and lead to incremental water quality improvement over decades.

   c. **Aeration**—This process involves pumping air to the bottom of a lake to prevent stratification and anoxic conditions in the deep part of the lake. This reduces internal loading (i.e., the release of phosphorus from deep sediments) and reduces the occurrence of algal blooms during the mixing periods. This method has had mixed results in various lakes throughout Wisconsin and appears to be most successful in smaller water bodies such as ponds. If not properly designed or operated, aeration can increase nutrient levels and intensify and/or prolong algal blooms.

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[73] *More information on alum treatments is available in Appendix E and at: http://www.pca.state.mn.us/index.php/water/water-types-and-programs/surface-water/lakes/lake-protection-and-management.html#frequently-asked-questions-about-in-lake-treatment.*

2. **Manual removal**—Manual removal of algae, using a suction device has recently been tested within the Region. This measure, though legal, is currently in the early stages of application. Additionally, "skimming" of algae has been tried by lake managers with little success. Consequently, it would be necessary to further investigate these kinds of measures prior to implementation.

As discussed previously, Whitewater and Rice Lakes exhibit internal phosphorus loading and sparse native aquatic plant communities, which, together, create a rich environment for heavy algal blooms throughout the year, particularly in Rice Lake. Therefore, the use of one, or a combination of, the approaches could reduce phosphorus and algal concentrations. The methods of algal control recommended for general water quality enhancement (i.e., pollution control, plant community maintenance, and carp control) are recommended for long-term algal control in both Whitewater and Rice Lakes.

ISSUE 4: BOG REMOVAL IN WHITEWATER LAKE

A floating bog in Whitewater Lake was as a concern to some lake users. The bog is located in the northeastern lobe and rises to the water's surface during summer months after methane gas accumulates beneath it. The bog is most likely a remnant of a bog that existed prior to the creation of Whitewater Lake, but was subsequently drowned. The bog covers several acres and can float just beneath the surface of the water, causing a recreational hazard to boaters. Pieces of it can also break off and float to other parts of the Lake, also causing a recreational hazard. Buoys are placed near the floating bog area during the summer months to notify boaters.

Currently, the Whitewater-Rice Lakes District is maintaining a DNR permit for bog removal. Removal is undertaken each year for approximately five weeks after Labor Day weekend. Material is broken up and transported to the closest Lake access location for transport and disposal. A turbidity fence is placed to the north of the removal area to reduce the spread of material as it is broken up for removal and to keep it from interfering with property owners' pier areas.

Other methods for bog removal have been investigated by the Lakes District, such as more powerful machinery designed specifically for cutting through bogs, tussocks, and dense aquatic vegetation. However, the District concluded that these methods would only exacerbate problems within Whitewater Lake by not removing the bog material and only creating smaller pieces. Smaller bog material would continue to interfere with recreational activities, and would not remove excess nutrient sources from the Lake. Consequently, maintenance and extension of current permits and activities for bog removal should be continued until the bog is completely removed. In addition, it is recommended that an underwater survey be periodically performed to assess the size of the bog in order to estimate rate of success and time needed to entirely remove the bog.

ISSUE 5: GROUNDWATER RECHARGE

Groundwater recharge has not been identified as an issue of high concern by Whitewater and Rice Lake residents. However, because groundwater contributes more than two-thirds of Whitewater Lake's inflow, and over 80 percent of its outflow,[74] and because much of the Whitewater and Rice Lake watershed is comprised of internally drained areas (as determined in "Issue 2: Water Quality"), potential effects of changes in future land use and buffer maintenance and creation as they pertain to groundwater recharge potential are discussed below.

Baseflow Recharge Rate Maintenance

Baseflow refers to water which reaches the Lake from groundwater. This groundwater is generally replenished through recharge (precipitation that soaks deeply into the ground and enters the aquifers). **Baseflow is crucial to Whitewater and Rice Lakes because the Lakes receive little surface runoff** during drier weather periods.

[74] *U.S. Geological Survey Water-Resources Investigations Report 94-410*, op cit.

Groundwater typically contains little to no sediment or phosphorus, has a more stable temperature regimen, and commonly contains a lower overall pollutant load when compared to surface water runoff, all of which are favorable to aquatic life and the ecology of waterbodies. Groundwater-derived baseflow sustains many wetlands and creeks during drier weather, enabling these features to act as refuges and maintain a diverse assemblage of plants and animals. Consequently, maintaining recharge to the aquifers which supply Whitewater and Rice Lakes is important.

Generally, humans deplete groundwater in two ways: 1) pumping from aquifers supplying baseflow, thereby reducing, or in extreme cases eliminating, flow from springs and seeps and 2) reducing groundwater recharge through land use changes that increase impervious cover. The first of these most commonly occurs when a high capacity well, or multiple smaller wells, are installed in the groundwatershed without considering the effect pumping may have on naturally occurring groundwater discharge areas. Since heavy pumping is not currently known to exist in the Whitewater and Rice Lake groundwatersheds, it is not considered an issue of particular concern. Nevertheless, future groundwater diversion or consumptive use (e.g., irrigation) could cause Lake levels to decline. If high capacity wells or numerous smaller wells were proposed in the Lakes' groundwatershed in the future, their effect on Lake levels should be carefully investigated, and, if those effects are found to be significant, they should be mitigated.[75]

The second common cause of groundwater depletion is reduced groundwater recharge. Aquifer recharge can be reduced in many ways. Hastening stormwater runoff, eliminating native vegetative cover, ditching and tiling and otherwise draining wet areas, disconnecting floodplains from streams, and increasing the amount of impervious land surface can all contribute to reduced stormwater infiltration, increased runoff, and reduced groundwater recharge. Similarly, if sanitary sewers are installed around the Lakes, and if the homes continue to rely upon wells for domestic water, much of the water that currently re-enters the shallow aquifer may be transported out of the watershed, a condition that could reduce the amount of groundwater entering the Lakes. Consequently, it is desirable to determine what areas need to be protected to maintain the baseflow to Whitewater and Rice Lakes. To determine this, two factors need to be analyzed, including:

1. **The direction of groundwater flow**—To understand the dynamics of baseflow to a lake, it is important to know where groundwater recharge occurs and in what direction groundwater is flowing. In most instances, groundwater elevation is a subdued reflection of surface topography. Topographically higher areas are commonly recharge areas, while lakes, wetlands, and streams in valleys are commonly groundwater discharge areas. Groundwater recharge/discharge systems occur on many spatial scales: long regional recharge/discharge relationships and short localized flow paths, both of which can be important contributors to a lake's overall water budget. While localized groundwater flow systems typically occur within the surface water watershed, regional groundwater flow paths may trace directions and distances out of phase with surface water feeding a lake. Therefore, the groundwater feeding a lake may originate in areas distant from the lake and/or outside the lake's surface-water watershed boundary. The relationship between short- and long-distance flow paths is illustrated in Figure 48.

   Smaller-scale local groundwater flow paths generally mirror surface water flow paths. However, to approximate the direction of deeper, more regionally extensive flow systems, groundwater elevation contours derived from measurements collected in water supply or monitoring wells need to be consulted. Since water normally moves perpendicular to elevation contours, groundwater flow directions can be predicted. When performing such analysis, it is necessary to consider the locations and elevations of streams, ponds, and lakes other than the waterbody of interest. This relationship can be used to predict if a surface water body is fed by groundwater, recharges groundwater, or has little interaction with groundwater. By combining these data, land areas that feed and convey groundwater to the Lakes can be mapped.

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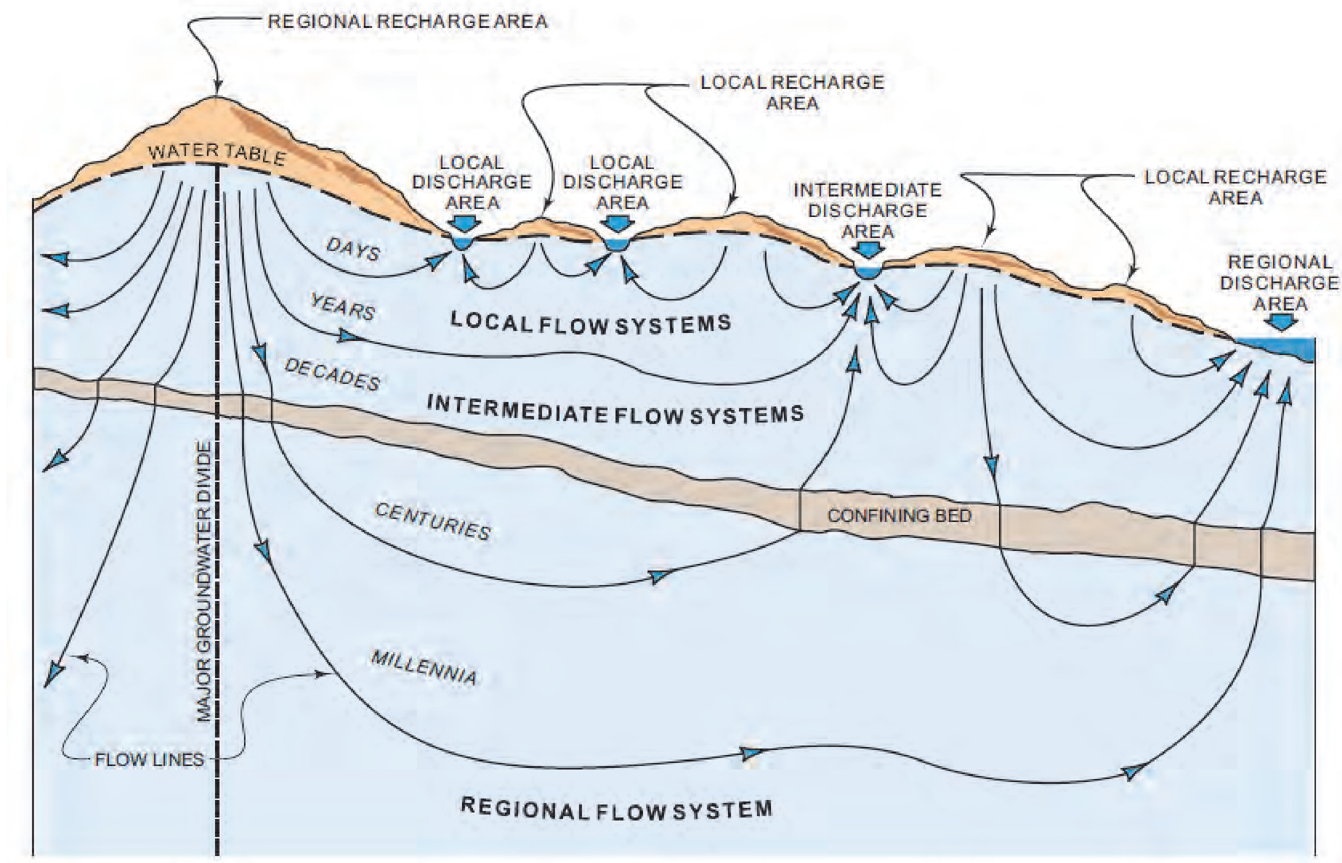
[75]*SEWRPC Planning Report No. 52,* A Regional Water Supply Plan for Southeastern Wisconsin, *December 2010.*

Figure 48

CROSS SECTION DEPICTING LOCAL VERSUS REGIONAL GROUNDWATER FLOW PATHS



Source: A. Zaporozec in SEWRPC Technical Report Number 37, Groundwater Resources of Southeastern Wisconsin, 2002.

2. **The groundwater recharge potential in the area that is likely contributing to the groundwater supply**—Groundwater recharge potential is related to slope, soil characteristics, the amount of impervious cover, and other factors. An area with no impervious cover and highly permeable soils, for example, is classified as having high or very high groundwater recharge potential, whereas an area with lower permeability (e.g., clay soils) would be classified as low potential. Identifying groundwater recharge potential enables the areas with the highest infiltration functions to be inventoried and protected (e.g., the areas where impervious surfaces should be avoided or where appropriate infiltration facilities should be sited)

To determine where management efforts should be employed to protect groundwater recharge to Whitewater and Rice Lakes, SEWRPC staff analyzed groundwater elevation contours and the groundwater recharge potential in the areas surrounding the Lakes.[76] This inventory was not confined to the surface watershed, as was the case for the other inventories completed in this report, because the groundwater flow may be coming from outside of the watershed. The results of these inventories are described below.

[76]*SEWRPC Planning Report No. 52*, op. cit.

Map 17 shows the general water table elevation contours, in feet above National Geodetic Vertical Datum, 1929 adjustment (NGVD 29), in the Whitewater and Rice Lake area. As indicated on the map, groundwater table elevations reflect a general southeast to northwest flow of groundwater to Whitewater and Rice Lakes. Groundwater elevation contours suggest that the area contributing groundwater to the Lakes is much larger than the surface watershed. **The groundwatershed likely extends two to three miles south and east of the Whitewater Lake, covering approximately 7,200 acres**. The nearly 3,000 acres of internally drained area is likely a particularly important groundwater recharge area and is therefore hydrologically connected to the Lake. Groundwater elevation contours suggest that groundwater discharges to Whitewater Lake along its entire eastern and southern shoreline, with particularly strong groundwater discharge areas located in the South Bay and east-central shore and adjacent lake bottom. Monitoring wells installed as part of a USGS study found that the South Bay and adjacent spring complexes are the predominant groundwater discharge area to Whitewater Lake and that much of the remaining lakeshore and lakebed may lose water to the groundwater flow system.[77] Groundwater elevation contours confirm that water leaves the Lake through the bottom and shore along essentially the entire north and west shoreline. Some of the water that leaves Whitewater Lake as groundwater recharge re-emerges as groundwater discharge in Rice Lake. Much of this water leaves Rice Lake by infiltrating into the western shoreline and adjacent lakebed. This water ultimately discharges to nearby water bodies such as Whitewater Creek or wetlands.

Even though considerable volumes of water enter and leave both Lakes, water only rarely discharges over the spillways of the outlet control dams. Unlike some dams, minimum discharge requirements have not been set for the Whitewater or Rice Lake Dams.[78] Groundwater both enters and exits the Lakes by seeping through the bed and banks of the Lakes and adjacent streams, a defining characteristic of a seepage lake, and a finding that can have significant management and regulatory implications.

Map 18 shows the groundwater recharge potential for the Whitewater and Rice Lake groundwatershed. The areas to the south and east of the Lakes is primarily underlain by conditions conducive to high and very high groundwater recharge rates. These areas are occupied by a mix of woodlands, open lands, and agricultural fields (discussed in more detail below) which can contribute to pollutant filtration and water infiltration. Future planning and development should limit impact to the woodland areas to maintain infiltration and filtration. Additionally, opportunities to preserve and enhance stormwater infiltration should be actively pursued wherever practical and open lands and fields should be maintained to retain groundwater recharge abilities. Where future development does occur, care should be taken to implement infiltration practices, stormwater management, and buffer enhancement to maintain existing groundwater recharge. In the interest of encouraging these kinds of actions, Chapter III of this report further details recommendations focused on increasing infiltration in the high and very high groundwater recharge potential areas in the Whitewater and Rice Lake watersheds. These recommendations should be implemented where practical.

Surface Water Runoff Management and Baseflow Recharge Rate Maintenance

Runoff from large, intense rainfall events moves across the land surface and through streams at a higher than average velocity. This speed can be decreased when the water encounters detention or retention basins, buffers, or wetlands which slow the flow, storing and gradually releasing it, and, in some instances, allowing the water to soak into the ground. Much of the water that soaks into the ground becomes part of groundwater baseflow and moves slowly toward a lake, maintaining flow to the lake over a period well beyond the day of the rain event.

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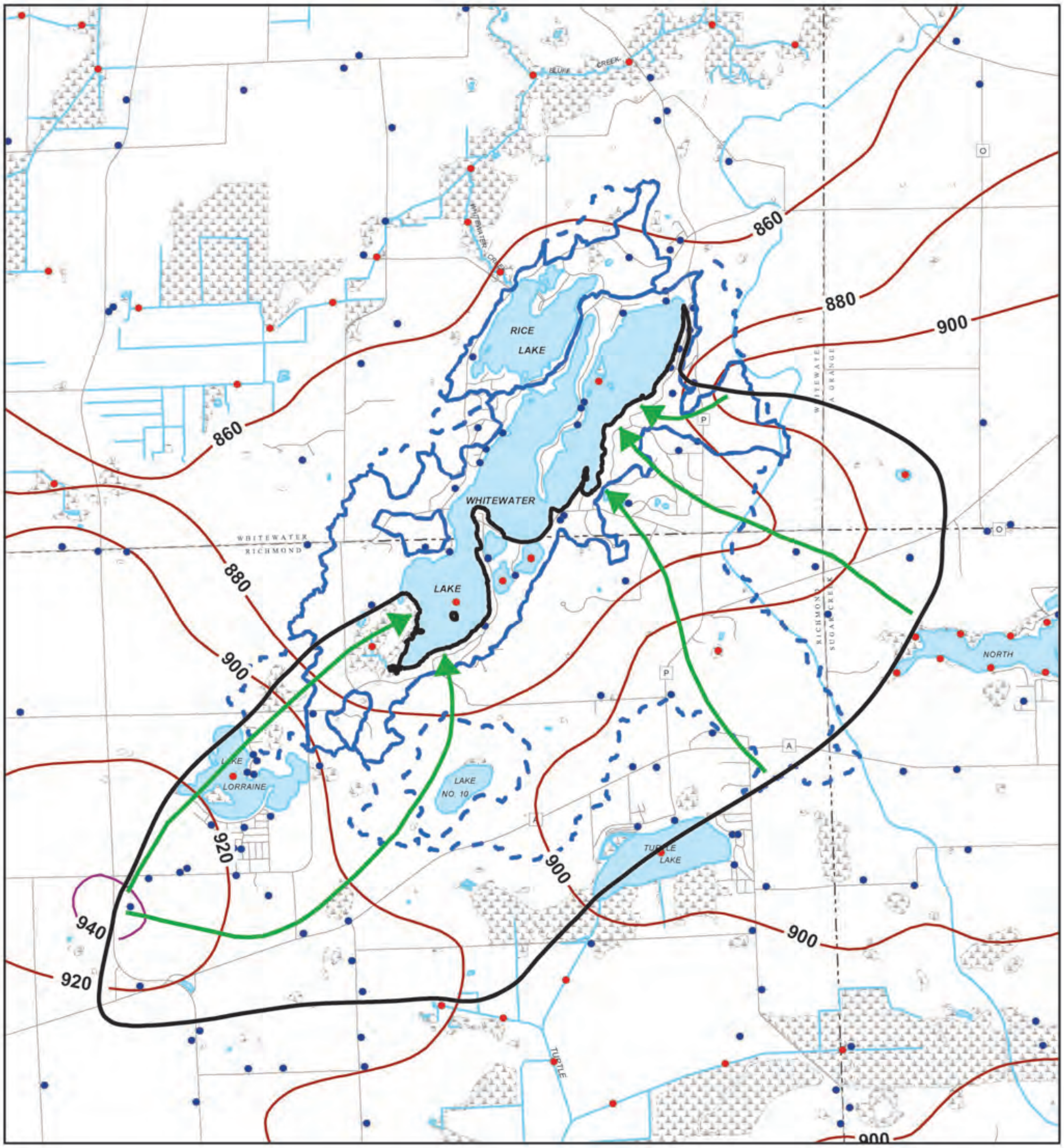
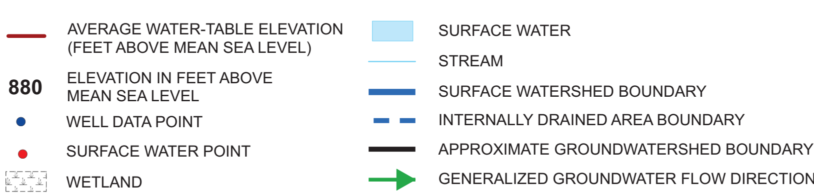
[77] *U.S. Geological Survey Water-Resources Investigations Report 94-410*, op cit.

[78] *Email from Tanya Lourigan (WDNR) to Dale Buser (SEWRPC), February 27, 2017.*

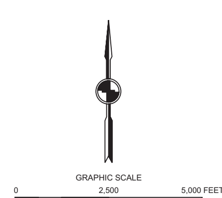
Map 17

WHITEWATER AND RICE LAKES GROUNDWATERSHED BOUNDARY





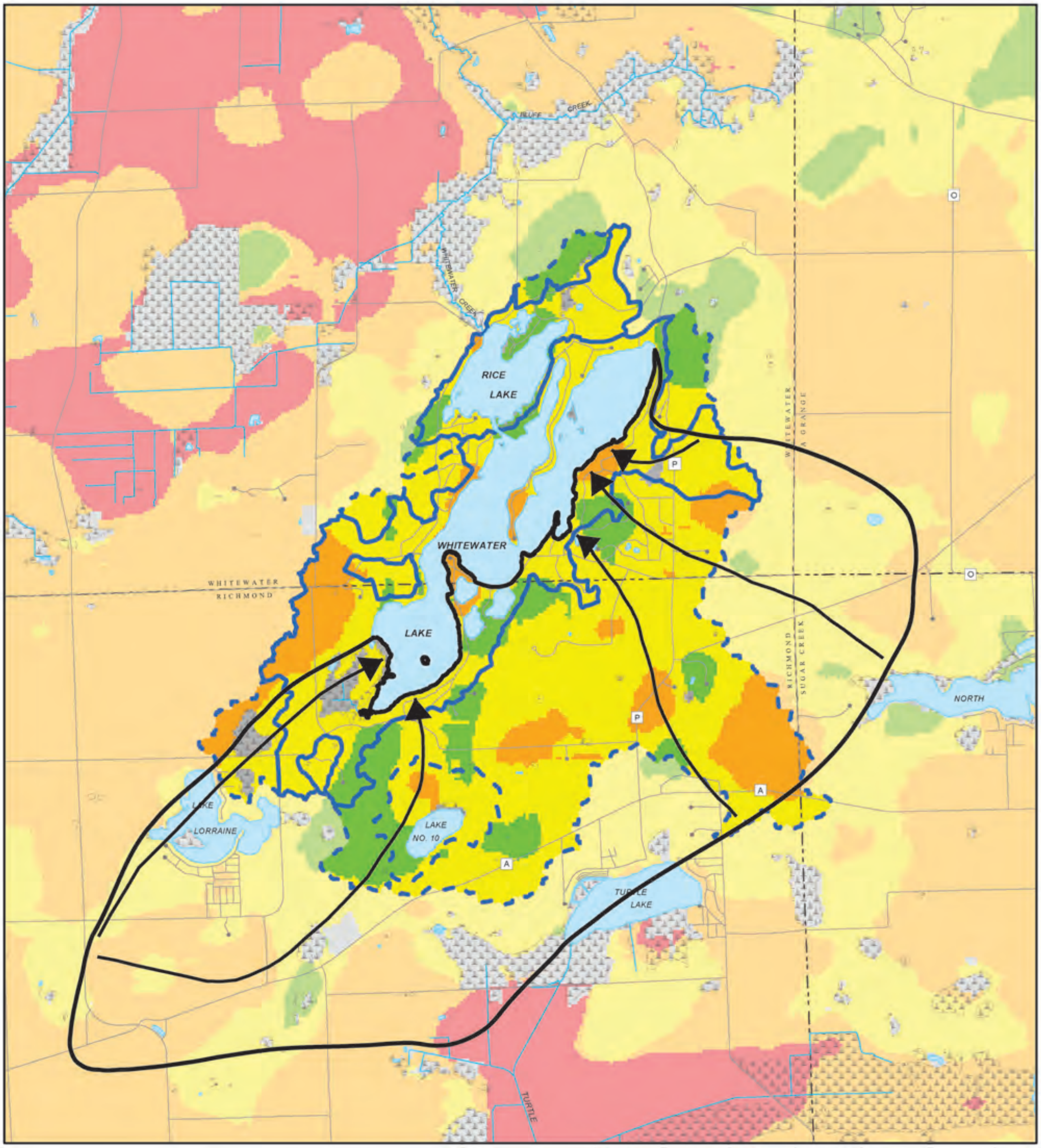
Note: Groundwater elevations are based upon measurements in water supply wells.



Source: Wisconsin Geological and Natural History Survey and SEWRPC.

Map 18

GROUNDWATER RECHARGE POTENTIAL



LOW

MODERATE

HIGH

VERY HIGH

UNDEFINED

SURFACE WATER

WETLAND

STREAM

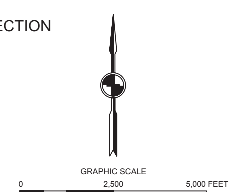
SURFACE WATERSHED BOUNDARY

INTERNALLY DRAINED AREA BOUNDARY

APPROXIMATE GROUNDWATERSHED BOUNDARY

GENERALIZED GROUNDWATER FLOW DIRECTION

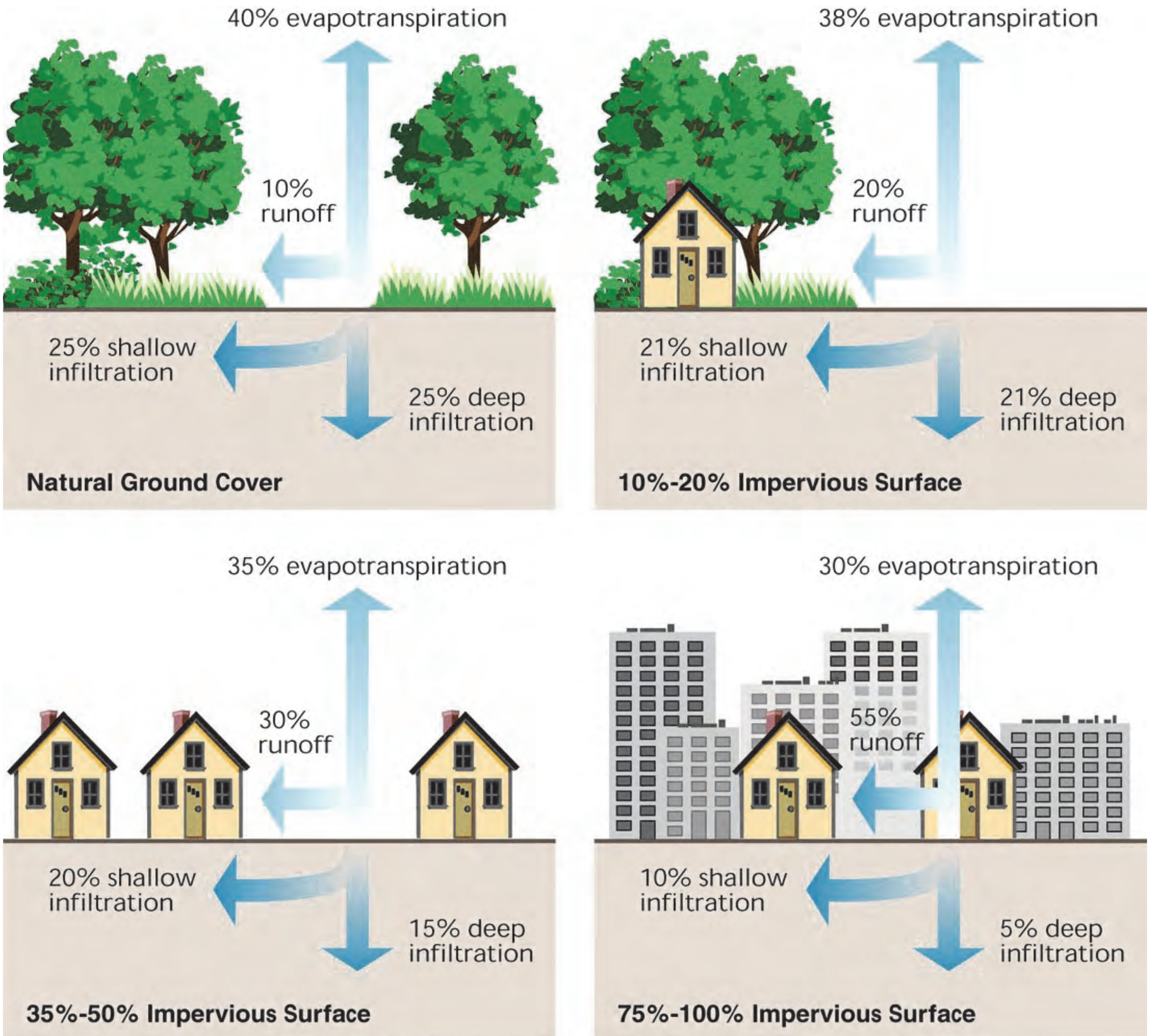
Note: Colors outside the watershed boundary are reduced in intensity to show the adjacent extent and distribution of each legend category.



Source: Natural Resources Conservation Service and SEWRPC.

Figure 49

SCHEMATIC OF EFFECTS OF IMPERVIOUS SURFACES ON RUNOFF AND GROUNDWATER RECHARGE



Source: Federal Interagency Stream Restoration Working Group.

Impervious surfaces decrease rainfall infiltration and increase the volume and velocity of runoff after a rainfall (see Figure 49).[79] Many studies directly link increases in impervious land surface to decreases in habitat quality and ecological integrity. For example, a 2003 study of 47 southeastern Wisconsin streams reported that fish and insect populations dramatically decline when impervious surfaces cover more than about 8 to 10 percent of the watershed and streams with more than 12 percent watershed impervious surface consistently have poor fish commu-

[79]*Impervious surfaces are those that resist or prevent absorption or transmission of water (e.g., asphalt or concrete parking areas and roadways, sidewalks, rooftops).*

nities.[80] Consequently, reducing or preventing impervious cover, or installing measures meant to reduce the runoff from impervious cover are critical components to help ensure adequate volumes of water supply to a lake. The effect of impervious surfaces can be reduced in many ways, including the following examples:[81]

1. **Limit the size of hard surfaces:**
    a. Limit driveway width or share between neighbors,
    b. Minimize building footprints, and
    c. Remove unneeded sidewalks and parking spots.
2. **Opt for pervious materials:**
    a. Green roads (e.g, incorporation of bioswales and grassed ditches),
    b. Mulch walkways, and
    c. Permeable pavers for walkways and driveways.
3. **Capture or infiltrate runoff:**
    a. Use rain barrels,
    b. Plant rain gardens,
    c. Channel gutters and downspouts to rain barrels, rain gardens, or places where water can infiltrate, and
    d. Assure that the soil in lawn areas in not compacted.
4. **Maintain and restore shoreline buffers (discussed previously in "Issue 2: Water Quality").**

To determine where improvements can be made to maintain and extend the volume of water supplied to Whitewater and Rice Lakes, several factors need to be assessed. These include:

1. **Current urban land use within the watershed**—Urban land uses generally have a much higher percentage of impervious cover than rural land uses. Consequently, to assess where management efforts can be made to reduce the amount of impervious cover (or where efforts can be made to slow down or reduce the runoff leaving these areas) it is necessary to identify where urban land use exists.
2. **Planned land use changes within the watershed**—Since urban land use has a higher percentage of impervious cover, it is important to know where rural land is expected to be converted to urban land in the future. In such cases, extra precautions can be taken to plan, design, and implement management efforts that will reduce runoff velocity and/or volume after development occurs. Ideally, to protect the lake and its tributaries, stormwater management infrastructure should enhance infiltration and runoff characteristics to conditions better than those of the undeveloped land cover. Such measures can help mitigate the effects of already existing impervious surfaces and stormwater conveyance systems that discharge directly to receiving water bodies, both of which are common in older developments that did not incorporate environmental considerations as part of stormwater management design.

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[80]*Wang, L, J. Lyons, P. Kanehl, R. Bannerman, and E. Emmons, "Watershed Urbanization and Changes in Fish Communities in Southeastern Wisconsin Streams,"* Journal of the American Water Resources Association, V*olume 36, Issue 5, pp. 1173-1187, 2000; Wang, L., J. Lyons, and P. Kanehl, "Impacts of Urbanization on Stream Habitat and Fish Across Multiple Spatial Scales,"* Environmental Management, *Volume 29, Issue 2, pp. 255-266, 2001.*

[81]*Wisconsin Department of Natural Resources Publication No. WT-990*, Impervious Surfaces: How They Impact Fish, Wildlife and Waterfront Property Values, *2013*.

3. **Natural areas and stormwater management structures**—Stormwater retention and detention basins and natural areas (e.g., buffers, floodplains, wetlands, and woodlands) can slow runoff, can trap or detain nutrients and pollutants, can promote infiltration of water into the soils, can help recharge groundwater aquifers, and, in some cases can store and gradually release water to sustain the Lake during dry periods. Consequently, if runoff passes through these kinds of areas, peak runoff rates are generally moderated, nutrient and pollutant loads are reduced, and the time during which water is supplied to the Lake can be lengthened.

To help target water volume management efforts, SEWRPC staff inventoried the three preceding factors for the Whitewater and Rice Lake watersheds using geographic information system techniques and 2010 color digital orthophotography collected under a Regional orthophotography program administered by the Commission. Current and planned land use data for the entire watershed are shown on Maps 19 and 20, respectively. **Urban land use currently occupies about 32 percent of the Whitewater Lake and Rice Lake watersheds**. Map 21 shows the areas within the watershed where land use is forecast to change from rural to urban uses by 2035, based upon a comparison of the current year 2010 land use map for the entire watershed (see Map 19) and the planned land use map for the entire watershed (see Map 20). The planned development located in areas of high groundwater recharge potential (see Map 18). Development of areas to the east of Whiewater Lake could reduce the volume of groundwater entering the Lakes. While planned development is only moderate in extent, that development could affect groundwater recharge and pollution entering the Lakes if infiltration practices, stormwater management, and buffer enhancement are not implemented in the areas of new development. Consequently, recommendations for stormwater management related to this new planned development, as well as general recommendations for slowing, storing, and infiltrating runoff, are included in Chapter III of this report.

Maps 14, 15, and 16 also indicate, as was discussed in "Section 2: Water Quality," that while most of the watershed is underlain by areas of high groundwater recharge potential, **runoff from much of the developed shoreline properties does not flow to a feature that promotes infiltration**. Consequently, recommendations to increase water infiltration on the shoreline properties are also included in Chapter III of this report.

