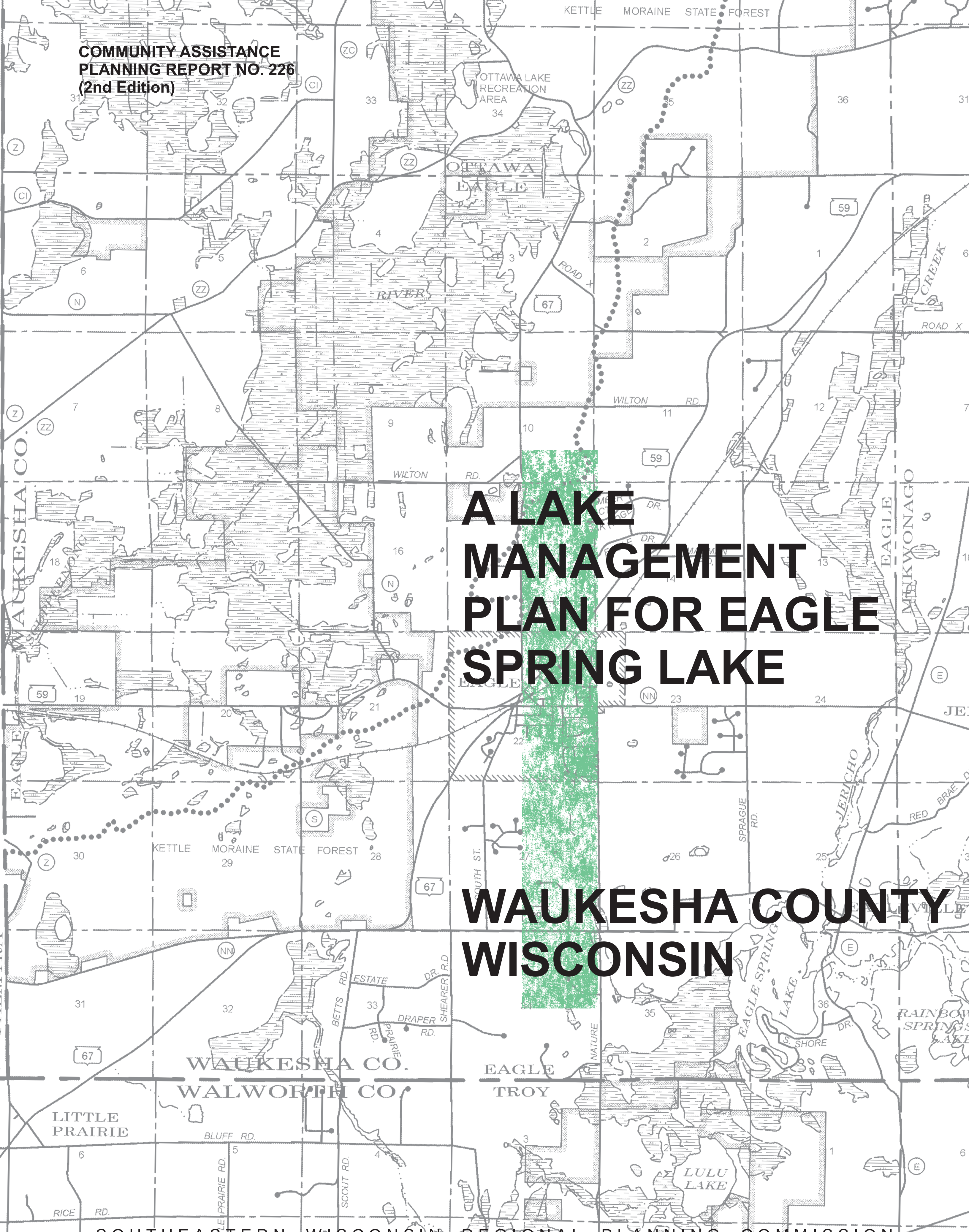
COMMUNITY ASSISTANCE
PLANNING REPORT NO. 226
(2nd Edition)

A LAKE MANAGEMENT PLAN FOR EAGLE SPRING LAKE

WAUKESHA COUNTY WISCONSIN



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WAUKESHA COUNTY WISCONSIN

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Chapter I

INTRODUCTION

Eagle Spring Lake is an impounded 279-acre[1] through-flow, or drainage, lake, located on the Mukwonago River within U.S. Public Land Survey Sections 25, 26, 35 and 36, Township 5 North, Range 17 East, in the Town of Eagle, Waukesha County. The Lake is fed and drained by the Mukwonago River, which forms an important tributary stream to the Fox [Illinois] River, joining the Fox River in the Village of Mukwonago, also in Waukesha County.

The Eagle Spring Lake community has undertaken an active program of lake protection and rehabilitation for many years. Seeking to improve the usability of Eagle Spring Lake and to prevent deterioration of the natural assets and recreational potential of the Lake, the residents concerned initially sought the creation of a Chapter 66, *Wisconsin Statutes*, town sanitary district, which, in 1990, was converted into the Eagle Spring Lake Management District (ESLMD), pursuant to provisions set forth in Chapter 33 of the *Wisconsin Statutes*. Since that time, the ESLMD has been actively involved in the process of lake management. The District undertook an extensive water quality monitoring program on Eagle Spring Lake in cooperation with the U.S. Geological Survey (USGS) beginning in the mid-1990s.[2] These data subsequently were used in the preparation of a comprehensive lake management plan for the Lake, developed for the District by the Southeastern Wisconsin Regional Planning Commission (SEWRPC) during 1997.[3]

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[1]*In the first edition of SEWRPC Community Assistance Planning Report No. 226,* A Lake Management Plan for Eagle Spring Lake, Waukesha County, Wisconsin*, published in October 1997, the area of Eagle Spring Lake was reported to be 311 acres. This acreage was determined by the Wisconsin Conservation Department (now the Wisconsin Department of Natural Resources) in 1969 using the U.S. Geological Survey 10-foot contour interval, 7.5 minute series topographic maps. The availability of two-foot contour interval, high-resolution orthophotography during 2007 resulted in the refinement of the surface area for Eagle Spring Lake and redelineation of the Lake's tributary drainage area.*

[2]*U.S. Geological Survey Water-Data Reports WI-91-1 through WI-96-2,* Water Resources Data–Wisconsin. *Water Year 1991 through Water Year 1996 published annually, March 1992 through March 1997; see also U.S. Geological Survey, Open-File Report No. 2004-1087,* Water-Quality and Lake-Stage Data for Wisconsin Lakes, Water Year 2003*, 2004.*

[3]*SEWRPC Community Assistance Planning Report No. 226,* A Lake Management Plan for Eagle Spring Lake, Waukesha County, Wisconsin*, October 1997.*

In addition to the foregoing monitoring and planning efforts, Eagle Spring Lake has been the subject of a number of other lake-oriented studies, including: those associated with the preparation of lake-specific plan elements within the regional water quality management plan,[4] and sewerage system facility plan,[5] and an in-lake sediment survey and watershed inventory.[6] The knowledge gained from all of these efforts not only contributed to the preparation of the aforereferenced comprehensive lake management plan for Eagle Spring Lake, but also supported the preparation of the lake-specific planning elements for the upper portions of the Mukwonago River that were utilized in the formulation of the Mukwonago River Protection Plan completed by SEWRPC in June 2010.[7]

As a result of this extensive data gathering effort, and consequent to the land use changes that have significantly altered the drainage area tributary to Eagle Spring Lake, beyond the levels considered in the initial SEWRPC plan, and considering the increasing concern about present and future impacts on the Lake and its ecosystem, the ESLMD resolved that a refined lake management plan be prepared for Eagle Spring Lake. The ESLMD Board of Commissioners were especially concerned that the refined lake management plan incorporate the extensive amount of new knowledge of the Lake and its watershed that had been acquired since the initial plan was completed.

This plan, consequently, seeks to address the need for an updated and refined, comprehensive lake management plan for Eagle Spring Lake. This planning effort also represents part of the ongoing commitment of the ESLMD to sound planning with respect to the Lake, and forms a logical complement to the lake management actions that have been implemented on and around the Lake. The refined plan was prepared by SEWRPC in cooperation with the ESLMD, and incorporates the data and analyses developed in the aforementioned lake and watershed management-related studies, pertinent water quality and other data gathered by the USGS and Wisconsin Department of Natural Resources (WDNR), and current land use and planning information generated through Wisconsin's comprehensive planning initiative.[8]

This report presents both land-based and in-lake measures for enhancing water quality conditions, maintaining the lake ecosystem, and providing opportunities for the safe and enjoyable use of Eagle Spring Lake by both community residents and its visitors. More specifically, this report updates and describes the physical, chemical, and biological characteristics of the Lake, and pertinent related characteristics of the tributary area, as well as the feasibility of various tributary area and in-lake management measures which might be applied to achieve these goals. To this end, the primary management objectives for Eagle Spring Lake include: 1) providing water quality suitable for the maintenance of fish and other aquatic life, 2) reducing the severity of existing concerns related to excessive macrophyte and algae growth and the presence of nonnative species which constrain or preclude intended water uses, and 3) improving opportunities for water-based recreational activities. The lake management

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[4]*SEWRPC Planning Report No. 30,* A Regional Water Quality Management Plan for Southeastern Wisconsin: 2000, *Volume Two,* Alternative Plans, *February 1979; see also, SEWRPC Memorandum Report No. 93,* A Regional Water Quality Management Plan for Southeastern Wisconsin: An Update and Status Report, *March 1995.*

[5]*Strand Associates, Inc.,* Environmental Information Document and Cost Effectiveness Analysis, Eagle Spring Lake Sanitary District, *October 1985.*

[6]*Swanson Environmental, Inc.,* Eagle Springs [sic] Lake Sediment Sampling and Analysis, *May 1990.*

[7]*SEWRPC Community Assistance Planning Report No. 309,* Mukwonago River Watershed Protection Plan, *June 2010.*

[8]*See Waukesha County Department of Parks and Land Use, Waukesha County University of Wisconsin-Extension, and Waukesha County Municipalities,* A Comprehensive Development Plan for Waukesha County, Waukesha County, Wisconsin, *February 2009.*

plan herein presented should constitute a practical guide for the management of Eagle Spring Lake and the lands which drain to this important body of water.

This plan summarizes the inventory data acquired since the publication of the initial comprehensive lake management plan for Eagle Spring Lake. These data form the basis for reviewing and refining the alternative lake management measures necessary to address current and future concerns identified both by the community and as a result of the data analysis and developing recommended management measures necessary to achieve the community goals in a sustainable manner. The inventory data include an overview of the Lake and its tributary area, a review of the governance structures currently in place surrounding the Lake, a summary of water quality, a summary of the Lake's aquatic biology, and a review of the water use objectives established for Eagle Spring Lake used to determine alternative and recommended plan elements for the management of the lake and its tributary area. A subset of these measures is recommended to address current and forecast future lake management issues relevant to Eagle Spring Lake. This plan conforms to the requirements of and standards set forth in the relevant *Wisconsin Administrative Codes.*[9]

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[9]*This plan has been prepared pursuant to the standards and requirements set forth in four chapters of the* Wisconsin Administrative Code: *Chapter NR 1, "Public Access Policy for Waterways;" Chapter NR 103, "Water Quality Standards for Wetlands;" Chapter NR 107, "Aquatic Plant Management;" and Chapter NR 109, "Aquatic Plants: Introduction, Manual Removal & Mechanical Control Regulations." The plan recommendations also are consistent with the requirements of the Chapter NR 198, "Aquatic Invasive Species Control Grants," and Chapter NR 7, "Recreational Boating Facilities Program."*

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Chapter II

PHYSICAL DESCRIPTION

INTRODUCTION

The physical characteristics of a lake and its tributary area are important factors in any evaluation of existing and likely future water quality conditions and lake uses, including recreational uses. Characteristics, such as tributary area topography, lake morphometry, and local hydrology, ultimately influence water quality conditions and the composition of the plant and fish communities within the lake. Therefore, these characteristics must be considered during the lake management planning process. Accordingly, this chapter provides pertinent information on the physical characteristics of Eagle Spring Lake, its tributary area, and on the climate and hydrology of the Eagle Spring Lake tributary area. Subsequent chapters deal with the land use conditions, and the chemical and biological environments of the Lake.

While the physical characteristics of the lake, its watershed, and its regional climate generally are considered to be relatively static during any given 20-year planning period, it is not unusual that new technologies and refined analyses of these attributes lead to changes in the information available. In the case of Eagle Spring Lake, as well as other lakes and their tributary watersheds in the Southeastern Wisconsin Region, these advances have included the availability of refined digital terrain modeling (DTMs) and its associated digital elevation mapping (DEMs). Such advances have enhanced the ability of the Southeastern Wisconsin Regional Planning Commission (SEWRPC) and its partners to identify lands draining to a specific waterbody, including identifying areas that may be internally drained and which do not regularly contribute to the hydrological condition of the subject waterbody. In the case of Eagle Spring Lake, advances in mapping have resulted in the generation of contour mapping at two-feet contour intervals which provide a level of topographic understanding that greatly exceeds that which was previously available, based upon 10-feet topographic contour intervals. As a consequence of this enhanced capability, the following descriptions of Eagle Spring Lake and its tributary area differ significantly from those presented in the initial comprehensive management plan for the Lake.

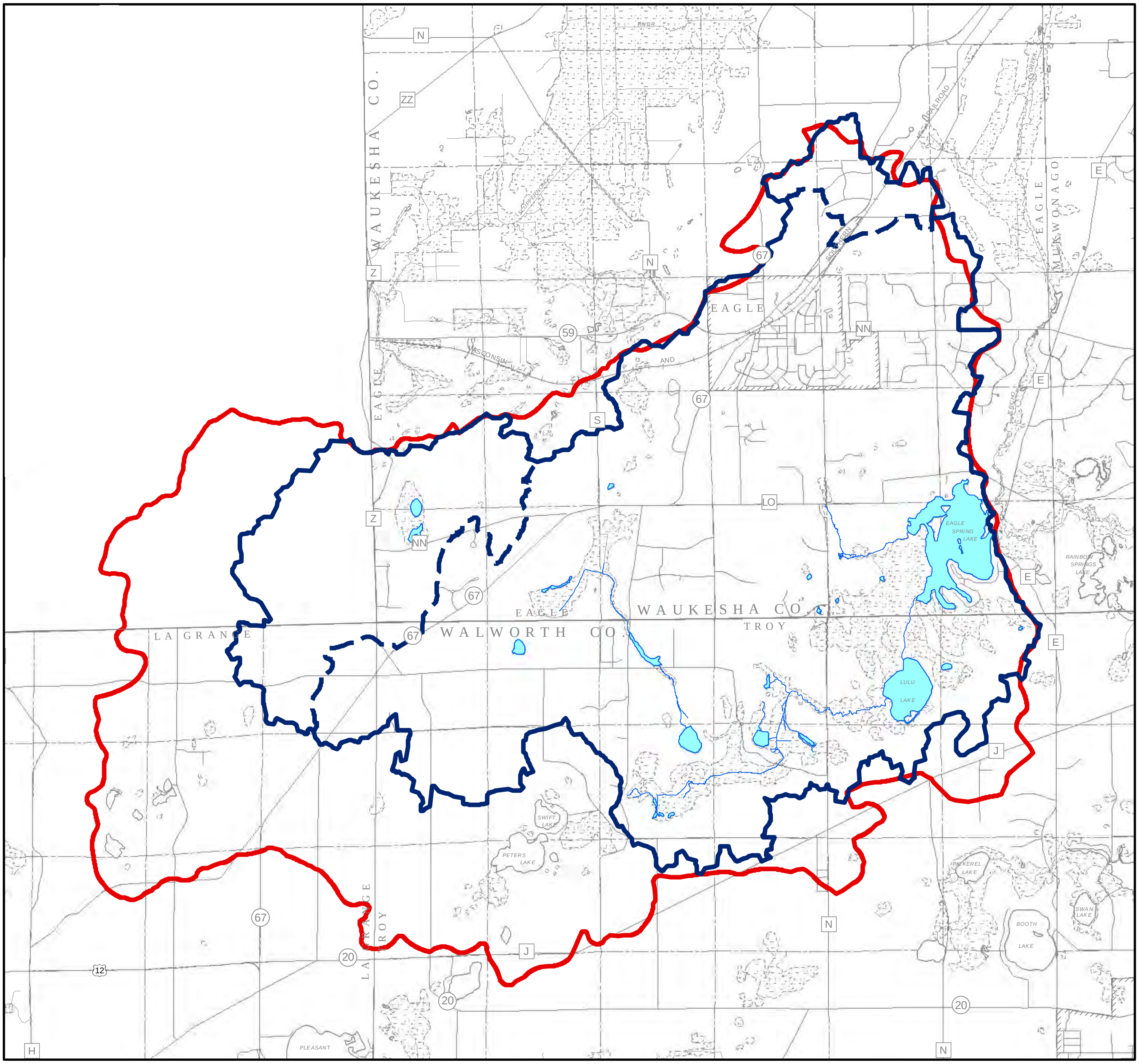
TRIBUTARY AREA CHARACTERISTICS

Geographic Extent of the Tributary Area

The tributary area to Eagle Spring Lake includes portions of southeastern Jefferson County, northeastern Walworth County, and southwestern Waukesha County in southeastern Wisconsin, as shown on Map 1. Based upon two-feet interval elevation contours generated from the 2005 Waukesha County DTM, the Commission staff estimated the drainage area tributary to Eagle Spring Lake to be 16,076 acres, which is 6,637 acres or 29 percent smaller than previously estimated. Additionally, of this total, a further 2,948 acres, including the portion of the total tributary area within Jefferson County, were determined to be internally drained and unlikely to contribute surface runoff to Eagle Spring Lake and the Mukwonago River Basin under most conditions. Table 1 summarizes the revised watershed area and other morphometric characteristics of Eagle Spring Lake and its watershed.

Map 1

HISTORIC AND CURRENT WATERSHED BOUNDARY TRIBUTARY TO EAGLE SPRING LAKE: 2008



Source: SEWRPC.

Table 1

COMPARISON OF HISTORIC AND CURRENT HYDROLOGY AND MORPHOMETRY OF EAGLE SPRING AND LULU LAKES: 1969-2005

Parameter	Eagle Spring Lake		Lulu Lake	
	1969	2005	1969	2005
Surface Area (acres)	310.5	279.2	84.26	95.5
Percent of Area Less than 3.0 Feet Deep	22	28 (78.3 acres)	10.1	10.8 (10.4 acres)
Percent of Area Greater than 6.0 Feet Deep	No data	13.3 (37.2 acres)	No data	78.6 (75.1 acres)
Percent of area Greater than 20.0 Feet Deep	0	0	63.1	52.5 (50.2 acres)
Total Watershed Area (acres)	22,713.6	16,076.1	6,387.2	- -[a]
Total Watershed Area Excluding Internally Drained Areas (acres)	- -	13,127.7	- -	- -
Ratio of Watershed Area to Lake Area	73.2	57.6	75.8	- -
Volume (acre-feet)	1,126.9	1,005.1	2,008.9	- -
Residence Time (years)	0.086	0.07	0.086	- -
Maximum Length of Lake (miles)	1.18	1.18	0.55	0.55
Maximum Width of Lake (miles)	0.65	0.65	0.42	0.42
Length of Shoreline (including islands) (miles)	6.30	7.44	2.40	2.07
Shoreline Development Factor[b]	- -	3.2[c]	- -	1.5
General Lake Orientation	- -	N-S	- -	N-S
Mean Depth (feet)	3.6	3.6	24	24
Maximum Depth (feet)	8.0	8.0	40	40
Ratio of Mean Depth to Maximum Depth	0.45	0.45	0.6	0.600

[a]*Watershed area was not calculated specific to Lulu Lake.*

[b]*Shoreline development factor is the ratio of the shoreline length to the circumference of a circular lake of the same area.*

[c]*This value was originally presented as 2.5 in the initial SEWRPC plan of 1992; the current measurement is based on elevation refinements made possible through Commission digital terrain modeling analysis.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

The size of a lake's tributary area compared to the size of the lake can have a significant impact on the flow and amount of nutrients and other contaminants entering a lake. As the ratio of tributary area size to lake size increases, so does the likelihood of a lake experiencing nutrient and contaminant inputs of sufficient mass to create conditions in the lake that are perceived as being unacceptable by local communities. In the case of Eagle Spring Lake, the tributary area to lake surface area ratio was initially reported to be 54:1; with the refinement of tributary area boundary and surface area of the Lake, the ratio was refined, becoming slightly larger, at approximately 58:1. Thus, while both the tributary area and lake surface area have been reduced as a result of the more detailed topographic information available, the ratio of land surface to water surface has increased slightly. This change suggests that the water load and contaminant loads to Eagle Spring Lake generated as a function of land surface draining to the Lake should be modified relative to those loads estimated in the initial plan. The impact of this change on the lake water quality will be more fully considered in Chapter IV of this plan, while the impact of the water load on the hydrology of the Lake is considered further below.

Soil Types and Conditions

Soil type, land slope, and land use are among the more important factors determining lake water quality conditions. Soil type, land slope, and vegetative cover are also important factors affecting the rate, amount, and quality of stormwater runoff. The texture of different soil types and the structure of soil particles influence the permeability, infiltration rate, and erodibility of soils. Land slopes are important determinants of stormwater runoff rates and of the susceptibility of soils to erosion; the erosivity of the runoff, for example, can be moderated or modified by vegetation cover or structural interventions. Consequently, knowledge of soil types and land slope is an important consideration in the management of external loads of nutrients and other contaminants to a lake.

The U.S. Natural Resources Conservation Service (NRCS), formerly the U.S. Soil Conservation Service (SCS), under contract to SEWRPC, completed a detailed soil survey of the Eagle Spring Lake area in 1966.[1] The four major soil associations within the Eagle Spring Lake tributary area were identified as:

- The Houghton-Palms-Adrian association soils, which are very poorly drained, organic soils that usually occur in depressions formed by old lakebeds and on flood plains. In general, the soils in the immediate vicinity around Eagle Spring Lake are those of the Houghton-Palms-Adrian association.

- The Rodman-Casco soils, which are soils that are excessively well-drained to well-drained and which have a subsoil of gravely sandy loam and clay loam, found to the west of the Lake and extensively throughout the northwestern part of the Lake's tributary area. The Rodman-Casco soils are shallow soils overlying gravel and sand within the Kettle Moraine.

- The Warsaw-Lorenzo soils, which are well-drained soils that have a subsoil of clay loam, are moderately deep soils found over sand and gravel, on outwash plains, and on river terraces in the northern part of the tributary area.

- The Casco-Fox soils, which are similar to the Warsaw-Lorenzo soils in that they also are typically well-drained soils that have formed on top of glacial outwash areas and are comprised of sand and gravel.

Using this regional soil survey, the soils within the area tributary to Eagle Spring Lake can be categorized as moderately well drained soils. This results in high to very high permeability with concomitant high to very high recharge potential.[2] The areal extent of the various classes of soils—designated as classes A (well-drained) through D (poorly drained)—and their locations within the total area tributary to Eagle Spring Lake are shown on Map 2.

In addition to the identification and delineation of soil types, the soil survey contained interpretations for planning and engineering applications, as well as for agricultural applications. The suitability of the soils for urban residential development was assessed using different common development scenarios. These ratings reflected the requirements of the then-current Chapter Comm 83 of the *Wisconsin Administrative Code* governing onsite sewage disposal systems as it existed through the year 2000. While the legal requirements governing onsite sewage disposal systems have since been amended,[3] the interpretations associated with the soil survey with respect to onsite sewage disposal systems are such that they provide insights into the potential for land-based sources of pollution to affect lake water quality, either as a consequence of overland flows during storm events, or

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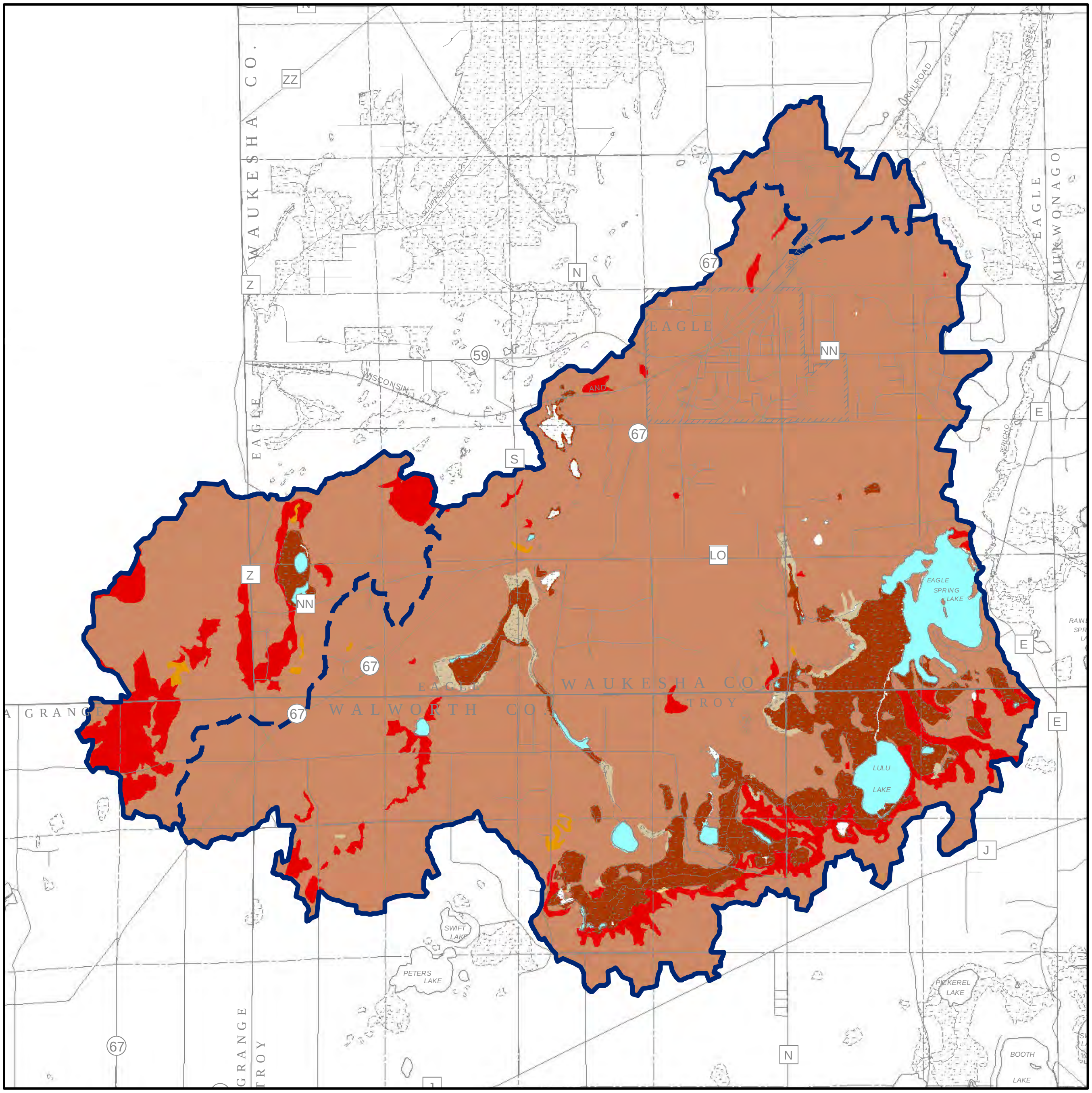
[1]*SEWRPC Planning Report No. 8,* Soils of Southeastern Wisconsin, *June 1966.*

[2]*See SEWRPC Technical Report No. 47,* Groundwater Recharge in Southeastern Wisconsin Estimated by a GIS-Based Water-Balance Model, *July 2008.*

[3]*During 2000, the Wisconsin Legislature amended Chapter Comm 83 and adopted new rules governing onsite sewage disposal systems. These rules, which had an effective date of July 1, 2000, significantly altered the existing regulatory framework. In effect, the year 2000 refinement of Chapter Comm 83 increased the area in which onsite sewage disposal systems may be utilized.*

Map 2

HYDROLOGIC SOIL GROUPS WITHIN THE TOTAL TRIBUTARY AREA TO EAGLE SPRING LAKE



GROUP A: WELL-DRAINED SOILS

GROUP A/D: WELL-DRAINED SOIL/VERY POORLY DRAINED SOIL (WELL-DRAINED IF WATER TABLE IS LOWERED THROUGH PROVISION OF A DRAINAGE SYSTEM. VERY POORLY DRAINED IF WATER TABLE IS NOT LOWERED.)

GROUP B: MODERATELY DRAINED SOILS

GROUP B/D: MODERATELY DRAINED SOIL/VERY POORLY DRAINED SOIL (MODERATELY DRAINED IF WATER TABLE IS LOWERED THROUGH PROVISION OF A DRAINAGE SYSTEM. VERY POORLY DRAINED IF WATER TABLE IS NOT LOWERED.)

GROUP C: POORLY DRAINED SOILS

GROUPS C/D AND D: VERY POORLY DRAINED SOILS; POORLY DRAINED SOIL/VERY POORLY DRAINED SOIL (POORLY DRAINED IF WATER TABLE IS LOWERED THROUGH PROVISION OF A DRAINAGE SYSTEM. VERY POORLY DRAINED IF WATER TABLE IS NOT LOWERED.)

HYDROLOGIC SOIL GROUP NOT DETERMINED

SURFACE WATER

TOTAL TRIBUTARY AREA BOUNDARY

INTERNALLY DRAINED AREA BOUNDARY WHERE NOT COINCIDENT WITH THE TOTAL TRIBUTARY AREA BOUNDARY

N

0 3,000 6,000 Feet

Source: SEWRPC.

through groundwater interflows in the Lake. Therefore, as an index of the likelihood of contaminants entering Eagle Spring Lake, the soil ratings for onsite sewage disposal systems in the total area tributary to Eagle Spring Lake, as determined pursuant to the then-existing requirements of Chapter Comm 83 of the *Wisconsin Administrative Code* governing onsite sewage disposal systems through early 2000, are shown on Map 3.

It should be noted that, based upon the pre-year 2000 conditions, the majority of the lands within the total area tributary to Eagle Spring Lake are covered by soils that are categorized as having moderate to severe limitations for onsite sewage disposal systems. Based upon this assessment, these soils are likely to have a potential sensitivity to disturbance and a high likelihood of being permeable to nonpoint source pollutants. Consequently, based upon soil characteristics, measures to limit the influx of nonpoint source contaminants to the Lake appear to be warranted, especially since the residential lands within the area tributary to Eagle Spring Lake currently are served by onsite sewage disposal systems.[4]

Land surface slopes within the total area tributary to Eagle Spring Lake, shown on Map 4, range from less than 1 percent to greater than 20 percent, as is typical of the morainal landscape within which the Lake and its watershed are located. In general, slopes of over 12 percent have limitations for urban residential development and, if developed, can present potential erosion and drainage problems. In the area immediately surrounding the Lake, the wetlands to the west have slopes in the 0 to 6 percent range, while parts of the northern shoreline have slopes of 20 percent or greater.

WATERBODY CHARACTERISTICS

Eagle Spring Lake is located entirely within the Town of Eagle, southeast of the Village of Eagle and west of the Village of Mukwonago, as shown on Map 1. The Lake is a drainage, or through-flow, lake, having both a defined natural channel inflow and a defined outflow, in both cases the Mukwonago River, a major tributary stream to the Illinois-Fox River. The Lake has extensive shallow areas and a single deep basin and is oriented in approximately a north-south direction. The bathymetry of Eagle Spring Lake is shown in Map 5, and of Lulu Lake on Map 6.

The maximum depth of Eagle Spring Lake was reported as 12 feet in 1963;[5] as eight feet in 1969;[6] and as eight feet in 2005.[7] During 1995-1996, the Eagle Spring Lake Management District (ESLMD) undertook limited dredging of the northwestern embayment of the Lake which restored the maximum Lake depth to about 12 feet, which is cited as the maximum depth of the impoundment in Table 1.[8] During 2007, the bathymetry of Eagle

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[4]*Pursuant to the recommendations set forth in the regional water quality management plan, the area surrounding Eagle Spring Lake was recommended for future extension of public sanitary sewerage services from the Village of Mukwonago, with such service being associated with urban density residential development then forecast for the Rainbow Springs area immediately downstream of Eagle Spring Lake. With the conversion of the Rainbow Springs development to a State Natural Area in 2008—as the Kettle Moraine State Forest-Mukwonago River Unit—the feasibility of extending public sanitary sewerage services to Eagle Spring Lake from the Village of Mukwonago appears to be compromised. Consequently, as of 2010, the Eagle Spring Lake Management District has withdrawn conceptual support from this proposal.*

[5]*Wisconsin Conservation Department,* Surface Water Resources of Waukesha County, *1963.*

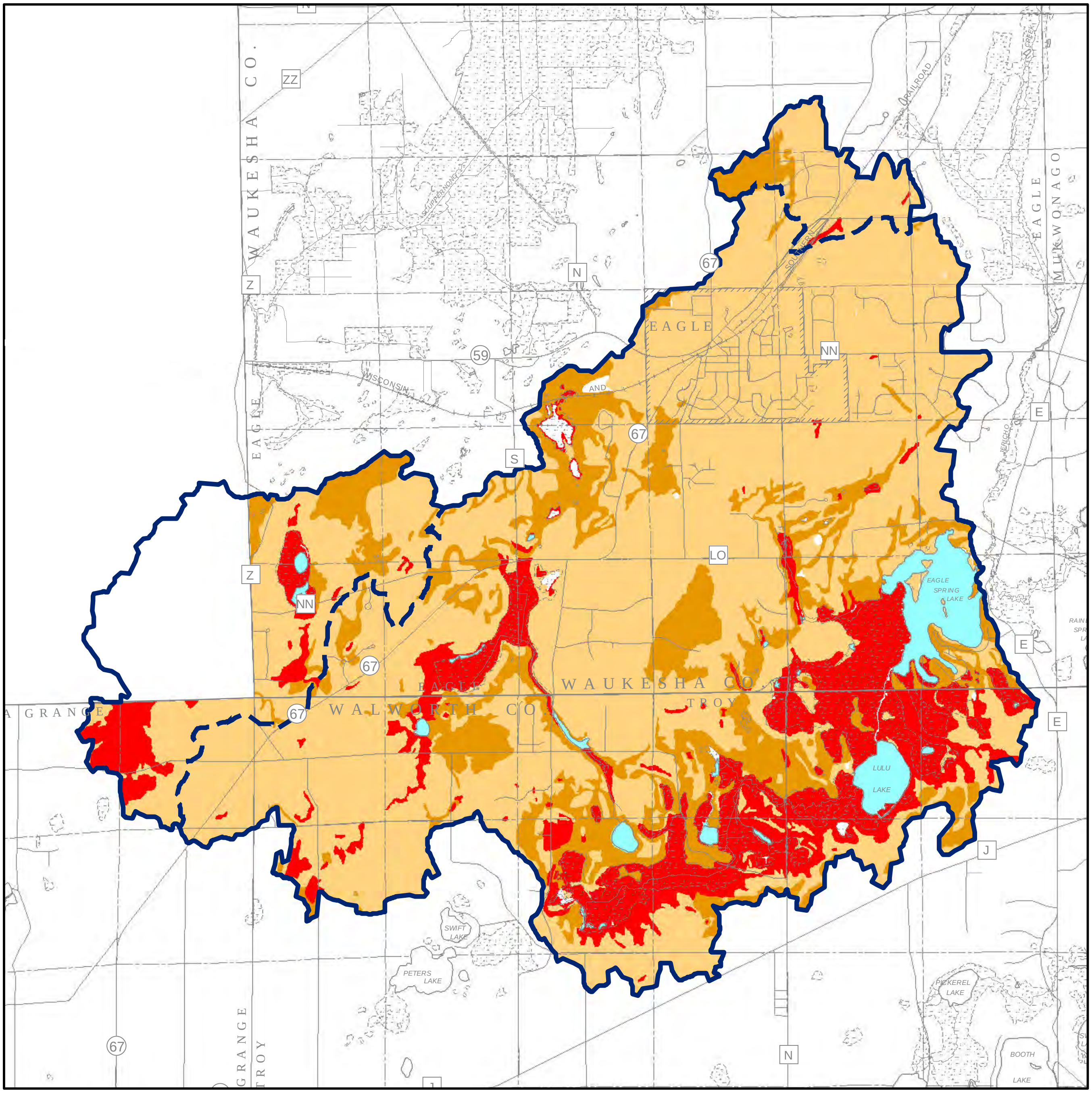
[6]*Wisconsin Department of Natural Resources Lake Use Report No. FX- 19,* Eagle Spring Lake, Waukesha County, Wisconsin, *1969.*