ISSUE 6: RECREATION

Whitewater and Rice Lakes are multi-purpose waterbodies serving a variety of recreational and other uses. Active recreation includes boating, waterskiing, tubing, swimming, and fishing during the summer months, and cross-country skiing, snowmobiling, and ice fishing during the winter. Public access to Whitewater Lake and Rice Lake is provided by two WDNR-owned and operated paved launch facilities, both with paved parking areas (See Map 22).[82] The Whitewater Lake WDNR-launch site is located along State Park Road, approximately mid-way along the western shoreline of the Lake; the Rice Lake WDNR-launch site is located just off State Park Road, on the peninsula of land located between the northwestern and northeastern lobes of Rice Lake. A fee of $8.00 per day is charged to residents of the Whitewater-Rice Lakes Management District, while an $11.00 fee is charged for non-residents. Annual passes are offered for a fee of $28.00 for District residents and $38.00 for non-residents. In addition, three Town-operated boat launches without parking are available for public use. One is located on the western shore of Whitewater Lake at Richmond Whitewater Townline Road just to the east of Krahn Drive. The other two are located along the eastern shore of Whitewater Lake: one at Richmond Whitewater Townline Road just west of Chapel Drive, and the other at Cruise Lane just west of East Lakeshore Drive (See Map 22). A fee of $4.00 per day is charged to residents of the Whitewater-Rice Lakes Management District, while a $6.00 fee is charged for non-residents. Annual passes are offered for a fee of $20.00 for District residents and $30.00 for non-residents. Boat mooring for the purpose of living, sleeping, or camping is prohibited. Given what is known about the site, **boat launch facilities and fees appear to conform to the minimum requirements set forth in Chapter NR 1 of the *Wisconsin Administrative Code***. Compliance with this section is important, since certain grant and assistance fund-

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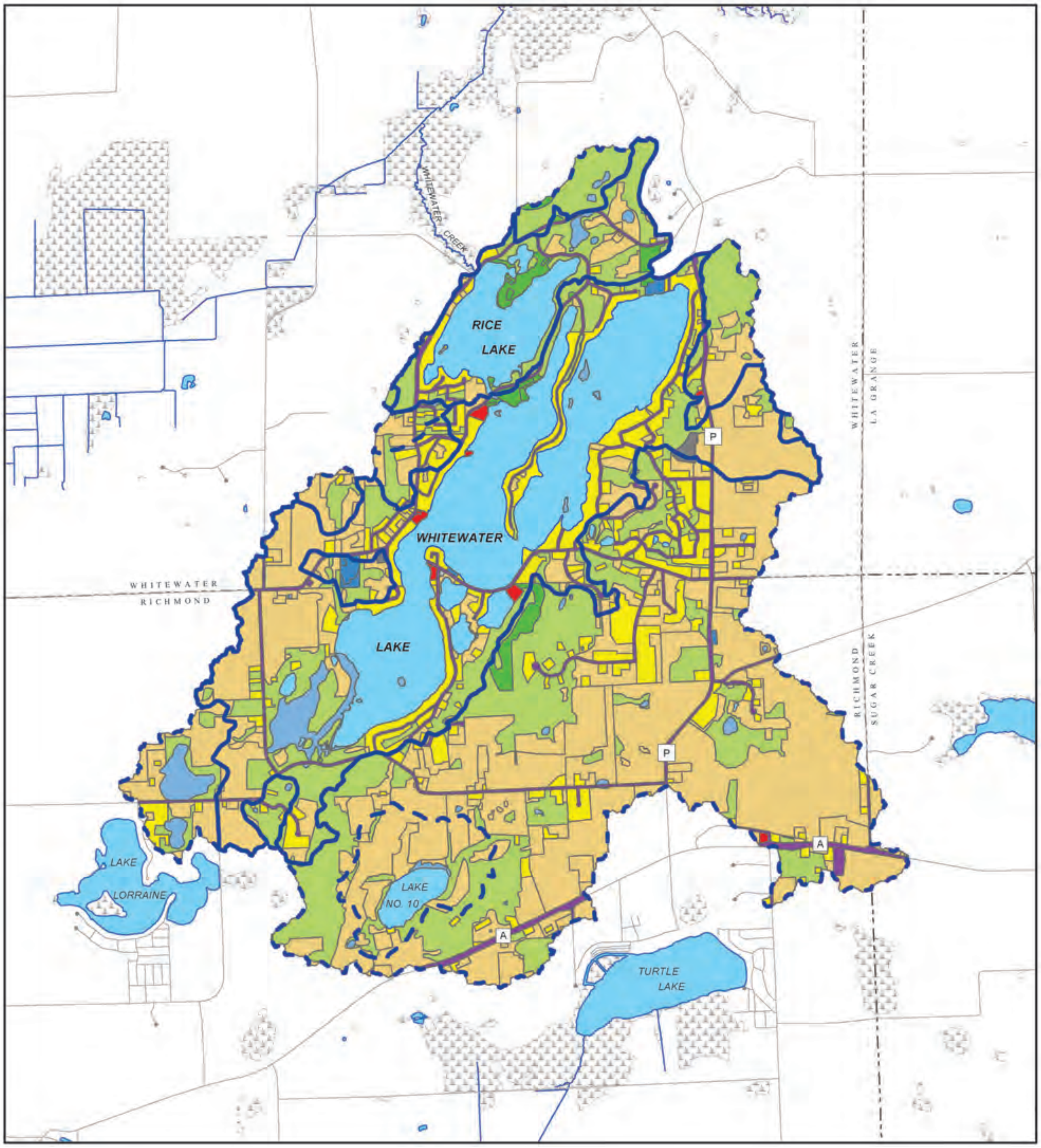
[82]*Maps available on the WDNR Surface Water Data Viewer also depict a canoe launch on the southwestern shore of Whitewater Lake.*

Map 19

2010 LAND USE FOR THE WHITEWATER AND RICE LAKE WATERSHEDS



SINGLE-FAMILY RESIDENTIAL	RECREATION
MULTI-FAMILY RESIDENTIAL	WETLANDS
COMMERCIAL	WOODLANDS
INDUSTRIAL	SURFACE WATER
TRANSPORTATION, COMMUNICATIONS, AND UTILITIES	AGRICULTURAL, UNUSED, AND OTHER OPEN LANDS
GOVERNMENT AND INSTITUTIONAL	EXTRACTIVE AND LANDFILL

INTERNALLY DRAINED AREA BOUNDARY

WATERSHED BOUNDARY

STREAM

WETLAND

Note: A property on the central western shore of Whitewater Lake currently identified as commercial land is actually used for residential purposes and will be corrected in soon-to-be-released SEWRPC 2015 Land Use Maps.

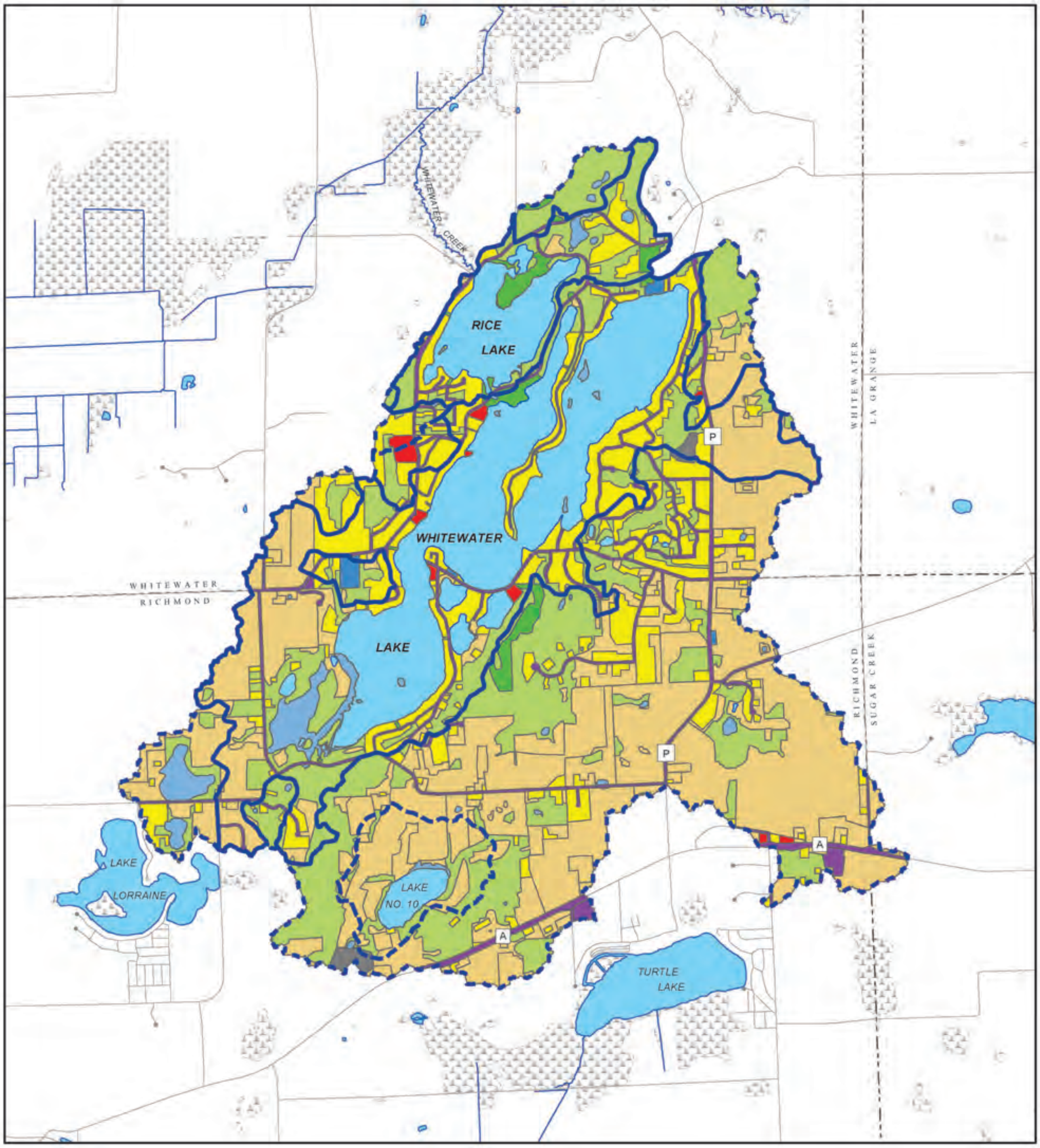
GRAPHIC SCALE

0 2,000 4,000 FEET

Source: SEWRPC.

Map 20

2035 LAND USE FOR THE WHITEWATER AND RICE LAKE WATERSHEDS



SINGLE-FAMILY RESIDENTIAL
MULTI-FAMILY RESIDENTIAL
COMMERCIAL
INDUSTRIAL
TRANSPORTATION, COMMUNICATIONS, AND UTILITIES
GOVERNMENT AND INSTITUTIONAL
RECREATION
WETLANDS
WOODLANDS
SURFACE WATER
AGRICULTURAL, UNUSED, AND OTHER OPEN LANDS
EXTRACTIVE AND LANDFILL
INTERNALLY DRAINED AREA BOUNDARY
WATERSHED BOUNDARY
STREAM
WETLAND

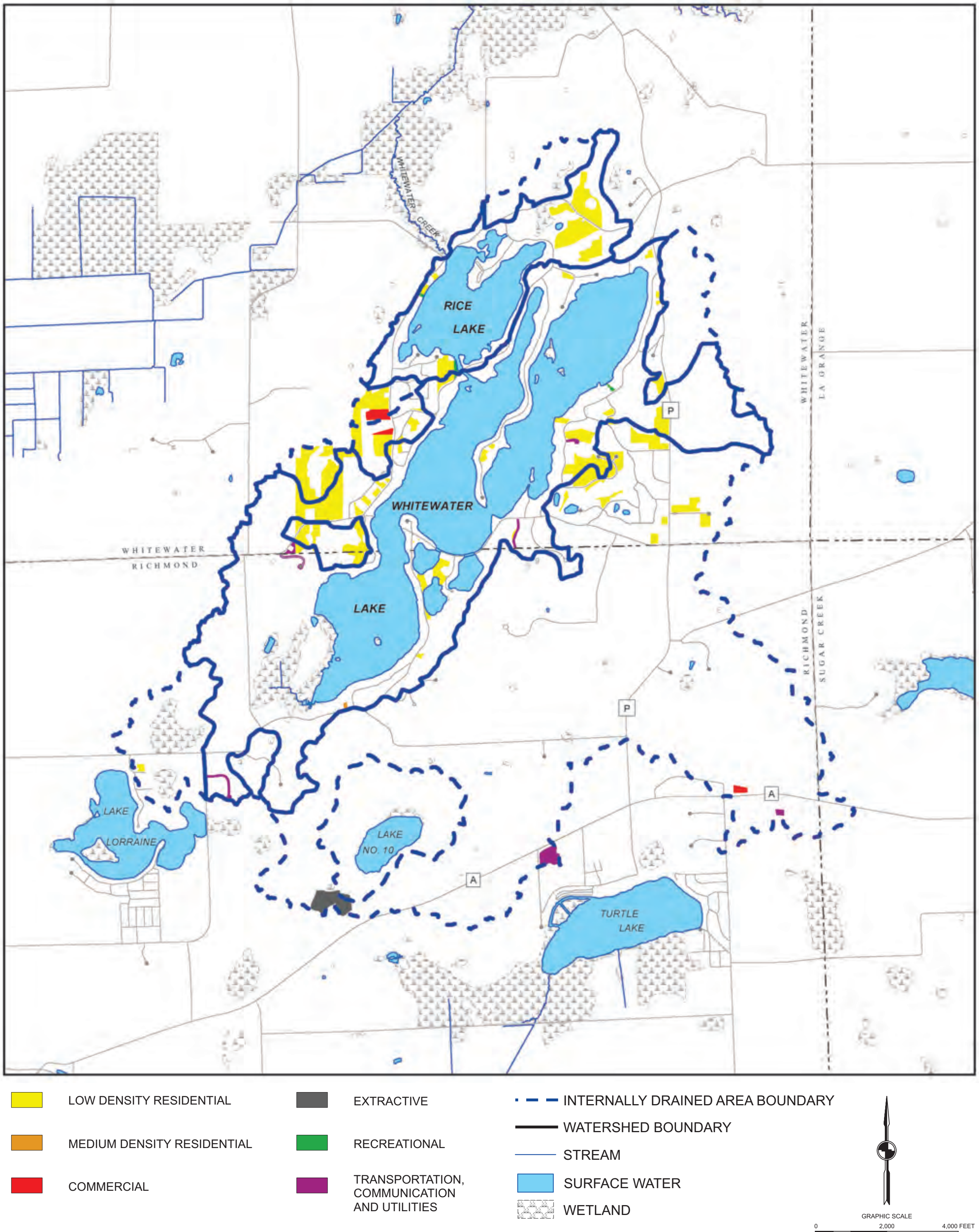
Note: A property on the central western shore of Whitewater Lake currently identified as commercial land is actually used for residential purposes and will be corrected in soon-to-be-released SEWRPC 2015 Land Use Maps.

GRAPHIC SCALE
0 2,000 4,000 FEET

Source: SEWRPC.

Map 21

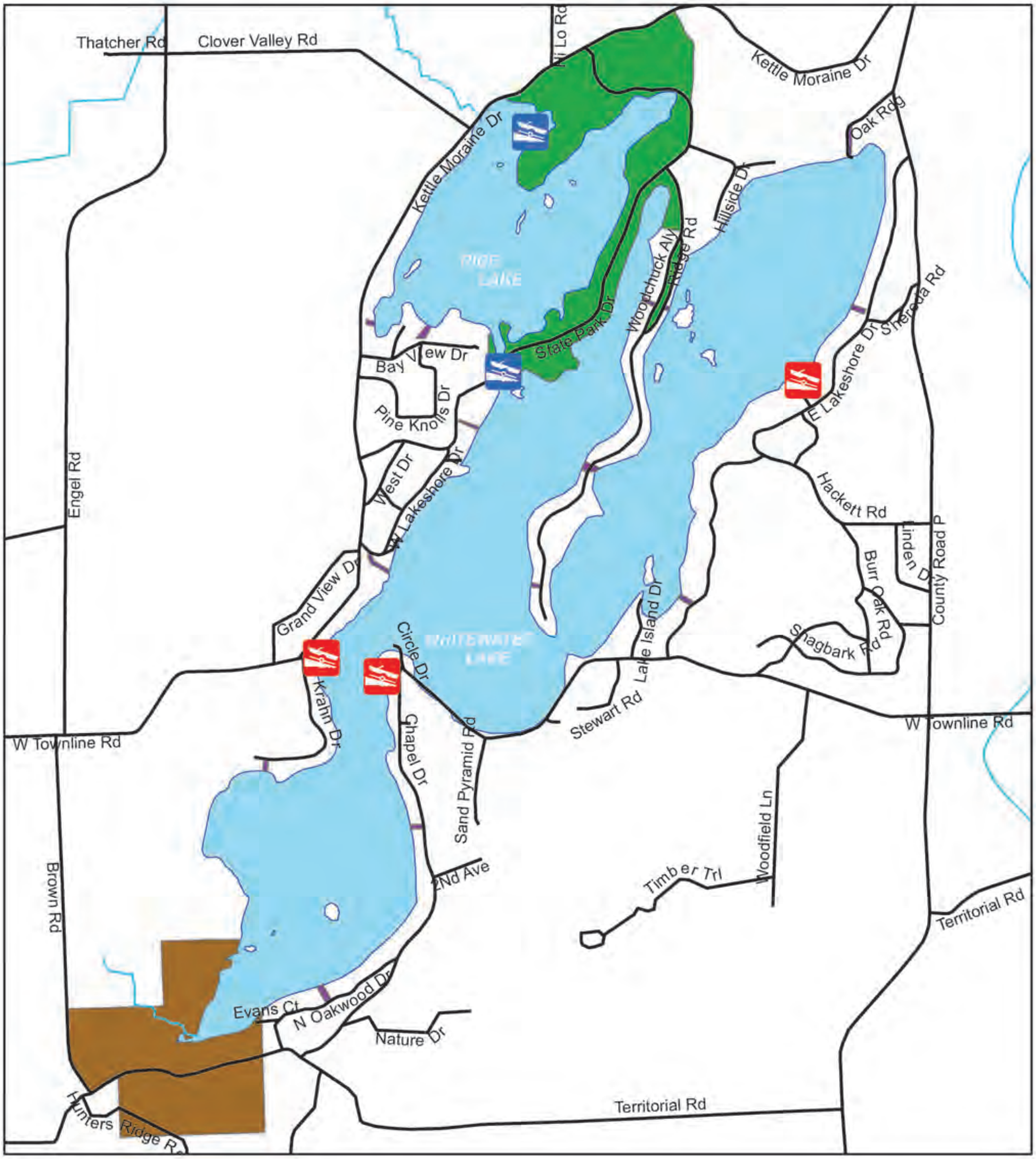
AGRICULTURAL LANDS AND OPEN LANDS THAT WOULD BE CONVERTED TO URBAN LAND USE UNDER YEAR 2035 PLANNED CONDITIONS WITHIN THE WHITEWATER AND RICE LAKE WATERSHEDS



Source: SEWRPC.

Map 22

RECREATIONAL USES ON WHITEWATER AND RICE LAKES: 2016



BOAT LAUNCHES

STATE PARK BOAT LAUNCH WITH PARKING

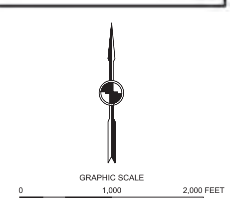
TOWN BOAT LAUNCH WITHOUT PARKING

RECREATIONAL AREAS

KETTLE MORAINE STATE PARK

NATURELAND COUNTY PARK

PUBLIC ACCESS



Source: WRLMD, WDNR, and SEWRPC.

ing is predicated by compliance with Chapter NR 1. It appears that the Town launch fees could be increased by at least $2.00.[83] Launch fees can influence the intensity of use of the launch facility, and can be considered as part of a program to help avoid excess boat densities on the Lake. This is discussed in more detail in Chapter III.

The Lakes are used year-round as visual amenities with walking, bird watching, and picnicking being popular passive recreational uses of these waterbodies. Their locations, lying in the vicinity of the Southern Unit of the Kettle Moraine State Forest and within easy travel distance from the metropolitan areas of Milwaukee and Chicago, make these Lakes, especially Whitewater Lake, popular recreational destinations. Rice Lake is partially surrounded by the Southern Unit of the Kettle Moraine State Forest on the northern and eastern shorelines and lies within the Whitewater Lake Recreation Area, while Whitewater Lake lies adjacent to the Southern Unit of the Kettle Moraine State Forest on the western shore of the upper basin. Whitewater Lake incorporates a State park with a popular swimming beach along the western shoreline of the Lake's western lobe. Additionally, a Walworth County-owned and operated park, Natureland County Park, is located at the southern tip of Whitewater Lake (Map 22).

The types of watercraft docked or moored on a lake, as well as the relative proportion of nonmotorized to motorized watercraft, reflect the attitudes of the primary users of the lake, the riparian residents. To help characterize the recreational use of Whitewater and Rice Lakes, a watercraft census (i.e., a boat count along the shoreline) was completed by SEWRPC staff during summer 2014. At the time of the survey, 1,069 boats were observed either moored in the water or stored on land in the shoreland areas around Whitewater Lake, and 87 boats were similarly observed around Rice Lake (Table 18). On Whitewater Lake, about 62 percent of all docked or moored boats were motorized, with power boats, pontoon boats, and personal watercraft the most common types. Of the nonmotorized watercraft observed, kayaks, canoes, and paddleboats were most common. On Rice Lake, only about 32 percent of all docked or moored boats were motorized, with fishing boats and pontoon boats the most common types. The majority of watercraft docked or moored on Rice Lake were nonmotorized canoes, paddleboats, and rowboats. To assess the degree of recreational boating use of a lake, it has been estimated that, in southeastern Wisconsin, the number of watercraft operating at any given time is 2 to 5 percent of the total number of watercraft docked and moored. On Whitewater Lake, this would amount to about 20-50 boats, while on Rice Lake this would amount to about two to four boats.

Another way to assess the degree of recreational boat use on a lake is through direct counts of boats actually in use on a lake at a given time. Surveys to assess the types of watercraft in use on a typical summer weekday and a typical summer weekend day on Whitewater and Rice Lakes were conducted by SEWRPC staff in the summer 2008.[84] The results of these surveys are shown in Tables 19 and 20 for Whitewater and Rice Lakes, respectively. As shown in these tables, power boats and fishing boats were the most popular types of watercraft in use on the Lakes during weekdays and weekends. Whitewater Lake experiences especially heavy use by recreational boaters during open water periods. On Whitewater Lake, pontoon boats, kayaks, and canoes were also popular types of watercraft in use, with mornings being an especially popular time for kayaking. Rice Lake generally had much less watercraft activity than Whitewater Lake on the observation dates. These observations were supported by general use observations on each Lake during the 2014 aquatic plant surveys.

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[83]*NR 1.91(11)a encourages free boat launching but allows a maximum one-day base fee equivalent to the one-day fee for residents to enter state parks ($8.00 at the time of this report). NR1.91(11)b allows additional surcharges based upon the presence of an attendant (20% base fee surcharge), the size of boats served (30% base fee surcharge for boats between 20 and 26 feet in length and 60% base fee surcharge for boats greater than 26 feet in length), and the presence of on-site toilet facilities (20% base fee surcharge).*

[84]*Due to the similar totals of docked and moored boats between the 2008 and 2014 shoreline survey, it is assumed that the results of this in-use survey would be similar in 2014.*

Table 18

WATERCRAFT DOCKED OR MOORED ON WHITEWATER AND RICE LAKES: 2014[a]

Lake	Type of Watercraft									
	Powerboat	Fishing Boat	Pontoon Boat	Personal Watercraft	Canoe	Sailboat	Kayak	Paddle Boat	Row Boat	Total
Whitewater	280	53	211	123	89	15	175	78	45	1069
Rice	13	2	9	4	18	1	7	18	15	87

[a]Includes trailered watercraft and watercraft on land observable during survey.

Source: SEWRPC.

Table 19

WATERCRAFT IN USE ON WHITEWATER LAKE: 2008

Date and Time	Weekend Boat Counts								
	Powerboat	Pontoon Boat	Fishing Boat	Personal Watercraft	Sailboat	Canoe/ Kayak	Wind Surf Board	Paddle Boat	Total
Sunday, August 17									
9:30 a.m. to 10:30 a.m.	7	5	12	0	1	7	0	2	34
1:30 p.m. to 2:30 p.m.	10	3	3	4	0	0	0	2	22

Date and Time	Weekday Boat Counts								
	Powerboat	Pontoon Boat	Fishing Boat	Personal Watercraft	Sailboat	Canoe/ Kayak	Wind Surf Board	Paddle Boat	Total
Thursday, August 7									
9:30 a.m. to 10:30 a.m.	7	6	13	0	1	7	0	2	36
1:30 p.m. to 2:30 p.m.	10	3	3	4	0	0	0	2	22
Tuesday, August 26									
10:00 a.m. to 11:00 a.m.	4	3	3	0	0	4	0	1	15
1:30 p.m. to 2:30 p.m.	1	2	4	3	0	0	0	0	10

Source: SEWRPC.

The type of boating taking place varies by the day of the week, time of day, and prevailing weather conditions. According to a statewide survey that subdivided results by region,[85] boaters in Southeastern Wisconsin took to the water in the greatest numbers during July, with slightly lower numbers of boaters found on the water during June and August (Table 21). These months account for approximately two-thirds of the total number of boater-days logged in the Region for the entire year. About three to four times as many boaters use their boats on weekends than weekdays (Table 22). The weekday/weekend statistics compare favorably with SEWRPC Rice Lake boat counts, although overall usage is much lower than that of other lakes in the region. However, weekday use can continue to be high on Whitewater Lake on days closer to the end of the work week.

Fishing was by far the most popular activity in Southeastern Wisconsin in both spring and fall, and remains a leading reason for boat use throughout the summer (Table 21). Again, the data produced by the Commission's boat count on Whitewater Lake corresponds quite well with regional averages, suggesting that Whitewater Lake

[85]*Wisconsin Department of Natural Resources Technical Bulletin 174*, Boating Pressure on Wisconsin's Lakes and Rivers, Results of the 1989-1990 Wisconsin Recreational Boating Study, Phase 1, *1991*.

Table 20

WATERCRAFT IN USE ON RICE LAKE: 2008

Date and Time	Weekend Boat Counts								
	Powerboat	Pontoon Boat	Fishing Boat	Personal Watercraft	Sailboat	Canoe/ Kayak	Wind Surf Board	Paddle Boat	Total
Sunday, August 17									
9:00 a.m. to 9:30 a.m.	0	0	0	0	0	0	0	0	0
1:00 p.m. to 1:30 p.m.	4	0	2	0	0	0	0	0	6

Date and Time	Weekday Boat Counts								
	Powerboat	Pontoon Boat	Fishing Boat	Personal Watercraft	Sailboat	Canoe/ Kayak	Wind Surf Board	Paddle Boat	Total
Thursday, August 7									
9:00 a.m. to 9:30 a.m.	0	0	0	0	0	0	0	0	0
1:00 p.m. to 1:30 p.m.	0	0	1	0	0	0	0	0	0
Tuesday, August 26									
9:30 a.m. to 10:00 a.m.	0	0	1	0	0	0	0	0	1
1:00 p.m. to 1:30 p.m.	0	0	0	0	0	0	0	0	0

Source: SEWRPC.

Table 21

BOATING ACTIVITY IN SOUTHEASTERN WISCONSIN BY MONTH: 1989-1990

Activity	Percent Respondents Participating[a]						
	April	May	Jun	July	August	September	October
Fishing	68	57	49	41	44	42	49
Cruising	29	39	42	46	46	47	43
Water Skiing	3	9	20	27	19	16	8
Swimming	2	4	18	31	25	19	5
Average boating party size: 3.4 people							

[a]*Repondents may have participated in more than one activity.*

Source: WDNR.

boating activity is in line with regional averages. Usage on Rice Lake does not correspond as well, but that may be attributed to the smaller size of the Lake. The typical boat used on inland lakes in Southeastern Wisconsin is an open hulled vessel measuring approximately 18 feet long, powered by a motor producing approximately 90 horsepower (Tables 23 and 24). Sailboats comprise approximately 24 percent of boat traffic (15 percent non-powered and 9 percent unpowered), while other unpowered boats comprise only two percent of boats found on waterbodies in the region.

Only a few respondents to the WDNR boating survey felt that excessive boat traffic was present on Southeastern Wisconsin lakes.[86] A study completed in Michigan attempted to quantify desirable levels of boat traffic on an array

[86]Ibid.

Table 22

DAILY DISTRIBUTION OF BOATING IN SOUTHEASTERN WISCONSIN: 1989-1990

Day of the Week	Percent Respondents Participating[a]
Sunday	46
Monday	16
Tuesday	14
Wednesday	16
Thursday	13
Friday	17
Saturday	46

[a]Respondents may have participated in more than one day.

Source: WDNR.

Table 23

BOAT HULL TYPES IN SOUTHEASTERN WISCONSIN: 1989-1990

Day of the Week	Percent Respondents Participating[a]
Open	68
Cabin	17
Pontoon	9
Other	6
Average length: 18.4 ft	
Average beam width: 6.4 ft	

[a]Respondents may have participated in more than one day.

Source: WDNR.

Table 24

PROPULSION TYPES IN SOUTHEASTERN WISCONSIN: 1989-1990

Day of the Week	Percent Respondents Participating[a]
Outboard	53
Inboard/outboard	14
Inboard	6
Other (powered)	1
Sail	15
Sail with power	9
Other (nonpowered)	2
Average horse power: 86.5	

[a]Repondents may have participated in more than one day.

Source: WDNR.

of lakes used for a variety of purposes. That study concluded that **10 to 15 acres of *useable lake area* provides a reasonable and conservative average maximum desirable boating density**,[87] and covers a wide variety of boat types, recreational uses, and lake characteristics.[88] **Use rates above this threshold are considered to negatively influence public safety, environmental conditions, and the ability of a lake to host a variety of recreational pursuits**. High-speed watercraft require more space, necessitating boat densities less than the low end of the range. The suggested density for a particular lake is:

Minimum desirable acreage per boat = 10 acres + (5 acres x (high-speed boat count/total boat count))

The SEWRPC watercraft survey demonstrates that highest boat use occurs during weekends on both Lakes. Approximately 30 to 60 percent of boats in use during peak periods were capable of high-speed operation. Given this range, the formula presented above suggests that 11.5 to 13.0 acres of useable open water should be available per boat on each lake. Given that roughly 562 useable acres are available for boating in Whitewater Lake, no more than 43 to 49 boats should be present on the lake at any one time to avoid use problems. No more than 9 to 11 to boats should be present on Rice Lake because it has only 121 useable acres available for boating. The density of boats actually observed on Whitewater and Rice Lakes is usually less than the maximum optimal density. **Use conflicts, safety concerns, and environmental degradation were not presented as an issue of concern on the Lakes during the preparation of this plan**. If densities increase to undesirable levels in the future, boating ordinances and regulations should be reviewed, and if necessary, modified. Such <u>ordinances and regulations should be conscientiously enforced to help reduce the potential for problems related to boat overcrowding during periods of peak boat</u>

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[87]*Useable lake area is the size of the open water area that is at least 100 feet from the shoreline.*

[88]*Progressive AE,* Four Township Recreational Carrying Capacity Study, Pine Lake, Upper Crooked Lake, Gull Lake, Sherman Lake, *Study prepared for Four Township Water Resources Council, Inc. and the Townships of Prairieville, Barry, Richland, and Ross, May 2001.*

traffic. In addition, the WRLMD should continue to offer boating safety classes and continue to encourage Lake patrols by the Walworth County Sheriff's Department to enforce ordinances and regulations. Additional details regarding these recommendation are presented in Chapter III.

Tables 25 and 26 show how people were using Whitewater and Rice Lakes, respectively, on a typical summer week day and a typical summer weekend in 2008. On Whitewater Lake, the most popular weekday recreational activities included swimming, pleasure boating, water skiing and tubing, and fishing from boats. Visiting the Southern Unit of the Kettle Moraine State Forest, which accounted for the vast majority of people swimming, also was a popular weekday activity. On Rice Lake, the most popular weekday activities included visiting the State Forest and fishing from shore, an activity mostly occurring in the State Forest on the two Lakes. Fishing from boats also was a popular activity on Rice Lake during the week. The most popular weekend recreational activities observed on Whitewater Lake were swimming—again, almost exclusively at the State Forest—as well as pleasure boating and waterskiing and tubing, as shown in Table 25. The most popular weekend activities on Rice Lake included going to the State Forest, water skiing and tubing, and fishing from boats, as shown in Table 26.

Recreational use of Whitewater and Rice Lakes is directly related to many of the topics discussed in this chapter (e.g., aquatic plants, water quality, algal blooms, and wildlife) because each topic can affect recreational uses. Given that the Lakes are utilized for a full variety of recreational activities, including swimming, kayaking, water-skiing, and fishing, maintaining these primary uses should be considered a priority. Consequently, the recommendations included in Chapter III of this report are made in the attempt to ensure full and balanced use of the Lakes. Since accommodating some users is not always advantageous for others, the recommendations contained in Chapter III seek to encourage compromise between conflicting users so that all users may enjoy the Lake for their intended purpose.

ISSUE 7: FISH AND WILDLIFE

Lake residents and SEWRPC staff identified protecting and enhancing aquatic and terrestrial wildlife populations that frequent and/or depend on Whitewater and Rice Lakes as an important concern. Investigation of the Lakes and their watersheds by SEWRPC staff identified the following considerations related to aquatic and terrestrial wildlife:

1. Fishing was identified as one of the primary recreational use of the Lakes, as observed during the 2014 aquatic plant survey and previous boat surveys;
2. Even though Whitewater and Rice Lakes are conjoined, the dam and general lack of flow over the dam prevent fish from swimming from one lake to the other. Therefore, the population densities and species of fish in each Lake respond independently to unique conditions occurring within each lake.
3. One species of special concern is present around the Lakes—the Blanding's turtle (Emydoidea blandingii), which was added to the special concern list in 1977;[89]
4. Four critical species habitats are located within the Lakes' watershed (see Map 23):[90]
   a. Whitewater Lake Island Woods (Site 108 on Map 23) is a woodland owned by the WDNR that supports a populations of kittentails (Besseya bullii), a State-designated threatened plant species;

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[89]*Wisconsin Department of Natural Resources - Natural Heritage Inventory.*

[90]*Critical species habitat areas designate areas that need to be protected to maintain specific species of concern. More information can be found in SEWRPC Planning Report No. 42,* A Regional Natural Areas and Critical Species Habitat Protection and Management Plan for Southeastern Wisconsin, *September 1997; Amendment to Planning Report No. 42,* Amendment to the Natural Areas and Critical Species Habitat Protection and Management Plan for Southeastern Wisconsin, *December 2010.*

Table 25

RECREATIONAL USE IN/ON WHITEWATER LAKE: 2008

Date and Time	Weekend Participants									
	Fishing from Shoreline	Pleasure Boating	Skiing/ Tubing	Sailing	Operating Personal Watercraft	Swimming	Fishing from Boats	Canoeing/ Paddle Boating	Park Goers	Total
Sunday, August 17										
9:30 a.m. to 10:30 a.m.	0	15	27[a]	0	6	4	18	7	4	81
1:30 p.m. to 2:30 p.m.	2	53	49	2	9	89	8	2	20	234
Total for the Day	2	68	76	2	15	93	26	9	24	315
Percent	1	22	24	1	5	31	8	3	5	100

Date and Time	Weekday Participants									
	Fishing from Shoreline	Pleasure Boating	Skiing/ Tubing	Sailing	Operating Personal Watercraft	Swimming	Fishing from Boats	Canoeing/ Paddle Boating	Park Goers	Total
Thursday, August 7										
9:30 a.m. to 10:30 a.m.	7	8	10	4	0	12	28	10	5	84
1:30 p.m. to 2:30 p.m.	3	20	29	0	4	54	6	4	15	135
Total for the Day	10	28	39	4	4	66	34	14	20	219
Percent	5	13	18	2	2	29	16	6	9	100
Tuesday, August 26										
10:00 a.m. to 11:00 a.m.	5	8	6	0	0	1	8	6	0	34
1:30 p.m. to 2:30 p.m.	2	21	0	0	6	7	10	0	30	76
Total for the Day	7	29	6	0	6	8	18	6	30	110
Percent	6	26	5	0	5	7	17	5	29	100

[a]*This number does not include approximately 25 members of a local water-ski club that practice from about 9:00-11:00 a.m. just offshore at the State park on Sunday mornings from May through Labor Day.*

Source: SEWRPC.

Table 26

RECREATIONAL USE IN/ON RICE LAKE: 2008

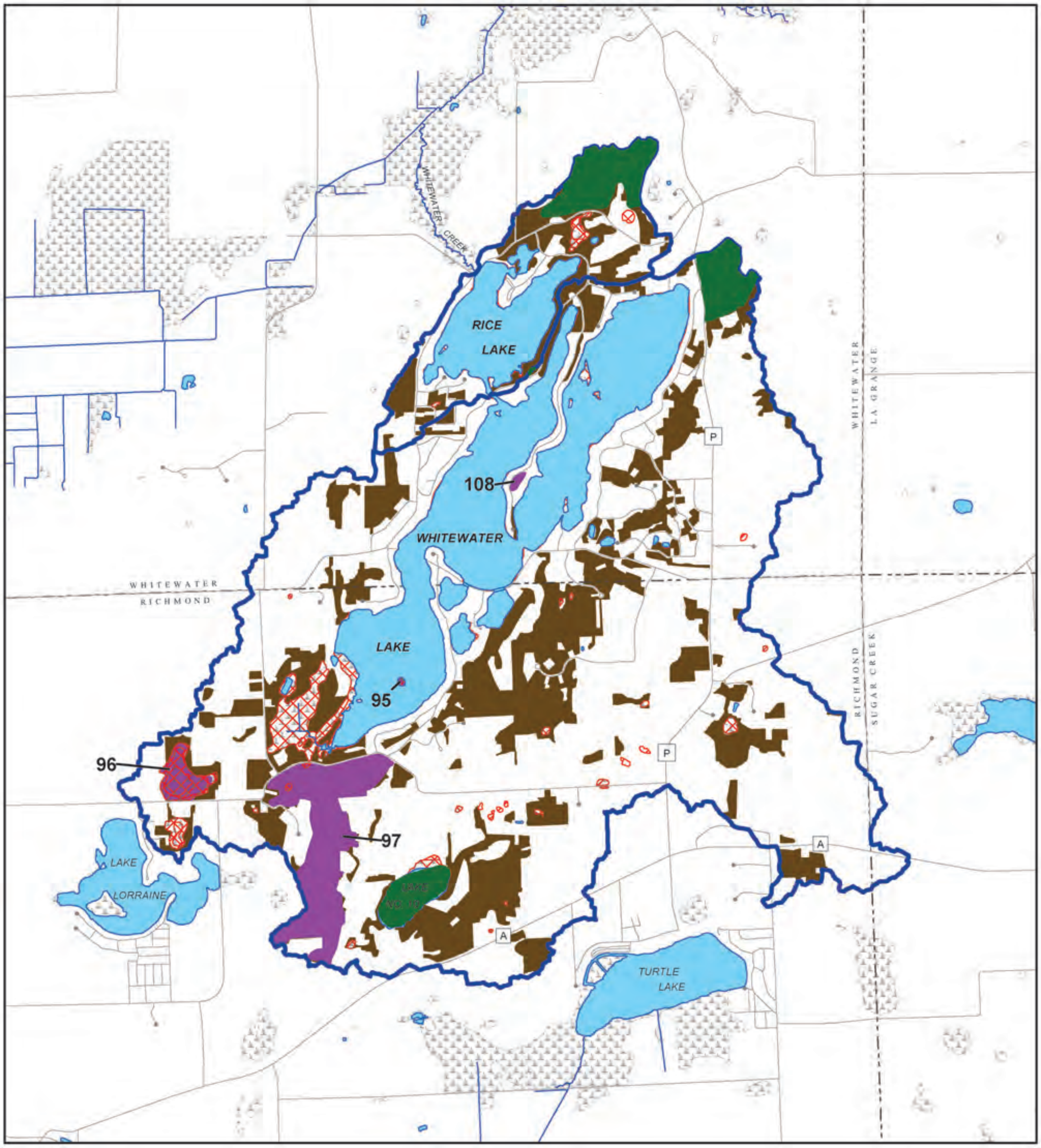
Date and Time	Weekend Participants									
	Fishing from Shoreline	Pleasure Boating	Skiing/ Tubing	Sailing	Operating Personal Watercraft	Swimming	Fishing from Boats	Canoeing/ Paddle Boating	Park Goers	Total
Sunday, August 17										
9:00 a.m. to 9:30 a.m.	0	0	0	0	0	0	0	0	0	0
1:00 p.m. to 1:30 p.m.	0	2	17	0	0	2	4	0	12	37
Total for the Day	0	2	17	0	0	2	4	0	12	37
Percent	0	5	47	0	0	5	11	0	32	100

Date and Time	Weekday Participants									
	Fishing from Shoreline	Pleasure Boating	Skiing/ Tubing	Sailing	Operating Personal Watercraft	Swimming	Fishing from Boats	Canoeing/ Paddle Boating	Park Goers	Total
Thursday, August 7										
9:00 a.m. to 9:30 a.m.	0	0	0	0	0	0	0	0	0	0
1:00 p.m. to 1:30 p.m.	0	0	0	0	0	0	2	0	5	7
Total for the Day	0	0	0	0	0	0	2	0	5	7
Percent	0	0	0	0	0	0	29	0	71	100
Tuesday, August 26										
9:30 a.m. to 10:00 a.m.	3	0	0	0	0	0	2	0	3	8
1:00 p.m. to 1:30 p.m.	2	0	0	0	0	0	0	0	6	8
Total for the Day	5	0	0	0	0	0	2	0	9	16
Percent	31	0	0	0	0	0	13	0	56	100

Source: SEWRPC.

Map 23

NATURAL AREAS, CRITICAL SPECIES HABITAT, WETLANDS, AND WOODLANDS WITHIN THE WHITEWATER AND RICE LAKE WATERSHEDS



NATURAL AREAS

CRITICAL SPECIES HABITAT SITES

WETLANDS: 2010

WOODLANDS: 2010

108 SITE IDENTIFICATION NUMBER

SURFACE WATER

STREAM

WATERSHED BOUNDARY

WETLAND

Note: The area identified as Site 108 is currently a residential area. The site may have been delineated incorrectly during digitizing in ArcGIS and may be located in a different area. Future natural area and critical species habitat investigations will correct the misidentification.

GRAPHIC SCALE

0 2,000 4,000 FEET

Source: SEWRPC.

b. Whitewater Lake Island (Site 95) is an island owned by Walworth County that supports a nesting colony of great egrets, a State-designated special concern bird species;

c. An unnamed wetland (Site 96), partially within State of Wisconsin Public Trust Lands and partially privately owned, provides habitat for black terns, a State-designated special concern bird species; and,

d. Lake Number 10 Open Woods (Site 97), a privately owned disturbed woodland that supports a population of kittentails (Besseya bullii), a State-designated threatened plant species.

5. Five WDNR-designated sensitive areas are located within the Lakes' watershed, as discussed in "Issue 1: Aquatic Plant Management" (see Map 6);

6. Approximately 14 species of amphibians and 16 species of reptiles are expected to be present in the Lakes' watershed (amphibians and reptiles, including frogs, toads, salamanders, turtles, and snakes, are vital components of a lake ecosystem);[91]

7. The Lakes' watershed is likely to support a significant population of waterfowl, including mallards and wood ducks, particularly during the migration seasons;[92] and,

8. The Lakes' watershed is likely to support both small and large mammals, such as foxes and whitetail deer.

A healthy fish, bird, amphibian, reptile, and mammal population requires: 1) good water quality, 2) sufficient water levels, 3) healthy aquatic plant populations, and 4) well maintained aquatic and terrestrial habitat. Additionally, wildlife populations can also be enhanced by the implementation of "best management practices." Since aquatic plant management, water quality, and water quantity have been discussed previously in this chapter, this section will focus on maintaining and expanding habitat, and on using best management practices to enhance wildlife populations. In general, these practices vary depending on the type of wildlife that is to be enhanced. Therefore, this section will first discuss aquatic wildlife enhancement and then terrestrial wildlife enhancement.

Aquatic Wildlife

Aside from being enhanced through aquatic plant management, water quality improvement, and water quantity management, aquatic wildlife populations can be enhanced by implementing best management practices and enhancing aquatic habitat. Each is discussed below.

Aquatic Best Management Practices

Aquatic best management practices can be implemented by homeowners, recreationalists, and resource managers. Such activities include catch and release angling and fish habitat enhancement, both of which help improve a lake's overall fishery. To determine the most needed and effective practices, it is important to consider the following:

1. **The population and size structure of the fish species present in a lake**—Examining the species, populations, and size structure of fish in a lake help managers understand issues that may face fish populations. For example, if low numbers of juvenile fish are found, this may suggest that the fish are not successfully reproducing in the lake, and, therefore, spawning and rearing habitat may need to be improved. Similarly, if abundant juveniles are found with few large fish, over-fishing may be a factor limiting the maturation of fish, thereby suggesting that catch and release should be promoted in the lake. This type of information can help lake managers target specific fish population enhancement efforts efficiently and effectively.

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[91]*Wisconsin Herpetological Atlas Project, University of Wisconsin-Milwaukee Field Station, http://www4.uwm.edu/fieldstation/herpetology/atlas.html.*

[92]*Wisconsin Breeding Bird Atlas, Wisconsin Society of Ornithology hosted by University of Wisconsin-Green Bay, http://www4.uwm.edu/fieldstation/herpetology/atlas.html.*

Table 27

FISH STOCKED INTO WHITEWATER LAKE (WDNR FISH ONLY)

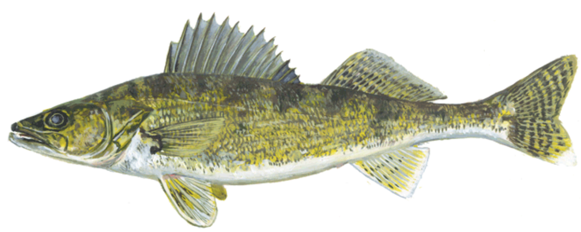
Year	Species Stocked	Number Stocked	Size	Average Length (Inches)
1980	Northern pike	1,100,000	Fry	- -
1991	Walleye	20,000	- -	2.0-3.0
1993	Walleye	1,500	- -	7.0
1994	Northern pike	1,280	Large fingerling	7.5
1997	Walleye	8,000	Small fingerling	2.7
1999	Walleye	64,000	Small fingerling	2.3
2000	Northern pike	1,280	Large fingerling	8.0
2001	Walleye	32,000	Small fingerling	1.3
2003	Walleye	32,000	Small fingerling	1.8
2005	Walleye	32,000	Small fingerling	1.4
2008	Northern pike	1,690	Large fingerling	10.2
2010	Walleye	22,400	Small fingerling	1.7
2011	Walleye	22,400	Small fingerling	1.9
2012	Northern pike	1,250	Large fingerling	8.0
2013	Walleye	22,400	Small fingerling	1.5
2015	Walleye	6,252	Large fingerling	- -
2016 (pending)	Northern pike	1,250	Large fingerling	- -

Source: WDNR and SEWRPC.

2. **The history of fish stocking in a lake**—To evaluate fish population studies, it is important to know the number, size, and species of fish introduced through stocking. For example, if only stocked fish exist in a lake it is likely that little to no effective natural spawning is actually taking place, which in turn means that the lake's fishery is highly dependent on fish stocking. This may suggest that enhanced or artificial spawning and rearing areas can add value to the lake's fishery.

Figure 50

WALLEYE



Source: WDNR.

SEWRPC staff completed an inventory of the studies and stocking efforts completed by WDNR since 1994. This inventory revealed that large efforts are being undertaken to maintain and improve the Lakes' fisheries.

Whitewater Lake has a moderate catch rate of average to above average sized largemouth bass, a low catch rate of nice sized northern pike and walleye, and an average catch rate of relatively small panfish.[93] The WDNR has periodically stocked northern pike and walleye since 1980 (See Table 27). The Lake has a history of low levels of natural walleye reproduction (see Figure 50) and was identified by WDNR as a good candidate for walleye stocking under the Wisconsin Walleye Initiative,[94] a program designed to help improve walleye populations and the success of natural repro-

[93] *Luke Roffler, Senior Fisheries Biologist, Racine, Kenosha, and Walworth Counties*, Whitewater and Rice Lakes Fish Stocking and Monitoring Summary (as of August 2015). *Wisconsin Department of Natural Resources Memorandum, Undated.*

[94] *The Wisconsin Walleye Initiative was developed by the Wisconsin Department of Natural Resources and the Wisconsin Governor's office. For more information and progress updates:* http://dnr.wi.gov/topic/fishing/outreach/walleyeinitiative.html.

Table 28

FISH STOCKED INTO RICE LAKE (WDNR FISH ONLY)

Year	Species Stocked	Number Stocked	Size	Average Length (Inches)
1978	Northern pike	428,000	- -	- -
1978	Walleye	300,000	- -	- -
1982	Northern pike	270	- -	9.0
1985	Northern pike	270	- -	8.0
1989	Walleye	4,000	- -	2.5
1991	Northern pike	600	- -	8.0
1992	Northern pike	270	- -	8.2
1994	Northern pike	274	Large fingerling	7.5
1999	Northern pike	274	Large fingerling	7.2
2001	Northern pike	137,000	Fry	- -
2001	Northern pike	342	Large fingerling	7.6
2005	Northern pike	342	Large fingerling	8.5
2013	Northern pike	217	Large fingerling	8.9
2015	Northern pike	1,370	Small fingerling	3.0
2015	Northern pike	1,370	Small fingerling	3.6

Source: WDNR and SEWRPC.

duction across Wisconsin. In addition, attempts are being made to increase the minimum walleye length on Whitewater Lake from 15 inches to 18 inches, since lakes with 18 inch walleye size limits typically see a markedly increase d in natural reproduction. Additionally, the WDNR believes an artificial walleye spawning reef would complement the ability of walleye size limit to bolster natural reproduction. If successfully adopted, the new minimum standard will be effective in 2018. Finally, Lake residents have expressed support for an initiative to construct an artificial walleye spawning reef to further aid future walleye populations within Whitewater Lake. Additional funding and permitting would be needed to actually construct the reef.

Figure 51

COMMON CARP

Source: U.S. Geological Survey

Rice Lake has a moderate catch rate of above average sized largemouth bass, a low catch rate of nice-sized northern pike, and an average catch rate of small panfish.[95] The WDNR has periodically stocked northern pike and walleye since 1978 (See Table 28). An electrofishing survey conducted in the spring of 2015 assessed the abundance of common carp,[96,97] a restricted species within Wisconsin (see Figure 51).

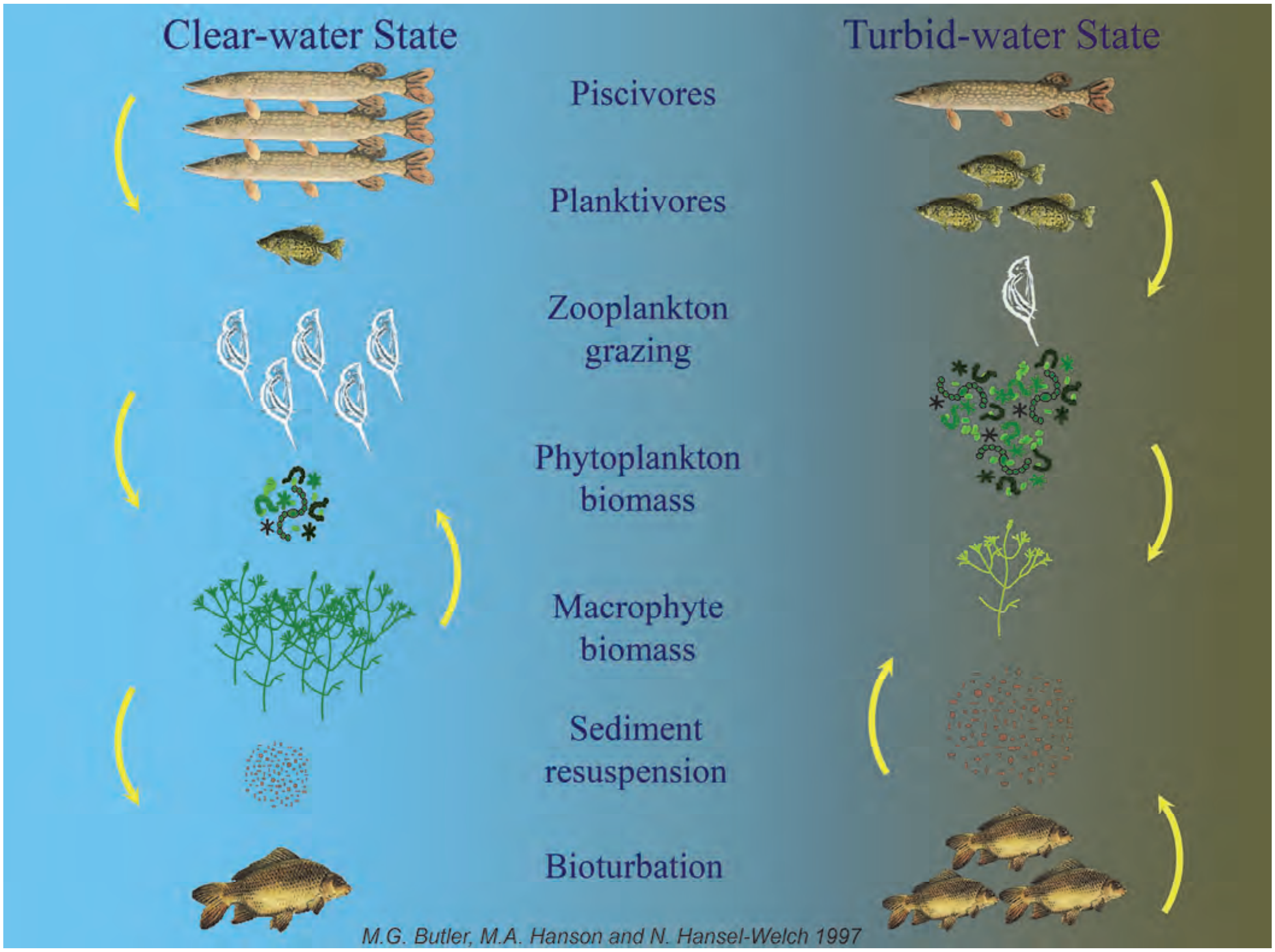
[95]*Roffler),* op cit.

[96]*Electrofishing is a process where an electrical pulse is placed in the water, causing fish to be stunned and to float to the top of the water body. This process allows for fisheries biologists to record fish types, counts, and sizes without harming the fish populations.*

[97]*Common carp, found throughout Wisconsin, are considered an issue of concern when found in high populations because their feeding method involves re-suspending sediments at the bottom of a lake and uprooting native aquatic plants, both of which can cause an increase in nuisance algal blooms.*

Figure 52

ALTERNATIVE STABLE STATES



Source: M.G. Hanson and N. Hansel-Welch 1997.

A moderate number of "thin-looking" carp were found, although several characteristics within Rice Lake (e.g., high turbidity, lack of aquatic plants) suggest high carp abundance. Studies have shown that carp densities less than 30 kilograms/hectare (kg/ha) have little impact on aquatic plants. Carp densities of 100 kg/ha noticeably change the aquatic plant community, while densities of 300 kg/ha or greater are very damaging to aquatic vegetation.[98]

Carp have been referred to as "ecological engineers" because they have the ability to modify the habitat and biology of water bodies they colonize. When carp are overly abundant, water quality and the types of algae, plants, and animals in a lake may change to a state less desirable to human use. Abundant carp are often associated with turbid water, fewer rooted aquatic plants, more free-floating algae, and fewer desirable fish (see Figure 52).

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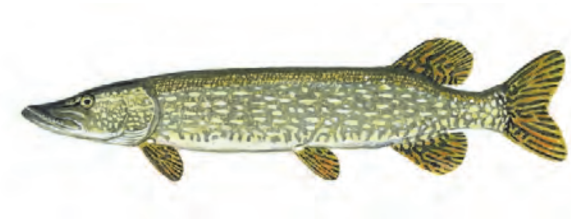
[98]*Bajer, Przemyslaw G and Peter W. Sorensen, Effects of common carp on phosphorus concentrations, water clarity, and vegetation density: a whole system experiment in a thermally stratified lake,* Hydrobiologia *Volume 746 Number 1: 303-311, 2015*.

Several measures are being taken to reduce the carp population in Rice Lake. Currently, the WDNR has issued a contract to a private commercial fishing crew to net carp. However, the contractor has reportedly not harvested carp in several years. In many inland lakes, the population of carp is not large enough to support an attractive, profitable harvest, decreasing the ability of for-profit fishing enterprises to manage carp populations. On account of this, some inland lakes groups pay a bounty on carp, encouraging commercial fishermen to pursue harvest. These subsidies typically pay a per pound premium for an initial mass of fish, with progressively lower subsidies for higher catch targets. Additionally, a premium may be set for achieving a particular harvest mass. Some lakes have deployed transponder-containing carp ("Judas fish") to identify winter carp congregation sites, allowing targeted under the ice netting when carp are concentrated in small areas. This can be coupled with a bounty system to improve carp harvest rates. Up to 90 percent of carp have been removed from lakes with such an approach.[99] See the following websites for additional information:

Figure 53

NORTHERN PIKE



Source: WDNR.

- http://www.uwsp.edu/cnr-ap/UWEXLakes/Documents/resources/newsletter/vol36-vol40/vol36-1.pdf,
- http://www.startribune.com/2-tons-of-carp-removed-from-silver-lake-to-improve-water-quality/248401671/
- https://www.maisrc.umn.edu/common-carp

Carp populations in shallow lakes with abundant breeding habitat can sustain extremely high (e.g., 90 per cent) harvest rates with little reduction of the mass of carp present per acre. Managers believe that removing adult carp fosters recruitment of young carp, a situation offsetting harvest. Some lakes have deployed barriers to reduce reproduction potential by preventing carp from using key breeding areas. When reproduction potential is reduced, commercial harvest can have a meaningful long-term impact on lake carp populations. Unfortunately, carp barriers also restrict movement of desirable aquatic species, and are therefore complicated to employ or inadvisable.

Predator populations help limit recruitment of young carp, and hence are a tool to limit adult carp populations. To support carp control, the WDNR has switched to stocking small northern pike fingerlings since these fish fare better in turbid waters such as those of Rice Lake and can be stocked at higher rates. The aim of this measure is to provide long-term carp population control by encouraging a healthy population of predatory size northern pike (see Figure 53), as pike eat juvenile carp. Bluegill sunfish have been shown to prey heavily on young carp, with some lakes reporting up to a 95 percent reduction in young carp accountable to bluegill predation.[100]

The Lakes exhibit conditions suitable for an abundant carp population. The information now available suggests that carp may exceed typical shallow lake management goals, especially in Rice Lake. A multifaceted approach should be employed to manage carp (high priority), elements of which are already underway. More information about the suggested management approach is presented in Chapter III.

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[99]*Lechelt, Joseph (WDNR),* Common Carp Recruitment Dynamics and Mechanical Removal; A Modeling Approach, *Presentation at the 2017 Training Workshop on the Ecology and Management of Shallow Lakes, Horicon, Wisconin, February 7 and 8, 2017.*

[100]*Lechelt, Joey,* op cit.

Aquatic Habitat Enhancement

Aquatic habitat enhancement generally refers to encouraging native aquatic plant (particularly pondweed) growth within a lake, as these plants provide food, shelter, and spawning areas for fish. Additionally, aquatic habitat enhancement also involves protecting wetlands (see "Terrestrial Habitat" subsection below), maintaining good ecological connectivity between each lake and its watershed, and encouraging the presence of coarse woody structure along shorelines. Coarse woody structure is found in abundance in natural environments, provides shelter for fish populations, acts as basking and rest areas for herptiles (e.g., frogs and turtles), may provide perch areas for important birds and insects, and can also help protect shorelines from erosion in some instances.

To determine the state of the aquatic habitat within the Lakes in the summer of 2014, SEWRPC staff completed an aquatic plant survey (see "Issue 1: Aquatic Plant Management" section), and a shoreline assessment (see "Issue 2: Water Quality" section). The results of the aquatic plant survey revealed that **both Whitewater and Rice Lakes have low plant diversity,** although an aquatic plant survey completed by WDNR in 2015 found three additional species in Whitewater Lake **including one new pondweed species**.[101] **The shoreline assessments concluded that Rice Lake has substantial areas of coarse woody structure along its shoreline while Whitewater Lake has very few areas with coarse woody structure in the water**. These conclusions indicate that the current aquatic plant communities should be maintained, coarse woody structure in Rice Lake should be maintained and that projects should be implemented to provide more coarse woody structure along the shorelines of Whitewater Lake. Consequently, recommendations related to both are presented in Chapter III of this report.

The WDNR describes the bottom of Whitewater Lake as being comprised of 10 percent sand, 10 percent gravel, 5 percent rock, and 75 percent muck (generally a mixture of organic debris and silt). Substrate composition was also noted as part of SEWRPC's 2014 aquatic plant survey. In Whitewater Lake, muck was the most predominant substrate, accounting for 528, or 92 percent, of the 575 points sampled. Sand was found at 35, or 6 percent, of the sampled points and rock or gravel was found at 12, or 2 percent, of the points sampled. Sand and gravel were primarily found scattered along the shorelines of Whitewater Lake, most likely placed by property owners to augment their shorelines and reduce aquatic plant growth. Locations deeper than 15 feet were not sampled for plants or substrate.

During the 2014 Rice Lake aquatic plant survey, 382 points were sampled. It was found that the bottom of Rice Lake was comprised of 7 percent sand, 4 percent rock and gravel, and 89 percent muck. Sand was primarily found scattered along the shorelines of Rice Lake, while rock and gravel were concentrated along the shoreline of the peninsula of land located between the northwestern and northeastern lobes of Rice Lake. During the 2014 survey, none of the sampling points in Rice Lake were deeper than 15 feet. However, 12 points were not sampled because aquatic plant growth was too dense to obtain access to those points.

It is important to note that healthy aquatic ecosystems require a variety of habitat and substrate. For example, fish spawning, rearing, refuge, and feeding commonly take place in very different environments. Buffer installation, water quality management, removing fish passage impediments on perennial and intermittent streams, reconnecting floodplains to tributary streams, and maintaining nearshore vegetation and coarse woody structure all promote fish populations. The shoreline maintenance recommendations in Chapter III of this report are further refined to promote healthy fish populations.

Terrestrial Wildlife

Two general practices can enhance terrestrial wildlife populations. These practices include active implementation of best management practices and terrestrial habitat enhancement. Each is discussed below.

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[101]*Pondweed species are significant in a lake because they serve as excellent habitat for providing food and shelter to many aquatic organisms.*

Terrestrial Best Management Practices

The way people manage their individual properties and interact with wild animals and natural plants can significantly affect terrestrial wildlife populations. Turtles, for example, often travel long distances from their home lake or stream to lay eggs. If pathways to acceptable habitats are unavailable, or are dangerous due to pets, fences, or traffic, turtle populations will likely decline. Many conservation organizations have developed "best management practices" or behaviors that homeowners and land managers can employ to sustain or even increase wildlife populations.

Though some of these best management practices are species- or animal-type specific (e.g., spaying or neutering cats to limit feral cat populations and thereby reducing desire to kill birds) many of these recommendations relate to general practices that can benefit all wildlife. In general, best management practices for wildlife enhancement target agricultural and residential lands. Agricultural measures tend to focus on encouraging land management that allows for habitat enhancement, such as allowing fallen trees to naturally decompose where practical or allowing for uneven topography in certain landscapes (which creates microhabitats needed by certain plants and animals to persist and procreate). In contrast, residential measures tend to focus on practices that owners of smaller parcels can initiate that provide habitat, enhance water quality, enhance aesthetics, and/or maintain natural communities. Examples include installing a rain garden, avoiding heavy applications of fertilizers or pesticides, landscaping to provide food and cover for native species, or preventing the introduction of nonnative plants and insects. Other recommendations are generally applicable to both types of landowners. For example, indiscriminant or careless killing of native wildlife, particularly amphibians, reptiles, and birds, is discouraged.

Actively communicating best management practices to the public often provides an excellent means of encouraging wildlife populations without major investment of public funds. Consequently, implementing and increasing the acceptance of best management practices is included in the recommendations set forth in Chapter III of this report

Terrestrial Habitat Enhancement

Terrestrial wildlife needs relatively large, well-connected areas of natural habitat. Consequently, protecting, connecting, and expanding natural habitat is crucial if wildlife populations are to be maintained or enhanced. Open space natural areas can generally be classified as either wetlands or uplands, as described below:

1. **Wetlands**—Wetlands are defined based on hydrology, hydric soils and the presence of wetland plants. There are many types of wetlands (Figure 54), from the familiar cattail/bulrush wetland to forested wetlands. Most aquatic and terrestrial wildlife relies upon, or is associated with, wetlands for at least a part of their lives. This includes crustaceans, mollusks, aquatic insects, fish, amphibians, reptiles, mammals (e.g., deer, muskrats, and beavers), and various bird species, (e.g., resident birds such as turkey and songbirds, and migrant species such as sandhill and whooping cranes).

2. **Uplands**—Uplands are areas not classified as wetland or floodplain. They are often characterized by greater depth to groundwater and drier, less organic, more stable soil. Like wetlands, natural uplands exist in many forms (e.g., prairies, woodlands) and provide many critical functions for many upland game and nongame wildlife species through provision of critical breeding, nesting, resting, and feeding areas, as well as providing refuge from predators. However, unlike wetlands, the dry and stable soils make uplands more desirable for urban development and, therefore, such areas are more challenging to protect.

Both wetlands and uplands are critical to wildlife populations. However, **the dynamic interactions and movement between these two types of land are also crucial** because many terrestrial organisms spend part of their time in wetlands and the rest of their time in upland areas. For example, toads live most of their lives in upland areas but depend on wetlands for breeding. Consequently, if connections between uplands and wetlands are compromised (e.g., if a large road is placed between two land types), it makes it dangerous, if not impossible, for amphibians to gain access to their breeding grounds, thereby reducing their ability to seasonally migrate and/or reproduce. In fact, habitat fragmentation (i.e., the splitting up of large connected habitat areas) has been cited as the primary global cause of wildlife population decreases.[102] Therefore, protecting and expanding uplands and wetlands, providing naturalized transition habitat, and maintaining or enhancing connectivity, help maintain or enhance wildlife populations.

To determine the extent of the uplands and wetlands in the Whitewater and Rice Lake watershed and gauge the state of the connections between these two habitat types, SEWRPC staff inventoried wetlands and uplands (woodlands) within the watershed as shown on Map 23. Wetlands are located primarily at the southern end of Whitewater Lake with a few small wetlands located north of Rice Lake, while several woodland complexes are located throughout the watershed, including around some of the wetlands. **These wetland and upland habitat complexes are likely ecologically connected**. Assuming that it is a priority to maintain or enhance wildlife populations, the WRLMD should maintain or enhance upland and wetland habitat whenever practicable. The intervening corridors should also be protected and naturalized to the full extent possible. It is important to note, however, that wetland and upland protection and enhancement require a number of actions, as listed below:

1. Prevent and/or limit development within wetlands, natural upland meadows, and woodlands;

2. Take steps to ensure new, reconstructed, or repaired infrastructure maintains or enhances environmental corridors and ecological connectivity between habitat areas;

3. Expand upland and/or wetland habitat areas where practical (e.g., reestablish wetlands that are currently farmed, create grasslands, or reforest cleared areas). Particular emphasis should be placed on connecting blocks of diverse habitat through naturalized corridors; and

4. Control and/or remove invasive plant species introduced to wetlands and uplands, and avoid activities that can disrupt habitat value (e.g., excessive use of motorsport vehicles, intense pedestrian or pet use).

Figure 54

EXAMPLES OF DIFFERENT WETLAND TYPES

MARSH WETLAND

Source: SEWRPC.

SCRUB/SHRUB WETLAND

Source: University of New Hampshire Cooperative Extension.

FORESTED WETLAND

Source: Prince William Conservation Alliance.

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[102] *Lenore Fahrig, "Effects of Habitat Fragmentation on Biodiversity,"* Annual Review of Ecology, Evolution, and Systematics, *Volume 34, pp. 487-515, 2003*.

A comprehensive plan must consider each of these elements as important. Therefore, recommendations related to each of these actions are included in Chapter III. Additionally, implementation guidance for these actions is included in the "Issue 8: Plan Implementation" section below and in Chapter III.

Other Wildlife Issues

Another issue of concern is the presence of cormorants (*Phalacrocorax auritus*) on Whitewater Lake Island and their effect on egret and heron populations on the island. Cormorants can negatively impact other bird species by destroying nesting areas and habitat.[103] The United States Department of Agriculture Animal and Plant Health Inspection Service (USDA APHIS) Wildlife Services has been surveying egret nests on Whitewater Lake Island since 2012.[104] These surveys indicate that Great Egret nests have declined from approximately 175 nests in 2012 to 79 nests in 2014.[105] Heron nests were not surveyed. Currently, the Walworth County Public Works Department owns the Island. No management tasks are being conducted and a sign is posted on the Island restricting public access. Cormorant control would be undertaken by Walworth County and would require a USDA APHIS permit. Consequently, it is recommended that the District contact Walworth County Public Works to propose management activities to reduce the cormorant population to non-nuisance levels allowing egret nesting site numbers to stabilize.

ISSUE 8: PLAN IMPLEMENTATION

A core issue for any lake protection plan is the need for guidance to implement plan recommendations, formulation of tangible goals, and measuring factors that quantify progress and relative success. Developing an action plan with timelines, goals, and identified responsible parties is an important and significant step toward plan implementation. Target metrics can help the implementing agencies and funders gauge progress over time and can help motivate participants, ensuring that the plan is carried through in the long term. When developing an action plan, it is important to identify what on-the-ground implementation involves, and how it will be carried out.

Some recommendations can be achieved using regulation while others involve proactively implementing new management efforts. Both are discussed below.

Regulatory Implementation

Relative to this plan, regulatory implementation refers to the maintaining and improving water quality, water quantity, and wildlife populations by enforcing local, State, and Federal rules, laws, and guidelines. A number of regulations already govern activities within the Whitewater and Rice Lake watersheds including zoning and floodplain ordinances, boating and in-lake ordinances, and State regulations related to water quality. These regulations already help protect the Lakes by mitigating pollution, preventing or limiting development, and encouraging use of best management practices.

Ordinances

Zoning ordinances dictate where development can take place, the types of development allowed, and the terms that need to be met for development to be permitted. Consequently, **zoning can be a particularly effective tool to protect buffers, wetlands, uplands, and shorelands if environmental goals are integrated into ordinance development, formulation, and enforcement**. One way to integrate environmental considerations is for local zoning authorities and other regulatory agencies to use SEWRPC-designated environmental corridors (see Figure 55).