[7]*Wisconsin Department of Natural Resources Publication No. PUBL-FH-800 2005*, Wisconsin Lakes, *2005.*

[8]*SEWRPC Community Assistance Planning Report No. 226,* A Lake Management Plan for Eagle Spring Lake, Waukesha County, Wisconsin, *October 1997.*

Map 3

GROUNDWATER CONTAMINATION POTENTIAL WITHIN THE TOTAL TRIBUTARY AREA TO EAGLE SPRING LAKE



UNSUITABLE: Areas covered by soils which have a high probability of not meeting the June 2000 criteria of Chapter Comm 83 of the *Wisconsin Administrative Code* governing conventional onsite sewage disposal systems

UNDETERMINED: Areas covered by soils which have a range of characteristics and/or slopes which span the June 2000 criteria of Chapter Comm 83 of the *Wisconsin Administrative Code* governing conventional onsite sewage disposal systems so that no classification can be assigned

SUITABLE: Areas covered by soils which have a high probability of meeting the June 2000 criteria of Chapter Comm 83 of the *Wisconsin Administrative Code* governing conventional onsite sewage disposal systems

OTHER: Areas consisting for the most part of disturbed land for which no interpretive data area available

SURFACE WATER

TOTAL TRIBUTARY AREA BOUNDARY

INTERNALLY DRAINED AREA BOUNDARY WHERE NOT COINCIDENT WITH THE TOTAL TRIBUTARY AREA BOUNDARY

N

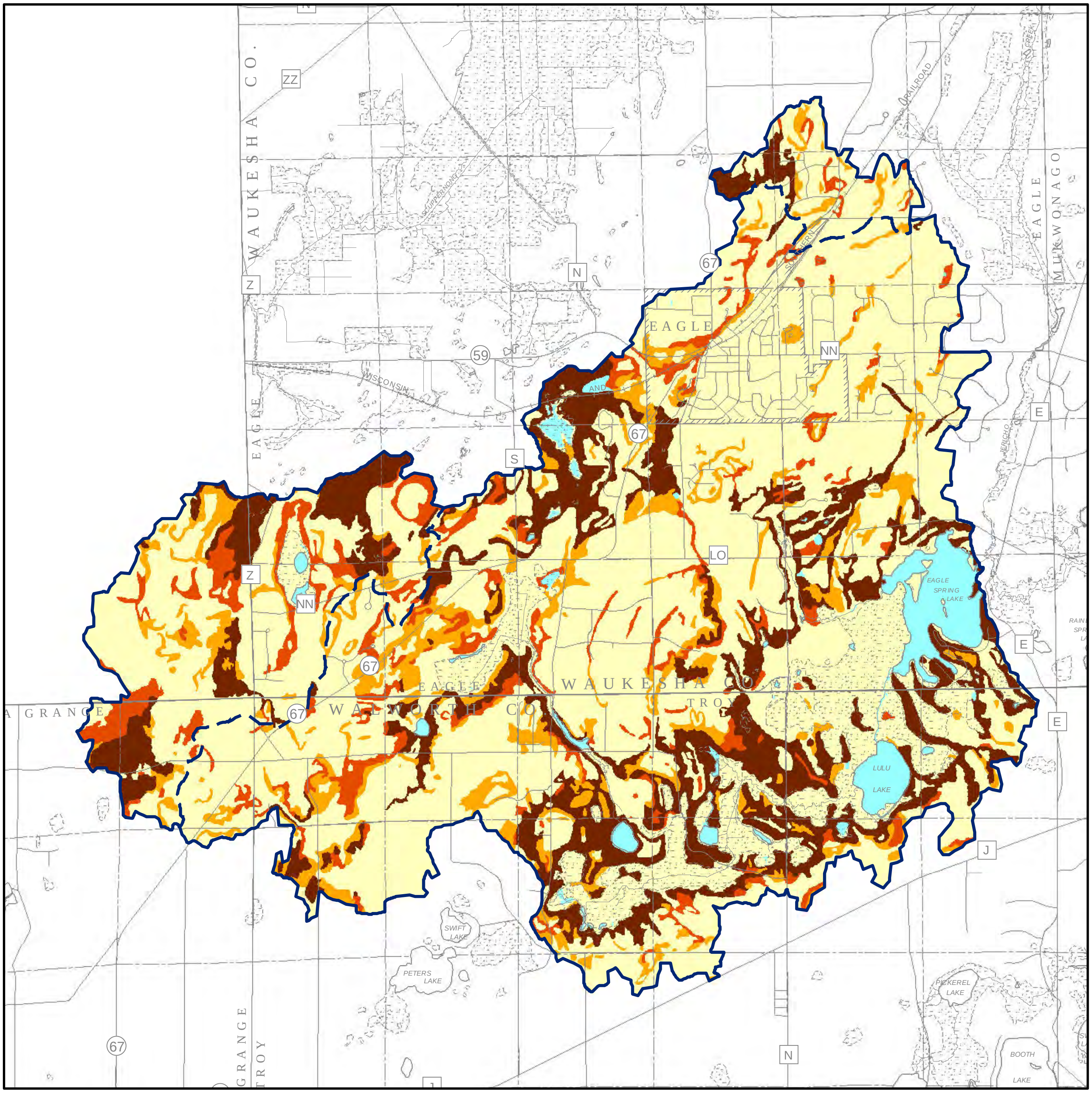
0 3,000 6,000 Feet

NOTE: This information is not available in Jefferson County.

Source: SEWRPC.

Map 4

LAND SURFACE SLOPES WITHIN THE TOTAL TRIBUTARY AREA TO EAGLE SPRING LAKE



SOILS HAVING SLOPES RANGING FROM 0 TO 6 PERCENT

SOILS HAVING SLOPES RANGING FROM 7 TO 12 PERCENT

SOILS HAVING SLOPES RANGING FROM 13 TO 19 PERCENT

SOILS HAVING SLOPES OF 20 PERCENT OR GREATER

NO SOIL SURVEY DATA/ SLOPE UNDETERMINED

SURFACE WATER

TOTAL TRIBUTARY AREA BOUNDARY

INTERNALLY DRAINED AREA BOUNDARY WHERE NOT COINCIDENT WITH THE TOTAL TRIBUTARY AREA BOUNDARY

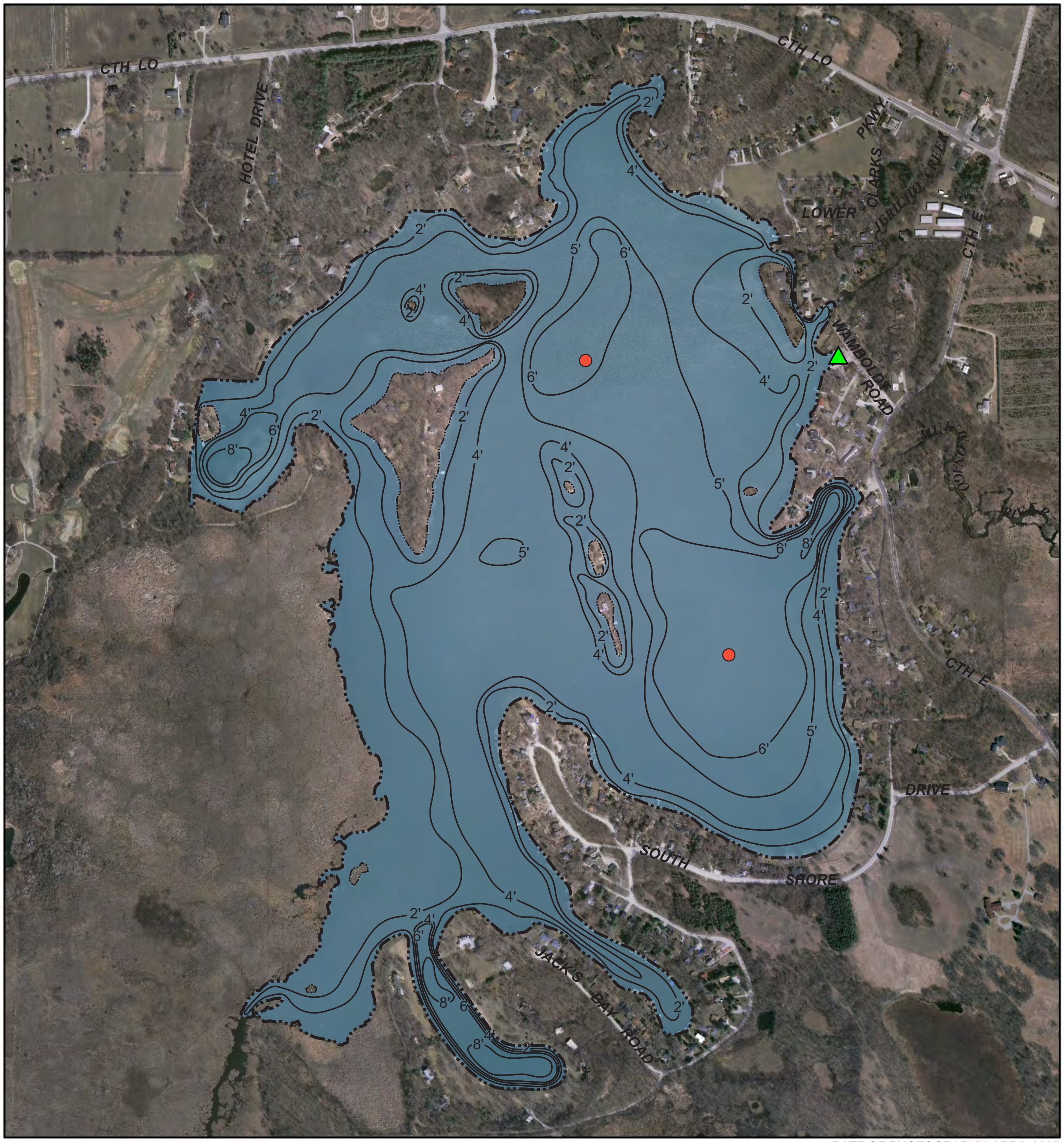
N

0 3,000 6,000 Feet

Source: SEWRPC.

Map 5

BATHYMETRIC MAP OF EAGLE SPRING LAKE



DATE OF PHOTOGRAPHY: APRIL 2005

— 4' — WATER DEPTH CONTOUR IN FEET

MONITORING SITE

PUBLIC ACCESS SITE

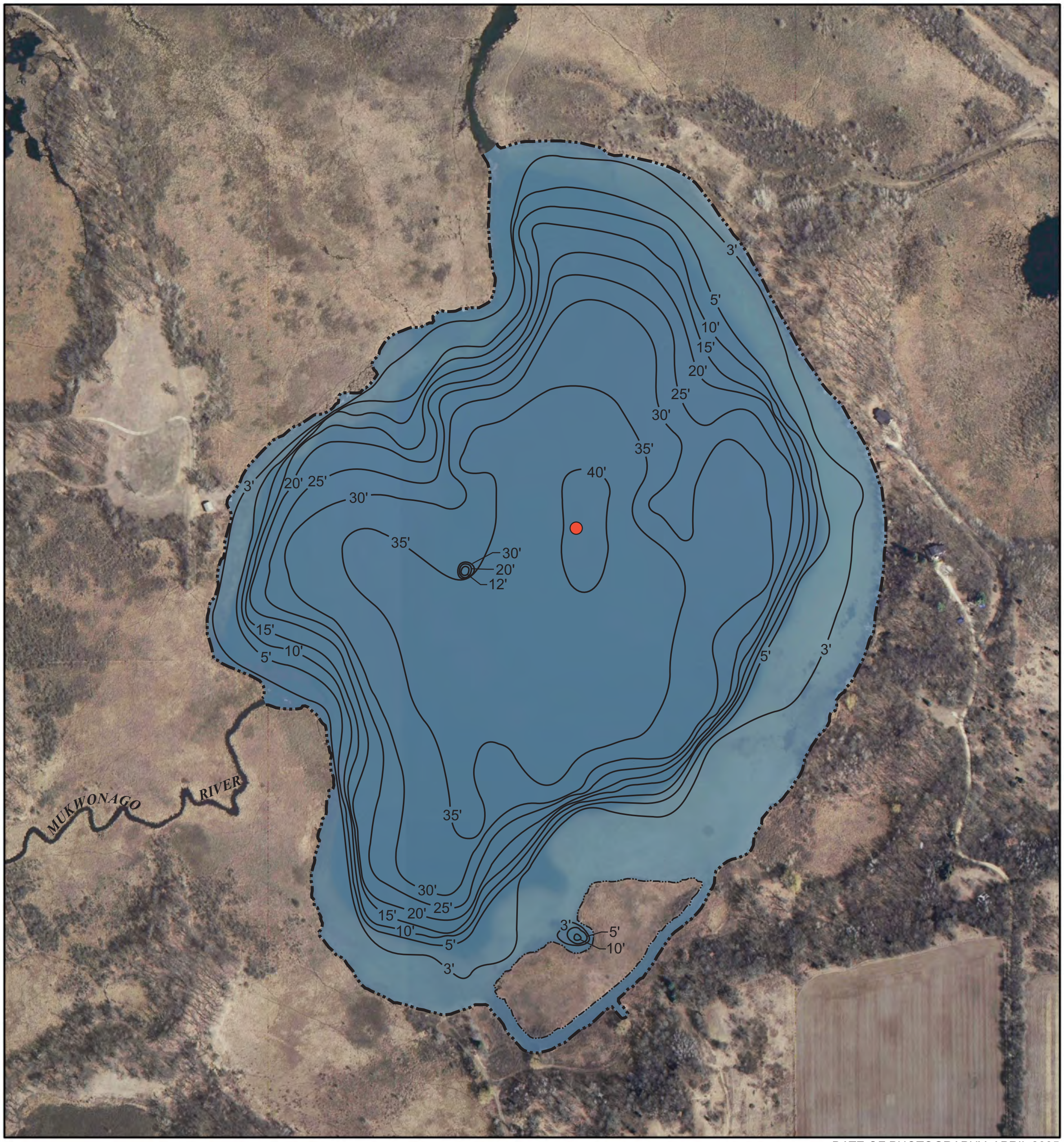
GRAPHIC SCALE

0 250 900 FEET

Source: U.S. Geological Survey and SEWRPC.

Map 6

BATHYMETRIC MAP OF LULU LAKE



DATE OF PHOTOGRAPHY: APRIL 2005

—20'— WATER DEPTH CONTOUR IN FEET

● MONITORING SITE

Source: Wisconsin Department of Natural Resources and SEWRPC.

GRAPHIC SCALE
0 250 500 FEET

Spring Lake was refined using data acquired by the WDNR and The Nature Conservancy (TNC) in partnership with the ESLMD. This survey showed, among other results, that siltation and sediment movements had occurred within the dredged portion of the Eagle Spring Lake basin again resulting in a current maximum depth of about eight feet. In addition, the use of high resolution orthophotography resulted in a refinement of the Lake surface areas for Eagle Spring Lake and Lulu Lake. Based upon these data the actual surface area of Eagle Spring Lake is approximately 280 acres and that of Lulu Lake is about 95 acres. These refined hydrographic characteristics of Eagle Spring Lake, together with the morphometric characteristics reported by the then Wisconsin Conservation Department—now the Wisconsin Department of Natural Resources (WDNR)—during 1969, are set forth in Table 1. These new data were used in this plan.

The lake level is augmented by an impoundment and is controlled by two outlet control structures, known locally as the Kroll dam and the Wambold dam, that are located on the northeastern shore of the Lake. These control structures, which maintain an approximately eight feet depth in the deepest portions of the Lake, form a part of a single impoundment, referenced in the WDNR file as Wambold dam FF #67.04. The outlet structures currently are controlled by gates. The operating permit for the Wambold dam was amended by the WDNR in 2010 to reflect the actual operating protocols and elevations applicable to the dam.[9] These operating levels currently are set at between 9.4 and 9.7, based upon the local datum initially established by the Wisconsin Public Service Commission (PSC). This action finally resolved the discrepancies associated with the location of the benchmark elevation on the dam, noted in the initial plan.

Eagle Spring Lake has a total volume of approximately 1,005 acre-feet. The Lake is about 1.2 miles long and about 0.6 mile wide at its widest point. The Lake shoreline is about 7.4 miles long (including islands), with a shoreline development factor of 3.2, indicating that, due to its irregular shape, bays, and islands, the shoreline (including the shorelines of the islands) is about 3.2 times longer than a perfectly circular lake of the same area. In contrast, nearby Lulu Lake has a shoreline development factor of 1.5, indicating that Lake's more nearly round shape. The shoreline development factor (SDF) is often related to the level of biological activity in a lake: the greater a lake's shoreline development factor (due to greater shoreline contour irregularity), the greater the likelihood the lake contains shallow, nearshore areas (called the "littoral zone") which usually provide habitat more suitable for plant and animal life. In other words, lakes with highly irregular shorelines usually have an extensive littoral zone and can be expected to have a fairly high level of biological activity.

Biological activity in a lake also can be influenced by other physical factors, such as bottom sediment composition and lake-basin contours. The original basin of Eagle Spring Lake was formed as the Michigan and Green Bay Lobes of the continental glacier retreated from southeastern Wisconsin during the late Wisconsin stage of glaciation. The Lake, like many others in the Southeastern Wisconsin Region, lies in a depressed area of this

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[9]*Eagle Spring Lake Water Level Order, News Release Published: March 24, 2010 by the Southeast Region:*

"The Department of Natural Resources approved a revised water level order for Eagle Spring Lake located in the Town of Eagle, Waukesha County. This revised order allows the lake elevation to be maintained at its current level. The revised order replaces the established lake level operating range approved in 1954 by the Wisconsin Public Service Commission. This new order is one-half foot lower [sic] *than the approved 1954 level, but is the actual level at which the lake has been maintained for the last 50 years.*

"The Department of Natural Resources produced an Environmental Assessment for this project and used it and information provided by the Eagle Spring Lake Management District and local citizens to make its decision. The department has determined that an Environmental Impact Statement will not be required for this action.