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[103]*U.S. Fish and Wildlife Service*, Final Environmental Impact Statement: Double-crested Cormorant Management in the United States, *2003*.

[104]*Personal communication from WDNR conservation biologist.*

[105]Ibid.

Figure 55

SYNOPSIS OF SEWRPC-DESIGNATED ENVIRONMENTAL CORRIDORS

SEWRPC has embraced and applied the environmental corridor concept developed by Philip Lewis (Professor Emeritus of Landscape Architecture at the University of Wisconsin-Madison) since 1966 with the publication of its first regional land use plan. Since then, SEWRPC has refined and detailed the mapping of environmental corridors, enabling the corridors to be incorporated directly into regional, county, and community plans and to be reflected in regulatory measures. The preservation of environmental corridors remains one of the most important recommendations of the regional plan. Corridor preservation has now been embraced by numerous county and local units of government as well as by State and Federal agencies. The environmental corridor concept conceived by Lewis has become an important part of the planning and development culture in southeastern Wisconsin.

Environmental corridors are divided into the following three categories.

- **Primary environmental corridors** contain concentrations of our most significant natural resources. They are at least 400 acres in size, at least two miles long, and at least 200 feet wide.
- **Secondary environmental corridors** contain significant but smaller concentrations of natural resources. They are at least 100 acres in size and one mile long, unless they link primary corridors.
- **Isolated natural resource areas** contain significant remaining resources that are not connected to environmental corridors. They are at least five acres in size and at least 200 feet wide.

Key Features of Environmental Corridors

- Lakes, rivers, and streams
- Undeveloped shorelands and floodlands
- Wetlands
- Woodlands
- Prairie remnants
- Wildlife habitat
- Rugged terrain and steep slopes
- Unique landforms or geological formations
- Unfarmed poorly drained and organic soils
- Existing outdoor recreation sites
- Potential outdoor recreation sites
- Significant open spaces
- Historical sites and structures
- Outstanding scenic areas and vistas

Source: SEWRPC.

Environmental corridors can be integrated into conservancy zoning district regulations to help determine where development is permitted and not permitted, and to help determine the types of allowable land uses.

The Whitewater Rice Lake watershed has four different units of government with different regulatory authorities that apply to Lake protection, including the Towns of Whitewater, Richmond, and Sugar Creek and Walworth County (see Map 24 and Table 29). **Walworth County has zoning authority in the majority of the watershed**. This is advantageous because the general zoning ordinance for **Walworth County** specifically states that **environmental corridors are to be protected and maintained**. The fact that these corridors are used in zoning decisions means that the areas within the Whitewater and Rice Lake watersheds that are contained within environmental corridors (see Map 25), are well protected.

In addition to general zoning, shoreland zoning and **construction site erosion control and stormwater management ordinances also play a key part in protecting the resources within the watershed**. Shoreland zoning, for example, which is primarily administered by Walworth County, follows statewide building setbacks standards around navigable waters.[106] Additionally, stormwater management and construction erosion control ordinances help minimize water pollution, flooding, and other negative impacts of development on water resources.

Boating and In-Lake Ordinances

Boating and in-lake ordinances regulate the use of the Lakes in general, and, when implemented properly, **can help prevent inadvertent damage to the Lakes such as excessive noise and wildlife disturbance, severe shoreline erosion from excessive wave action reaching the shoreline, and agitation of sediment and aquatic vegetation in shallow areas**. The boating ordinance for the Town of Whitewater (including Whitewater and Rice Lakes) is provided in Appendix G. This ordinance is generally enforced by a warden or by the Walworth County Sheriff's Department.

State Regulations

The State Legislature required the WDNR to develop performance standards for controlling nonpoint source pollution from agricultural and nonagricultural land and from transportation facilities.[107] The performance standards,

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[106]*The 2015-2017 State Budget (Act 55) changed State law relative to shoreland zoning. Under Act 55 a shoreland zoning ordinance may not regulate a matter more restrictively than it is regulated by a State shoreland-zoning standard unless the matter is not regulated by a standard in Chapter NR 115, "Wisconsin's Shoreland Protection Program," of the* Wisconsin Administrative Code*. (Examples of unregulated matters may involve wetland setbacks, bluff setbacks, development density, and stormwater standards.) In addition, under Act 55, a local shoreland zoning ordinance may not require establishment or expansion of a vegetative buffer on already developed land and may not establish standards for impervious surfaces unless those standards consider a surface to be pervious if its runoff is treated or is discharged to an internally drained pervious area.*

[107]*The State performance standards are set forth in the Chapter NR 151, "Runoff Management," of the* Wisconsin Administrative Code*. Additional code chapters that are related to the State nonpoint source pollution control program include: Chapter NR 152, "Model Ordinances for Construction Site Erosion Control and Storm Water Management" (This Chapter will be revised in response to the 2013 Wisconsin Act 20 as noted in WDNR Guidance #3800-2014-3, "Implementation of 2013 Wisconsin Act 20 for Construction Site Erosion Control and Stormwater Management," October 2014.); Chapter NR 153, "Runoff Management Grant Program;" Chapter NR 154, "Best Management Practices, Technical Standards and Cost-Share Conditions;" Chapter NR 155, "Urban Nonpoint Source Water Pollution Abatement and Storm Water Management Grant Program;" and Chapter ATCP 50, "Soil and Water Resource Management." Those chapters of the* Wisconsin Administrative Code *became effective in October 2002. Chapter NR 120, "Priority Watershed and Priority Lake Program," and Chapter NR 243, "Animal Feeding Operations," were repealed and recreated in October 2002.*

Table 29

LAND USE REGULATIONS WITHIN THE AREA TRIBUTARY TO WHITEWATER AND RICE LAKES IN WALWORTH COUNTY BY UNIT OF GOVERNMENT: 2015

	Type of Ordinance				
Unit of Government	General Zoning	Floodplain Zoning	Shoreland Zoning	Subdivision Control	Construction Site Erosion Control and Stormwater Management
Walworth County	Adopted	Adopted	Adopted	Adopted	Adopted
Town of Richmond	Regulated under County ordinance	Regulated under County ordinance	Regulated under County ordinance	Adopted[a]	Regulated under County ordinance
Town of Sugar Creek	Regulated under County ordinance	Regulated under County ordinance	Regulated under County ordinance	Adopted[a]	Regulated under County ordinance
Town of Whitewater	Regulated under County ordinance	Regulated under County ordinance	Regulated under County ordinance	Regulated under County ordinance	Regulated under County ordinance

[a]Both the Walworth County and respective Town subdivision ordinances apply in the Towns of Richmond and Sugar Creek. In the event of conflicting regulations, the more restrictive regulation applies.

Source: SEWRPC.

which are set forth in Chapter NR 151, "Runoff Management," of the *Wisconsin Administrative Code*, set forth requirements for best management practices. Similar regulations cover construction sites, wetland protective areas, and buffer standards.

Water quality objectives are presented in Chapter NR 102, "Water Quality Standards for Wisconsin Surface Waters," of the *Wisconsin Administrative Code*. These rules set water quality standards that promote healthy aquatic ecosystems and public enjoyment of the water body. Some of the standards set in this rule applicable to Whitewater and Rice Lakes include the following:

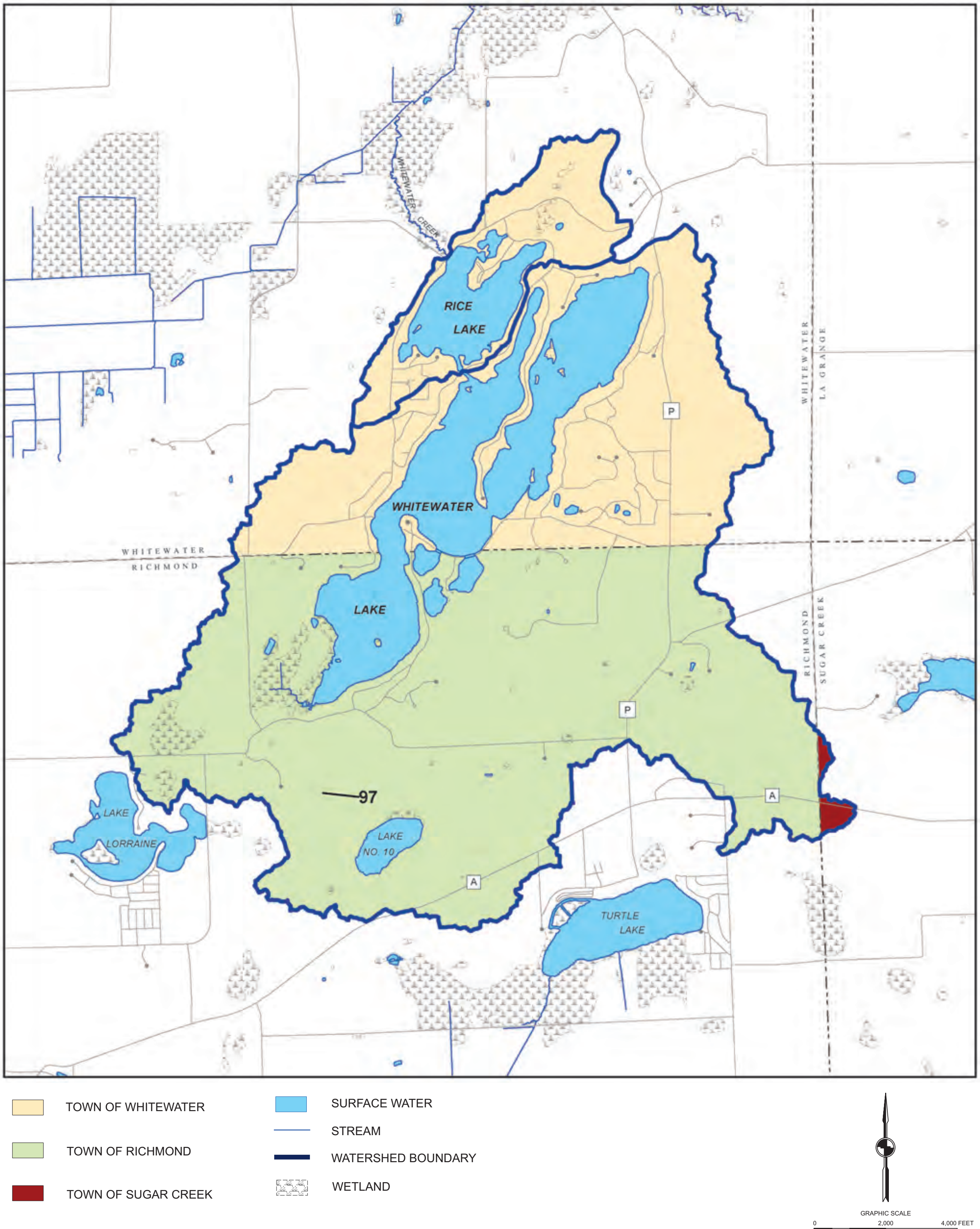
1. Dissolved oxygen greater than or equal to 5.0 mg/L;
2. pH between 6.0 and 9.0 SU;
3. Fecal coliform geometric mean less than or equal to 200 colonies per 100 milliliters, single sample maximum less than or equal to 400 colonies per 100 milliliters;
4. Total phosphorus (summer epilimnion) 20 μg/L (or 0.020 mg/L); and
5. Chloride acute toxicity 757 mg/L, chronic toxicity 395 mg/L.

The rule further stipulates maximum temperatures for each month, with the highest standards applying to July and August when the following maxima apply; ambient water temperature of less than or equal to 77°F, sublethal water temperature of less than or equal to 80°F for one week or less, and acute water temperature of less than or equal to 87°F for one day or less.

The regulations described above play a crucial part in maintaining the health of Whitewater and Rice Lakes and of all the resources within their watersheds. However, even though developers, residents, and Lake users are legally obligated to adhere to the ordinances, limited resources within the enforcement bodies at a State, County, and municipal level can sometimes make the task of ensuring compliance difficult. Consequently, Chapter III recommends ways lake organizations can help regulatory agencies effectively enforce existing ordinances and regulations.

Map 24

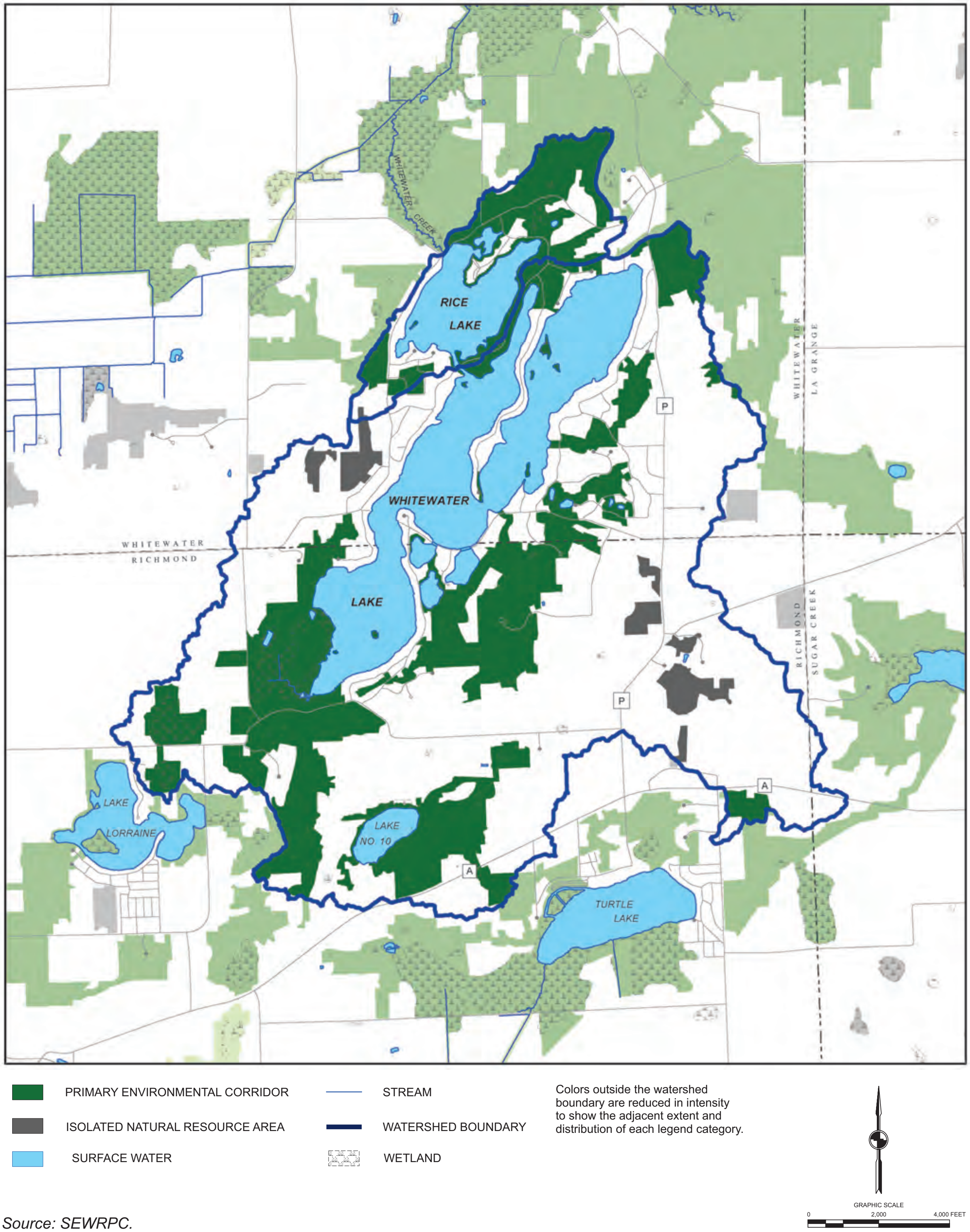
CIVIL DIVISIONS WITHIN THE WHITEWATER AND RICE LAKE WATERSHEDS: 2015



Source: SEWRPC.

Map 25

PRIMARY ENVIRONMENTAL CORRIDORS AND NATURAL AREAS WITHIN AND NEAR THE WHITEWATER AND RICE LAKE WATERSHEDS: 2010



Source: SEWRPC.

Proactive Management Efforts

In addition to continued and enhanced ordinance enforcement, this plan recommends a number of actions to proactively improve conditions within the Lakes through voluntary management efforts. Chapter III details these recommendations and guidance on implementation. However, several challenges can limit the ability of Lake residents and the WRLMD to engage in certain management efforts recommended in this plan. Some of these challenges include:

1. **Lack of adequate funding**—Concerns have been expressed regarding the costs associated with management efforts recommended under this plan. A list of available grants for lake management efforts is included in Chapter III.

2. **Institutional cooperation and capacity**—Institutional capacity refers to assets available through agencies, universities, schools, service groups, and non-governmental organizations that can be used to implement projects. These assets can be defined in terms of knowledge, staff, equipment, and other resources.

   Whitewater and Rice Lakes have an association, The Greater Whitewater Lake Property Owners Association (GWLPOA) and a district, the Whitewater-Rice Lakes Management District (WRLMD) (see Map 26) that share interest in the health of the Lakes. Lake associations are voluntary groups where both membership and payment of dues are voluntary. However, because, unlike a district, they are not a government body, they have the ability to act more quickly on some issues. Lake districts are considered "special purpose units of government" and are a taxing body. They also have some capabilities to regulate lake use (e.g. boating ordinances, sewage management).[108] With two lake groups interested in Whitewater and Rice Lakes, it may be in their best interest to divide the burden of project implementation, keeping in mind which group may be better suited for each project. Maintaining this open line of communication may be important for ensuring effective implementation of this plan.

3. **Volunteers**—To increase the advocacy, learning opportunities, and volunteer base for labor intensive or broad-based projects (e.g., hand pulling or monitoring of wetland invasive species), it is desirable to reach a broad stakeholder group—The Greater Whitewater Lake Property Owners Association, the Whitewater Rice Lake Management District, members of the general public, organizations, and agencies with an interest in the water resources of the Whitewater and Rice Lake watershed. The planning process for Whitewater and Rice Lakes reveals that many stakeholders have strong connections to the Lakes. However, participants in the planning process were almost entirely composed of lakeshore or near-lakeshore residents. To increase the advocacy and volunteer base for projects, it will be necessary to reach a group that extends beyond lakeshore residents.

Chapter III provides recommendations and suggested actions that seek to help ensure that the above capacity issues are addressed.

In addition to capacity building, openly sharing and communicating plan details is a crucial element to encouraging voluntary management efforts. For example, communicating the difference between invasive, native, and nonnative plants and the fact that removing aquatic plants can spur algae growth helps ensure that homeowners understand why a "clean" shoreline is not always the best option for a lake, and that a healthy plant community includes aquatic plants within and along the Lakes' shorelines. Consequently, another major recommendation in Chapter III is openly and actively communicating the critical components of this plan.

SUMMARY

Many opportunities exist to help promote sustainable use of Whitewater and Rice Lakes and their watersheds. All issues of concern identified by Lake residents during plan development have merit, and specific recommendations for each concern are presented in Chapter III. Addressing these issues will positively contribute to effectively managing the resources of the Lakes and their watersheds and improving the overall health of the Lakes.

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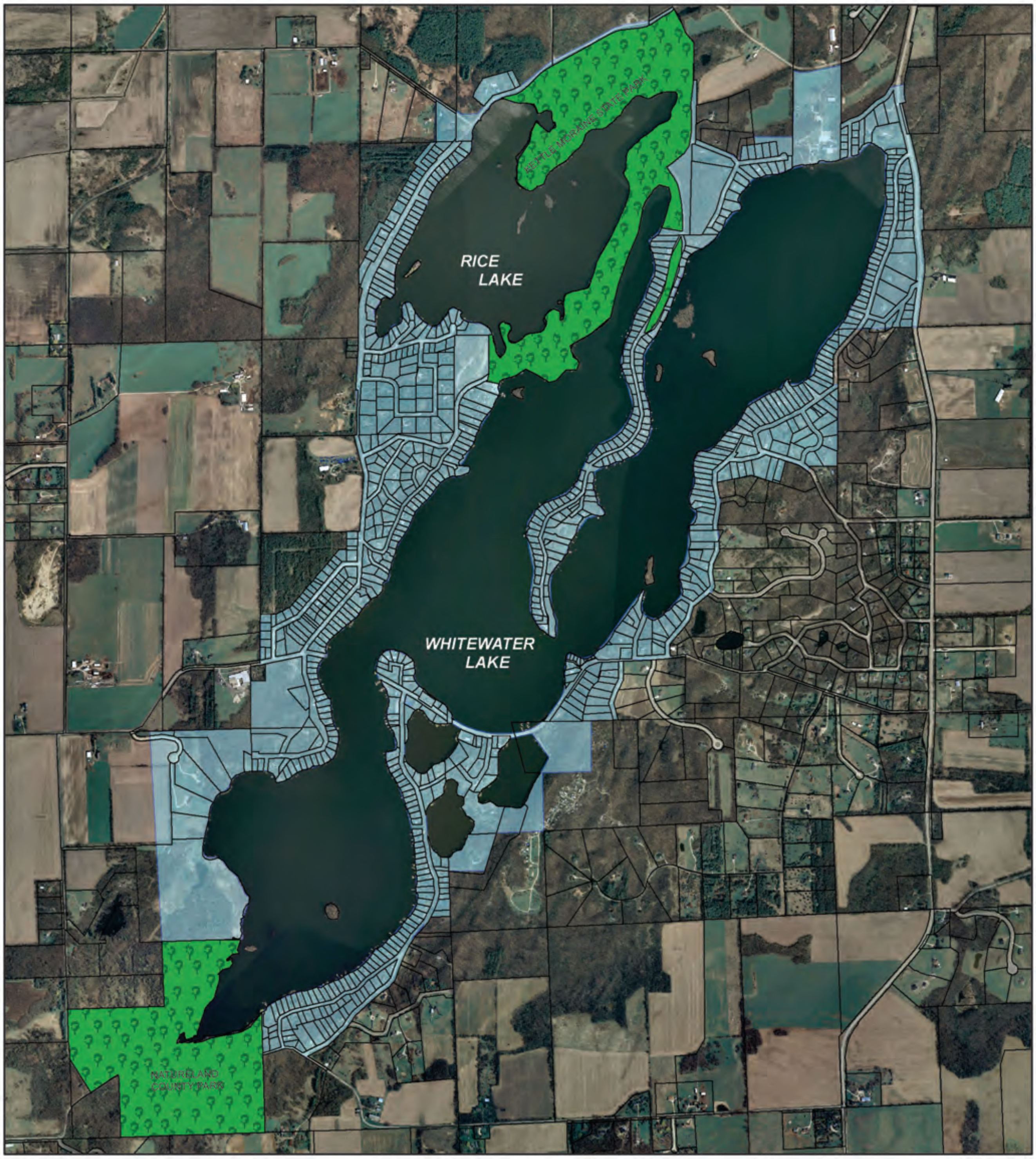
[108]*For more information visit wisconsinlakes.org or contact Eric Olson at eolson@uwsp.edu.*

Map 26

WHITEWATER-RICE LAKES MANAGEMENT DISTRICT



WHITEWATER-RICE LAKES MANAGEMENT DISTRICT

PARCEL BOUNDARY

PARK

Source: WRLMD, WDNR, AND SEWRPC.

GRAPHIC SCALE
0 1,000 2,000 FEET

Chapter III

LAKE MANAGEMENT RECOMMENDATIONS AND IMPLEMENTATION

INTRODUCTION

This chapter provides recommendations that address issues of concern identified in Chapter II. Implementing these recommendations helps maintain and enhance the health of the Lakes and encourages their continued enjoyment. The recommendations are based upon concerns identified by stakeholders – the Whitewater-Rice Lakes Management District (WRLMD), Walworth County, the Towns of Richmond and Whitewater, members of the public, organizations, and agencies with an interest in the Lakes and the natural resources of their watersheds, subsequent data collection and analysis, and suggestions developed and presented in the preceding chapter.

The recommendations cover a wide range of topics and seek to address all factors and conditions that significantly influence the health and recreational use of both Lakes. Consequently, it may not be feasible to implement every recommendation in the immediate future. To promote efficient plant implementation, the relative importance and significance of each recommendation is described to help guide lake managers in prioritizing plan elements. Nevertheless, all recommendations should eventually be addressed, subject to possible modification based on analysis of new data (e.g., future aquatic plant surveys and water quality monitoring), project logistics, and/or changing conditions.

The measures discussed in this chapter are primarily focused on those that can be implemented by the WRLMD, lake property owners, and other stakeholders with a vested interest in the Lakes. Nevertheless, collaborative partnerships with the WDNR, developers, watershed landowners, and other nearby municipalities are encouraged and may be necessary to ensure the long-term ecological health of Whitewater and Rice Lakes. Therefore, those individuals responsible for lake and plant management should actively conceptualize, seek, and promote projects and partnerships that enable plan implementation.

As a planning document, this chapter provides concept-level descriptions of activities that may be undertaken to help protect and enhance Whitewater and Rice Lakes. The full logistical and design details needed to implement most recommendations will need to be considered and developed in the future when the individual recommendations are implemented. It is important to note that these project suggestions do not necessarily constitute detailed technical specifications; they are instead presented to provide stakeholders and decision makers with ideas about the types and nature of projects to pursue. In summary, this chapter provides a context for understanding what needs to be done, as well as to help the reader picture what those efforts might look like. This type of information can be invaluable for coalition building, grant requests, and preliminary project design work.

ISSUE 1: AQUATIC PLANT MANAGEMENT

Whitewater and Rice Lakes support an aquatic plant community of very limited diversity. Whitewater and Rice Lakes are enriched with plant nutrients, such as phosphorus and nitrogen, promoting abundant aquatic plants and fish. Nonetheless, the 2014 and 2015 surveys (see Appendix A for distribution maps) reveal two major reasons why aquatic plant management should be considered a high priority including: 1) excessively high volumes of plants that deter recreational use in the South Bay of Whitewater Lake and 2) existence of invasive Eurasian water milfoil, hybrid water milfoil, and curly-leaf pondweed, all of which could potentially threaten the native aquatic plant community. This section describes a comprehensive aquatic plant management plan that includes active management, based on the preliminary recommendations provided in Chapter II.

The individual recommendations presented below, and which collectively constitute the recommended aquatic plant management plan, balance three major goals. These goals include: 1) improving navigational access within the Lakes; 2) protecting the native aquatic plant community; and 3) controlling curly-leaf pondweed, Eurasian water milfoil, and hybrid water milfoil populations. Plan provisions also ensure that current recreational use of the Lakes (e.g., swimming, boating, and fishing) is maintained to the greatest extent practical. The plan recommendations described below consider common, State-approved, aquatic plant management alternatives (see Chapter II), including manual, biological, physical, chemical, and mechanical measures.

Plant Management Recommendations for Whitewater Lake

The most effective plans for managing nuisance and invasive aquatic plant growth rely on a *combination* of methods and techniques. A "silver bullet" single-minded strategy rarely produces the most efficient, most reliable, or best overall result. Therefore, to enhance access and navigation throughout Whitewater Lake, seven aquatic plant management techniques are recommended under this plan, as described below:

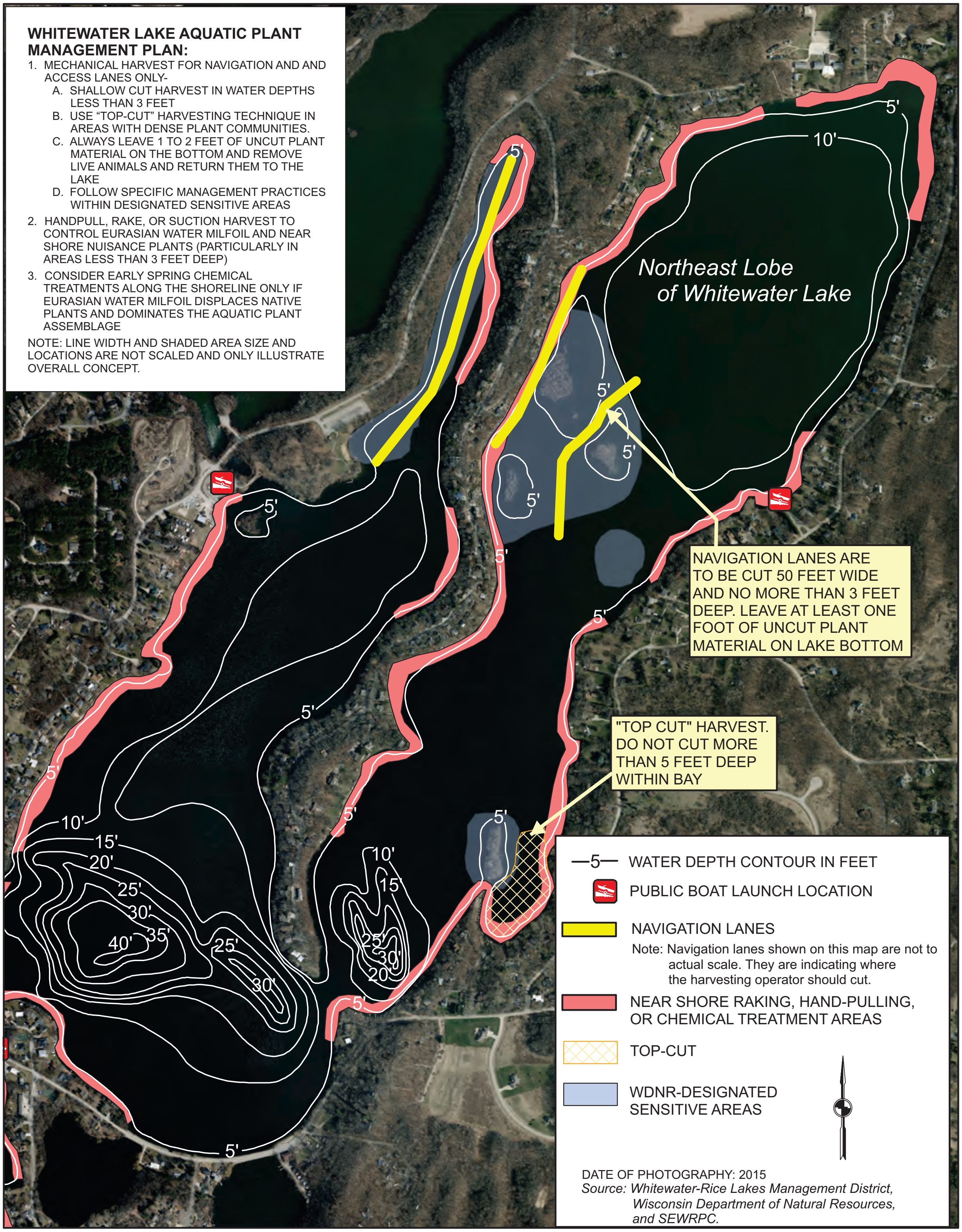
1. **Aquatic plant harvesting to create navigation and access lanes for Whitewater Lake** should be considered a <u>high priority</u>. As can be seen on Figures 56 and 57, harvesting for *navigation and access lanes is* recommended in areas of the Lake with dense aquatic plant growth to create impeding recreational boating and boat access to the main body of the Lake. Aquatic plants within marked 50-foot-wide navigational lanes should be cut to a depth of no more than three feet below the water's surface. Access lanes between piers, such as the west side of South Bay, are recommended to be cut 20 feet wide and no more than three to four feet deep. A 50-foot-wide navigation lane is recommended running parallel along the southeast shoreline within South Bay. This navigation lane will allow residents boating access into and out of the deeper waters of the South Lobe. A harvesting map for Whitewater Lake is located in Appendix H. The following specifications should be added to current practices to help assure continued recreational use of the Lake and the health of the native plant community.

    a. **Leave more than one foot of plant material at the Lake bottom while harvesting** to help lessen bottom-sediment disturbance and maintain native plants communities. This should be considered a <u>high priority</u>. Disturbing lake bottom sediment can uproot native plants and can promote colonization of new areas by Eurasian water milfoil. Leaving at least one to two feet of uncut plant material will likely not present an implementation problem in the areas with water depths greater than three feet. Harvesting should normally not be employed in portions of the Lake less than three feet deep or where the harvester cannot leave one foot of uncut plant. In such shallow areas, raking, hand-pulling, or shallow cut harvesting should be substituted. Although harvesting may be conducted in portions of the Lake between three and seven feet deep, it should be restricted to shallow top cutting to provide navigational lanes around the Lake's perimeter.

       Applying the concepts described in the previous paragraph, areas with healthy native plant communities *coexisting* with Eurasian water milfoil (particularly in the South Bay area) should use the "top-cut" harvesting technique. Top cut harvesting removes plants no more than three to four feet below the water's surface and leaves at least two feet of plant material on the bottom (see Figures 56, 57, and 58). A

Figure 56

EARLY SPRING AQUATIC PLANT MANAGEMENT RECOMMENDATIONS
FOR THE NORTH PORTION OF WHITEWATER LAKE



Source: Whitewater-Rice Lakes Management District, Wisconsin Department of Natural Resources, and SEWRPC.