"The Environmental Assessment and new order are accessible on the Department Web site at http://dnr.wi.gov/org/water/wm/dsfm/flood/eaglespringlakeea/.*"*

interlobate, or “kettle moraine,” area that is characterized by unconsolidated glacial sediments consisting predominantly of silty-clay till and sandy outwash deposits. These glacial sediments, ranging in thickness from 100 to 200 feet are underlain by Silurian dolomite and are overlain by organic deposits formed after glaciation. The Lake bottom sediment types were surveyed in 1990, 2002, and 2003.[10] About 80 percent of the surveyed bottom was covered by “muck (combination of flocculent silt, clay, marl, and organics that pass through a #200 µm sieve screen),” although limited portions of the nearshore area along the developed shoreline contained sand or gravel bottom. This is due, in part, to the placement of imported sand along the shoreline to develop a more useable beach area. The depths of the soft sediments ranged from less than one foot to more than 10 feet in the western embayment. Based upon the observed results of 19 transects by SEWRPC staff in the summer 2008 survey, the bed of Eagle Spring Lake is comprised of approximately 30 percent silt/sand, 29 percent marl, 23 percent silt, 8 percent sand, 6 percent silt/sand, and 4 percent sand/gravel substrates. This is consistent with the aforementioned previous surveys on Eagle Spring Lake.

As shown in Table 1, approximately 28 percent of the lake area is less than three feet deep; only about 13 percent of the Lake has a water depth greater than six feet. Thus, a preponderance of soft bottom sediments and flatness of bottom contour, along with a relatively high shoreline development factor as described above, identify Eagle Spring Lake as having conditions consistent with lakes of high level of biological activity.

The shoreline of Eagle Spring Lake, except for the western portion, is almost entirely developed for residential uses. The western shoreline is comprised of about 1.6 miles of wetland and accounts for about 28 percent of the total Eagle Spring Lake shoreline (not including islands). That wetland area is contiguous with a major wetland complex associated with Lulu Lake and the Mukwonago River inlet upstream.

A public recreational boating access site, owned by the WDNR, is located on the eastern side of the Lake. This public recreational boating access site provides the Lake with adequate public access, pursuant to Chapter NR 1 of the *Wisconsin Administrative Code*.

Erosion of shorelines results in the loss of land, damage to shoreline infrastructure, and interference with recreational access and lake use. Such erosion is usually caused by wind-wave erosion, ice movement, and motorized boat traffic. A survey of the Eagle Spring Lake shoreline, conducted during the summer of 1993 by Waukesha County Department of Parks and Land Use, Land Conservation Division staff, identified existing shoreline protection conditions around this lake. Most of the developed shoreline of Eagle Spring Lake in 1993 had some form of shoreline protection of which most were in good condition. Only the undeveloped western shore was unprotected except for extensive growths of aquatic vegetation. This situation was observed to be largely unchanged during a subsequent reconnaissance in 2008 by SEWRPC staff, as shown on Maps 7 and 8. Improperly installed and failing shoreline protection structures and the erosion of natural shorelines on Eagle Spring Lake are issues of limited concern.

CLIMATE

Long-term average annual air temperature and precipitation values for the Eagle Spring Lake watershed are set forth in Table 2. These averages were taken from official National Oceanic and Atmospheric Administration (NOAA) records for the Southeastern Wisconsin Region. Table 2 also provides monthly air temperature and precipitation data for the 2008 study year. In addition, Table 2 presents runoff data for both periods—long-term and the 2008 study year (which was the most recent year complete data was available at time of printing)—derived from U.S. Geological Survey (USGS) flow records for the Mukwonago River, station number 05544200, at Mukwonago, Waukesha County, Wisconsin.

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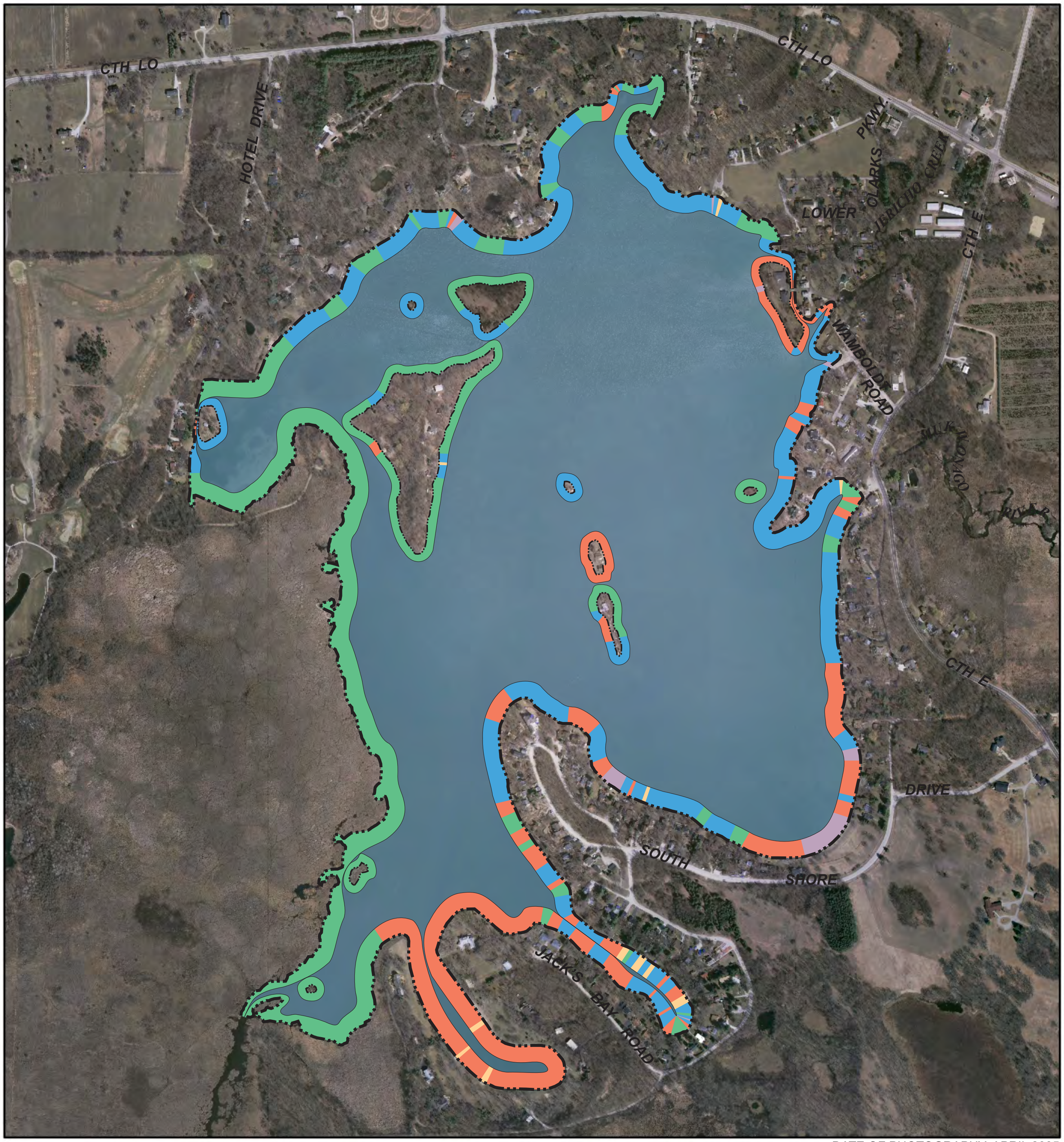
[10] *Hey and Associates, Inc., “Eagle Spring Lake Water Quality Summary and Management Report,” January 2005.*

Map 7

SHORELINE PROTECTION STRUCTURES ON EAGLE SPRING LAKE: 2008



DATE OF PHOTOGRAPHY: APRIL 2005

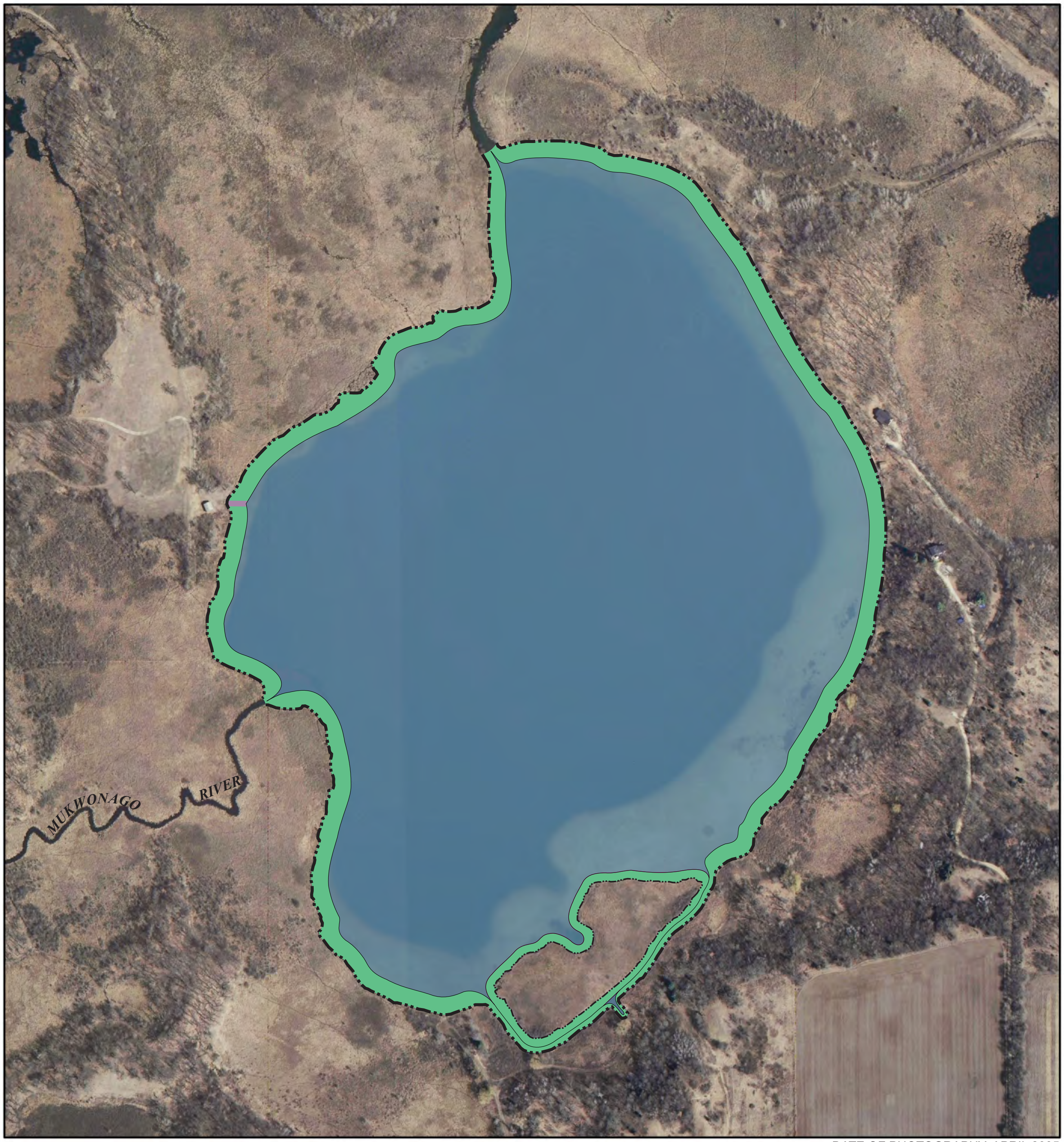
RIPRAP
BULKHEAD
BEACH
REVETMENT
NATURAL

GRAPHIC SCALE
0 250 900 FEET

Source: SEWRPC.

Map 8

SHORELINE PROTECTION STRUCTURES ON LULU LAKE: 2008



DATE OF PHOTOGRAPHY: APRIL 2005

REVETMENT

NATURAL

Source: SEWRPC.

GRAPHIC SCALE

0 250 500 FEET

Table 2

LONG-TERM AND 2008 STUDY YEAR TEMPERATURE, PRECIPITATION, AND RUNOFF DATA FOR THE EAGLE SPRING LAKE AREA

Temperature													
Air Temperature Data (°F)	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Long-Term Mean Monthly	18.9	24.0	34.0	45.0	56.3	66.0	71.2	69.4	61.4	49.9	37.0	24.7	46.4
2008 Mean Monthly	20.3	18.2	30.3	46.6	52.8	66.6	70.3	69.0	63.7	49.6	37.0	18.9	45.3
Departure from Long-Term Mean	1.4	-5.8	-3.7	1.6	-3.5	0.6	-0.9	-0.4	2.3	-0.3	0.0	-5.8	-1.1

Precipitation														
Precipitation Data (inches)	January	February	March	April	May	June	July	August	September	October	November	December	Mean	Annual
Long-Term Mean Monthly	1.56	1.32	2.19	3.48	3.13	3.76	3.82	4.22	3.48	2.51	2.55	2.09	2.83	33.93
2008 Mean Monthly	2.06	3.86	2.46	5.26	2.34	9.86	4.21	1.31	4.57	2.57	1.22	4.51	3.69	44.23
Departure from Long-Term Mean	0.50	2.54	0.27	1.78	-0.79	6.10	0.39	-2.91	1.09	0.06	-1.33	2.60	0.86	10.30

Runoff[a]													
Runoff Data (inches)	January	February	March	April	May	June	July	August	September	October	November	December	Mean
Long-Term Mean Monthly	0.74	0.76	1.15	1.17	1.00	0.88	0.68	0.72	0.70	0.74	0.82	0.84	0.85
2008 Mean Monthly	1.20	0.99	1.59	2.14	1.30	2.94	1.83	0.92	1.26	0.99	0.86	1.15	1.43
Departure from Mean Monthly	0.46	0.23	0.45	0.97	0.30	2.06	1.15	0.20	0.56	0.25	0.04	0.31	0.58

[a]*Runoff data were computed for 2008, which was the most recent calendar year data available at the time of printing.*

Source: National Oceanic and Atmospheric Administration, U.S. Geological Survey and SEWRPC.

As shown in Table 2, for the study year 2008, the mean annual temperature was 45.3 degrees Fahrenheit (°F), which was 1.1°F below the long-term mean annual temperature of 46.4°F. For the calendar year of 2008, monthly average temperatures were below the long-term monthly averages in seven of the 12 months; the greatest variance below the long-term monthly average occurred in February and December, when temperatures were 5.8°F below normal. The month with the greatest variance above normal temperature in 2008 was September, which was 2.3°F above the normal. In general, temperatures for the study year indicate that 2008 was a slightly cooler year than normal. Figure 1 shows that both mean temperature and mean precipitation have been increasing over the period from 1950 through 2005; however, variability in each parameter remains unpredictably high from year to year. This is consistent with historical weather changes as well as other indicators of warmer conditions such as decreasing ice-cover duration on lakes throughout the State of Wisconsin.[11] It is important to note that only the increasing mean annual temperature trend was shown to be statistically significant ($p \leq 0.009$; multiple $R^2 = 0.122$).

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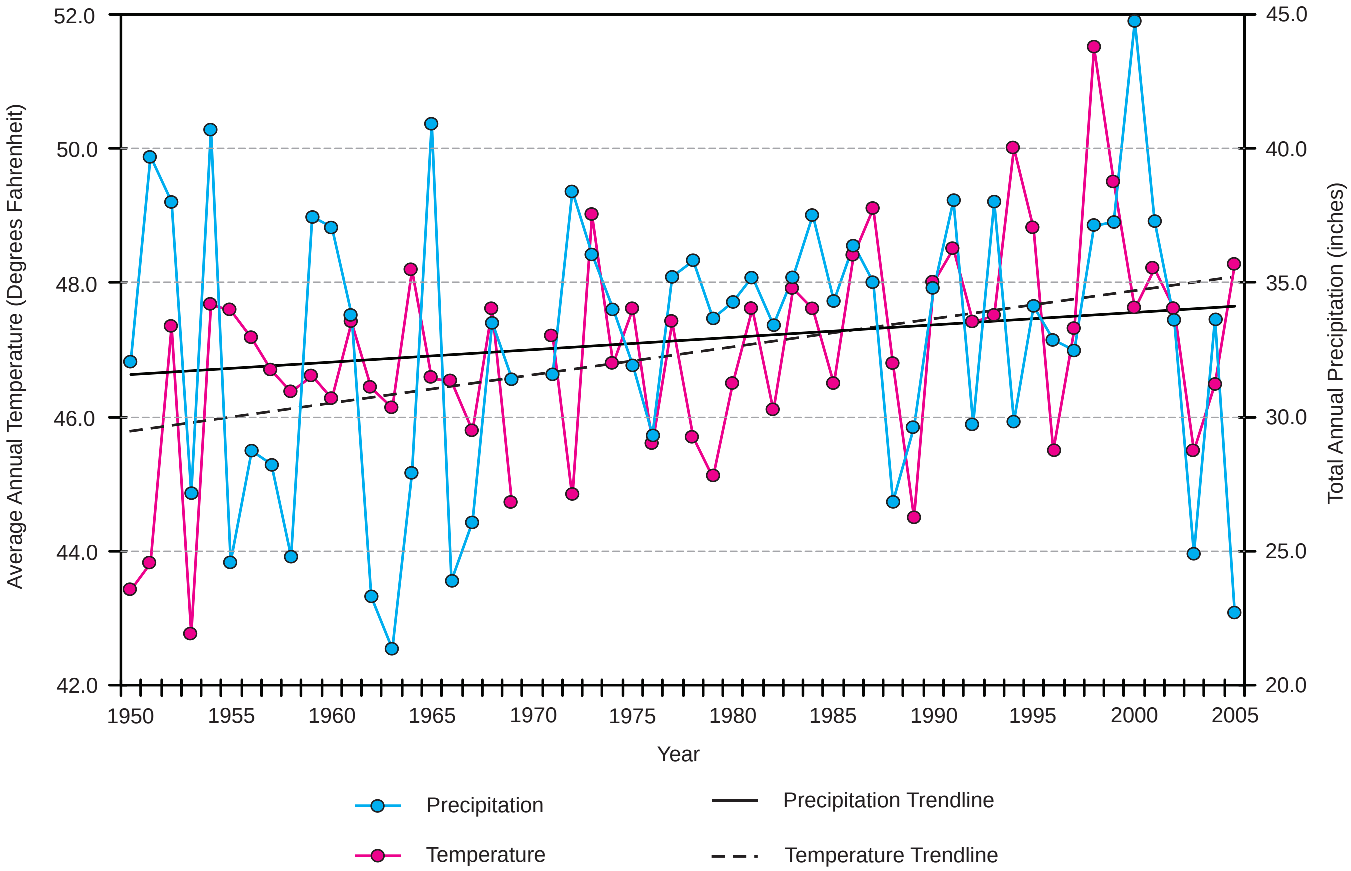
[11]*J.J. Magnuson, J. Krohelski, K. Kunkel, and D. Robertson. "Wisconsin's Waters and Climate: Historical Changes and Possible Futures," In: Wisconsin's Waters: A Confluence of Perspectives,* Transactions of the Wisconsin Academy of Sciences, Arts and Letters*, volume 90, 2003.*

Figure 1

AVERAGE ANNUAL TEMPERATURE AND TOTAL ANNUAL PRECIPITATION FOR THE NOAA WAUKESHA WEATHER RECORDING STATION NEAR THE EAGLE SPRING LAKE WATERSHED: 1950-2005



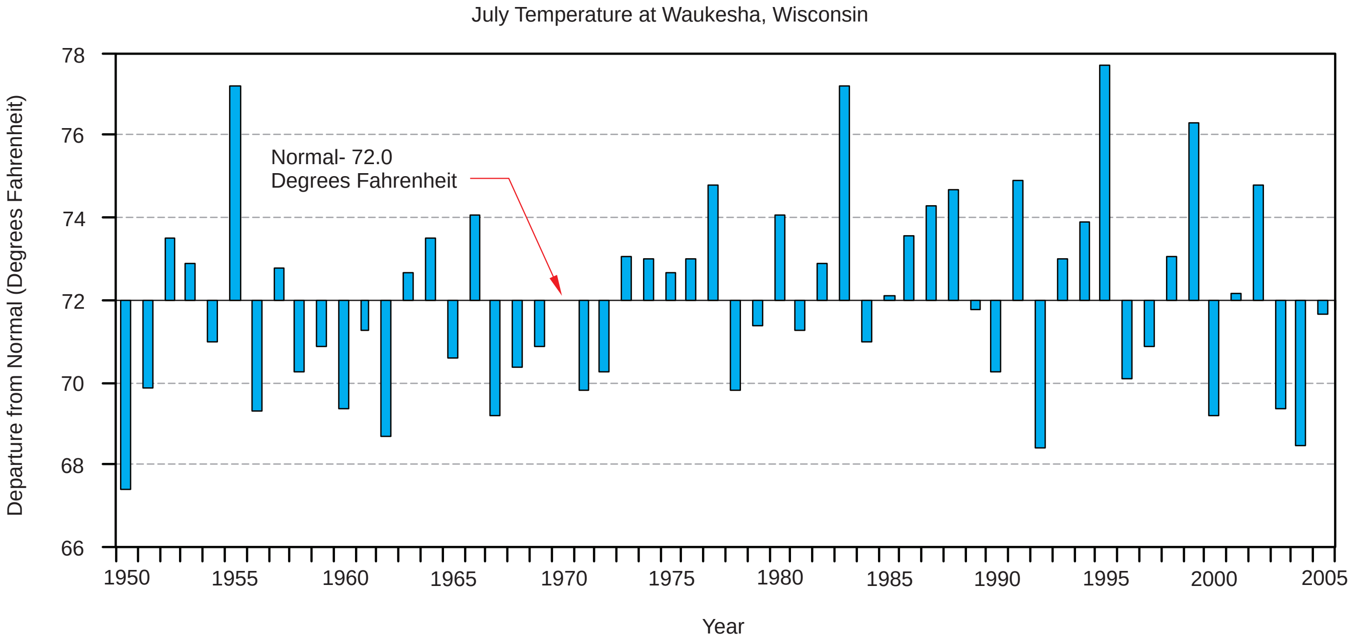
Source: National Oceanic and Atmospheric Administration, National Climatic Data Center, and SEWRPC.

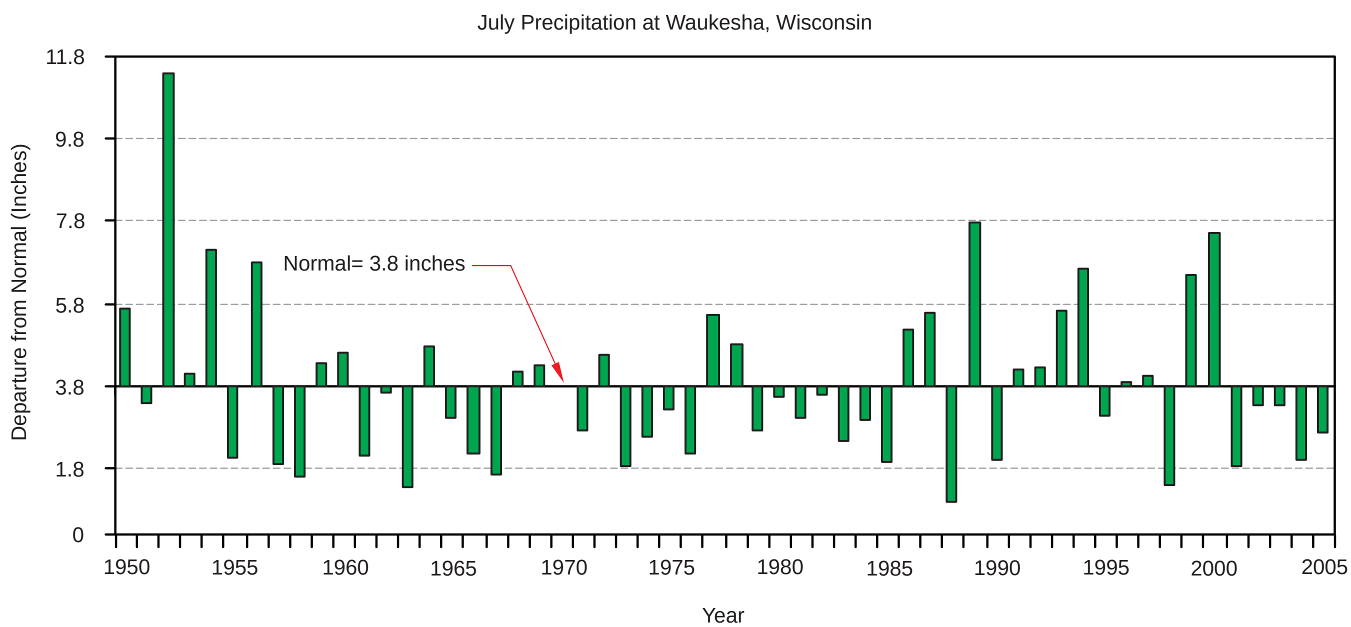
Higher air temperatures can lead to higher water temperatures, which have a major influence on fish and other ectothermic organisms in terms of their physiology, growth, and development, including reproduction.[12] High air temperatures which warm water and land surfaces, when combined with periods of decreased precipitation during the summer, can also negatively affect surface water dissolved oxygen concentrations. Hence, low dissolved oxygen concentrations are a major concern during the summer months, because even short periods of time where concentrations fall below 5.0 milligrams per liter (mg/l) can cause significant decreases in the abundance and diversity of the aquatic organisms in lakes and streams. Figure 2 shows that the average temperature and precipitation for the month of July to be 72.0°F and 3.8 inches, respectively, over the 55-year period from 1950 through 2005. Similar to the annual trends described above, variability in both July average temperature and precipitation remains unpredictably high from year to year. The deviation from normal air temperature can range from 2°F to almost 6°F and the deviation from normal precipitation can range from two to nearly eight inches. Fortunately, Eagle Spring Lake's discharge is supplemented by a high proportion of cold, well-oxygenated

[12]*W. Tonn, "Climate Change and Fish Communities: A Conceptual Framework,"* Transactions of the American Fisheries Society, *volume 119, pages 337-352, 1990.*

Figure 2

JULY AVERAGE TEMPERATURE AND PRECIPITATION DEPARTURES FROM NORMAL AT THE WAUKESHA STATION: 1950-2005





NOTE: Normal is defined as 3.8 inches, which is the average precipitation in the month of July from 1950-2005.

Source: National Oceanic and Atmospheric Administration, National Climatic Data Center, and SEWRPC.

groundwater flow, which helps to mitigate temperature in critical summer periods that are warmer and/or dryer than normal. Figure 2 also shows the monthly average July temperature to be increasing slightly over this 56-year period of record, which emphasizes the importance of protecting the quality and quantity of groundwater as future development occurs in this watershed.

Table 2 also shows precipitation amounts for study year 2008, as well as long-term data. The mean annual precipitation for 2008 was 44.23 inches, which was 10.3 inches above the long-term mean annual amount of 33.93 inches. Precipitation amounts in 2009 were above normal in nine of the 12 months with June having the greatest monthly amount in excess of long-term values, more than six inches above normal. Only May, August, and November had monthly amounts below the long-term. These significantly higher-than-normal precipitation amounts in 2008 produced areawide high-water concerns in numerous lakes and rivers, as is reflected in the runoff values and water budget calculations described below.

More than half the normal yearly precipitation falls during the growing season, from May to September. During this time period, runoff volumes are moderated because evapotranspiration rates are high, vegetative cover is good, and the soils are not frozen, so infiltration can occur. However, the occurrence of intense thunderstorms during this period can result in high rates of runoff and associated flooding. Normally, about 20 percent of the summer precipitation is expressed as surface runoff. Approximately 45 percent of the annual precipitation occurs during the winter or early spring when the ground may be frozen, and may result in high surface runoff rates and/or volumes when air temperatures are high enough for the precipitation to fall as rain or as a result of rapid snowmelt or rainfall with snowmelt.

During 2007, there was a weather station established on the eastern shoreline of Eagle Spring Lake, as shown on Map 9. The Commission staff analyzed precipitation data from this station and found that they were statistically correlated with the precipitation data reported from the Mukwonago River gauge station, confirming agreement between the two gauges, and suggesting that these data sources can be used in a complementary manner.

WATER RESOURCES AND LAKE STAGE

Stream Flows

Flows to the Mukwonago River from Eagle Spring Lake are controlled by two outlet structures—a dam with a manually operated control gate (Wambold dam) and a former mill race (locally known as the Kroll dam)—both located at the east side of Eagle Spring Lake just west of CTH E. The confluence of Jericho Creek and the Mukwonago River is located about 350 feet downstream of the Wambold dam structure. The southernmost lake outlet channel, from the Kroll dam, joins the Mukwonago River about 500 feet downstream of the dam structure. Todd Shoemaker demonstrated that the discharge from the Kroll dam was fairly constant at about 3.5 cfs during 2001, over a range of precipitation events.[13] Hilary Erin Gittings confirmed this average base flow to the Eagle Spring-Lulu Lakes system as 3.5 cubic feet per second (cfs), based upon measurements obtained from September 2002 through September 2004, at the TNC bridge upstream of Lulu Lake, as shown on Figure 3.[14]

Assuming that, over the long term, inflow to Eagle Spring Lake is balanced by or equal to outflow from Eagle Spring Lake, outflow from the Wambold dam has been estimated to be about four times that of the Kroll dam. Shoemaker reported the long-term average base flow in the Mukwonago River, where it enters Eagle Spring Lake,

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[13]*Todd Shoemaker, “Evaluation of the Hydrology and Hydraulics of Eagle Spring Lake, Eagle Wisconsin,” Master of Science Thesis submitted to the Department of Civil and Environmental Engineering at the University of Wisconsin-Madison, May 2002.*

[14]*Hilary Erin Gittings, “Hydrogeologic Controls on Springs in the Mukwonago River Watershed, SE Wisconsin,” Master of Science Thesis submitted to the University of Wisconsin-Madison, 2005.*

Map 9

WEATHER STATION AND TEMPERATURE LOGGER LOCATIONS: 2007-2008

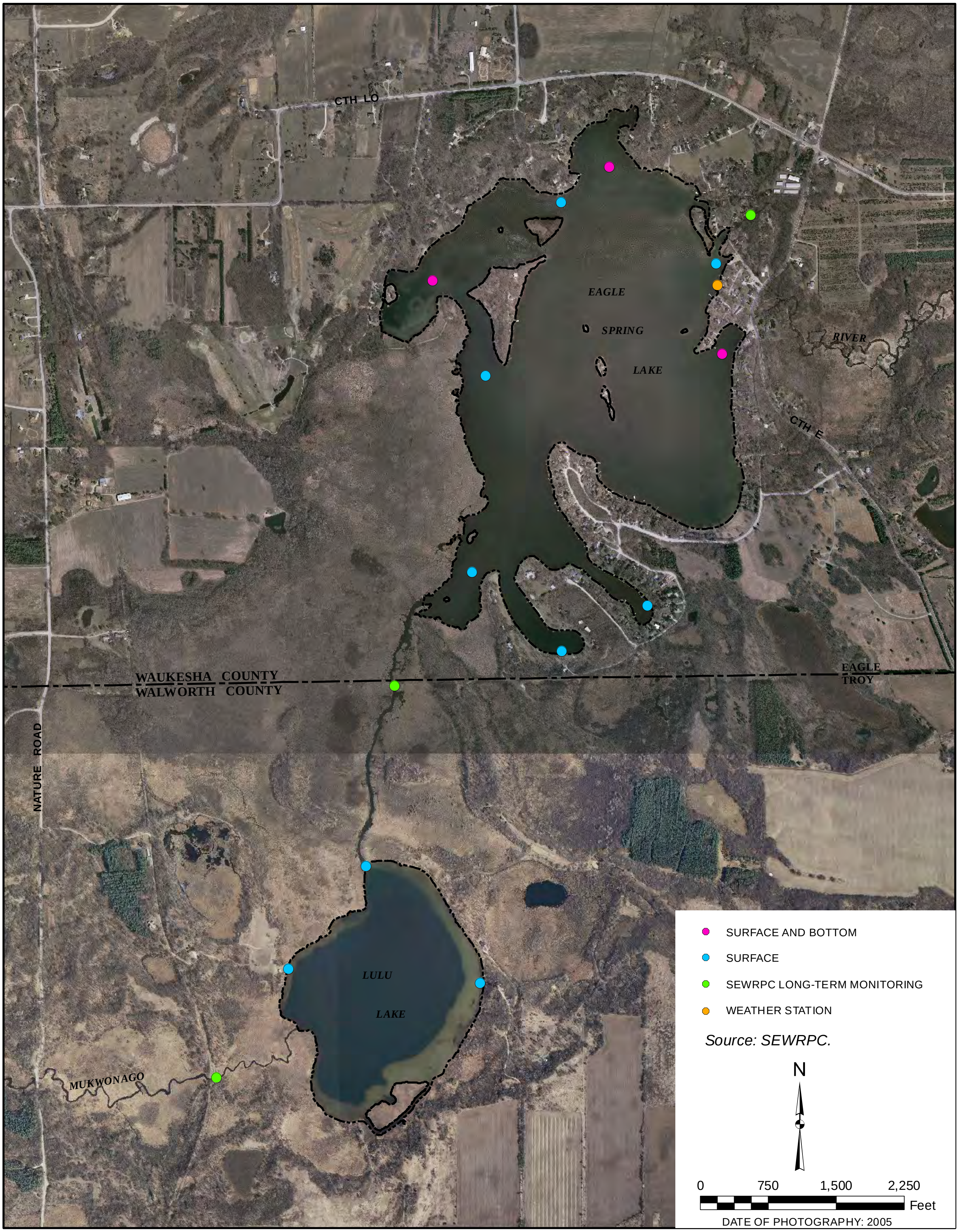
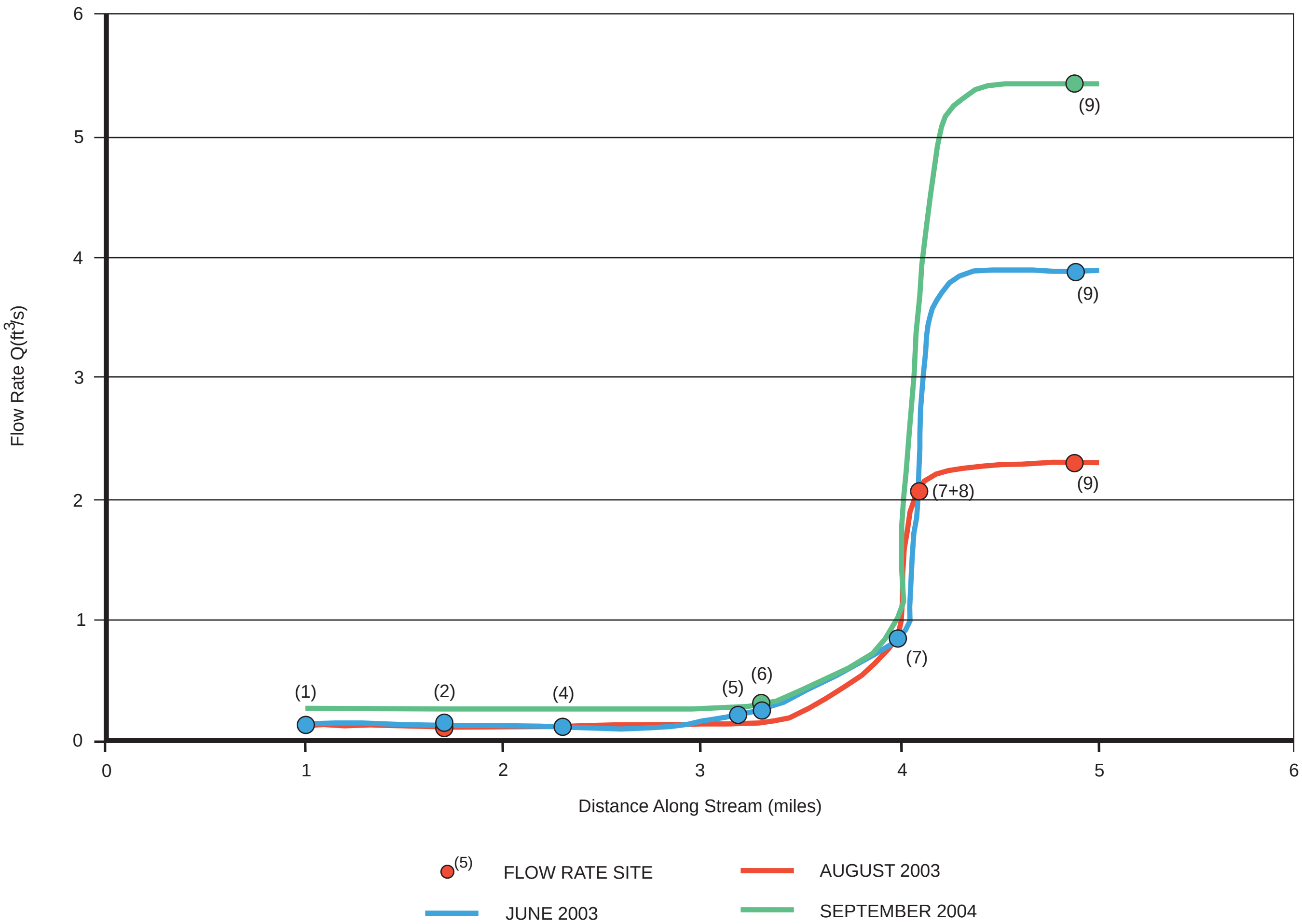


Figure 3

FLOW RATE MEASUREMENTS IN THE UPPER REACH OF THE MUKWONAGO RIVER



NOTE: Site No. 9 is upstream of Lulu Lake located at The Nature Conservancy bridge.