Figure 57

EARLY SPRING AQUATIC PLANT MANAGEMENT RECOMMENDATIONS
FOR THE SOUTH PORTION OF WHITEWATER LAKE

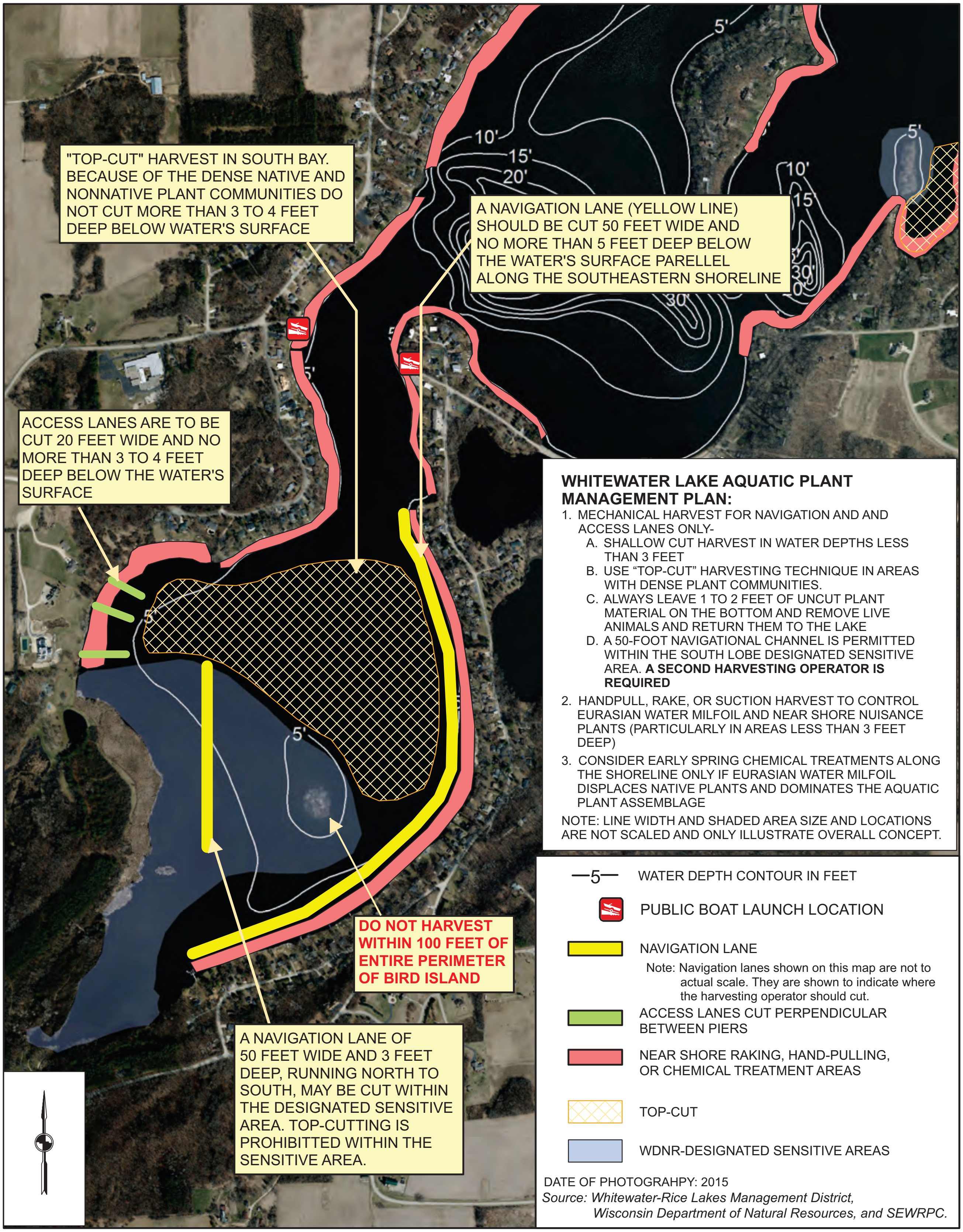
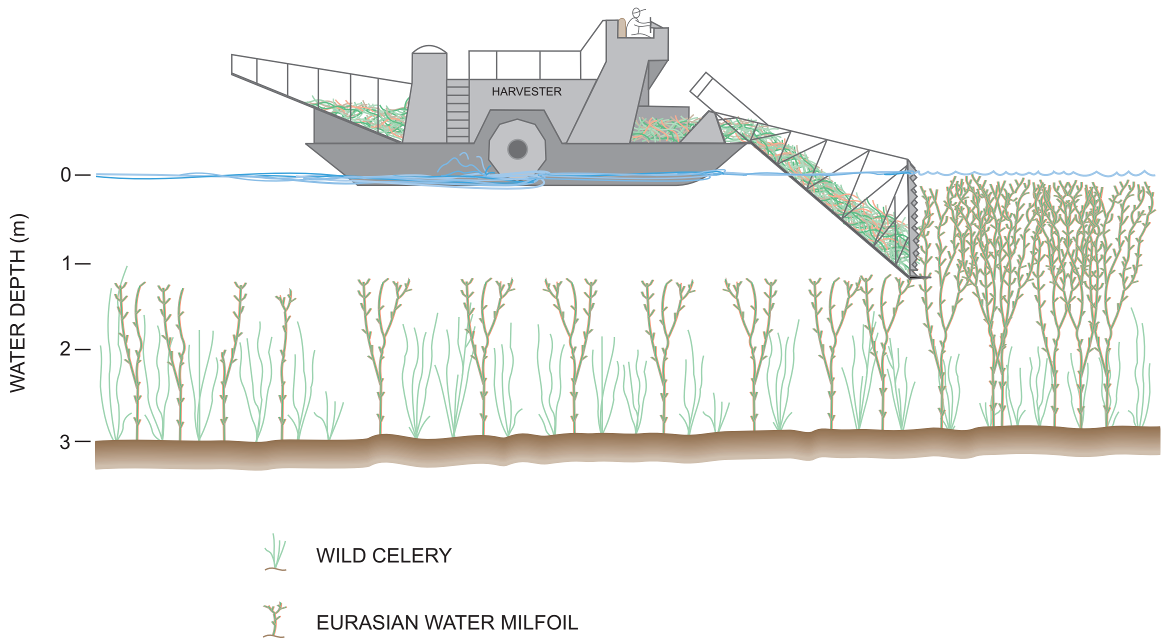


Figure 58

PLANT CANOPY REMOVAL OR "TOP CUTTING" 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.

50-foot-wide, three feet deep navigational channel may be harvested within the Sensitive Area in South Bay. Top cutting (or canopy cutting) plants, such as Eurasian water milfoil, has been shown to reduce the competitive advantage of Eurasian water milfoil and encourages native plant growth. Harvesting should not occur where the harvester is unable to leave one foot of plant material; raking and hand-pulling should be used instead of harvesting in these areas. Harvesting is also prohibited within 100 feet of the entire perimeter of "Bird Island" (i.e., the island located in South Bay). The Lake District has the option to purchase a small skimmer or "floater" harvester more suited and capable of mechanical harvesting in shallow water or areas near the shore and around piers—often a limiting factor with large harvesters several manufacturers produce small harvesters. Examples include Inland Lakes Harvesters, Incorporated and Aquarius Systems (see Appendix I for more details on the FB-120 harvester). These references and information are provided solely for illustrating equipment types and appearance, and are not an endorsement. Other manufacturers provide similar equipment.

b. **Inspect all cut plants for live animals. Live animals should be immediately returned to the water.** This should be considered a medium priority. A second staff person equipped with a net should accompany and assist the harvester operator. A second person **must** be on the harvester at all times when cutting in the south lobe Sensitive Area. Animals can get caught in the harvester and harvested plants, particularly when cutting larger plant mats. Consequently, cut materials must be carefully examined to avoid inadvertent harvest of fish, crustaceans, amphibians, turtles, and other animals.

c. **Do not harvest in the early spring** (high priority) to avoid disturbing fish spawning. Many fish species spawn in early spring and some studies suggest that spawning can be significantly disturbed by harvesting activities. Thus, avoiding harvesting during this time can benefit the Lake's fishery. If a chemical treatment is applied in the early spring, harvesting should not occur until after Memorial Day to allow time for the chemical treatment to be effective.

d. **All harvester operators must successfully complete formal training to help assure adherence to harvesting permit specifications and limitations** (high priority). Training should be provided by the regional WDNR aquatic invasive species coordinator and/or taught by the Lake District foreman and should cover, at a minimum 1) "deep-cut" versus "shallow-cut" techniques and when to employ each in accordance with this plan; 2) review of the aquatic plant management plan and associated permits with special emphasis focused on the need to restrict cutting in shallow areas; 3) identifying the location of and special regulations within WDNR-designated Sensitive Areas, and 4) plant identification to help protect and preserve desirable native plant communities. Additionally, this training course should emphasize that all harvester operators are obligated to record their work for inclusion in annual harvesting permit-required reports.

e. Aquatic plant harvest and transport can fragment plants. Plant fragments may float in the Lake, accumulate on shorelines, and help spread undesirable plants. The harvesting program should include **a comprehensive plant pickup program** that all residents can use (high priority). This helps assure that harvesting and transporting does not create a nuisance for Lake residents. The program typically includes residents raking plants, placing them in a convenient location accessible to the harvester (e.g., the end of a pier), and regularly scheduled pickup of cut plants by harvester operators. This effort should be as collaborative as practical.

f. **All plant debris collected from harvesting and transporting activities should be collected and disposed at designated disposal sites,** as shown on Map 27. Special care should be taken to assure that plant debris is not disposed in wetland locations or within floodplains (high priority). Map 27 also illustrates the plant pick-up locations and routes taken by the harvesting contractor to the proper disposal sites. Note that the southern site (see Map 28) has a wetland nearby while the northern disposal site, shown in Map 29, contains both a wetland and a floodplain within the designated property. **Disposing any aquatic plant material within identified floodplain and wetland areas is prohibited.** No mapped wetland or floodplain exist within the identified boundary of the central disposal site (Map 30).

g. **Record the mass or volume of aquatic plants removed from each Lake.** This information will help lake managers understand harvesting effect on the nutrient mass balance of each Lake, is relatively easy to estimate, and should therefore be given a high priority.

2. **Hand-pull and/or rake nuisance plant growth in near-shore areas.** These management options should be considered a medium priority in areas too shallow, inaccessible, or otherwise unsuitable for plant harvesting. A permit is not required for individual riparian landowners clearing a 30-foot width of shoreline (including the recreational use area such as a pier) that does not extend more than 100 feet into the Lake, provided that all resulting plant material is removed from the Lake. A permit is required for manual removal of aquatic plants in WDNR Designated Sensitive Areas. A permit *is also* required if the WRLMD or other group actively engages in such work.[1] Prior to the "hand-pulling" season, an educational campaign should be actively promoted to help assure that shoreline residents appreciate the value of native plants, understand the relationship between algae and plants (i.e., more algae will grow if fewer aquatic plants remain), know the basics of plant identification, and understand the specifics about the actions they are allowed to legally take to "clean up" their shorelines.[2] This action will help reduce the potential for harm or adverse effects to local wildlife and plant communities. Volunteers should continue hand-pulling Eurasian and its hybrid in shallow areas of the Lake as well as in any other feasible places.

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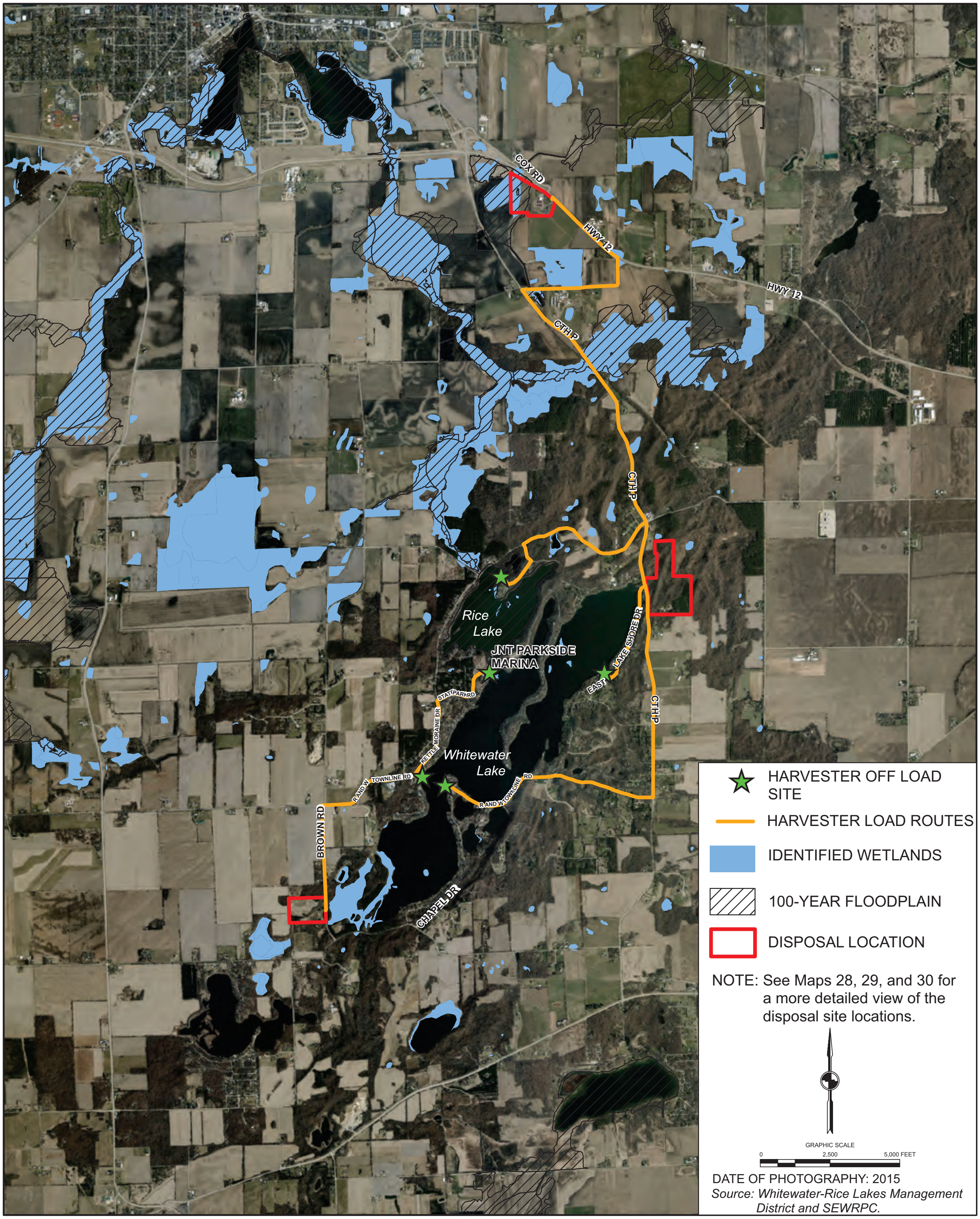
[1] *If a lake district or other group wants to complete a project that consists of removing invasive species along the shoreline a NR 109 permit is necessary, as the removal of invasive plants is not being completed by an individual property owner along his or her property.*

[2] *SEWRPC and WDNR staff could help review educational materials.*

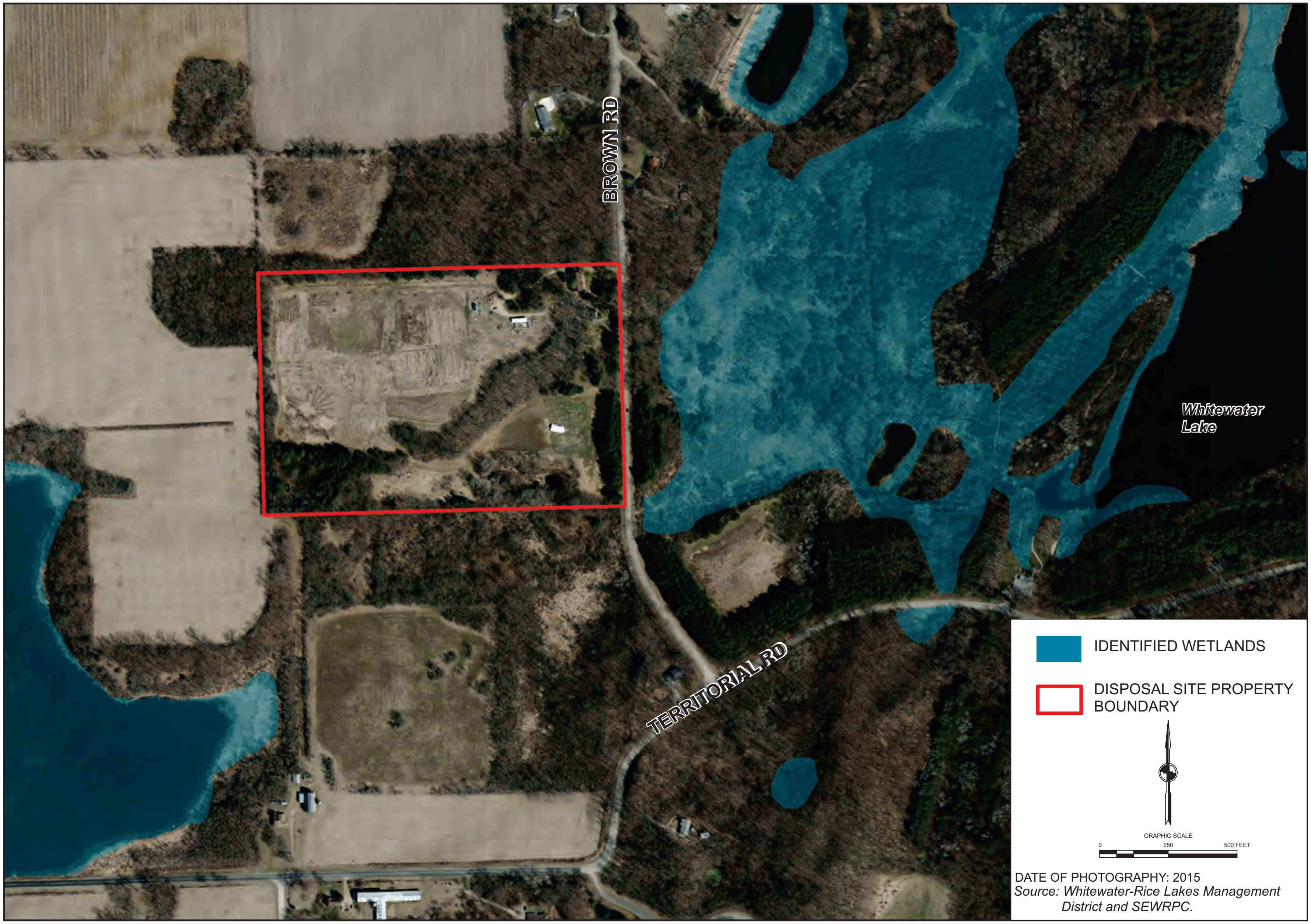
Map 27

MECHANICAL HARVESTING DISPOSAL SITE LOCATIONS, OFF-LOAD SITES, AND LOAD ROUTES FOR WHITEWATER AND RICE LAKES



Map 28

SOUTHERN MECHANICAL HARVESTING DISPOSAL SITE LOCATION, WHITEWATER AND RICE LAKES

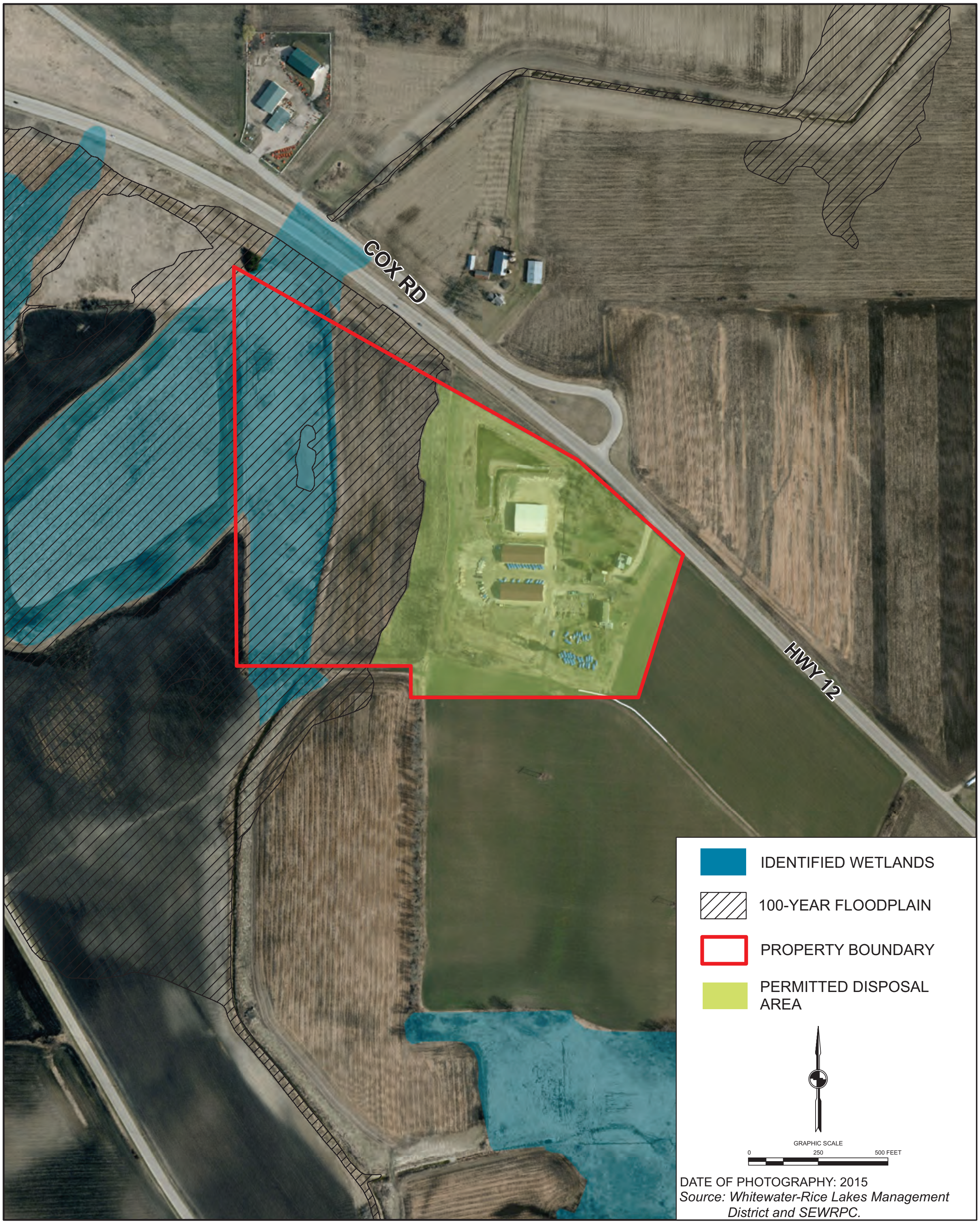


DATE OF PHOTOGRAPHY: 2015

Source: Whitewater-Rice Lakes Management District and SEWRPC.

Map 29

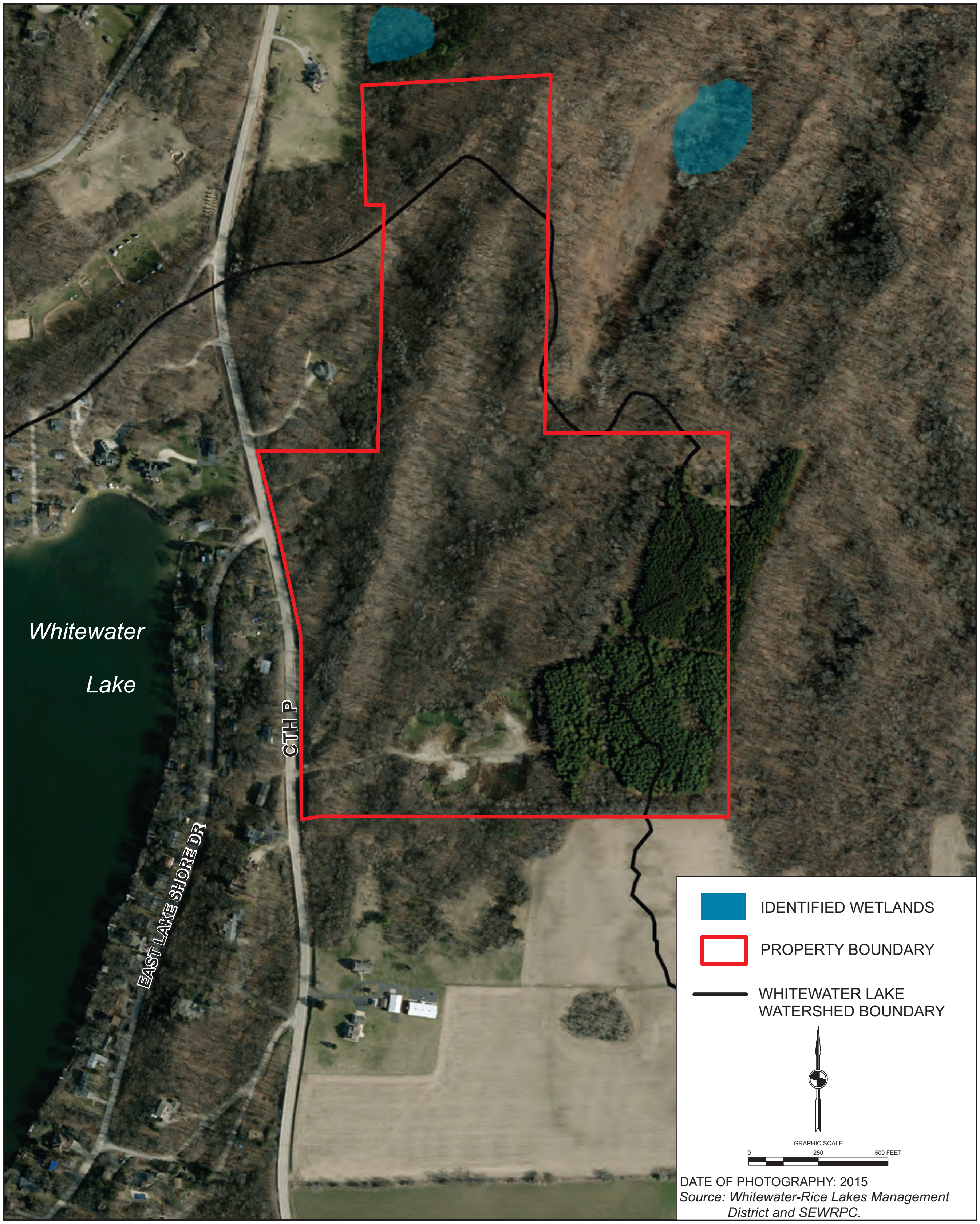
NORTHERN MECHANICAL HARVESTING DISPOSAL SITE LOCATION, WHITEWATER AND RICE LAKES



DATE OF PHOTOGRAPHY: 2015
Source: Whitewater-Rice Lakes Management District and SEWRPC.

Map 30

CENTRAL MECHANICAL HARVESTING DISPOSAL SITE LOCATION, WHITEWATER AND RICE LAKES



3. **Suction harvesting (DASH) to help control Eurasian and hybrid water milfoil populations** should be considered a medium priority in certain parts of the Lake. A contractor would be retained to implement such work. Suction harvesting could also be employed as an alternative management technique to help control *native* nuisance plant growth along selected shoreline locations during mid-summer months. This activity requires a WDNR harvesting permit.

4. **Biological measures (i.e., aquatic weevils)**—If Eurasian water milfoil and its hybrid become the dominant plant in Whitewater and Rice Lakes (based on a future aquatic plant survey), measures *other than* harvesting and hand-pulling may be necessary. If this occurs, the use of the aquatic weevil, if commercially available, should be investigated first. Weevils need undeveloped shoreline vegetation and natural vegetative litter to successfully overwinter, and areas of limited boat traffic. Therefore, Whitewater Lake's southern bay and Rice Lake should provide suitable weevil habitat and would be primary targets for weevil application. At present, introducing weevils should be considered a low priority.

5. ***Early spring* navigational shoreline chemical treatment to control Eurasian water milfoil, hybrid water milfoil, and curly-leaf pondweed in areas where these plants begin displacing the native community.** Chemical treatment, along with mechanical harvesting, have been the primary methods of aquatic plant management employed in both Whitewater and Rice Lakes, and have been an effective short-term management technique for navigation and access. If chemical treatments continue to be applied along developed shoreline and critical boating areas that cannot be mechanically harvested, treatment should only occur in the *early spring* when human contact and risks to native plants are most limited. Additionally, to prevent the loss of native aquatic species, only herbicides that selectively control Eurasian water milfoil and its hybrid and curly-leaf pondweed (e.g., 2,4-D and Endothall) should be used.[3] A WDNR permit and WDNR staff supervision are required to implement this alternative. Lakeshore property owners need to be informed of the chemical treatment and permit conditions well before chemicals are applied. If chemical treatment does occur, chemical residue monitoring in the Lake is also recommended (high priority).

6. ***Mid-summer* navigational shoreline treatment to control nuisance native plant populations.** By mid-summer, aquatic native plants within the littoral zone of Whitewater Lake often become a nuisance for Lake residents and users. During summer 2015, the WDNR approved a second chemical treatment in Whitewater Lake for navigational and access purposes (see Figure 59). Given the positive results experienced during 2015, WRLMD again requested a mid-summer shoreline chemical applications in **selected areas** (see Map 31), if native plants become a nuisance and create navigational concerns. Again, **a WDNR permit and WDNR staff supervision are required to implement this alternative** (medium priority). The use of DASH is also recommended for mid-summer control of nuisance plants, especially near piers.

7. ***Whole-lake chemical treatment of* Whitewater Lake to help control curly-leaf, Eurasian and hybrid water milfoil if populations begin displacing native plant communities.** A chemical whole-lake approach has been suggested for managing Eurasian and hybrid water milfoil and curly-leaf pondweed in Whitewater Lake (medium priority). The WDNR considers such treatments on a lake-by-lake basis. The Lake District needs to assemble a comprehensive set of information for WDNR to consider whole-lake treatment. The Lake District, or commonly the applicator, must assemble information on all of the following as part of the permit application process:

    a. A list of proposed treatment chemicals and/or mixtures,

    b. Proposed target concentrations, timing, and application methods,

    c. Probable cost and schedule, and

[3] *Wisconsin Department of Natural Resources PUBL-WR-236 90*, Chemical Fact Sheet: 2,4-D, *May 1990; Wisconsin Department of Natural Resources PUBL-WR-237 90*, Chemical Fact Sheet: Endothall, *May 1990*.

d. The anticipated longevity of the treatment.

The WDNR will consider the following during review of the whole-lake permit application:

a. **Lake volume.** The entire Whitewater Lake volume needs to be accurately estimated. The volume of the epilimnion layer needs to be segregated because the amount of chemical applied depends upon the volume of water in the epilimnion.[4]

b. **Water temperature profile.** Whole-lake treatments are most effective and typically required to be implemented in spring as soon as possible after the Lake stratifies. Whitewater Lake temperature profiles must be monitored to ensure the whole Lake is fully stratified and to ensure that the minimum temperature requirements on the chosen chemical's label are met.[5]

c. **Target plant density.** The relative abundance of undesirable plants should be measured in Whitewater Lake. Depending on the lake, average Eurasian and hybrid water milfoil rake fullness rating of between two and three at a minimum of 35 percent of vegetated sampling sites are required to achieve the undesirable condition, based on a recent comprehensive point-intercept survey. Other factors such as water depths and history of plant abundance may also need to be taken into account.

d. **Native plants.** The type and abundance of native plant populations and their sensitivity to treatment chemicals must be considered.

Figure 59

WHITEWATER LAKE 2015 MID-SUMMER TREATMENT FOR NAVIGATION LANES

NOTE: Letter-number codes are assigned by Clean Lakes Midwest, Inc. for the purpose of identifying areas to be treated. Letters are assigned counter-clockwise in alphabetical order. The number denotes the year of treatment.

Source: Clean Lakes Midwest, Incorporated and SEWRPC.

e. **Aquatic plant distribution.** This evaluation helps determine if plants in Whitewater Lake are found in more monotypic beds or intermixed with Eurasian water milfoil and natives.

Care must be exercised to carefully select herbicides that selectively control Eurasian water milfoil, hybrid water milfoil, and curly-leaf pondweed to prevent excessive loss of native aquatic species. **A WDNR permit and WDNR staff supervision are required to implement this alternative.** Additionally, lakeshore property owners need to be informed of the chemical treatment and permit conditions before chemicals are applied. **Residual chemical**

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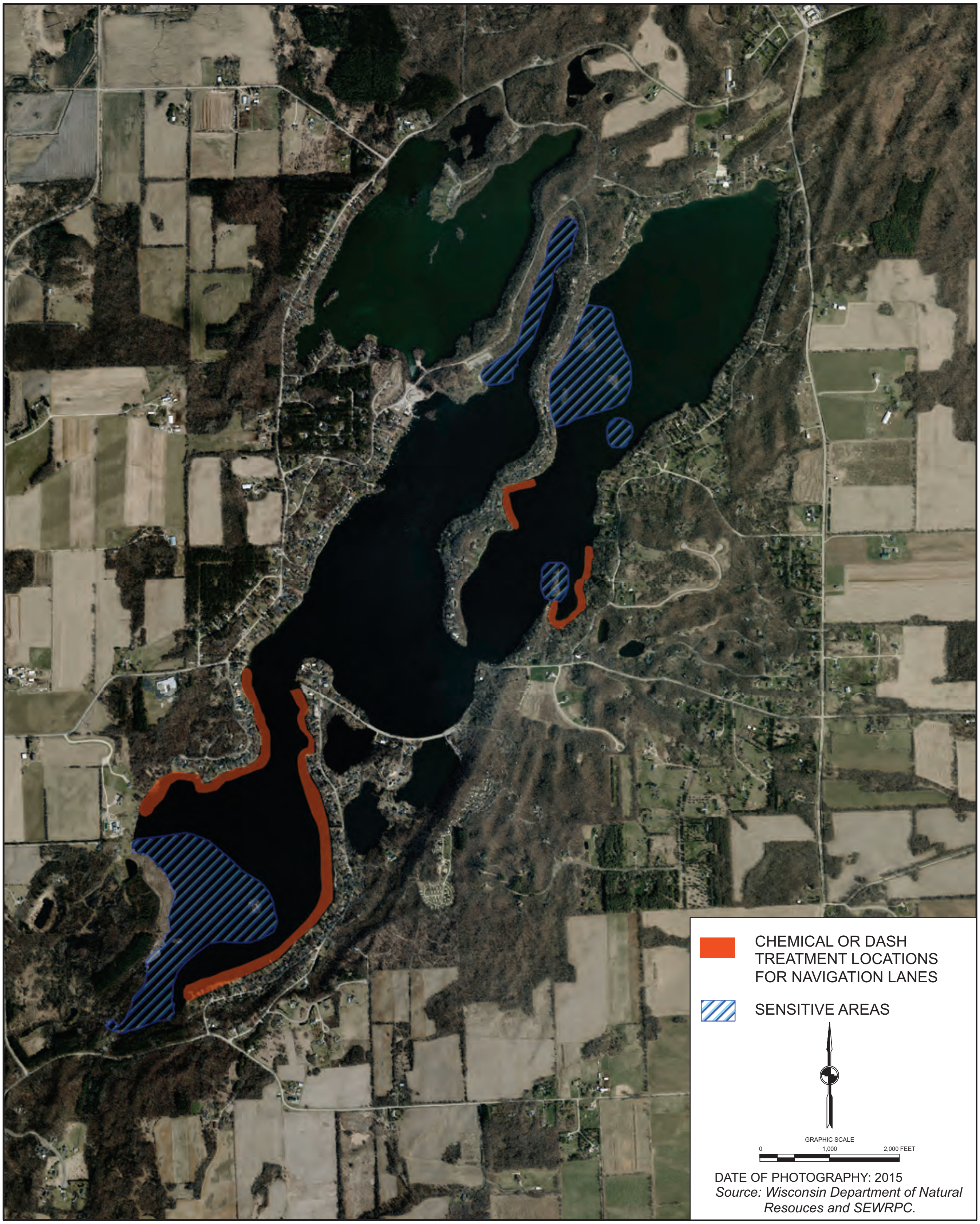
[4] *When completely stratified, the epilimnion layer is the top layer of the lake that is warmer and less dense.*

[5] *WDNR has volunteers measure the temperature profile of the lake before it becomes stratified up until the point the lake is completely stratified. This is to ensure that the lake can be chemically treated with the proper dosage of chemical herbicides.*

Map 31

POTENTIAL MID-SUMMER NATIVE AQUATIC PLANT NAVIGATION LANE ACTIVE MANAGEMENT AREAS



concentrations should be monitored after application is complete. Generally chemical residue monitoring is undertaken as a standard component of whole-lake treatments to determine if applied chemicals are well dispersed throughout the Lake. Chemical monitoring should be given a high priority whenever a whole-lake treatment is completed.

A further complication of the whole-lake treatment process is the presence of hybrid water milfoil (HWM). HWM was observed in Whitewater Lake as part of the 2015 WDNR aquatic plant inventory survey. HWM is becoming more widespread throughout the Region **and properly adjusting treatment chemical dosage can be a difficult task.** Too high a dosage could significantly damage the native plant population, while too low a dosage could promote evolution of herbicide resistant HWM by killing susceptible plants but leaving the heartier strains to propagate into an infestation that would be increasingly difficult to control with chemical treatments. Furthermore, determining the accurate and adequate dosage relies on precise knowledge of lake bathymetry, confirmed HWM identification (possibly through DNA testing), and may require collection of multiple HWM samples for herbicide tolerance testing (through a process known as “challenge testing”) to accurately determine the plant’s susceptibility to various chemical mixes.

Figures 56 and 57 is provided to help aquatic plant managers implement aquatic plant management plan recommendations. However, aquatic plant management must react to what is actually occurring at the time of treatment. Consequently, **this aquatic plant management plan must be reevaluated in three to five years (near the end of the five-year permitting cycle), and is assigned a high priority**. This effort should include a comprehensive point-intercept aquatic plant survey and a summary of aquatic plant management activities actually completed during the current permit period. This analysis will help lake managers quantify and judge the effectiveness of the aquatic plant management plan described in this report and will allow appropriate adjustments to be made.

All the above recommendations are made primarily for Whitewater Lake. **With a limited amount of aquatic plants (shown in Appendix A) and excessive algae growth within Rice Lake, it is important to allow time for Rice Lake to establish a healthy aquatic plant community before applying the above recommendations.** Consequently, active aquatic plant management recommendations are not made for Rice Lake at this time. Improved water quality will decrease algae abundance and will allow more aquatic plants to grow within Rice Lake (see “Issue 2: Water Quality” and “Issue 3: Cyanobacteria and Floating Algae” for more detail regarding Rice Lake’s algae concern).

Native Plant Community and Invasive Species Recommendations

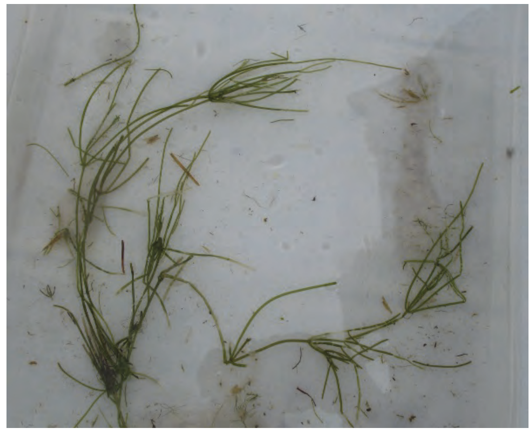
A number of actions should be taken to retain native aquatic plants whenever practical and focus control efforts on aquatic invasive plants. Figures 56 and 57 helps aquatic plant managers implement aquatic plant management plan recommendations. All are considered high priority. These recommendations include:

1. **Protect native aquatic plants** to the highest degree feasible through careful application of aquatic plant management and water quality recommendations. Although Whitewater and Rice Lakes support a limited array of aquatic plant species compared to most lakes, the plant species that are present provide excellent wildlife habitat and are an integral part of the Lakes’ ecosystems. **Muskgrass growth is particularly beneficial as it enhances marl formation and sequestration of phosphorus from the water column.**

2. Invasive species are highly damaging to native plant and wildlife communities and are a nuisance to lake recreation. Consequently, **invasive species management** is recommended. The most problematic invasive species currently in or around Whitewater and Rice Lakes are Eurasian water milfoil, curly leaf pondweed, and reed canary grass. All of these may be treated through manual or chemical methods. Mechanical and chemical aquatic plant control methods should follow best management practices to avoid spreading invasive plants and lower the stress imposed by invasive species on the native plant community.

Figure 60

AQUATIC INVASIVE SPECIES WATCHLIST



STARRY STONEWORT
(*Nitellopsis obtuse L.)*

- Distinctive star-shaped bulbils

- Side branches arranged in whorls or 4-6 branchlets; more robust than other members of family

Source: Paul Skawinski, Skawinski, P. M. (2014). *Aquatic Plants of the Upper Midwest: A Photographic Field Guide to Our Underwater Forests*. Wausau, Wisconsin, USA: Self-Published; *Wisconsin Department of Natural Resources; and SEWRPC.*

3. **Avoid disrupting bottom sediment or leaving large areas of bottom sediment devoid of vegetation,** because this could increase the risk of nonnative species recolonization. Invasive species tend to thrive on disturbed lake bottom. EWM in particular thrives in such areas. For this reason, care should be taken to judiciously and sensitively remove vegetation from problem areas.

4. **Eurasian water milfoil, hybrid water milfoil, and curly-leaf pondweed grow early in the season, earlier than many native aquatic plants. Hence, implementing control methods as early as practical in the spring can help minimize damage to native aquatic plant communities.** Moreover, early spring chemical applications are more effective due to colder water temperatures, a condition enhancing the herbicidal effect and reducing the concentrations needed for effective treatment. Early spring chemical treatment also helps reduce human exposure through lower human contact with lake water when water temperatures are still cold. Lastly, early season eradication of curly-leaf pondweed helps lower production of turions (a dormant plant propagule) that is the dominant preproduction method for this plant.

5. The introduction of new invasive species is a constant threat. **Preventing introduction of new invasive species is crucial to maintaining healthy lakes**. Starry stonewort (see Figure 60), though not discussed in Chapter II, is the newest invasive species posing a distinct risk to the Lakes. To help decrease the chance of this occurring, the following recommendations are given a high priority:

   a. **Educate residents how they can help prevent invasive species from entering the Lakes** (Appendix J and K).

   b. The WRLMD should **continue enrollment in the Clean Boats Clean Waters program** (a State program targeting invasive species prevention) to proactively encourage Lake users to clean boats and equipment before launching and using them in Whitewater and Rice Lakes.[6] This will help lower the probability of invasive species entering the Lakes;

[6] *Further information about Clean Boats Clean Waters can be found on the WDNR website at: http://dnr.wi.gov/lakes/cbcw/.*

c. Since boat launches are likely entry points for alien species, **boat launch sites should be targeted for focused aquatic plant control;** and

d. **If a new alien species infestation is found in the Lake, efforts to eradicate the new species should immediately be evaluated and, if possible, be employed to help prevent establishment**. The WDNR has funding that can aid in early eradication efforts, particularly as it pertains to aquatic plants (Table 30). Therefore, **citizen monitoring for new invasive species is recommended.** The Wisconsin Citizen Lake Monitoring Network (CLMN) provides training to help local citizens participate in these efforts.

Finally, as described in Chapter II, excessive nutrients can promote nuisance-level abundance and growth of aquatic plants. Accordingly, efforts to improve water quality - which often go along with improving the overall quality of the Lake and its watershed—can also reduce the amount of plant growth in general. Consequently, **implementing the recommendations highlighted in the "Issue 2: Water Quality" section of this chapter is an important facet of overall aquatic plant management and is assigned a <u>high priority</u>.**

ISSUE 2: WATER QUALITY

As described in Chapter II, only limited water quality data are presently available for Rice Lake, a situation limiting thorough analysis of Lake conditions and use problems. Similarly, ongoing sampling within Whitewater Lake does not provide sufficient detail needed to make fully informed lake management decisions. However, the available data does indicate that Whitewater and Rice Lakes are rich in plant nutrients (i.e., the Lakes are eutrophic). The fact that many Lake residents have concerns about various water-quality-related issues (e.g., sources of pollution in the watershed, the volume of aquatic plant growth, and algal growth) suggests that water quality management is warranted on the Lakes.

As explained in Chapter II, management efforts to improve Whitewater and Rice Lakes' water quality should focus on the following strategies:

1. **Re-establish comprehensive water quality monitoring within Rice Lake and continue and enhance comprehensive water quality monitoring within Whitewater Lake.** Water quality monitoring is an important tool that allows the Lake's current condition to be quantified, longer term changes to be understood, and the factors responsible for change to be identified. Monitoring is a key factor to maintaining and improving Lake health. To allow historical data to be contrasted to current conditions and thereby allow trends to be identified, samples should continue to be collected at the sites identified as the "deep hole" sites (i.e., the point above the deepest part of the each lake, Map 1, Map 2, and Map 3) in both Lakes. Samples sites should also be located in the northwest lobe, the northeast lobe, and the south bay of Whitewater Lake because those areas are much shallower and exhibit differing water quality characteristics. At a minimum, water quality samples should be collected and submitted to a laboratory in early spring shortly after ice out (e.g., early April) and at least once during mid-summer (e.g., late July). Field measurements (e.g., water clarity, temperature, and dissolved oxygen) should be collected much more frequently. At a minimum, water quality samples should be analyzed for the following parameters:

   a. Field measurements
      - Water clarity (i.e., Secchi depth)
      - Temperature (profiled over the entire water depth range at the deepest portion of the Lakes with more frequent readings near the thermocline)
      - Dissolved oxygen (profiled over the entire water depth range at the deepest portion of the Lakes with more frequent readings near the thermocline)
      - Specific conductance (near-surface sample, profiles with depth if equipment is available)

   b. Laboratory samples
      - Total phosphorus (near-surface sample with supplemental samples collected near the deepest portions of the Lakes)

Table 30

EXAMPLE WDNR GRANT PROGRAMS SUPPORTING LAKE MANAGEMENT ACTIVITIES

Category	Program	Grant Program	Maximum Grant Award	Minimum Financial Match	Application Due Date	Examples of Potentially Eligible Issues as designated in Chapters II and III
Water	Surface Water Grants	Aquatic Invasive Species (AIS) Prevention and Control	Education, Prevention, and Planning Projects: **$150,000**	25%	December 10	Issue 3
			Established Population Control Projects: **$200,000**	25%	February 1	
			Early Detection and Response Projects: **$20,000**	25%	Year-Round	
			Research and Development: annual funding limit of **$500,000**	25%	Year-Round	
			Maintenance and Containment: **permit fee reimbursement**	25%	Year-Round	
		Lake Classification and Ordinance Development	**$50,000**	25%	December 10	Issues 1, 2, 5, 6
		Lake Protection	**$200,000**	25%	February 1	All
		Lake Management Planning: Large and Small Scale	Small-Scale: **$3,000**	33%	December 10	
			Large Scale: **$25,000**	33%	December 10	
	Citizen-Based Monitoring Partnership Program		**$4,999**		Spring	Issues 1, 2
	Targeted Runoff Management	- -	Small-Scale: **$150,000**	30%	April 15	Issues 1, 3, 4
			Large-Scale: **$1,000,000**	30%	April 15	
	Urban Nonpoint Source & Stormwater Management	- -	Design/construction: **$150,000**	50%	April 15	
			Property Acquisition: **$50,000**	50%	April 15	
Conservation & Wildlife	Knowles-Nelson Stewardship Program	Acquisition of Development Rights		- -	May 1	Issues 1, 2, 3, 4, 5, 7
		Natural Areas		- -	February 1, August 1	
		Sport Fish Restoration	- -	50%	February 1	Issue 7
		Streambank Protection		- -	February 1, August 1	Issues 1, 2, 3, 4, 7
Boating	Boat Enforcement Patrol	- -	Up to **75% reimbursement**	None	Various	Issue 6
	Recreational Boating Facilities	- -	Up to **50% of total eligible cost**	- -	- -	
Recreation	Knowles-Nelson Stewardship Program	Acquisition and Development of Local Parks	- -	- -	- - May 1	Issues 6, 7
		Habitat Area	- -	- -	February 1, August 1	
		Urban Green Space	- -	- -	May 1	

Note: More information regarding these example grant programs may be found online at the following address: http://dnr.wi.gov/aid/grants.html. Additional Federal, state, and local grant opportunities are available.

Source: Wisconsin Department of Natural Resources and SEWRPC.

- o Total nitrogen (near-surface sample)
- o Chlorophyll-*a* (near-surface sample)
- o Chloride (near-surface sample),

Laboratory tests quantify the amount of a substance within a sample under a specific condition at a particular moment in time, and are valuable benchmark values. Field measurements can often serve as reasonable surrogates for common laboratory tests. For example, water clarity decreases when total suspended solids and/or chlorophyll-*a* concentrations are high, samples with high concentrations of total suspended solids commonly contain more phosphorus, and water with higher specific conductance commonly contains more salt and, therefore, more chloride. Periodically sampling water and running a targeted array of laboratory and field tests not only provides data for individual points in time, but can also allow laboratory results to be correlated with field test results. Once a relationship is established between laboratory and field values, this relationship can be used as an inexpensive means to estimate the concentrations of key water quality indicators normally quantified using laboratory data.

The Clean Lakes Monitoring Network (CLMN) provides training and guidance regarding monitoring lake health.[7] Volunteers commonly monitor water clarity, temperature, and dissolved oxygen throughout the open water season (preferably every 10 to 14 days) and basic water chemistry (i.e., phosphorus and chlorophyll-*a* concentrations) four times per year (two weeks after ice off and during the last two weeks of June, July, and August).

Supplemental temperature/oxygen profiles collected at other times of the year (e.g., other summer dates, nighttime summer, fall, winter) can be helpful. For example, oxygen profiles collected during midsummer nights, just before sunrise, help evaluate diurnal oxygen saturation swings. In addition, chloride should also be monitored once per year when the Lake is fully mixed. Monitoring chloride concentrations allows the rate of concentration increase over time to be quantified. This will help discern the overall impact of cultural influence on the Lake and to evaluate if chloride concentrations are approaching levels that could foster negative changes in the Lake's ecosystem.

Regular water quality monitoring helps Lake managers promptly identify variations in the Lakes' water quality and improves the ability to understand problems and propose solutions. Given the rapidly changing landscape in which Whitewater and Rice Lakes are situated, water quality and the conditions influencing water quality can rapidly change. **Regular review and revision of water quality monitoring recommendations should be considered a <u>high priority</u>.**

2. **Manage in-lake phosphorus sources.** Whitewater and Rice Lakes have relatively small watersheds and are not known to have any large point source or watershed-derived phosphorus loading, making the Lakes excellent candidates for in-lake treatment. The available evidence suggests that phosphorus internal loading and recycling have likely been significant contributors to the Lakes total phosphorus budget since the Lakes were created. **Based upon the data analyzed as part of this report, phosphorus internal loading and recycling are believed to be the most significant sources of phosphorus fueling aquatic plant and algae growth in the Lakes.** Overall water and habitat quality could likely be enhanced by decreasing the Lakes' limiting plant nutrient (phosphorus). This in turn would help the Lakes be less eutrophic, reduce the incidence and severity of algal blooms, lessen stress on the Lakes' fish and aquatic life communities, help assure that natural plant-induced phosphorus sequestration processes continue, and sustain a high-quality ecosystem with more long-term resilience. Reducing excess phosphorus is key to this dynamic; therefore, managing in-Lake phosphorus is important. Additional data may need to be collected to more fully evaluate

[7] *More information regarding the CLMN may be found at the following website: http://www.uwsp.edu/cnr-ap/UWEXLakes/Pages/programs/clmn/default.aspx*

internal loading dynamics and monitor effectiveness. For example, additional water chemistry profiles and sediment samples from the deep portion of the Lakes may need to be collected to better quantify internal loading rates.

While a large variety of techniques can be used to reduce internal loading of phosphorus, five approaches appear to be the most promising for Whitewater and Rice Lakes. It should be remembered that a combination of approaches, as opposed to choosing a single strategy, will typically provide the best results. Additional details regarding each approach are provided below:

a. **Removing nutrients through aquatic plant harvesting** should be considered a high priority in both Whitewater and Rice Lake. Historical harvesting patterns were shown to at least remove the phosphorus load contributed by the Lakes' watersheds. More aggressive plant harvesting has the potential to remove additional phosphorus, offsetting phosphorus loading from precipitation and other sources, and potentially reducing the availability of legacy phosphorus. Chemical treatments should be avoided, since they allow nutrients to remain in the Lakes. A new small aquatic plant harvester specially designed for tight quarters and shallow waters may be a good alternative in areas inaccessible to current harvesting equipment. See Issue 1: Aquatic Plant Management for additional information.

b. **Promoting conditions conducive to muskgrass growth** should be considered a high priority. Muskgrass growth sequesters phosphorus, and is a significant factor in some lakes' ability to absorb high phosphorus loads yet maintain good water quality. Muskgrass commonly favors areas of groundwater discharge. Hence, the east and south shorelines of each Lake likely provide the best growing conditions for muskgrass. Clearer water can contribute to muskgrass growth, forming a positive self-reinforcing feedback loop. Carp are known to feed heavily on muskgrass,[8] so carp population control (see approach c below) can help increase muskgrass growth. See Issue 1: Aquatic Plant Management for additional aquatic plant management advice.

c. **Carp population** control should be considered a high priority in Rice Lake and a medium priority in Whitewater Lake. Carp are known to affect water clarity and aquatic plant abundance in ways that are undesirable for most lake users. More information is presented in the Issue 7: Fish and Wildlife section of this Chapter.

d. **Chemical inactivation using alum.** Alum is used to purify drinking water and has been used for over four decades to improve lake water quality. Although all types of lakes have been treated with alum, lakes that lack significant external sources of phosphorus and owe much of their plant-available phosphorus to internal loading are most amenable to this approach. While the Lakes fit both these criteria quite well, only the deepest areas of Whitewater Lake appear to be well suited for alum treatment.

   Alum treatments trap water-borne particles which in turn settle to the lake bottom and form a layer of sediment that does not release phosphorus to overlying lake water under oxygenated or anoxic conditions. To be effective, this "skin" of nonreactive sediment must not be disrupted. Fish, boat traffic, and strong currents can breach the layer of nonreactive sediment, rendering the treatment ineffective in the longer term. It is most effectively employed in anoxic waters of a lake's hypolimnion, which in Whitewater Lake's case typically covers approximately 50 acres. No deep water area is present in Rice Lake, making it a poor candidate for long-term improvement by alum treatments alone. Carp control (and attendant native rooted aquatic plant recovery), discussed in more detail in Issue 7: Fish and Wildlife in this Chapter, is likely a more promising method to reduce phosphorus loads stemming from shallow water areas of Whitewater Lake and all of Rice Lake.

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[8] *Johnson, James A.*, Effects of carp on the survival and growth of aquatic plants in Rice Lake. *Prepared for Rice Lake Area Association, Maple Grove, Minnesota, Freshwater Scientific Services LLC, 2010.*

After an alum treatment is completed, water is immediately much clearer and phosphorus concentrations are markedly lower. Improved water clarity catalyzes additional synergistic responses that further limit phosphorus concentrations in the lake. Clearer water allows the plants that naturally produce marl to spread to greater depths, reinforcing the abundance of plant types that promote natural phosphorus sequestration. Lower phosphorus concentrations reduce the concentration of algae in open waters of the lake, increasing water clarity and decreasing the load of organic matter decomposed in the hypolimnion. Decreased oxygen demand related to reduced algal decomposition allows oxygen concentrations in deeper areas to increase and/or the volume of anoxic water to decrease. Since oxygen-deficient water is the catalyst for internal loading, reducing the volume (and hence extent) of anoxic water reduces a lake's overall internal loading potential.

Care must be taken to achieve proper alum dosing. A dose should create a capping layer thick enough to form a nonreactive barrier above phosphorus-bearing sediment. Since alum is acidic, buffering agents are commonly applied with the treatment. According to the WDNR, the cost for an alum treatment averaged less than $500 per acre of lake surface area in 2003 (Appendix F). Assuming average conditions and adjusting for inflation, the WDNR cost data suggests that an alum treatment for the 50 acres of Whitewater Lake deep enough to stratify may cost roughly $25,000. Others report significantly higher costs.[9]

Most information sources state that benefits from alum treatments can tangibly improve water quality in stratified lakes for decades. Alum treatments on deep stratified lakes typically benefit the lake for 21 years. Alum treatments have reduced epilimnetic total phosphorus concentrations in some lakes for as long as 45 years. It is important to note that an alum treatment could significantly reduce algae blooms and could allow more light to penetrate to the bottom of the Lake. Without competition and shading from algae, the aquatic plant population, particularly that of Eurasian water milfoil and curly-leaf pondweed, could dramatically increase. As a result, harvesting operations may have to increase following the treatment.

Given the other opportunities available for phosphorus management, alum treatment is given a <u>low priority.</u>

e. **Hypolimnetic withdrawal and on-shore treatment** involves drawing water from deep anoxic areas of a lake, piping it to a convenient location on the shoreline, and manipulating water chemistry using natural processes and/or induced physical and/or chemical means to cause phosphorus to come out of solution. On-shore treatment may also be employed to treat stormwater before it enters a lake.

   Water can be treated in several ways. For example, it can be drawn from a lake or stream, or treated in-line in a stormwater conveyance system. Several treatment processes can be combined for the desired result. The treatment process can rely on common municipal/industrial treatment practices, often employing prefabricated treatment system components. Alternatively, nature-like processes can be promoted in purpose-built treatment cells to enhance water quality. Such treatment cells may take the appearance of ponds or wetlands. Examples of treatment processes that could benefit the Lakes include:

   1.) **Aeration.** The simplest form of on-shore treatment is aeration. Air is pumped through water, increasing water oxygen concentration. The oxygenated water is then returned to deeper portions of the lake. This helps reduce the volume of anoxic water, reducing the areal extent of sediment/water conditions prone to release phosphorus to the water column, and, thereby, decreasing the amount of phosphorus released to the lake from bottom sediment.

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[9] *Bassett Creek Watershed Management Commission, "Twin Lake Phosphorus Internal Loading Investigation," March 2011.*

2.) **Dissolved phosphorus removal.** Dissolved phosphorus can be removed from the Lake water by introducing certain compounds that combine with phosphorus forming a solid precipitate that is then collected and removed. Oxygen is the simplest to introduce, and can enable dissolved phosphorus to precipitate immediately after aeration. Iron, alum, and lime can also be used to precipitate dissolved phosphorus under various pH and dissolved oxygen conditions. Since the treated water is in a controlled environment, water chemistry can be manipulated to allow any of these compounds to precipitate phosphorus.

3.) **Clarification.** Particles are removed from water by allowing the water to remain motionless for a period of time, by active filtration, or by centrifugal action. All of these clarification processes can be enhanced using flocculants such as alum.

4.) **Nature-like processes.** Water is allowed to flow, be detained, or otherwise handled in ways that help remove pollutants. An example includes pumping deep lake water to a dug pond or created wetland. Water is then aerated upon discharge, phosphorus precipitates, and the treated water comes in contact with plant material, filters through the underlying substrate, and is returned to the lake or a tributary of the lake through a diffuse path (e.g., created wetlands) or through the shallow groundwater system. This type of system would need to be built upon areas not occupied by natural wetlands. Significant open upland soils areas, some in public ownership, are found near the Lakes.

On-shore treatment is currently used to improve water quality in many other lakes. For example, an active treatment system operating on Crystal Lake (a 79 acre, 35-foot-deep lake in the Minneapolis metropolitan area) removed 200 pounds of phosphorus from stormwater and water drawn from the hypolimnion during its first full season of operation. This system is composed of a large vessel that operates between May and November and can treat over one million gallons of water per day. This treatment volume equals about one-third of Crystal Lake's entire volume over the period of operation.[10] Another community chose to polish wastewater to remove phosphorus using constructed wetlands and a carefully engineered groundwater recharge area to supplement flow in a high quality river.

The prevailing water elevation and lake outlet flow rate influences the method chosen to withdraw water. If the rate of withdrawal could be expected to exceed the lake outlet's discharge rate, the treated water should normally be returned to the lake to reduce the potential for lowered lake levels. In this case, lake water can be actively pumped to an area topographically higher than the lake, treated, and be allowed to return to the lake directly (via tributaries) or indirectly (via shallow groundwater). Large areas of upland soil suitable for dug ponds and created wetlands are present east of Whitewater Lake. Prefabricated treatment equipment could also be situated in any number of areas.

If elevations and outlet flow are moderate to high, water can be drawn from deep portions of the lake with little or no active pumping under favorable topographic conditions. Flashboards or gates can be used to prolong the period of time such a system could operate without reducing lake levels from normal elevation ranges. Water is treated prior to discharge. Unfortunately, little to no water discharges from either Lake for long periods of time, making this approach largely unsuitable.

The cost of on-shore treatment varies widely and depends upon the type and intensity of treatment desired. Custom-built on-shore treatment plants require significant capital investment to construct and continual input of labor, services, and consumable supplies over long periods of time. For example, the large system installed on Crystal Lake, Minnesota to resolve severe stormwater quality issues (see above) cost over one million dollars to build and $90,000 per year to operate. Equipment may some

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[10] *Dullinger, Danielle,* Robbinsdale Working to Clean Up Crystal Lake, *StarTribune, March 11, 2014,* http://www.startribune.com/robbinsdale-working-to-clean-up-crystal-lake/249536501/.

times be leased and delivered onto a site as a prefabricated package plant. In such a case, the risk of long-term commitment is reduced. Furthermore, smaller plants operating over extended periods of time can incrementally reduce the amount of phosphorus in a lake that does not suffer from heavy external loads. The cost of nature-like systems depends upon desired location and treatment capacity. In the right setting, little special investment may be needed aside from pumps, piping, and ongoing utility and maintenance costs.

As in the case with alum treatment, only the deepest portions of Whitewater Lake are well- suited for this approach. Rice Lake lacks a phosphorus-rich hypolimnion creating a situation where a large volume of water would need to be pumped to remove a significant mass of phosphorus from the Lake. **Other strategies are available that appear more promising for application at either Lake.** Therefore, hypolimnetic withdrawal and treatment are given a low priority.

3. **Maintaining healthy and robust native aquatic plant populations** should be considered a high priority. Native aquatic plants compete for nutrients with algae and undesirable plant species. Some species (particularly muskgrass) help remove phosphorus from the water column, reducing the fertility of the Lakes. Aquatic plant harvesting has been shown to remove large amounts of phosphorus from the Lakes, equaling or exceeding the mass of phosphorus supplied by the watershed. Therefore, aquatic plant harvesting appears to benefit the water quality of the Lakes. Additional information regarding aquatic plant management is given as part of "Issue 1: Aquatic Plant Management."

4. **Protect and enhance buffers, wetlands, and floodplains.** Protecting these features helps safeguard areas that already benefit the Lakes and require little to no additional inputs of money and labor. On a landscape scale, it is important to protect all such features. However, with a narrower focus on Whitewater and Rice Lakes, **it is most important to protect and enhance buffers, wetlands, and floodplains in areas directly tributary to the Lakes.** Protecting and enhancing buffers, wetlands, and floodplains in this area should be assigned a high priority.

   Implementing this recommendation could involve:

   a. Continuing to apply development limitations in SEWRPC-delineated environmental corridors (see Map 18 in Chapter II of this report) through various town, village, city, and County zoning and as part of State park management public input to protect existing natural buffer, floodplains, and wetland systems.

   b. Continuing enforcement of shoreland setback requirements and continuing active enforcement of construction site erosion control, drainage, and stormwater management ordinances.[11]

   c. Controlling the spread of invasive species and, when possible, eradicating invasive species in shoreland and wetland areas. A common wetland aquatic invasive species includes reed canary grass (*Phalaris arundinacea*). Many other invasive plant species are already found in, or threaten, Wisconsin wetlands.[12]

   d. Providing information to shoreland property owners including those with real estate abutting mapped tributaries. This information should describe the benefits that nearshore and terrestrial buffers provide to the Lakes, and should encourage landowners to protect buffers where they remain and to enhance,

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[11] *Ordinances are commonly overlooked and/or poorly understood. Stakeholders can increase the impact of existing ordinances by educating the regulated community and reporting infractions when education fails to provide results.*

[12] *Common and early detection wetland invasive plant species are described on the WDNR's website at the following address: http://dnr.wi.gov/topic/Invasives/documents/wetland_species.pdf*

restore, or create buffers in favorable areas where they are highly degraded or absent. Educational resources could include installation instructions, typical costs, and potentially a list of suppliers of services and supplies. Such programs are most productive if accompanied by an incentive program that helps share installation cost.

The U.S. Department of Agriculture Farm Service Agency sponsors programs such as the Conservation Reserve Program (CRP) and affiliated Conservation Reserve Enhancement Program (CREP) which can be applied in agricultural areas. Both of these initiatives use vegetation to slow and filter stormwater runoff. If thoughtfully designed and located, groundwater recharge may also be enhanced. Grants may also be available for novel initiatives such as cropped buffers, a program where farmers receive compensatory payment for growing crops that help filter runoff. Rain gardens can be installed in residential areas.

e. Implementing a shoreline best management practice and shoreline buffer enhancement program. This program could encourage installation of rain gardens, disconnected roof and driveway drains, bioswales, or buffers along shorelines. WDNR recently introduced a "Healthy Lakes" grant program that could help fund some of these efforts, particularly in areas of urban development along lakeshores.[13]

f. Actively seeking and obtaining conservation or use easements and purchase of wetlands, floodplains, and uplands in key areas. Buffers can be preserved indefinitely and their ecological value can be enhanced to improve habitat, filtering, and hydrologic functions.

g. Monitoring and protecting areas of natural vegetation and taking steps to control invasive species that threaten ecological value. The major recommendation is to monitor and control reed canary grass and phragmites in wetlands and shorelands. These grass species spread and quickly displaces the native wetland plants that help treat polluted water and provide desirable habitat.

h. Maintaining or restoring natural stream channel form and function. The floodplains of natural stream channels temporarily store water, improving water quality and reducing downstream flood peaks. Ditched and/or straightened channels should be naturalized to restore such function whenever possible.

5. **Monitoring and actively managing woodlands** should be assigned a medium priority. Perhaps the largest threat to many woodlands in Southeastern Wisconsin is the combined problem of: a) disease and insects that destroy the native tree canopy, and b) invasive plants such as buckthorn (common buckthorn, *Rhamnus cathartica*, and glossy buckthorn, *Frangula alnus*) that inhibit or prevent native tree regeneration. Introduced pests have attacked ash, elm, butternut, and oak species. New pests are on the horizon that target black walnut, beech, and other trees. Existing woodlands should be kept free of invasive plant species and actions should be taken to prepare the woodland for the arrival of pests. For example, increasing the diversity of tree species through careful stand management and or planting can help assure that complete canopy loss does not occur in the future. State programs are available to assist woodland owners with stand management, tax implications, and professional forestry advice.[14]

6. **Encouraging pollution reduction efforts along the shorelines (best management practices)** is currently recommended and is considered a high priority. Pollution reduction measures include eliminating use of fertilizer where practical, ensuring cars are not leaking fluids on driveways, establishing and maintaining

[13] *More information regarding the WDNR Healthy Lakes program may be found at the following website: http://www.uwsp.edu/cnr-ap/UWEXLakes/Pages/healthylakes/default.aspx*

[14] *The following website provides an overview of WDNR forestry information and programs: http://dnr.wi.gov/topic/ForestLandowners/.*

rain gardens to mitigate impermeable surface runoff volume and quality, preventing soil erosion, properly disposing of leaf litter and grass clippings, and properly storing salts and other chemicals so they do not drain to the Lakes. Communicating these best management practices, and engaging in a campaign to encourage their use (e.g., offering to pick up grass clipping or leaves) will incrementally reduce their contribution to water quality problems.

7. **Stringently enforcing construction site erosion control and stormwater management ordinances** should be considered a medium priority. However, this priority level should increase to high priority at the onset of any major construction. Ordinances must be enforced by the responsible regulatory entities in a manner consistent with current practices; however, local citizens can help by reporting potential violations to the appropriate authorities (see "Issue 8: Implementation" section).[15]

8. **Maintaining septic systems** is considered a high priority. Maintenance is regulated by Walworth County.[16] Outreach to educate septic system owners on the maintenance of their systems could have a positive impact on the Lakes with minimal effort. This effort, for example, could include a program where septic system owners are automatically reminded when they should maintain their septic tanks. For example, Washington County provides information on operation and maintenance of "Private Onsite Wastewater Treatment Systems" on its website and an educational poster. This guidance states that septic systems should be pumped at recommended intervals of two years for mound systems and three years for all other systems. This maintenance is of most importance to locations adjacent to the Lakes (as shown on Map 32); therefore, efforts should target these areas first.

Implementation of these recommendations will significantly contribute to tracking and improving the water quality within Whitewater and Rice Lakes.

ISSUE 3: CYANOBACTERIA AND FLOATING ALGAE

As was mentioned in Chapter II, algae is an issue of concern, and there is currently evidence supporting the need for in-Lake management efforts to limit algal growth within Rice Lake. Furthermore, the additional recommendations provided in this section focus on monitoring algal growth, preparing Lake residents on how to respond if algae growth becomes excessive, and on preventing excessive algal growth. The five recommendations are:

1. **Reduce phosphorus concentrations.** Algal growth in the Lakes is limited by available phosphorus. Several techniques are discussed under Issue 2: Water Quality that are designed to reduce phosphorus concentrations in the Lakes. Allied issues are discussed in Issue 1: Aquatic Plant Management and Issue 7: Fish and Wildlife. Lower phosphorus concentrations generally decrease the potential for algal blooms. These recommendations are assigned medium to high priorities.

2. **Monitor algae in the Lakes.** This effort should focus on monitoring chlorophyll-*a*, as was described in the water quality monitoring recommendation above. Additionally, if large amounts of suspended algae grow in the future, this monitoring could also include collecting and identifying algae to check whether it is a toxic strain. These initiatives shoud be assigned a high priority.