Source: Hilary E. Gittings.

to be 14.3 cfs, with 9.6 cfs, or about 70 percent of this flow, arising from groundwater sources. During low flow periods, Gittings confirmed that the spring complex above Nature Road contributed about 70 percent of the total volume of water flow into Lulu Lake and thereby to Eagle Spring Lake.

Finally, Shoemaker showed that, at the time of his study, Eagle Spring Lake and Lulu Lake essentially operated as one hydrological unit with water levels at elevations of 820.60 and 820.68 feet above NGVD-29, respectively.[15] This difference in elevation between the lakes decreased with increasing discharge at the Wambold dam,

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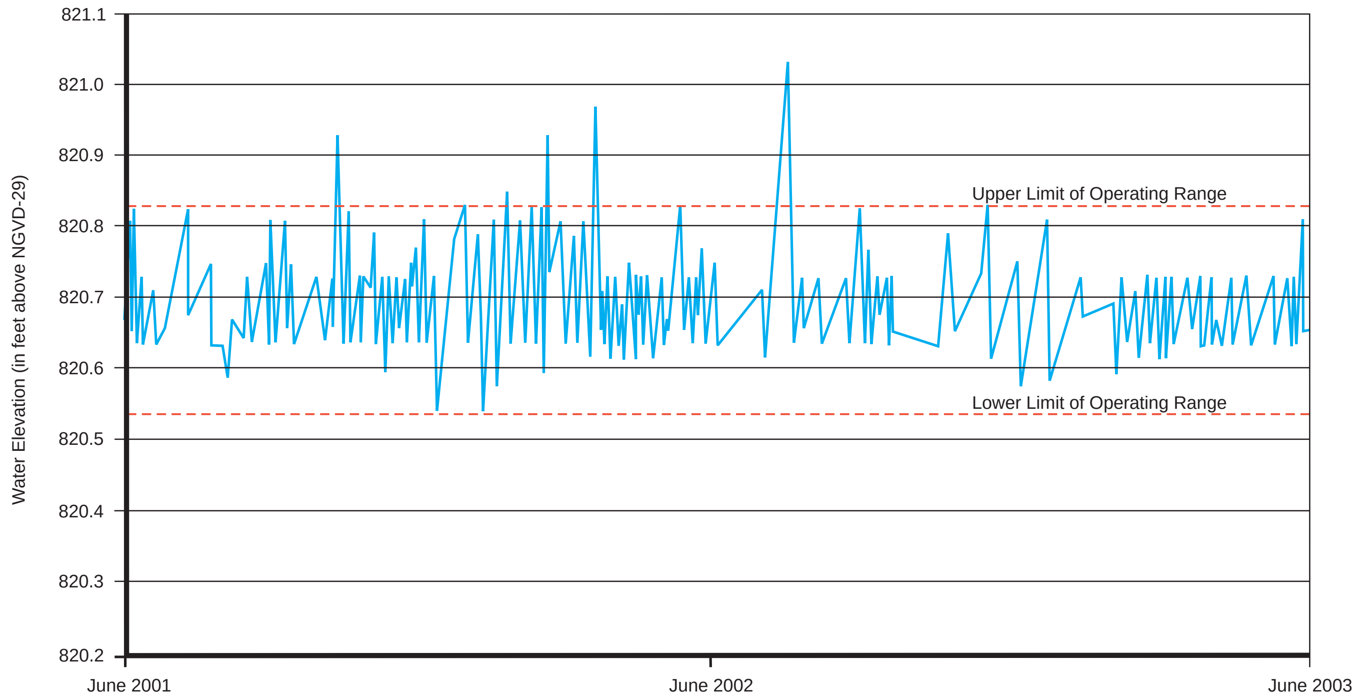
[15]*This is consistent with the surface water elevation profile developed by SEWRPC staff based upon the 2005 Waukesha County DTM data. Shoemaker's findings are also consistent with observations by SEWRPC staff, obtained during 2008, that showed fairly constant water depths of about 3.5 feet along the channel linking Eagle Spring Lake with the Lulu Lake outlet.*

Figure 4

WATER LEVEL IN EAGLE SPRING LAKE: JUNE 2001-JUNE 2003



Source: Karin M. Hollister.

indicating that the Wambold dam influences water levels in both Lakes. In a parallel investigation, Karin Marie Hollister documented water level fluctuations from June 2001 through June 2003.[16] The standard deviation of the range in elevation was documented to be plus or minus one inch around a mean stage of 820.69 feet NGVD-29, as shown in Figure 4.

The surface water elevation profile shown in Figure 5 indicates that the Wambold dam at the Eagle Spring Lake outlet affects surface water elevations of Lulu Lake and extends approximately 1,650 feet upstream of Lulu Lake to the TNC bridge, shown on Maps 10 and 11. The TNC bridge is located on a historic, abandoned railroad bed upon which significant amounts of gravel and rock have been placed to create a stable foundation for the railroad. Therefore, the streambed adjacent to and underneath the TNC bridge contains a significant amount of gravel and cobble substrates of the same sizes and types as observed within the fill in the railroad berms at this location. This historical fill material has established a unique riffle habitat comprised of a mixture of gravel and cobble substrates, which is the only riffle habitat found within the 7,000 linear feet of channel surveyed by SEWRPC staff in the summer of 2008. This riffle was the only location where muck sediments were not observed to be predominant, and it is the shallowest of all the cross sections surveyed, as shown in Figure 6.[17] The TNC bridge

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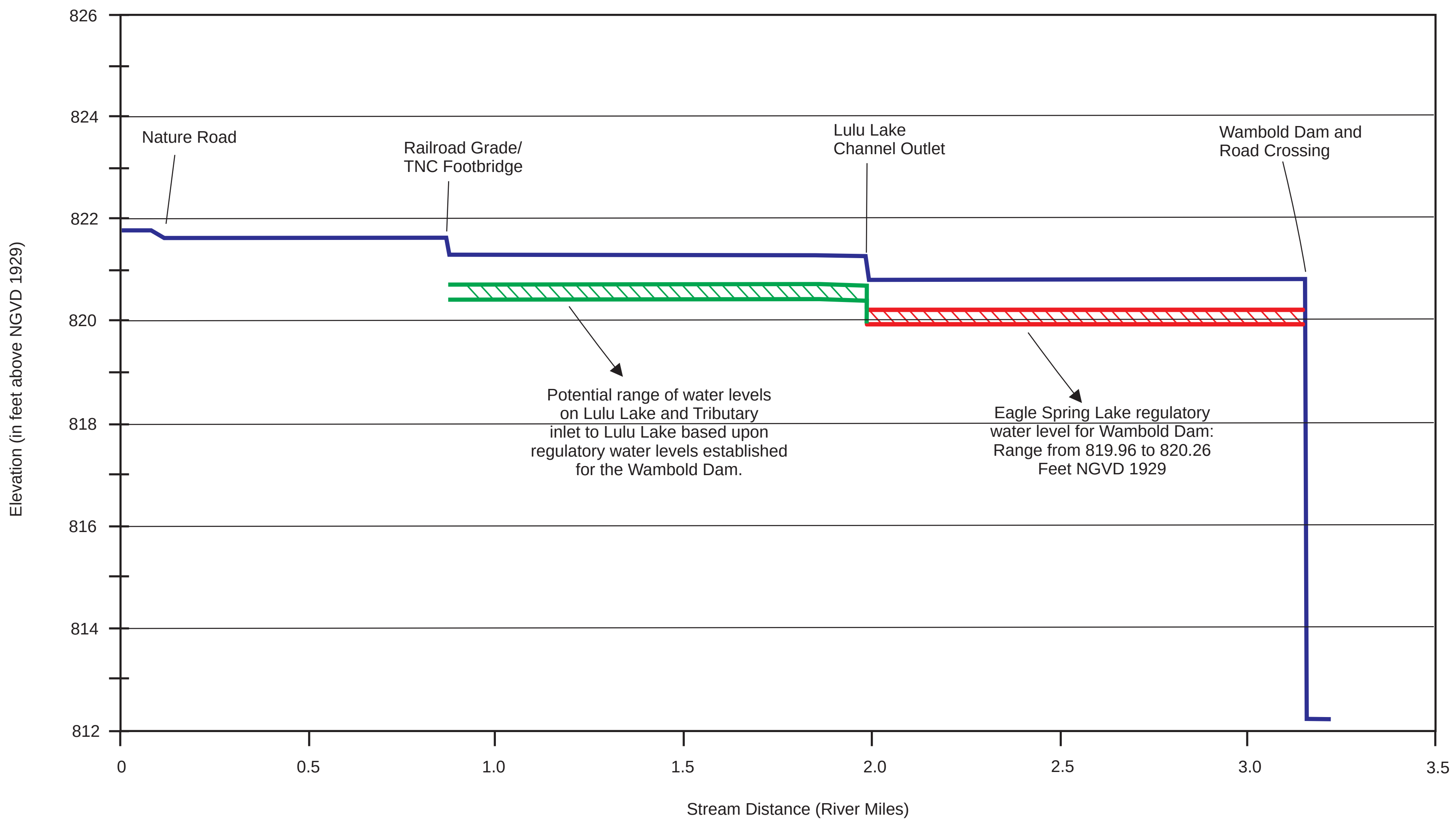
[16]*Karin Marie Hollister, "Hydrologic Modeling of the Upper Mukwonago River: An Investigation of the Effects of Urban Development and an Evaluation of Mitigation Schemes, Southeastern Wisconsin," Master of Science Thesis submitted to the University of Wisconsin-Madison, May 2006.*

[17]*Based upon the 27 transects surveyed at the locations shown on Maps 10 and 11, about 96 percent were comprised of muck substrates, 85 percent contained peat substrates, and sand was found in 18 percent.*

Figure 5

EXISTING SURFACE WATER ELEVATION PROFILE OF LULU AND EAGLE SPRING LAKES: 2005

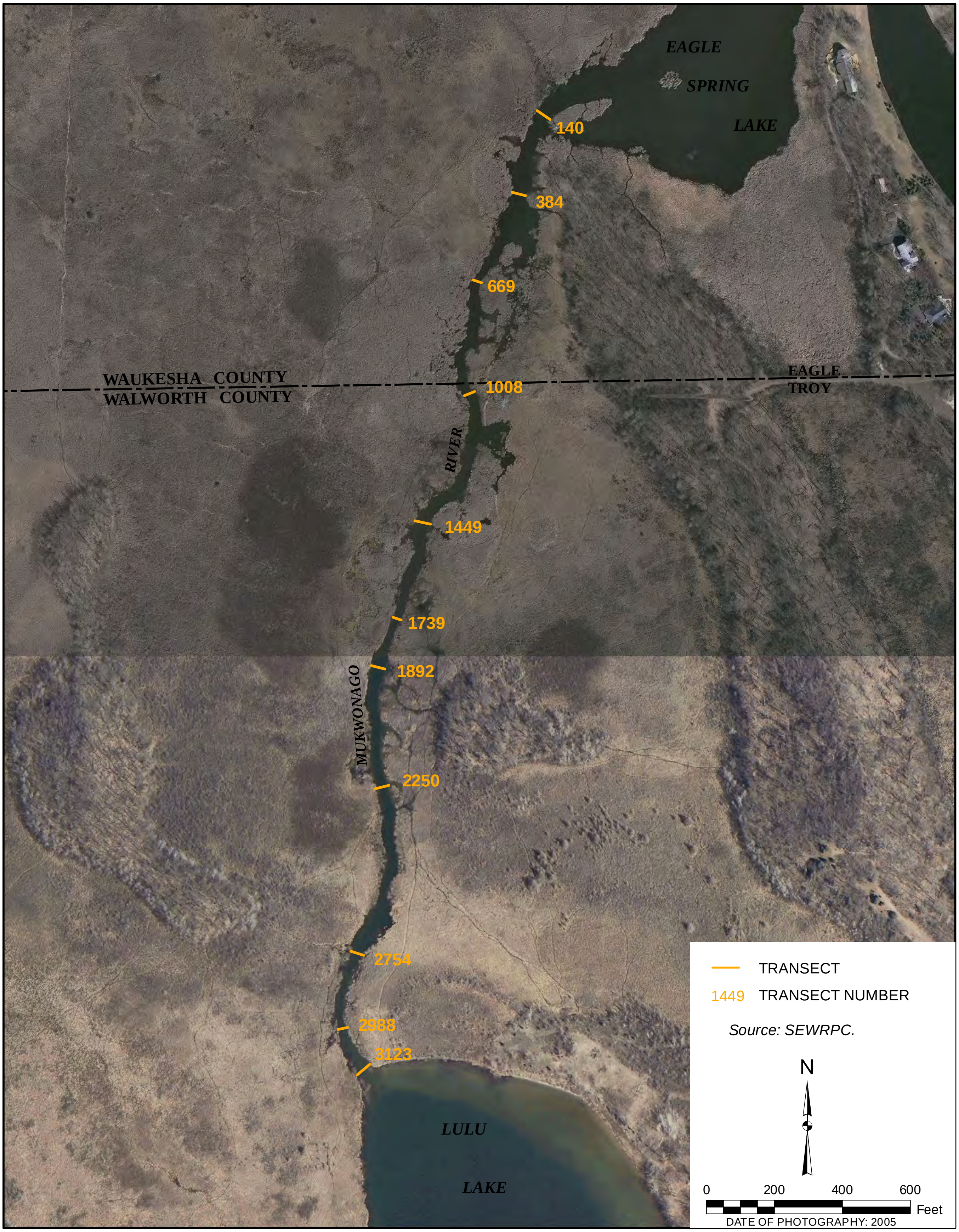


NOTE Surface water elevation is based upon the 2005 Waukesha County Digital Terrain Model (DTM) data.

Source: SEWRPC.