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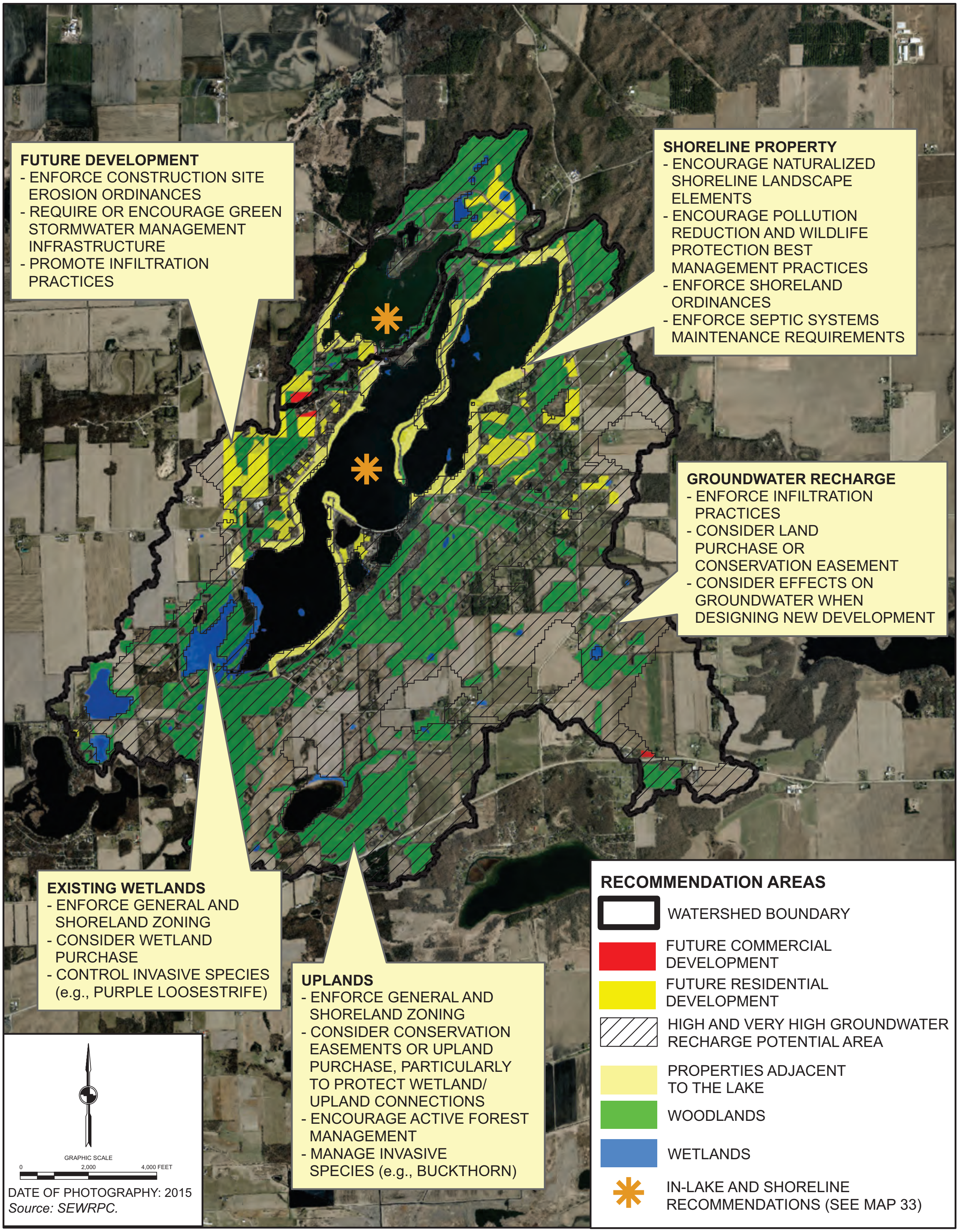
[15] *Enforcement of the construction site erosion control and stormwater management ordinances is addressed in the* Walworth County Land Disturbance, Construction Site Erosion and Sediment Control, Conservation Standards for Vegetation Removal, Pond Construction and Retaining Wall Construction ordinance.

[16] *Chapter SPS 383*, "Private Onsite Wastewater Treatment Systems," *of the* Wisconsin Administrative Code *sets forth regulations related to administration and enforcement, design and installation, management, and monitoring of septic systems.*

Map 32

SELECTED RECOMMENDATIONS FOR THE WHITEWATER AND RICE LAKE WATERSHEDS



DATE OF PHOTOGRAPHY: 2015

Source: SEWRPC.

3. **Warn residents not to enter the water in the event of an algal bloom.** This should be considered a high priority unless testing positively confirms the absence of toxic algae. Therefore, methods for rapidly communicating unhealthful water conditions that are not conducive to body contact should be developed.

4. **Maintain or improve water quality** through implementing recommendations provided in the "Issue 2: Water Quality" section of this chapter. This should be assigned a high priority.

5. **Maintain a healthy aquatic plant community** to compete with algal growth. This can be promoted by implementing recommendations provided in "Issue 1: Aquatic Plant Management" section of this chapter. This should be assigned a high priority.

Implementing the above recommendations will help manage excess algal growth in Rice Lake and will not preclude or significantly inhibit use of Whitewater Lake. However, **if future monitoring reveals excessive or greatly increased algal growth, or should toxic algae be identified, these recommendations should be reevaluated (high priority). Reevaluation should include rethinking all relevant-Lake management efforts.**

ISSUE 4: BOG REMOVAL IN WHITEWATER LAKE

As discussed in the Chapter II, activities are currently being undertaken to remove the floating bog hazard in Whitewater Lake. Consequently, **maintaining and extending the current permits and activities for bog removal** is considered a high priority and should be continued until complete removal is achieved. In addition, an underwater survey to assess the total coverage of the bog to estimate rate of success and time needed to remove the bog entirely is considered a medium priority.

ISSUE 5: GROUNDWATER RECHARGE

As discussed in the Chapter II, maintaining groundwater recharge can be crucial to the health of the Lakes. Consequently, the following recommendations help quantify factors related to this issue.

1. **Lake water level monitoring** should be considered a medium priority. Monitoring is already completed by volunteers. Water levels should be measured at least once per month on both Lakes.

2. **Implementing measures to promote infiltration** is a medium priority. Implementation of this recommendation could involve:

   a. **Enhancing the ability of rainfall and snowmelt to infiltrate into soils to recharge small and large scale groundwater flow systems.** This could be most easily achieved by installing innovative BMPs associated with low-impact development, including rain gardens[17] (Figure 61) and other stormwater infrastructure specifically designed and carefully located to promote infiltration. Some practices and projects, especially on public property, may qualify for partial funding through the WDNR "Healthy Lakes" initiative.

   b. **Retrofitting current urban development with stormwater management infrastructure elements.** The intensity of this process can vary. An example of its simplest form is voluntarily directing stormwater to areas of permeable soil and favorable topography or encouraging reduction in the extent of impermeable surfaces. These can be promoted by active education outreach, providing instructions and supplies to property owners, or through subsidies (some of which may be grant eligible). A step

[17] *Rain gardens are depressed basins that maintain native plants and help water infiltrate into the ground rather than entering the Lakes through surface runoff. The installation of rain gardens can help reduce the amount of erosion and unfiltered pollution entering the Lakes and can stabilize baseflow to the Lakes.*

toward a more comprehensive approach would be an ordinance requiring onsite stormwater management practices such as porous pavement as a condition of issuance of a building permit affecting the overall impermeable surface area of a parcel. More capital-intensive public works retrofit projects such as stormwater retention/infiltration basins and bioswales can also help reduce the impact of existing development on groundwater recharge. In certain instances, stormwater infrastructure built for new development may be located and sized to manage stormwater runoff from existing development.

Figure 61

EXAMPLE OF A RAIN GARDEN

NOTE: Further details are provided on Natural Resource Conservation Service and Wisconsin Department of Natural Resources websites at:
http://www.nrcs.usda.gov/Internet/FSE_PLANTMATERIALS/publications/ndpmctn7278.pdf; and
http://dnr.wi.gov/topic/Stormwater/raingarden/.

Source: U.S. Department of Agriculture, Natural Resource Conservation Service.

3. **Reducing the impacts of future urban development** is a high priority. This recommendation can be implemented by:

   a. Enforcing the infiltration recommendations in the current Walworth County – Land Disturbance, Construction Site Erosion and Sediment Control, Conservation Standards for Vegetation Removal, Pond Construction and Retaining Wall Construction ordinance which sets criteria for infiltration requirements;[18]

   b. Purchasing land or obtaining conservation easements on agricultural and other open lands with high groundwater recharge potential; and

   c. Encouraging developers to incorporate infiltration in stormwater management designs and encouraging local government to consider groundwater recharge as an integral part of new development and infrastructure replacement proposals. Some Southeastern Wisconsin communities have integrated analysis of groundwater and surface water impact into the process through which developers obtain permission to build new buildings and subdivisions.[19]

4. **Continuing to protect wetlands and uplands by enforcing County zoning and drainage ordinances** as discussed in the "Issue 2: Water Quality" section of this chapter. This should be considered a high priority.

As with the other recommendations made in this chapter, significant future changes in Lake levels will spur the need for a reevaluation of the recommendations above. Consequently, **this periodic reevaluation is recommended** as a high priority.

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[18] *Walworth County Municipal Code*, Land Disturbance, Construction Site Erosion and Sediment Control, Conservation Standards for Vegetation Removal, Pond Construction and Retaining Wall Construction, *Chapter 26, Article II. This recommendation can be found at: https://www.municode.com/library/wi/walworth_county/codes/code_of_ordinances?nodeId=WACOCOOR_CH26EN_ARTIILADICOSIERSECOCOSTVEREPOCOREWACO_DIV2COTESTSPCOSIERSECOGUPRPESTSIDRSTWAMA*

[19] *The Village of Richfield in Washington County is such an example. More information may be found at the Village's website: http://www.richfieldwi.gov/index.aspx?NID=300*

ISSUE 6: RECREATION

As was discussed in Chapter II, the primary uses for Whitewater and Rice Lakes (in no particular order) are boating, swimming, and fishing. Since recreation is a priority under this plan, it is necessary to emphasize the recommendations that help maintain or encourage these recreational uses. Consequently, the following recommendations are made:

1. **Maintain and enhance boat access to navigable portions of the Lakes.** This can be achieved through implementing the harvesting recommendations included in this chapter (see “Issue 1: Aquatic Plant Management” section).

2. **Maintain and enhance swimming through engaging in “swimmer-conscious” management efforts.** This can be achieved by adopting the aquatic plant management recommendations made earlier in this chapter (see “Issue 1: Aquatic Plant Management” section), including 1) implementing a plant pickup program, 2) ensuring that any future chemical treatments occur *only in the early spring* (to prevent human contact), 3) implementing hand-pulling and raking in the nearshore areas (to facilitate nearshore swimming), 4) implementing hand-pulling and suction harvesting recommendations aimed at controlling Eurasian water milfoil (as this species often deters swimming), improving water quality (see “Issue 2: Water Quality”), and controlling algae (see “Issue 3: Cyanobacteria and Floating Algae”)

3. **Maintain and enhance fishing by protecting and improving aquatic habitat and ensuring the fish community remains viable.** This recommendation can be achieved by implementing the aquatic wildlife recommendations provided in the “Issue 7: Fish and Wildlife” section of this chapter.

In general, **all management efforts should be considered <u>high priorities</u> and all management efforts should enhance the health and, in turn, the recreational use of the Lakes**. This should be a general principal guiding all future management, including the efforts which are undertaken consistent with the recommendations of this plan.

ISSUE 7: FISH AND WILDLIFE

As discussed in Chapter II, wildlife is a key indicator of Lake health. Additionally, the presence of wildlife increases recreational use and enjoyment of the Lake and the functionality of the Lake as an ecosystem. To enhance wildlife within the Whitewater and Rice Lake watersheds, the following recommendations are made:

1. **Continue current fish stocking practices and promote abundant naturally reproducing predatory gamefish populations.** This should be considered a <u>high priority</u> and will help assure that the fishery is maintained while efforts to increase natural spawning and juvenile recruitment are improved. Efforts that promote natural reproduction of gamefish and panfish that eat young carp should be given a particularly high priority. This includes assuring northern pike have access to suitable spawning and juvenile habitat, promoting healthy bluegill and bass populations, and promoting increased abundance and reproduction of walleye.

2. **Improve aquatic habitat in the Lakes by allowing or installing coarse woody structure and/or vegetative buffers along the Lakes’ edge.** Implementation of this should be considered a <u>high priority</u>. Elements could include educational or incentive-based programs to encourage riparian landowners to install “fish sticks”[20] (see Figure 62), leave fallen trees in the water, and develop buffer systems along the shoreline.

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[20] *Natural shorelines generally have hundreds of fallen trees along the shoreline (per mile). “Fish sticks” is a term coined for engineered installation of woody debris (logs) along Lake shorelines to mimic natural conditions. Generally these projects involve anchoring logs into the shore so that the log is oriented perpendicular to the shoreline.*

Grant funding is available through the Healthy Lakes program on a competitive basis for the implementation of fish sticks projects. Installing buffers will also have the added benefit of deterring geese populations from congregating on shoreline properties.

3. **Mitigate water quality stress on aquatic life and maximize areas habitable to desirable fish.** The primary issue in this category is presently low oxygen and supersaturated oxygen concentrations during some seasons at certain depths. The water quality recommendations discussed earlier in this chapter incorporate this element and should be considered a high priority. Other stressors may develop in the future (e.g., new invasive species and other water quality concerns) and conditions should be carefully monitored for their impact on aquatic life.

4. **Reduce carp populations.** Over-abundant carp create conditions that degrade water quality, aesthetics, recreational opportunities, and ecological value. While carp are present in both Lakes, they are believed to be particularly numerous in Rice Lake. A study should be completed to estimate carp population density and winter congregation areas. This study should be considered a medium priority for Whitewater Lake and a high priority for Rice Lake. Once complete, these studies will generate data that will help prioritize netting and possibly other carp control activities.

   If carp density is excessive, action should be taken to reduce carp populations. Efforts are now underway to reinforce predator populations. However, adult carp are too large to be eaten by native predatory fish. Fish netting is a way to remove adult carp. Although netting has already been approved as a method of carp population control, the netting contractor has not been active enough to meaningfully reduce carp populations. The number of carp harvested by commercial enterprises can typically be increased by using a bounty system. Generally, the commercial harvester is paid a set figure for each pound of carp removed, with higher premiums paid on all fish up to a certain total harvest weight. A gradationally lower premium is paid for additional mass of carp. A bonus is sometimes fixed to achieving a certain total harvest weight. The population density study will help Lake managers determine threshold weights and premiums to be paid. If netting is to be employed on the Lakes, bounty payments should be considered integral to netting. Furthermore, a winter harvest of congregated carp may provide the most complete removal with the least amount of bycatch. A Judas fish study would need to be coordinated with a winter harvest. Fish netting should be assigned a high priority for Rice Lake and a medium priority for Whitewater Lake

   For carp harvests to have longer term effects on Lake conditions, action needs to be taken to reduce carp reproductive success. Given that the Lakes likely have ample breeding and nursery areas for carp, harvest alone may not meaningfully reduce carp populations. Therefore, the reproductive success of the resident carp population must be supressed by either reducing spawning success and/or increasing predation of young carp. Predator stocking and habitat enhancement are crucial to this effort and should be considered

Figure 62

EXAMPLES OF COMPLETED "FISH STICKS" PROJECTS

Source: Wisconsin Department of Natural Resources.

a high priority. Given the shape and configuration of the Lakes, it is unlikely that all breeding areas can be isolated from the Lakes without great cost and complication. Therefore, barriers are assigned a low priority.

5. **Adopt best management practices to improve wildlife habitat.** This should be considered a medium priority, although this should increase to a higher priority if wildlife populations decline. The acceptance and employment of best management practices can be fostered through voluntary, educational, or incentive-based programs for properties adjacent to the shoreline, and by directly implementing these practices on public and protected lands. Some special interest non-governmental organizations ("NGOs", e.g., Pheasants Forever, Ducks Unlimited, Trout Unlimited) foster habitat improvement projects and collaborate with land owners to install beneficial projects. If this recommendation is implemented, a detailed list of best management practices and relevant NGOs should be compiled and provided to landowners.

6. **Ensure proper implementation of the aquatic plant management plan** described earlier in this chapter (see "Issue 1: Aquatic Plant Management" section)—specifically as it relates to avoiding inadvertent damage to native species—should be considered a high priority.

7. **Preserve and expand wetland and terrestrial wildlife habitat, while making efforts to ensure connectivity between these natural areas.** This could be achieved through implementation of the buffer and wetland protection recommendations provided in the "Issue 2: Water Quality" section of this chapter. Benefit could also be accrued by reconnecting floodplains to ditched and straightened tributary streams. These reconnected floodplains detain floodwater, may enable groundwater recharge, and provide seasonally wet areas that are of great value for a wide range of birds, fish, amphibians, insects, and terrestrial animals. This should be assigned a high priority.

8. **Work closely with the Walworth County Public Works Department to initiate management of cormorant populations on Whitewater Lake Island.** This should be considered a medium priority, will help reduce the cormorant population to non-nuisance levels, and should help re-establish egret nesting. A USDA APHIS permit will need to be obtained for cormorant management.

9. **Track species diversity and abundance.** In general, tracking the diversity and abundance of fish and wildlife will help future Lake managers detect change. Consequently, **continued monitoring of fish populations and periodic recording of the types of animals found on and in the Lakes and within their watersheds** is also a high priority. Monitoring **data can be collected from government agencies, non-governmental organizations (e.g., Audubon Society), and from volunteers** around the Lake and throughout the watershed.

ISSUE 8: PLAN IMPLEMENTATION

The methods to implement the plan vary with the type of recommendation made. For example, several important recommendations relate to municipal or county ordinance enforcement (e.g., shoreline setbacks, zoning, construction site erosion control, drainage, and boating). Such agencies often have limited resources at their disposal to assure rules are respected and properly applied. Consequently, the following recommendations are aimed at local citizens and management groups, and are made to enhance the ability of the responsible entities to succesfully monitor and enforce existing regulations. **These tasks should be considered central to the WRLMD's mission.**

1. **Maintain and enhance relationships with County and municipal zoning administrators and law enforcement officers.** This helps build open relationships with responsible entities and facilitates efficient communication and collaboration whenever needed. High priority.

2. **Keep abreast of activities within the watershed** (e.g., construction, filling, erosion) that have the potential to affect the Lakes, **maintain good records (e.g., notes, photographs)**, and judiciously notify relevant regulatory entities of problems whenever appropriate. High priority.

3. **Educate watershed residents about relevant ordinances and update ordinances as necessary to face evolving use problems and threats.** This will help ensure that residents know why these rules are important, that permits are required for almost all significant grading or construction, and that such permits offer opportunities to regulate activities that could harm the Lakes. High priority.

In addition to regulatory enforcement, a number of voluntary and/or incentive-based programs can be considered, all of which focus on proactive efforts to protect and manage the Lake.

A number of factors commonly hinder local citizens and management groups from effectively executing lake management projects. Consequently, the following suggestions are offered to enhance project execution:

4. **Apply for grants, when available,** to support implementation of programs recommended under this plan (Appendix L). This should be considered a high priority. This process requires coordination, creativity, and investment of stakeholder time to be effective. Table 30 provides a list of grant application opportunities that can potentially be used to implement plan recommendations.

5. **Encourage Lake users and residents to actively participate in future management efforts.** Not only does this effort help assure community support, but also supplements the donor and volunteer pool working toward improving the Lakes. This should be considered a medium priority. This should include cooperation with The Greater Whitewater Lake Property Owners Association and volunteer groups (e.g., Boy Scout troops, NGOs, church groups). Broad-based resident engagement on future efforts benefits the Lakes but also benefit the economic value of their properties.

6. **Encourage key players to attend meetings, conferences, and/or training programs to build their lake management knowledge** and to enhance institutional knowledge and capacity. In recognition of limits on financial resources and time available for such activities, this element is assigned a medium priority. Some examples of capacity-building events are the Wisconsin Lakes Conference (which targets local lake managers) and the "Lake Leaders" training program (which teaches the basics of lake management and provides ongoing resources to lake managers). Both of these are hosted by the University of Wisconsin-Extension. Additionally, in-person and on-line courses, workshops, training, regional summits, and general meetings can also be of value. Attendance at these events should include follow-up documents/meetings to help assure that the lessons learned are communicated to the larger Lakes group.

7. **Continue to reinforce stakeholder inclusivity and transparency with respect to all Lake management activities.** If stakeholders do not fully understand the aims and goals of a project, or if they do not trust the process, excess energy can be devoted to conflict, a result that benefits no one. For this reason, this element is assigned high priority. These efforts should be implemented through public meetings, social media, newsletters, emails, and any other mechanism that helps disperse and gather a full suite of information and builds consensus. In this way, all data and viewpoints can be identified and considered, and conflicts can be discussed, addressed, and mitigated prior to finalizing plans and implementing projects.

8. **Foster and monitor efforts to communicate concerns, goals, actions, and achievements to future Lake managers.** Institutional knowledge is a powerful tool that should be preserved whenever possible. Actions associated with this are sometimes embedded in organization bylaws (e.g., minutes), and are therefore assigned high priority. Open communication helps further increase the capacity of Lake management entities. This may take the form of annual meetings, internet websites, social media, newsletters, emails, reports and any number of other means that help compile and report actions, plans, successes, and lessons learned. These records should be kept for future generations.

Additionally, as discussed in Chapter II, a major recommendation that should be considered a high priority is the **creation of an action plan which highlights action items, timelines, goals, and responsible parties.** This document will help ensure that the plan recommendations are implemented in a timely, comprehensive, transparent, and effective manner. Additionally, an action plan can help ensure that all responsible parties are held accountable for their portions of the plan's implementation.

As a final note, a major recommendation to promote implementation of this plan is educating Lake residents, users, and governing bodies on the content of this plan. A campaign to communicate the relevant information in the plan should therefore be given a high priority.

SUMMARY AND CONCLUSIONS

The future is expected to bring change to Whitewater and Rice Lakes and their watersheds. Projections suggest that some of the agricultural land use in the watershed of today will give way to urban residential land use. It is critical that proactive measures be actively pursued that lay the groundwork for effectively dealing with and benefiting from future change. Working relationships with appropriate local, County, and State entities need to be nurtured now and in the future to help protect critical natural areas in the watershed during development, to initiate actions (such as residential street leaf litter pickup and disposal), and to instill attitudes among current and future residents that will foster cooperation and coordination of effort on many levels.

To help implement plan recommendations, Table 31 summarizes all recommendations and their priority level. Additionally, Maps 32 and 33, in combination with the aquatic plant management recommendation map (see Figures 56 and 57), indicate where recommendations should be implemented. These maps will provide current and future Whitewater and Rice Lake managers with a visual overview of where to target management efforts.

As stated in the introduction, this chapter is intended to stimulate ideas and action. The recommendations should, therefore, provide a starting point for addressing the issues that have been identified in Whitewater and Rice Lakes and their watersheds. Successful implementation of the plan will require vigilance, cooperation, and enthusiasm, not only from local management groups, but also from State and regional agencies, Walworth County, municipalities, and Lake residents. The recommended measures will provide the water quality and habitat protection necessary to maintain and establish conditions in the watershed that are suitable for maintaining and improveing of the natural beauty and ambience of Whitewater and Rice Lakes and their ecosystems and the enjoyment of their human population today and in the future.

Table 31

SUMMARY OF RECOMMENDATIONS

Number	Recommendations	Suggested Priority Level
ISSUE 1: AQUATIC PLANT MANAGEMENT		
Plant Management Recommendations – Whitewater Lake		
1	Harvest aquatic plants to create navigation and access lanes in Whitewater Lake	
a	Leave more than one foot of plant material at Lake bottom while harvesting	HIGH
b	Inspect all cut plants for live animals	MEDIUM
c	Do not harvest in early spring to avoid disturbing fish spawning	HIGH
d	All harvester operators must successfully complete formal training to assure adherence to harvesting permit specifications and limitation	HIGH
e	Include comprehensive plant pickup program	HIGH
f	Collect and dispose harvested plants at designated disposal sites	HIGH
g	Record mass or volume of harvested plants	HIGH
2	Hand-pull and/or rake nuisance plant growth in near-shore areas	MEDIUM
3	Implement suction harvesting (DASH) to help control Eurasian and hybrid water milfoil populations	MEDIUM
4	Use biological measures of control when commercially available after investigating effectiveness	LOW
5	Early spring navigational shoreline chemical treatment for Eurasian and hybrid water milfoil and curly-leaf pondweed to early spring and conduct chemical residue monitoring when chemical treatment occurs	HIGH
6	Mid-summer navigational chemical and/or DASH shoreline treatment if native plants become a nuisance and create navigation concerns	MEDIUM
7	Whole-lake chemical treatment of Whitewater Lake to control Eurasian and hybrid water milfoil and curly-leaf pondweed if permit application is completed by the WRLMD and approved by the WDNR	MEDIUM
8	Reevaluate aquatic plant management plant every five years	HIGH
Native Plant Community and Invasive Species Recommendations		
1	Protect native aquatic plants to the highest degree feasible	HIGH
2	Manage invasive species to reduce stress on native species	HIGH
3	Avoid disturbing lake bottom sediment or leaving large areas devoid of vegetation to reduce spread of EWM	HIGH
4	Implement invasive species control methods as early as practical in the spring to help minimize damage to native aquatic plants	HIGH
5	Prevent introduction on new invasive species	
a	Educate residents how they can help prevent invasive species from entering their lake	HIGH
b	Enroll in Clean Boats Clean Waters program	HIGH
c	Target boat launch sites for aquatic plant control	HIGH
d	Participate in citizen monitoring for new invasive species through Wisconsin Citizen Lake Monitoring Network	HIGH
	Implement “Issue 2: Water Quality” recommendations to reduce the conditions that encourage aquatic plant growth	HIGH

Table 31 (continued)

Number	Recommendations	Suggested Priority Level
ISSUE 2: WATER QUALITY		
1	Re-establish a comprehensive water quality monitoring program covering Rice Lake and continue and enhance the comprehensive water quality monitoring effort on Whitewater Lake	HIGH
2	Manage in-lake phosphorus sources	
a	Remove nutrients through aquatic plant harvesting	HIGH
b	Promote muskgrass growth	HIGH
c	Control common carp population	HIGH (Rice) MEDIUM (Whitewater
d	Chemical inactivation	LOW
e	Hypolimnetic withdrawal and on-shore treatment	LOW
3	Maintain healthy and robust native aquatic plant populations	HIGH
4	Protect and enhance buffers, wetlands, and floodplains	HIGH
5	Monitor and actively manage woodlands	MEDIUM
6	Encourage pollution reduction efforts along the shorelines (best management practices)	HIGH
7	Stringently enforce construction site erosion control and stormwater management ordinances	MEDIUM (HIGH during major construction)
8	Maintain septic systems	
ISSUE 3: CYANOBACTERIA AND FLOATING ALGAE		
1	Reduce phosphorus concentrations	HIGH
2	Monitor algae in the Lakes	HIGH
3	Warn residents not to enter the water in the event of an algal bloom unless blooms is identified as non-toxic	HIGH
4	Maintain and improve water quality through implementing of “Issue 2: Water Quality” recommendations to reduce the conditions that encourage algae growth	HIGH
5	Maintain a healthy aquatic plant community through implementing of “Issue 1: Aquatic Plant Management” to compete with algal growth	HIGH
6	Reevaluate management efforts if future monitoring reveals excessive or greatly increased algal growth, or should toxic algae be identified	HIGH
ISSUE 4: BOG REMOVAL IN WHITEWATER LAKE		
1	Maintain and extend current permits and activities for bog removal until complete removal is achieved	HIGH
2	Conduct an underwater survey to assess total coverage of the bog to estimate rate of success and time needed to remove bog entirely	MEDIUM
ISSUE 5: GROUNDWATER RECHARGE		
1	Monitor lake water levels on both Lakes	MEDIUM
2	Implement measure to promote infiltration	MEDIUM
3	Reduce the impact of future urban development	HIGH
4	Continue to protect wetlands and uplands by enforcing County zoning and drainage ordinances	HIGH
5	Periodically reevaluate groundwater recharge management recommendations	HIGH
ISSUE 6: RECREATION		
1	Maintain and enhance boat access by implementing harvesting recommendations in “Issue 1: Aquatic Plant Management”	HIGH
2	Maintain and enhance swimming through engaging in “swimmer-conscious” management efforts	HIGH
3	Maintain and enhance fishing by protecting and improving aquatic habitat and ensuring the fish community remains viable by implementing recommendations in “Issue 7: Fish and Wildlife”	HIGH

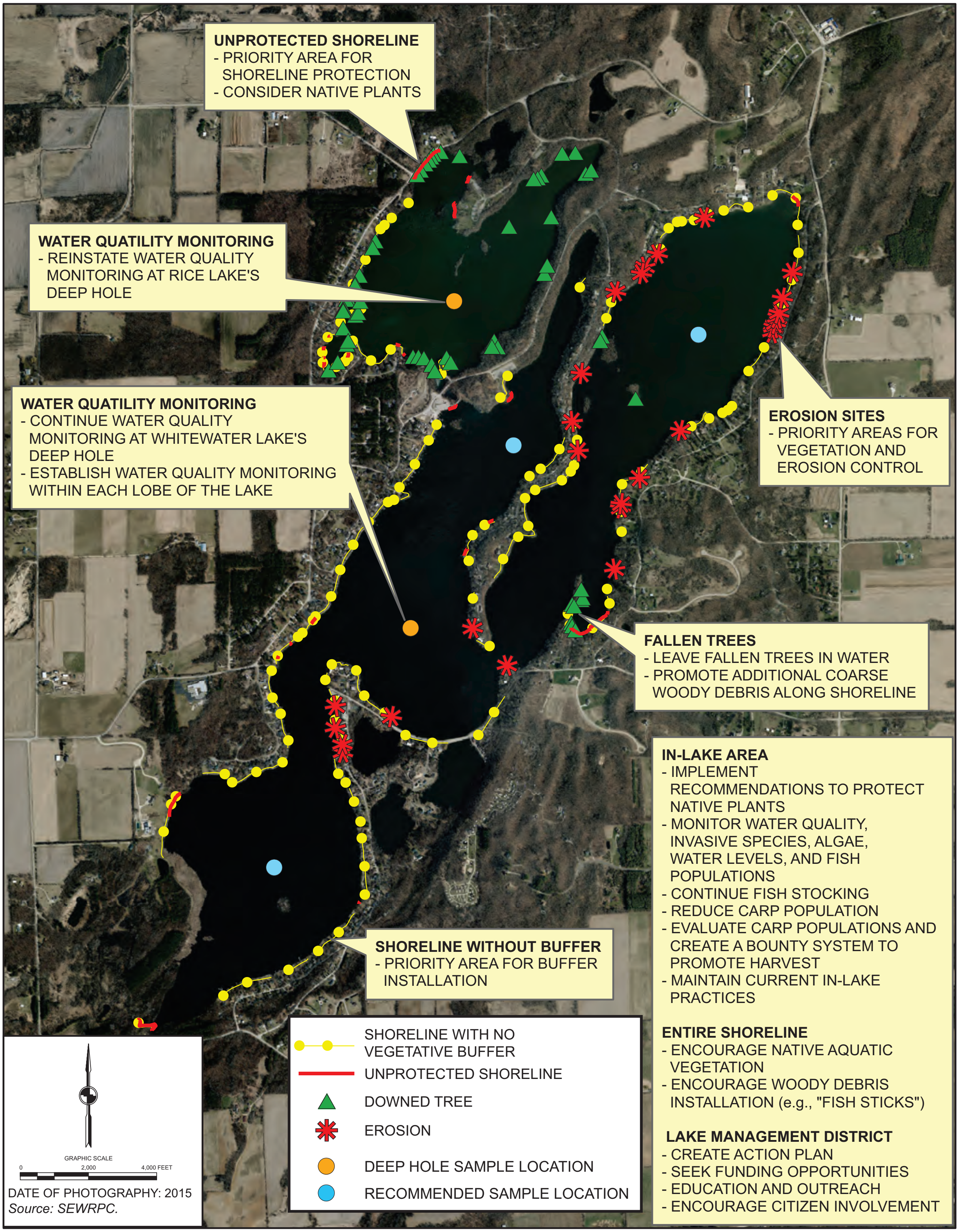
Table 31 (continued)

Number	Recommendations	Suggested Priority Level
ISSUE 7: FISH AND WILDLIFE		
1	Continue current fish stocking and promote self-sustaining populations	HIGH
2	Improve aquatic habitat in the Lakes by retaining or installing woody structure and/or vegetative buffers along the Lakes' edge	HIGH
3	Mitigate water quality stress on aquatic life and maximize habitable areas	HIGH
4	REDUCE CARP POPULATIONS	HIGH
a	Population estimates and congregation area identification	
	Rice Lake	HIGH
	Whitewater Lake	MEDIUM
b	Netting - Rice Lake	HIGH
c	Netting - Whitewater Lake	MEDIUM
d	Spawning Migration Barriers	LOW
e	Increase young-carp predator populations	HIGH
5	Adopt best management practices to improve wildlife habitat	MEDIUM (HIGH if wildlife populations decline)
6	Ensure proper implementation of the aquatic plant management plan to avoid inadvertent damage to native aquatic plant species	HIGH
7	Preserve and expand wetland and terrestrial wildlife habitat, while making efforts to ensure between these natural areas	HIGH
8	Work closely with Walworth County Public Works to initiate management of cormorant populations on Whitewater Lake Island	MEDIUM
9	Track species diversity and abundance	HIGH
ISSUE 8: PLAN IMPLEMENTATION		
1	Maintain and enhance relationships with County and municipal zoning administrators as well as law enforcement officers	HIGH
2	Keep abreast of activities within the watershed and maintain good records	HIGH
3	Educate watershed residents about relevant ordinances and update ordinances as necessary to face evolving use problems and threats	HIGH
4	Apply for grants when available	HIGH
5	Encourage Lake users and residents to actively participate in future management efforts	MEDIUM
6	Encourage key players to attend meetings, conferences, and/or training programs to build their lake management knowledge	MEDIUM
7	Continue to reinforce stakeholder inclusivity and transparency with respect to all Lake management activities	HIGH
8	Foster and monitor efforts to communicate concerns, goals, actions, and achievements to future Lake managers	HIGH
9	Create an action plan	HIGH
10	Educate Lake residents, users and governing bodies on the content of this plan	HIGH

Source: SEWRPC.

Map 33

SELECTED IN-LAKE, SHORELINE, AND INSTITUTIONAL RECOMMENDATIONS, WHITEWATER AND RICE LAKES



APPENDICES

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Appendix A

WHITEWATER AND RICE LAKES
AQUATIC PLANT SPECIES DETAILS

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Figure A-1

RAKE FULLNESS RATINGS

Source: Wisconsin Department of Natural Resources and SEWRPC.

SOURCES OF INFORMATION:

Borman, S., Korth, R., & Temte, J. (2014). *Through the Looking Glass: A Field Guide to Aquatic Plants, Second Edition.* Stevens Point, WI, USA: Wisconsin Lakes Partnership.

Robert W. Freckman Herbarium: *http://wisplants.uwsp.edu*

Skawinski, P. M. (2014). *Aquatic Plants of the Upper Midwest: A Photographic Field Guide to Our Underwater Forests, Second Edition*. Wausau, Wisconsin, USA: Self-Published.

University of Michigan Herbarium: *http://www.michiganflora.net/home.aspx*

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WHITEWATER LAKE

Note: Aquatic plant species found in more than one year of plant surveying have map distributions from both years shown. Species found only during one year of plant surveying have only one distribution map.

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Ceratophyllum demersum
Native

Coontail

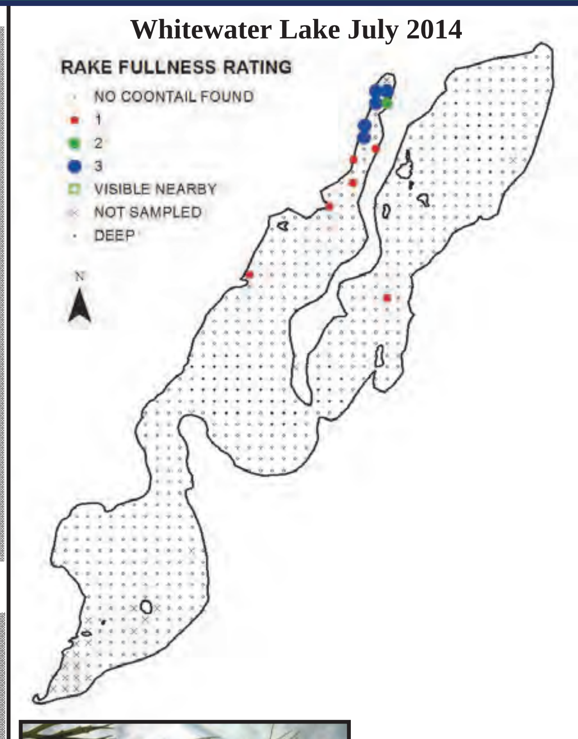
Identifying Features

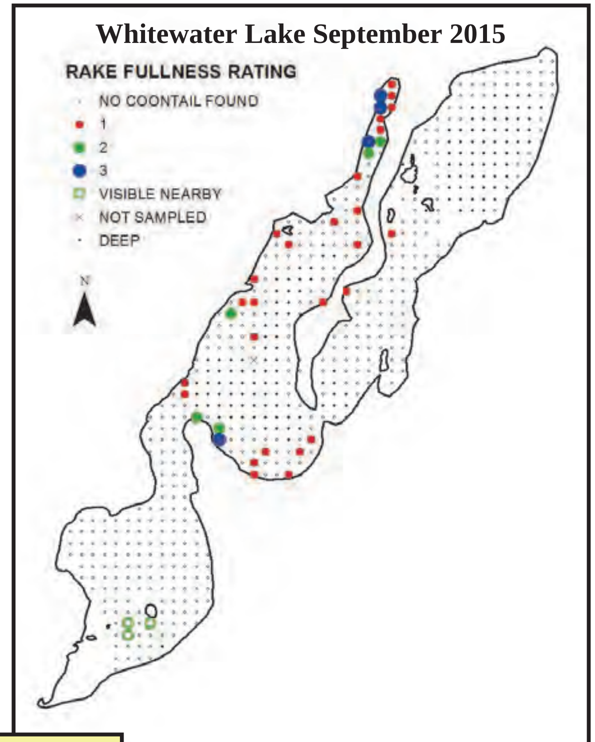
- Often bushy near tips of branches, giving the raccoon tail-like appearance ("coontail")
- Whorled leaves with one to two orders of branching and small teeth on their margins
- Flowers (rare) small and produced in leaf axils

Coontail is similar to spiny hornwort (*C. echinatum*) and muskgrass (*Chara* spp.), but spiny hornwort has some leaves with three to four orders of branching, and coontail does not produce the distinct garlic-like odor of muskgrass when crushed

Ecology

- Common in lakes and streams, both shallow and deep
- Tolerates poor water quality (high nutrients, chemical pollutants) and disturbed conditions
- Stores energy as oils, which can produce slicks
on the water surface when plants decay
- Anchors to the substrate with pale, modified leaves rather than roots
- Eaten by waterfowl, turtles, carp, and muskrat





Second-Order Leaf

First-Order Leaf Branching

Toothed Leaf Margins

Chara spp.
Native

Muskgrasses
Algae (not vascular plants)

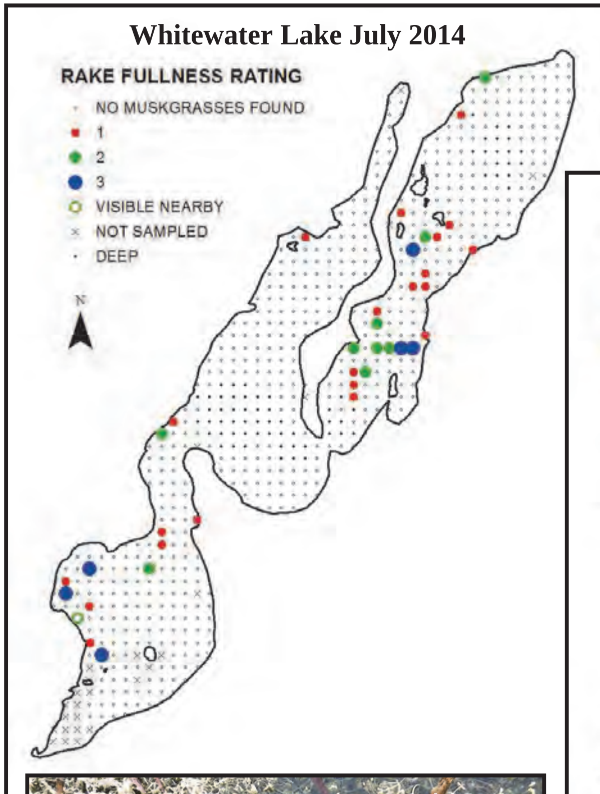
Identifying Features

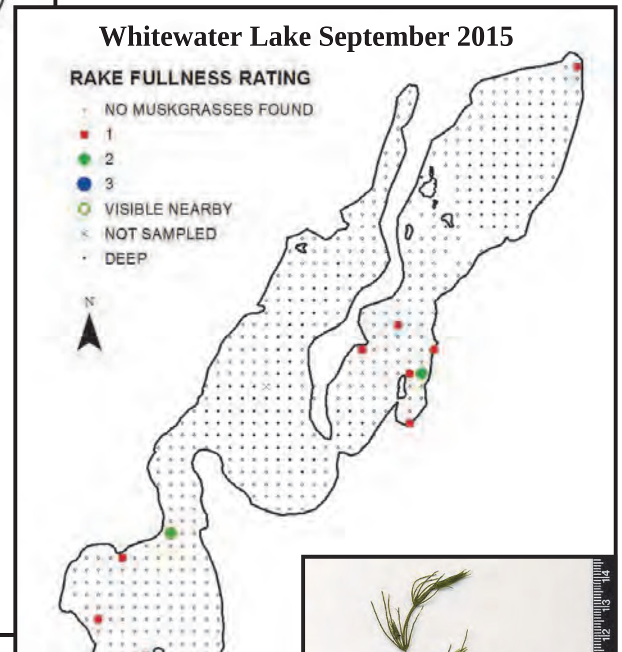
- Leaf-like, ridged side branches develop in whorls of six or more
- Often encrusted with calcium carbonate, which appears white upon drying (see photo on left, below)
- Yellow reproductive structures develop along the whorled branches in summer
- Emits a garlic-like odor when crushed

Stoneworts (*Nitella* spp.) are similar large algae, but their branches are smooth rather than ridged and more delicate

Ecology

- Found in shallow or deep water over marl or silt, often growing in large colonies in hard water
- Overwinters as rhizoids (cells modified to act as roots) or fragments
- Stabilizes bottom sediments, often among the first species to colonize open areas
- Food for waterfowl and excellent habitat for small fish



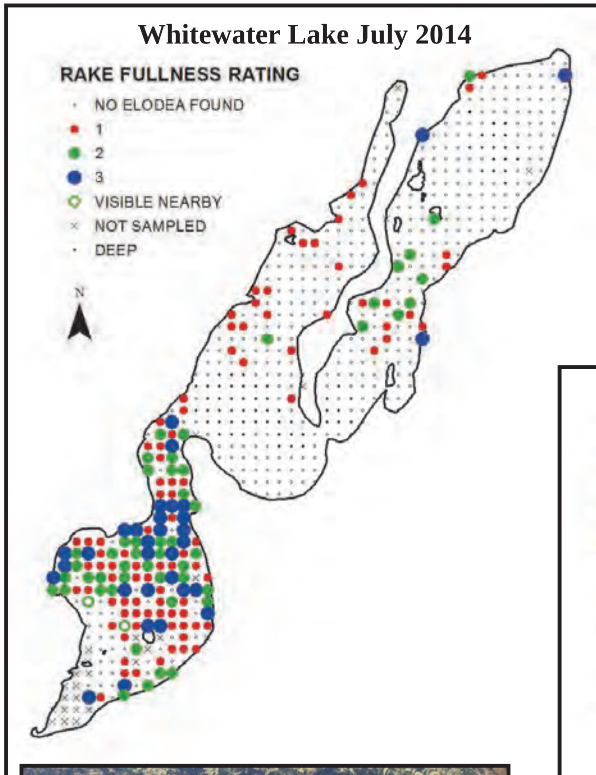


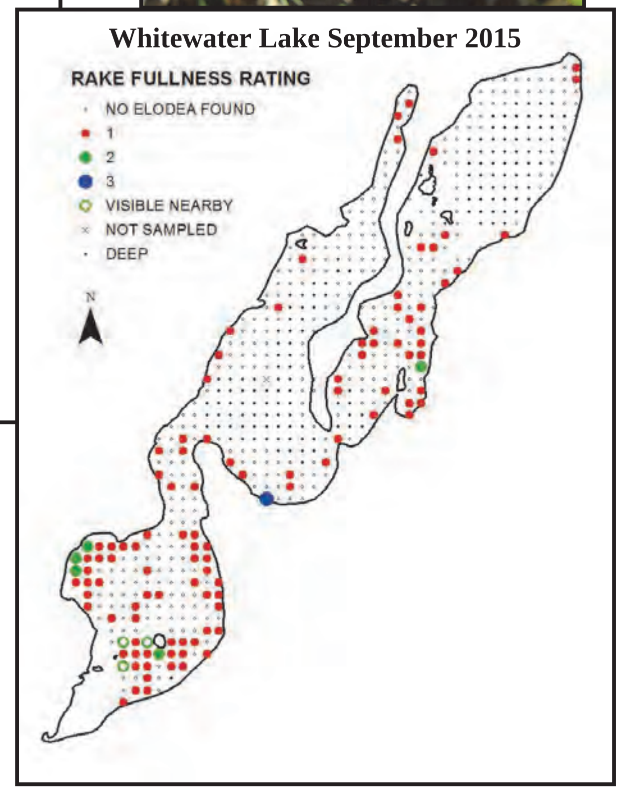
Elodea canadensis
Native

Common Waterweed

Identifying Features

- Slender stems, occasionally rooting
- Leaves lance-shaped, in whorls of three (rarely
  two or four), 6.0 to 17 mm long and averaging 2.0 mm wide
- When present, tiny male and female flowers on separate plants (females more common), raised
  to the surface on thread-like stalks





Ecology

- Found in lakes and streams over soft substrates tolerating pollution, eutrophication and disturbed conditions
- Often overwinters under the ice
- Produces seeds only rarely, spreading primarily
  via stem fragments
- Provides food for muskrat and waterfowl
- Habitat for fish or invertebrates, although dense stands can obstruct fish movement

Heteranthera dubia — Water Stargrass

Native

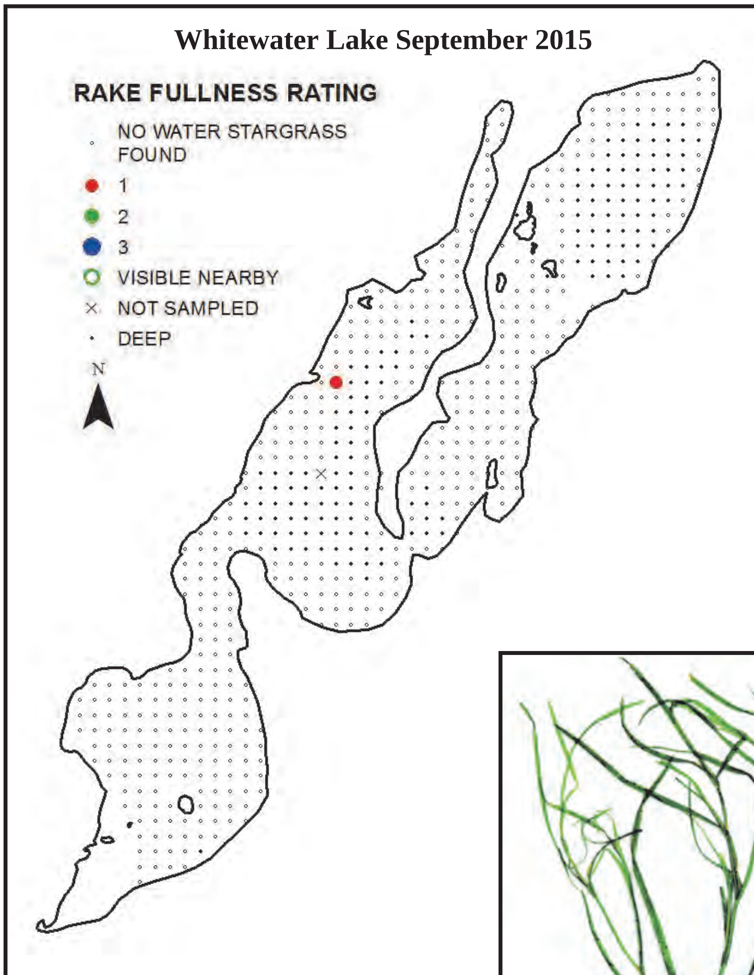
Identifying Features

- Stems slender, slightly flattened, and branching
- Leaves narrow, alternate, with no stalk, and lacking a prominent midvein
- When produced, flowers conspicuous, yellow, and star-shaped (usually in shallow water) or inconspicuous and hidden in the bases of submersed leaves (in deeper water)

Yellow stargrass may be confused with pondweeds that have narrow leaves, but it is easily distinguished by its lack of a prominent midvein and, when present, yellow blossoms

Ecology

- Found in lakes and streams, shallow and deep
- Tolerates somewhat turbid waters
- Overwinters as perennial rhizomes
- Limited reproduction by seed
- Provides food for waterfowl and habitat for fish



Myriophyllum spicatum

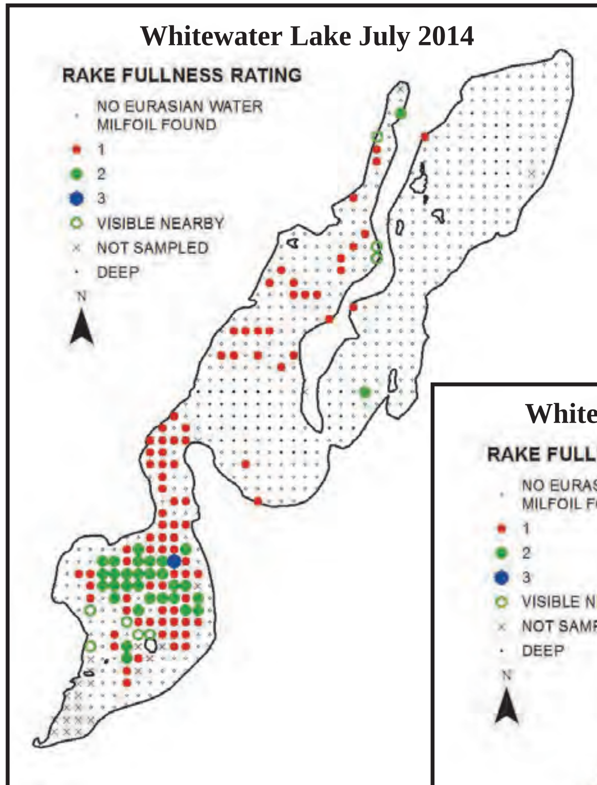
Nonnative/Exotic

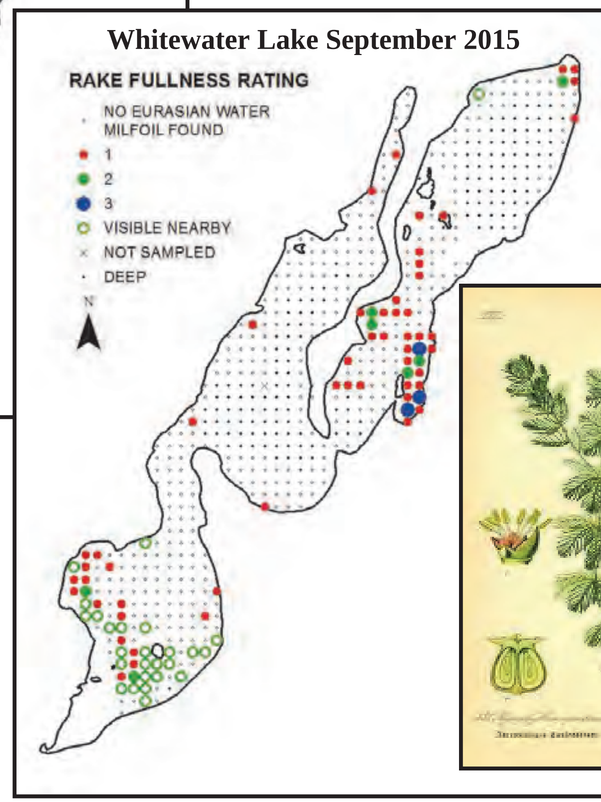
Eurasian Water Milfoil

Identifying Features

- Stems spaghetti-like, often pinkish, growing long with many branches near the water surface
- Leaves with 12 to 21 pairs of leaflets
- Produces no winter buds (turions)

Eurasian water milfoil is similar to northern water milfoil (*M. sibiricum*). However, northern water
milfoil has five to 12 pairs of leaflets per leaf and stouter white or pale brown stems





Ecology

- Hybridizes with northern (native) water milfoil, resulting in plants with intermediate characteristics
- Invasive, growing quickly, forming canopies, and getting a head-start in spring due to an ability to grow in cool water
- Grows from root stalks and stem fragments in both lakes and streams, shallow and deep; tolerates disturbed conditions
- Provides some forage to waterfowl, but supports fewer aquatic invertebrates than mixed stands of aquatic vegetation

Najas guadalupensis — Southern Naiad

Native

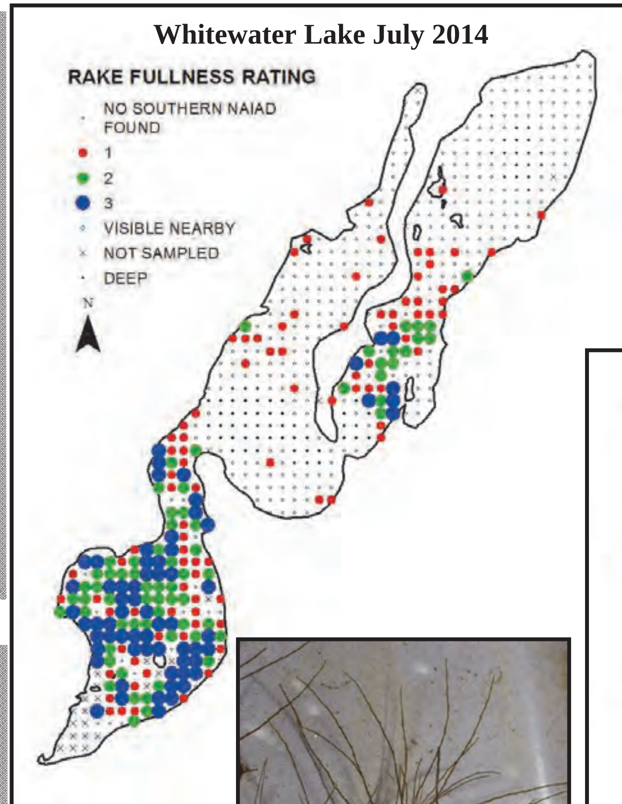
Identifying Features

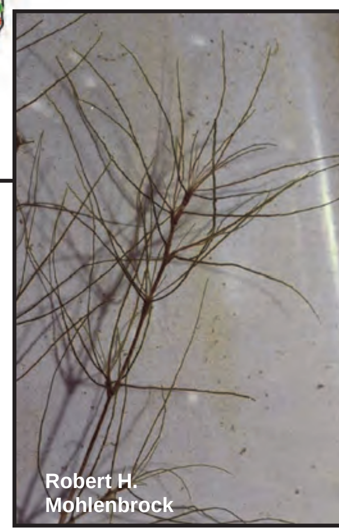
- Leaves 0.2 to 2.0 mm wide and blunt with slight shoulder bases where they attach to the stem
  and finely serrated margins
- Flowers, when present, tiny and located in leaf axils
- Leaves opposite and may appear loosely whorled

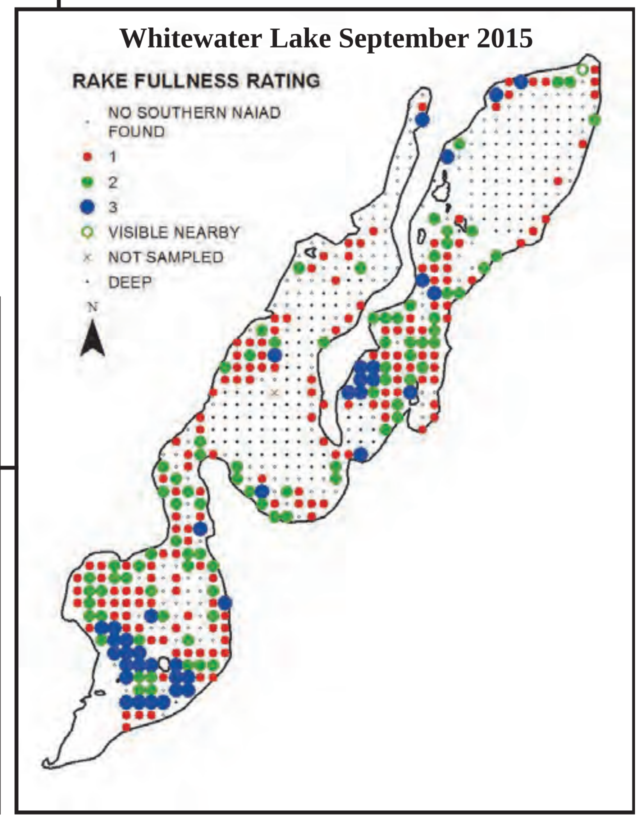
Two other *Najas* occur in southeastern Wisconsin. Slender naiad (*N. flexilis*) has narrower leaves (to 0.6 mm) with a pointed tip. Spiny naiad (*N. marina*) has coarsely toothed leaves with spines along the midvein below

Ecology

- In shallow to deep lakes and sandy, gravelly soil
- An annual plant that completely dies back in fall and regenerates from seeds each spring; also spreading by stem fragments during the growing season







Nitella spp.

Native

Nitellas (Stoneworts)

Algae (not vascular plants)

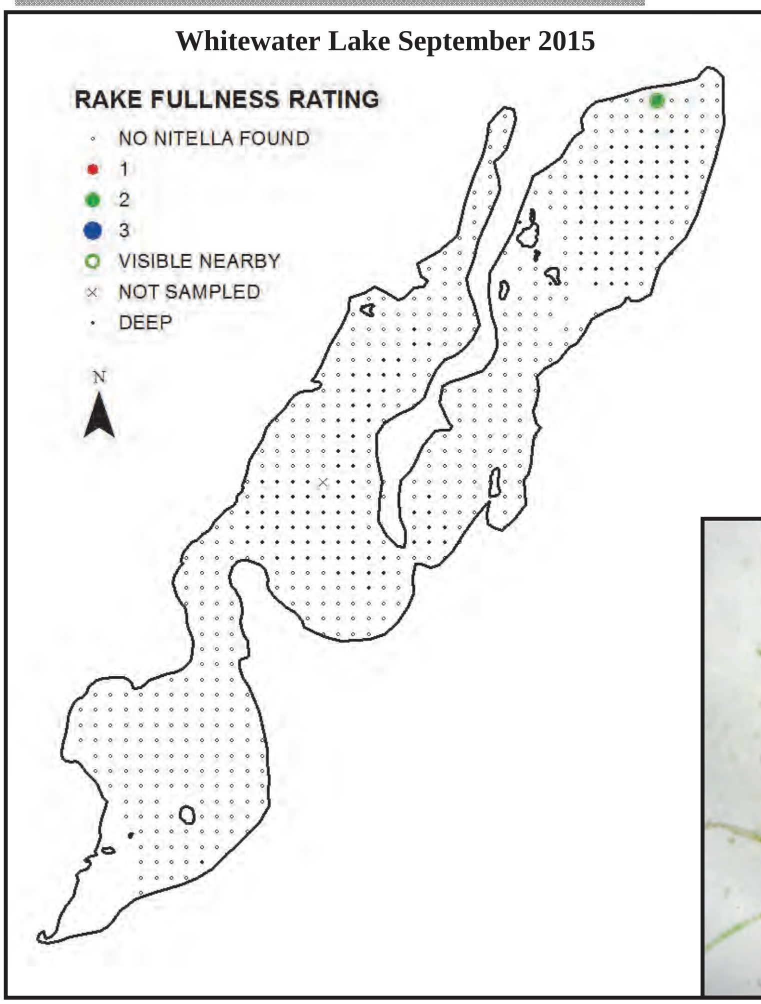
Identifying Features

- Stems and leaf-like side branches delicate and smooth, side branches arranged in whorls
- Bright green
- Reproductive structures developing along the whorled branches

Muskgrasses (*Chara* spp.) are large algae similar to stoneworts (*Nitella* spp.), but their branches are ridged and more robust than those of stoneworts. Another similar group of algae, *Nitellopsis* spp., differ from stoneworts by having whorls of side branches that are at more acute angles to the main stem and star-shaped, pale bulbils that, when present, are near where side branches meet the main stem

Ecology

- Often found in deep lake waters over soft sediments
- Overwinters as rhizoids (cells modified to act as roots) or fragments
- Habitat for invertebrates, creating foraging opportunities for fish
- Sometimes browsed upon by waterfowl



Potamogeton crispus — Curly-Leaf Pondweed

Nonnative/Exotic

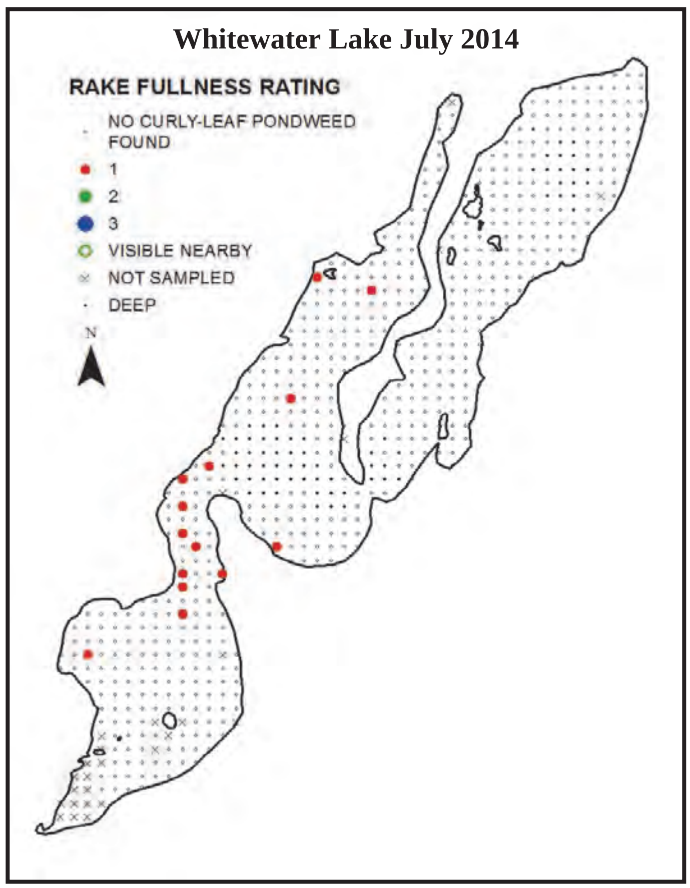
Identifying Features

- Stems slightly flattened and both stem and leaf veins often somewhat pink
- Leaf margins very wavy and finely serrated
- Stipules (3.0 to 8.0 mm long) partially attached to leaf bases, disintegrating early in the season
- Produces pine cone-like overwintering buds (turions)

Curly-leaf pondweed may resemble clasping-leaf pondweed (*P. richardsonii*), but the leaf margins of the latter are not serrated

Ecology

- Found in lakes and streams, both shallow and deep
- Tolerant of low light and turbidity
- Disperses mainly by turions
- Adapted to cold water, growing under the ice while other plants are dormant, but dying back during mid-summer in warm waters
- Produces winter habitat, but mid-summer die-offs can degrade water quality and cause algal blooms
- Maintaining or improving water quality can help control this species, because it has a competitive advantage over native species when water clarity is poor



Potamogeton pusillus — Small Pondweed

Native

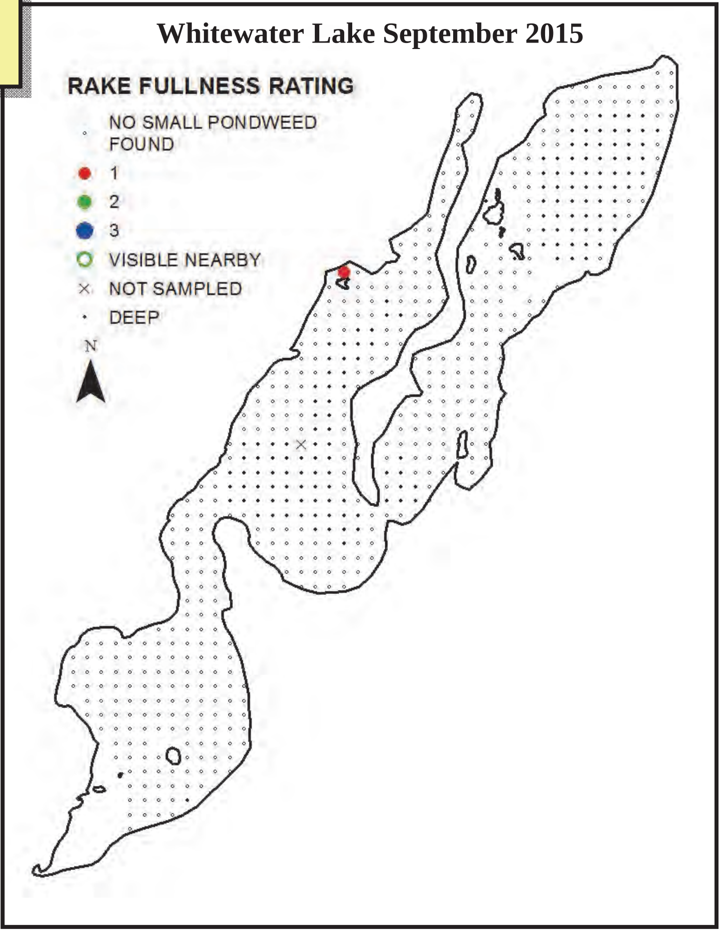
Identifying Features

- Narrow, submersed leaves (1-7 cm long and 0.2-2.5 mm wide), attaching directly to the stem, with 3 veins, leaf tips blunt or pointed, and often with raised glands where the leaf attaches to the stem
- Produces no floating leaves
- Numerous winter buds (turions) produced with rolled, inner leaves resembling cigars
- Flowers and fruits produced in whorls spaced along slender stalk

Small pondweed is similar to leafy pondweed (*P. foliosus*), when not in flower and fruit. However, unlike leafy pondweed, it often has raised glands where the leaves meet the stem. The flowers and fruits of small pondweed are also borne on longer, more slender stalks and in whorls that are spaced apart.

Ecology

- Shallow or deep waters over soft sediments in lake and streams
- Overwinters as rhizomes or winter buds (turions)
- Food for waterfowl, muskrat, deer, and beaver
- Cover for invertebrates and fish



Stuckenia pectinata — Sago Pondweed

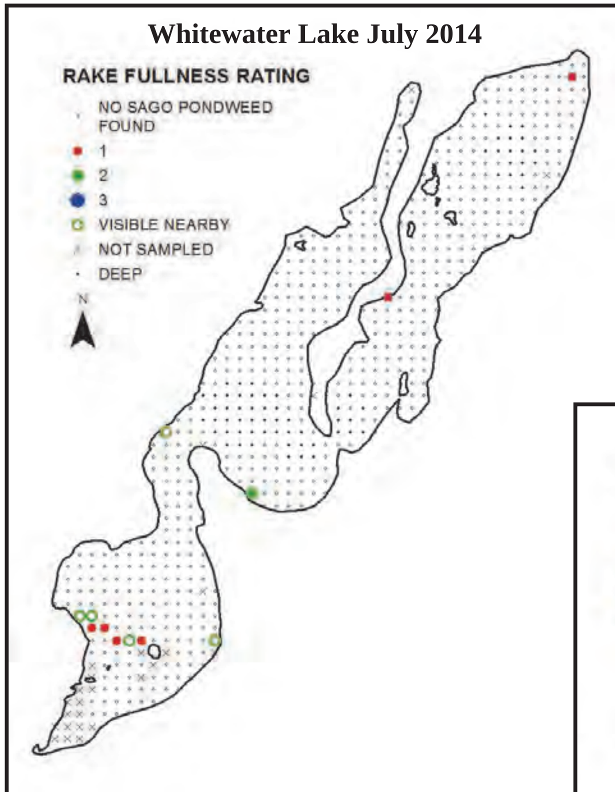
Native

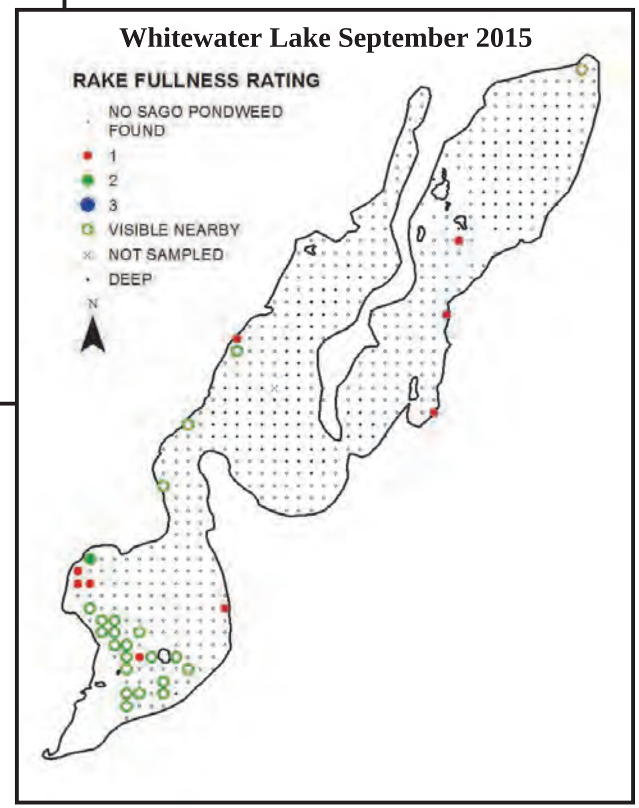
Identifying Features

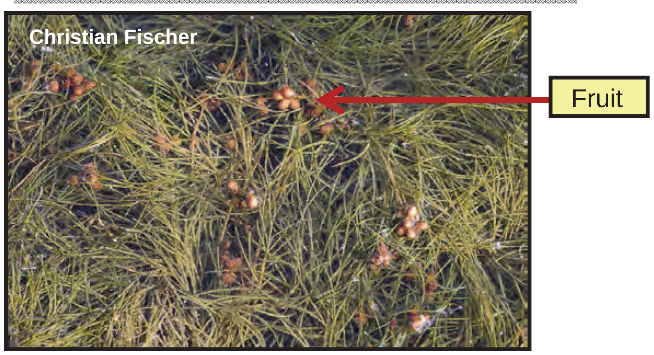
- Stems often *slightly zig-zagged* and forked multiple times, yielding a fan-like form
- Leaves one to four inches long, very thin, and ending in a sharp point
- Whorls of fruits spaced along the stem may appear as beads on a string

Ecology

- Lakes and streams
- Overwinters as rhizomes and starchy tubers
- Tolerates murky water and disturbed conditions
- Provides abundant fruits and tubers, which are an *important food for waterfowl*
- Provides habitat for juvenile fish







RICE LAKE

Note: Rice Lake was only surveyed by SEWRPC staff during the summer of 2014. WDNR staff did not survey Rice Lake during 2015..