Map 10

TRANSECT LOCATIONS BETWEEN LULU AND EAGLE SPRING LAKES: 2008



Map 11

TRANSECT LOCATIONS UPSTREAM OF LULU LAKE: 2008

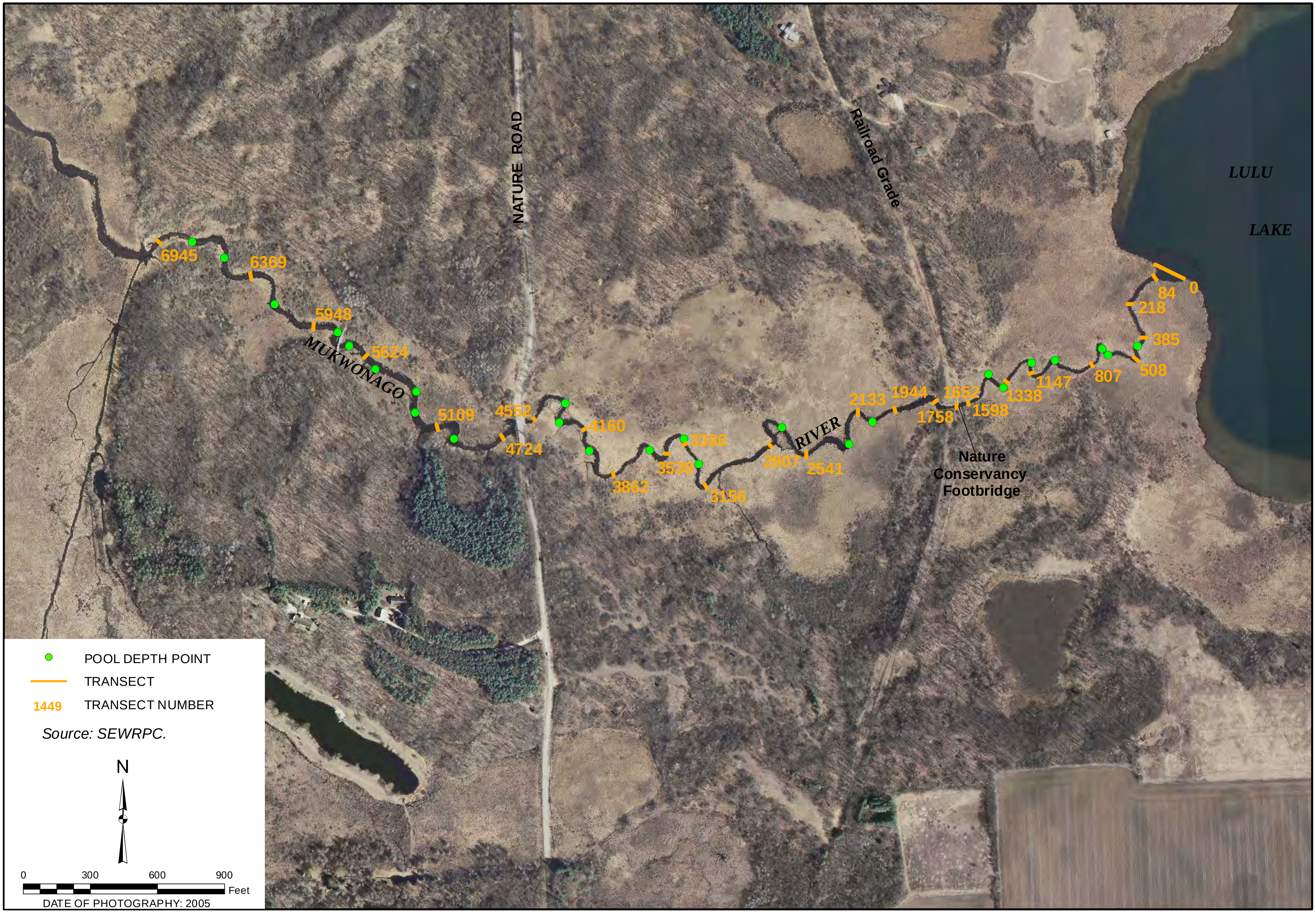
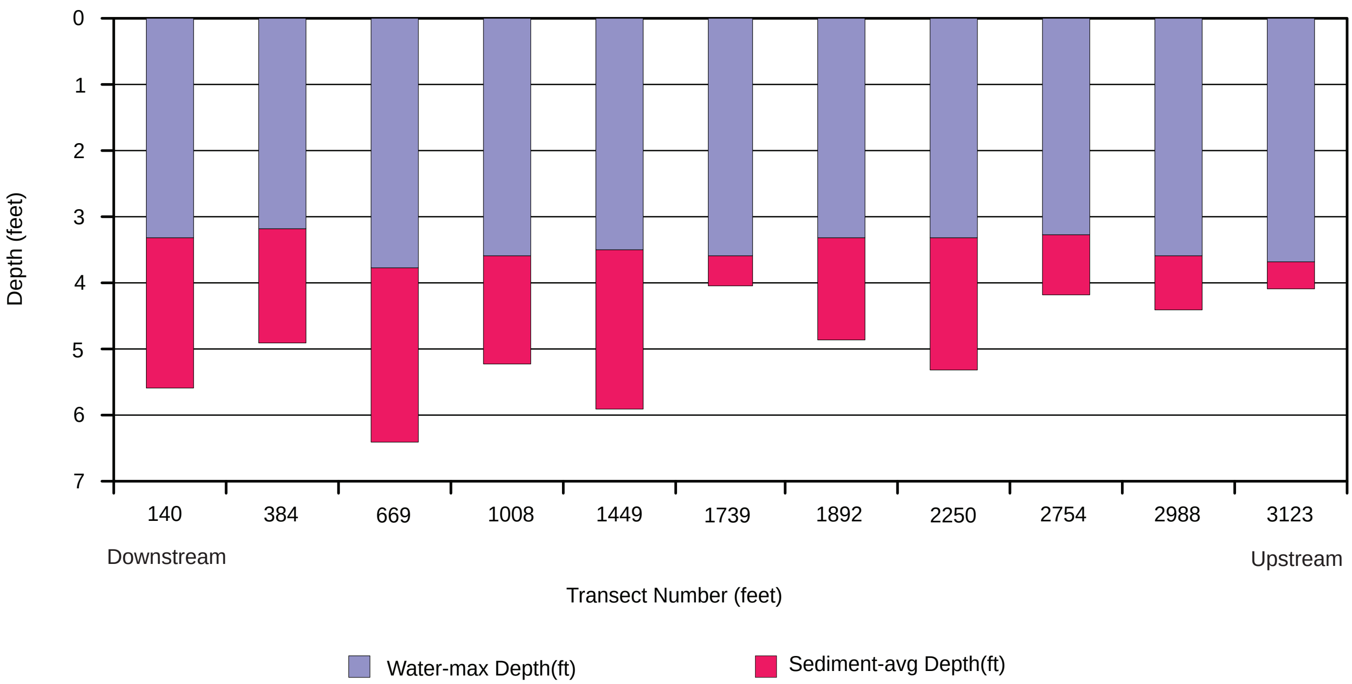


Figure 6

MAXIMUM WATER DEPTH AND MEAN SEDIMENT DEPTH AMONG TRANSECTS BETWEEN EAGLE SPRING AND LULU LAKES: 2008



Source: SEWRPC.

riffle is a high point on the streambed that causes a backwater effect up to the Nature Road culvert approximately 2,900 linear feet upstream. The Nature Road culvert is also causing an upstream backwater effect. These control points are likely to be the main cause for the observed decreasing stream width from upstream to downstream, which is opposite of what is expected to occur, as can be seen in Figure 7.

The sediment depth distribution also indicates the significant backwater effect of Lulu Lake, with the deepest sediments being located closer to Lulu Lake, as shown in Figure 8. This backwater effect also is reflected in maximum pool depth within this portion of the Mukwonago River. Maximum pool depths are less than three feet upstream of Nature Road, range from three feet to four feet between Nature Road and the TNC bridge, and range from three feet to nearly six feet downstream of the TNC bridge.

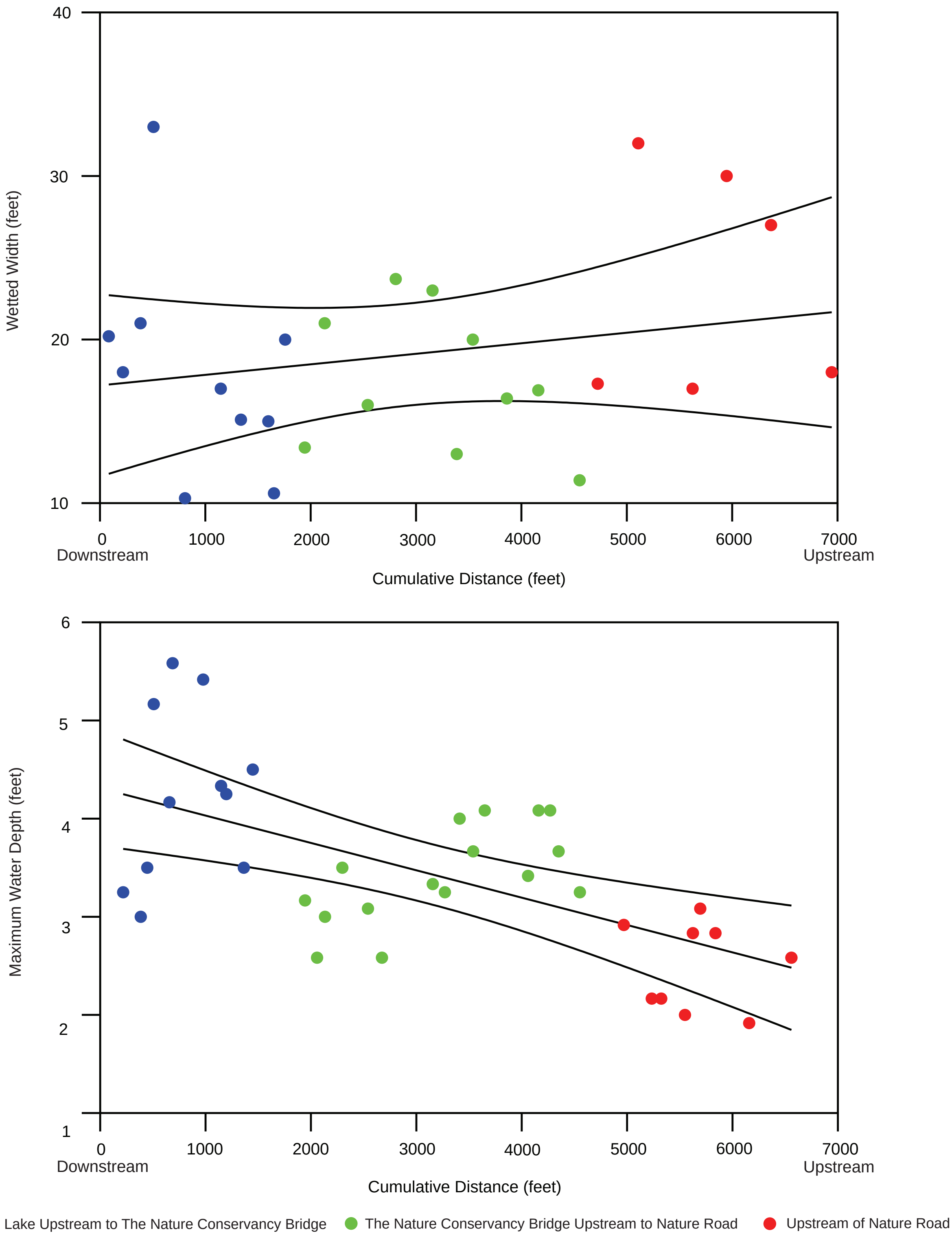
Runoff values for the Eagle Spring Lake tributary area considered in the plan were based on USGS Water Year 2008 data, which was the most recent complete calendar year data available for the current study. The above-average runoff volumes for 2008, as shown in Table 2, are consistent with the above-average precipitation that occurred during that year.

Groundwater

In general, the Mukwonago River streamflow, and, subsequently, the lakes it supplies water to, is highly dependent upon groundwater discharge. Hilary Erin Gittings has shown that flow in the Mukwonago River system is dependent upon groundwater discharges from multiple aquifers, including the surficial shallow sand and

Figure 7

WATER WIDTH AND MAXIMUM POOL DEPTH PROFILES WITHIN THE MUKWONAGO RIVER UPSTREAM OF LULU LAKE: SUMMER 2008

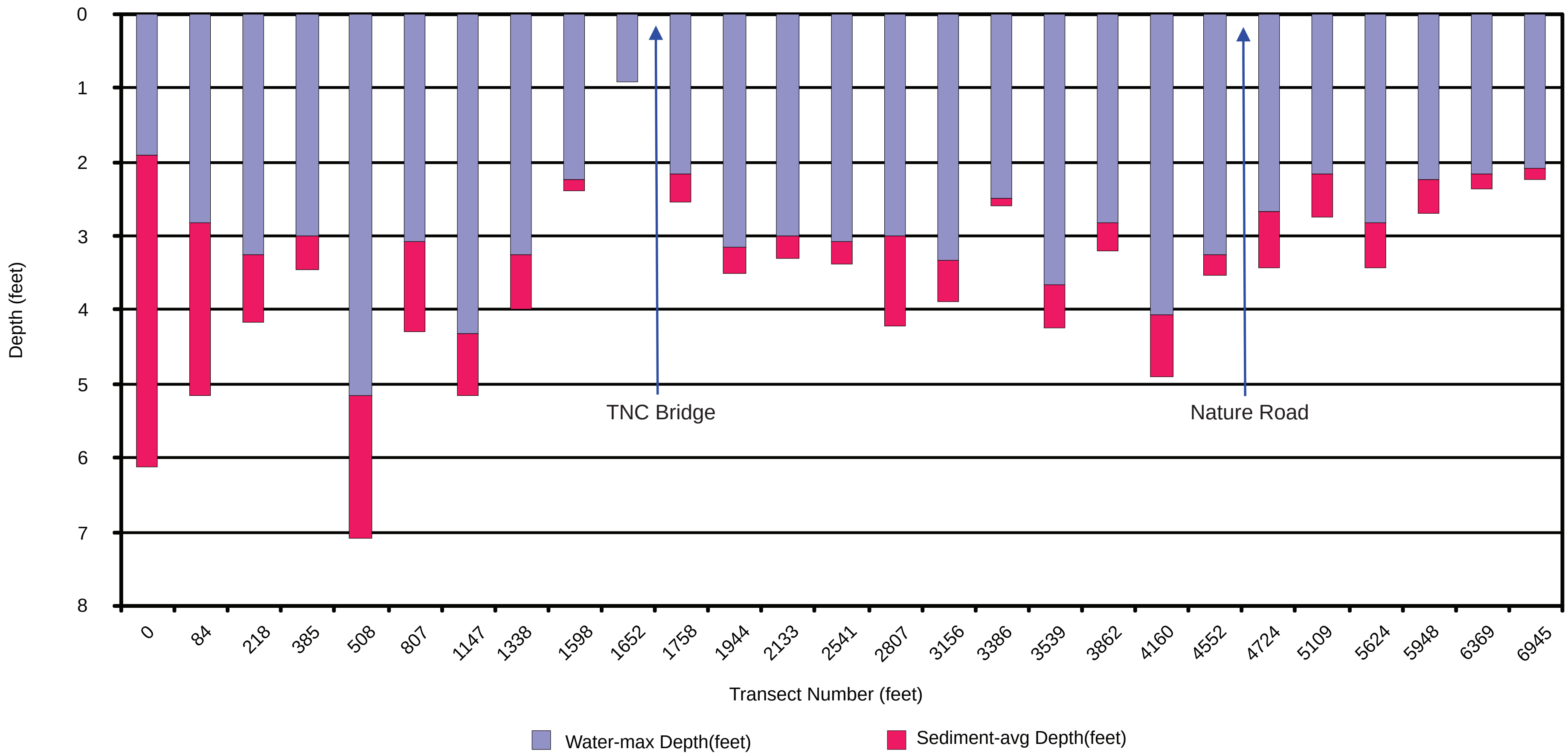


NOTE: There are more data points associated with the maximum pool depth graph because this includes additional data taken in between the transect lines.

Source: SEWRPC.

Figure 8

MAXIMUM WATER DEPTH AND MEAN SEDIMENT DEPTH AMONG TRANSECTS UPSTREAM OF LULU LAKE: 2008



Source: SEWRPC.

gravel aquifer and the shallow bedrock aquifer.[18] Of the groundwater contributed to the spring complex upstream of Lulu Lake, about 15 to 100 percent was discharged through "boils" from a bedrock source, entering the springs through preferential flow paths within the fractured bedrock; the sand and gravel aquifer was estimated to contribute from 0 to 20 percent to this flow, between the spring complex and the TNC bridge—total groundwater inputs during any given year could equal up to 100 percent of the inflow to Lulu Lake, with the ratio of shallow bedrock aquifer to surficial shallow sand and gravel aquifer flows varying as a function of rainfall, runoff, and degree of aquifer recharge experienced during a specific year. A similar relationship was reported for the Lake Beulah area which also received a small contribution of groundwater from the deep aquifer. Gittings further reported high levels of chloride in water samples obtained from the open water and shallow groundwater sites upstream of Lulu Lake. This is consistent with findings reported by the ESLMD.[19]

Groundwater inflows within the Eagle Spring Lake and Lulu Lake basins have a direct effect on the thermal structure of the Lakes and can be clearly seen in the temperature records obtained from the 18 temperature data-loggers placed in the nearshore areas of the two lakes by SEWRPC staff between May and September 2008, as shown on Map 9. These data-logger records document a longitudinal thermal gradient along the Mukwonago River system from upstream Lulu Lake to downstream of Eagle Spring Lake. Significant warming occurred at the outlet of Lulu Lake, which seemed to indicate that surface water from Lulu Lake discharged directly into the outlet. Temperatures generally remain relatively constant beyond this point, as shown in Figure 9, although the influence of groundwater inflows within Eagle Spring Lake significantly decreased water temperatures in the northwestern portions of that Lake—see Figure 10. Additionally, the temperature data set forth in Figure 11 showed that the eastern portions of each lake were warmer than the western portions; however, the southern portions of Eagle Spring Lake exhibited the highest maximum temperatures of any station on Eagle Spring Lake, indicating that the southern bays are likely to be less well mixed and more susceptible to heating than all other areas within Eagle Spring Lake.

Within Eagle Spring Lake there were three sites where both surface and bottom temperatures were recorded. These data, shown in Figure 10, demonstrate the significant cooling effects of groundwater at the northwestern station, which is located above an area of groundwater discharge. This station exhibited the coldest deep and surface water temperatures compared to the other stations. Conversely, the eastern station located near the Kroll dam exhibited the warmest temperatures compared to the two other stations. In addition, the differences between the surface and bottom temperature records at the eastern station were minimal in comparison to the other stations, indicative of a portion of the Lake that would tend to be better mixed than the northern and western portions of the basin. This is consistent with the effect of the prevailing westerly winds. This same phenomenon was observed on Lulu Lake, which showed that the eastern surface water station was consistently about two to four degrees warmer than the western station from May through August. Further comparison between Eagle Spring Lake and Lulu Lake indicates that the surface water at the eastern station on Eagle Spring Lake was consistently warmer than that at the eastern station on Lulu Lake, as shown in Figure 12. However, the southern portion of Eagle Spring Lake was consistently the warmest area compared to all stations throughout the Eagle Spring Lake and Lulu Lake system. As mentioned above, this indicates that the southern bays were likely to be less well mixed and more susceptible to heating than other areas within the Eagle Spring and Lulu Lakes system. These temperature differences are significant in terms of fish spawning and/or degree-day egg development as well as potential for growth differences within and among fish species or temperature tolerances, among others.[20]

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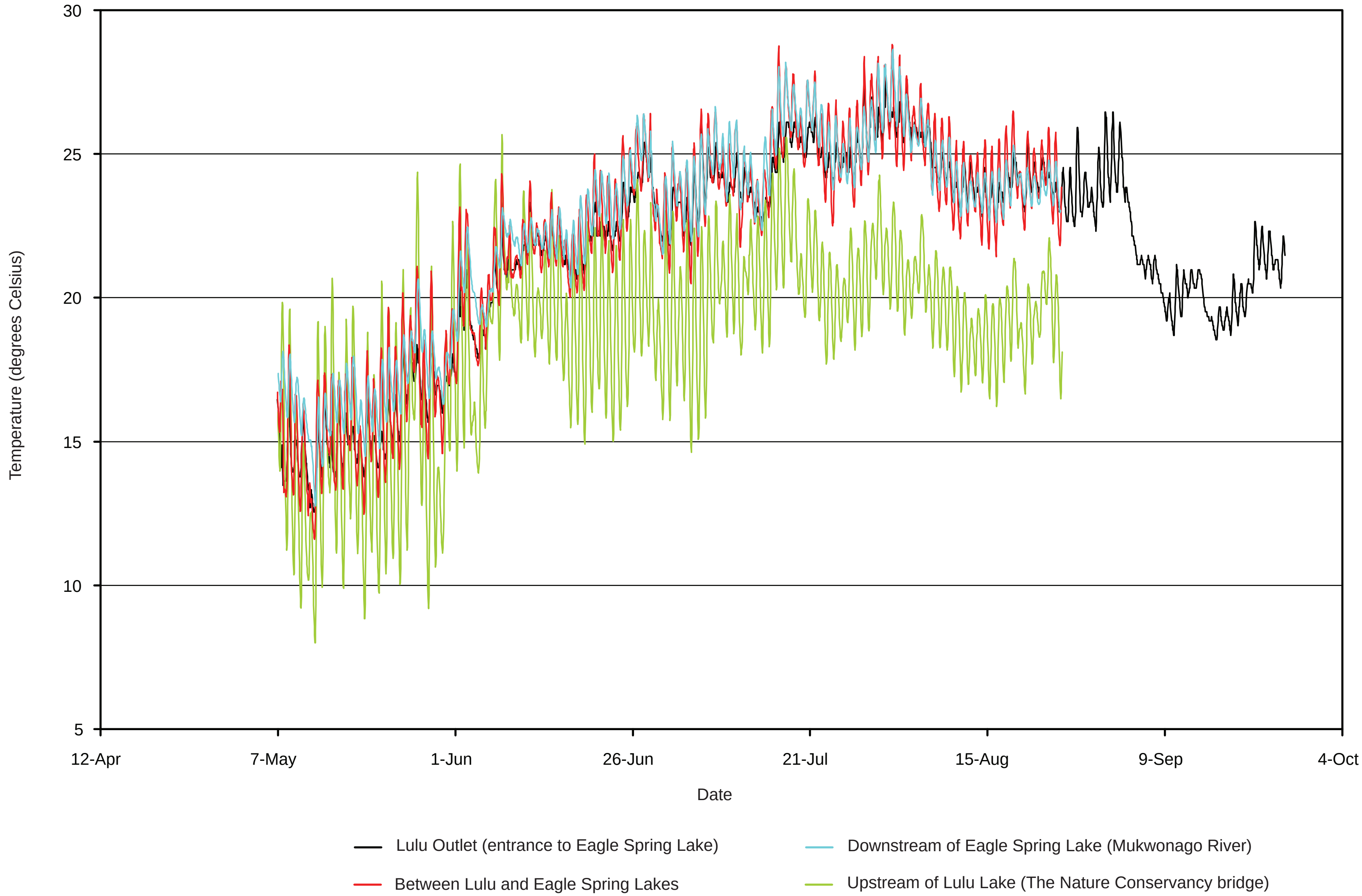
[18]*Hilary Erin Gittings, "Hydrogeologic Controls on Springs in the Mukwonago River Watershed, SE Wisconsin," Master of Science Thesis submitted to the University of Wisconsin-Madison in 2005.*

[19]*Eagle Spring Lake Management District, "Mukwonago River-Watershed Nutrient Study: August 2004–October 2008," August 2008.*

[20]*See, for example, G.W. Becker,* Fishes of Wisconsin, *University of Wisconsin Press, Madison, 1983.*

Figure 9

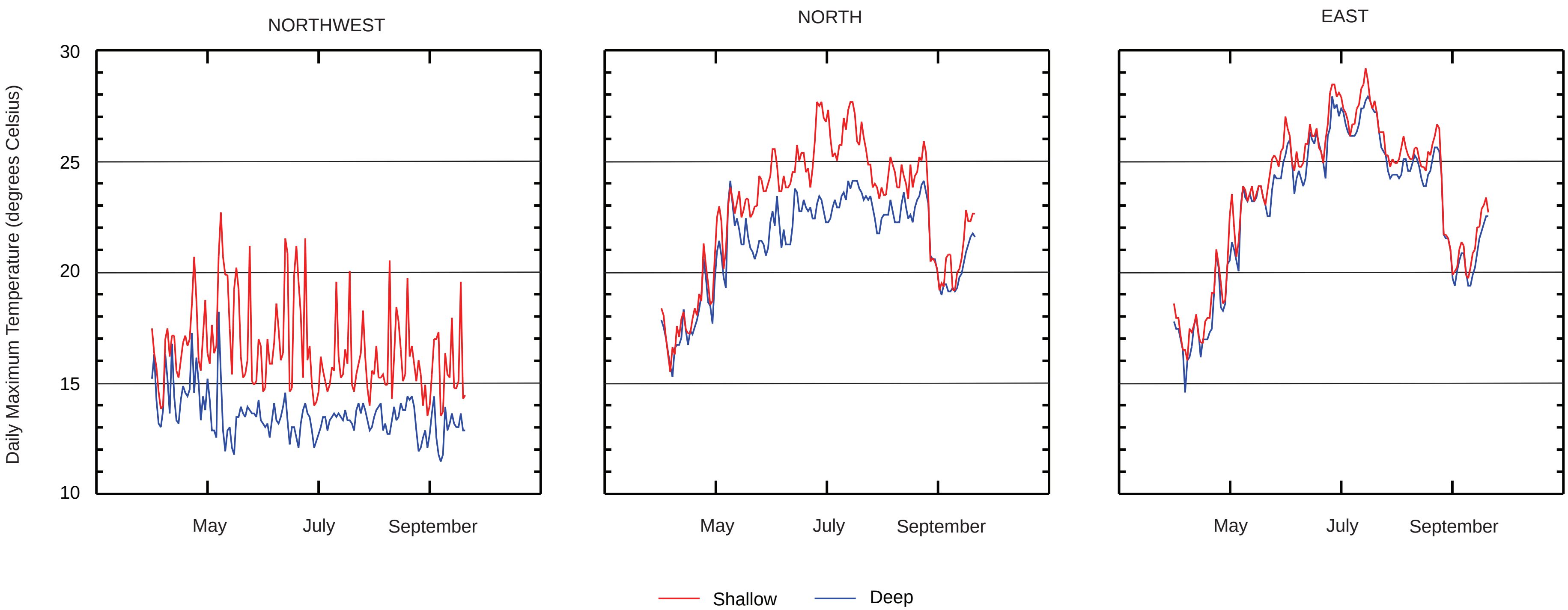
HOURLY SURFACE WATER TEMPERATURES AT SITES UPSTREAM OF LULU LAKE TO DOWNSTREAM OF EAGLE SPRING LAKE: MAY-SEPTEMBER 2008



Source: SEWRPC.

Figure 10

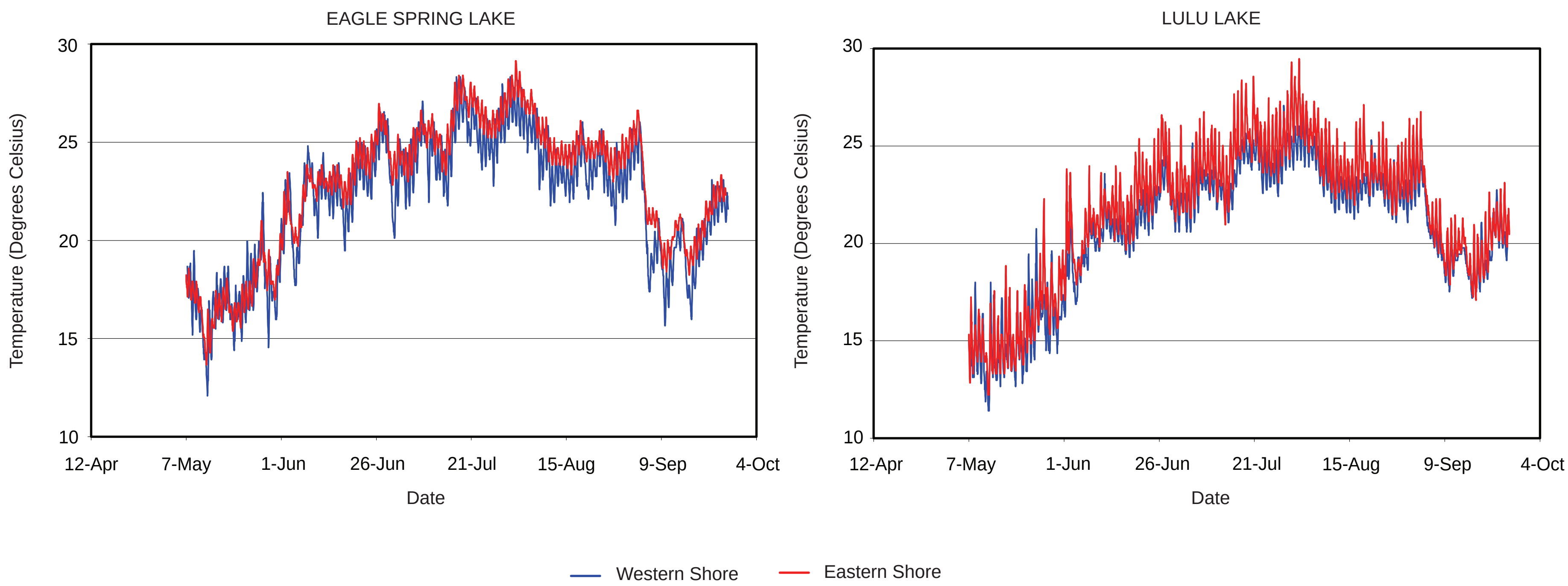
DAILY MAXIMUM WATER TEMPERATURE AMONG SURFACE AND DEEP SITES IN EAGLE SPRING LAKE: MAY-SEPTEMBER 2008



Source: SEWRPC.

Figure 11

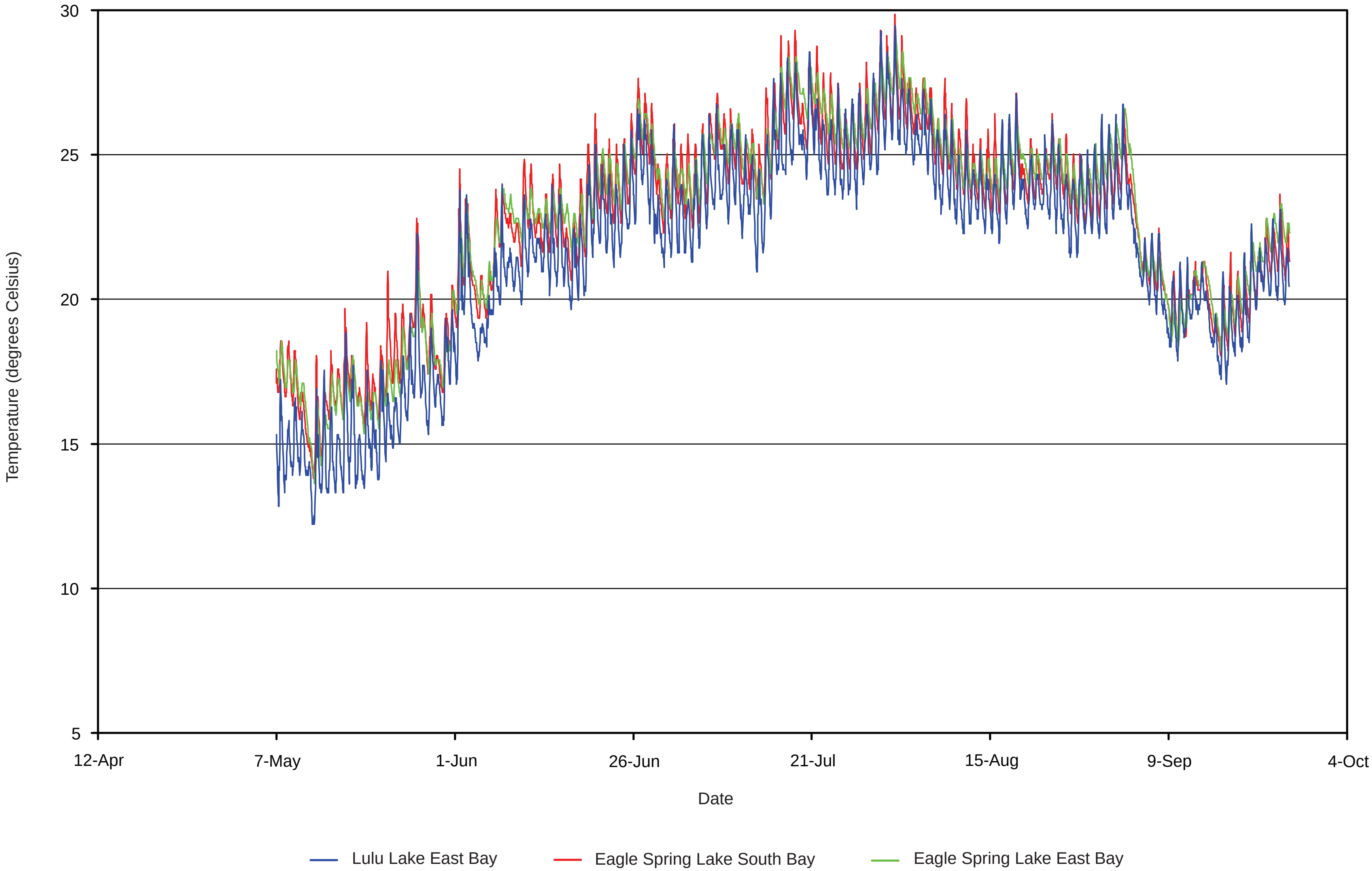
HOURLY SURFACE WATER TEMPERATURES BETWEEN SITES ON THE WESTERN SHORE VERSUS THE EASTERN SHORE IN EAGLE SPRING LAKE AND LULU LAKE: MAY-SEPTEMBER 2008



Source: SEWRPC.

Figure 12

HOURLY SURFACE WATER TEMPERATURES AT SITES IN LULU AND EAGLE SPRING LAKES: MAY-SEPTEMBER: 2008



Source: SEWRPC.

Water Budget

In the initial comprehensive lake management plan, a water budget for the study period 1993-1994 was computed for Eagle Spring Lake. Inflow amounts were based on estimated precipitation directly onto the lake surface, inflow from the Mukwonago River, and groundwater inflow; outflow amounts were based on estimated evaporation, outflow to the Mukwonago River, and groundwater outflow. This earlier water budget indicated that about 94 percent of the water entering Eagle Spring Lake was contributed by the Mukwonago River and groundwater, and the remaining 6 percent by precipitation directly to the Lake surface; of the water flowing out of Eagle Spring Lake, evaporation accounted for about 6 percent of the total outflow of water, while the remaining 94 percent was discharged from the Lake via the Mukwonago River.

During the current study period, using data from the USGS, long-term and study year 2008 hydrologic budgets for Eagle Spring Lake were calculated, as shown in Table 3; the long-term water budget also is displayed in Figure 13.

During the calendar year 2008, during which precipitation was more than 10 inches above the long-term average, 19,414 acre-feet of water were estimated to have entered the Lake. Of this total, about 1,028 acre-feet, or about 5 percent, were contributed by direct precipitation onto the Lake's surface; about 14,198 acre-feet, or 73 percent, as inflow from the Mukwonago River; and, about 4,188 acre-feet, or 22 percent, as net groundwater inflow. Of the water lost from Eagle Spring Lake during the 2008 study year, about 674 acre-feet, or about 3 percent, evaporated from the lake surface, and about 18,740 acre-feet, or 97 percent, were discharged through the Mukwonago River. Water flows in the Mukwonago River during 2008, compared to long-term flows, were consistent with the increased precipitation observed during 2008.

Over the long term, represented by a 35-year period of gauging records on the Mukwonago River, about 788 acre-feet of water, or 7 percent of the total inflow, enter the Lake each year as a result of direct precipitation onto the Lake's surface; about 10,890 acre-feet, or 91 percent, as inflow from the Mukwonago River; and, about 286 acre-feet, or about 2 percent, as net groundwater inflow. Of the water lost from Eagle Spring Lake each year, about 674 acre-feet, or about 6 percent, are estimated to evaporate from the Lake surface and about 11,290 acre-feet, or 94 percent, are discharged through the Mukwonago River.

Water Residence Time

As noted above, Eagle Spring Lake has a tributary area-to-lake area ratio of about 58:1. Lakes with large tributary area-to-lake area ratios, in the range of several hundred or more to one, typically have shorter water residence times than lakes with smaller ratios. The water or hydraulic residence time, also referred to as the retention time or flushing rate, is the time needed for the full volume of a lake to be completely replaced by an equal volume of inflowing water. Water residence time is reported in units of years or fractions of a year, even though it is recognized that flow events vary with season; for example, "spring floods" would have the effect of reducing water residence time during that season, while "summer droughts" may result in longer water residence times.

In the initial comprehensive lake management plan, the hydraulic residence time was reported to be about 0.1 year. Using the refined measurements of the total tributary area of Eagle Spring Lake and the currently estimated volumes of runoff, groundwater inflow, and direct precipitation, the long-term water residence time has been refined to about 0.07 year, or about 26 days.

Residence time is important in determining the expected response time of a lake to increased or reduced nutrient and other pollutant loadings. Lakes having a short residence time of less than a year, such as small drainage lakes, through-flow lakes, such as Eagle Spring Lake, and lakes with large amounts of groundwater inflow and outflow, will allow nutrients and pollutants to be flushed from the lake fairly rapidly and generally respond well when nutrient inputs are decreased. Lakes with longer residence times, such as seepage lakes having no outflow streams, typically respond slowly to changes in their tributary area, since it takes a long time for a volume equivalent to the full volume of the lake to enter the lake from its tributary area. Such lakes can accumulate

Table 3

HYDROLOGIC BUDGETS FOR EAGLE SPRING LAKE

Element	2008 (acre-feet)	Long-Term (acre-feet)
Inflows		
Direct Precipitation to Lake Surface	1,028	788
Inflow from Mukwonago River	14,198	10,890
Groundwater Net Inflow[a]	4,188	286
Total	19,414	11,964
Outflows		
Evaporation from Lake Surface	674	674
Outflow to Mukwonago River	18,740	11,290
Total	19,414	11,964

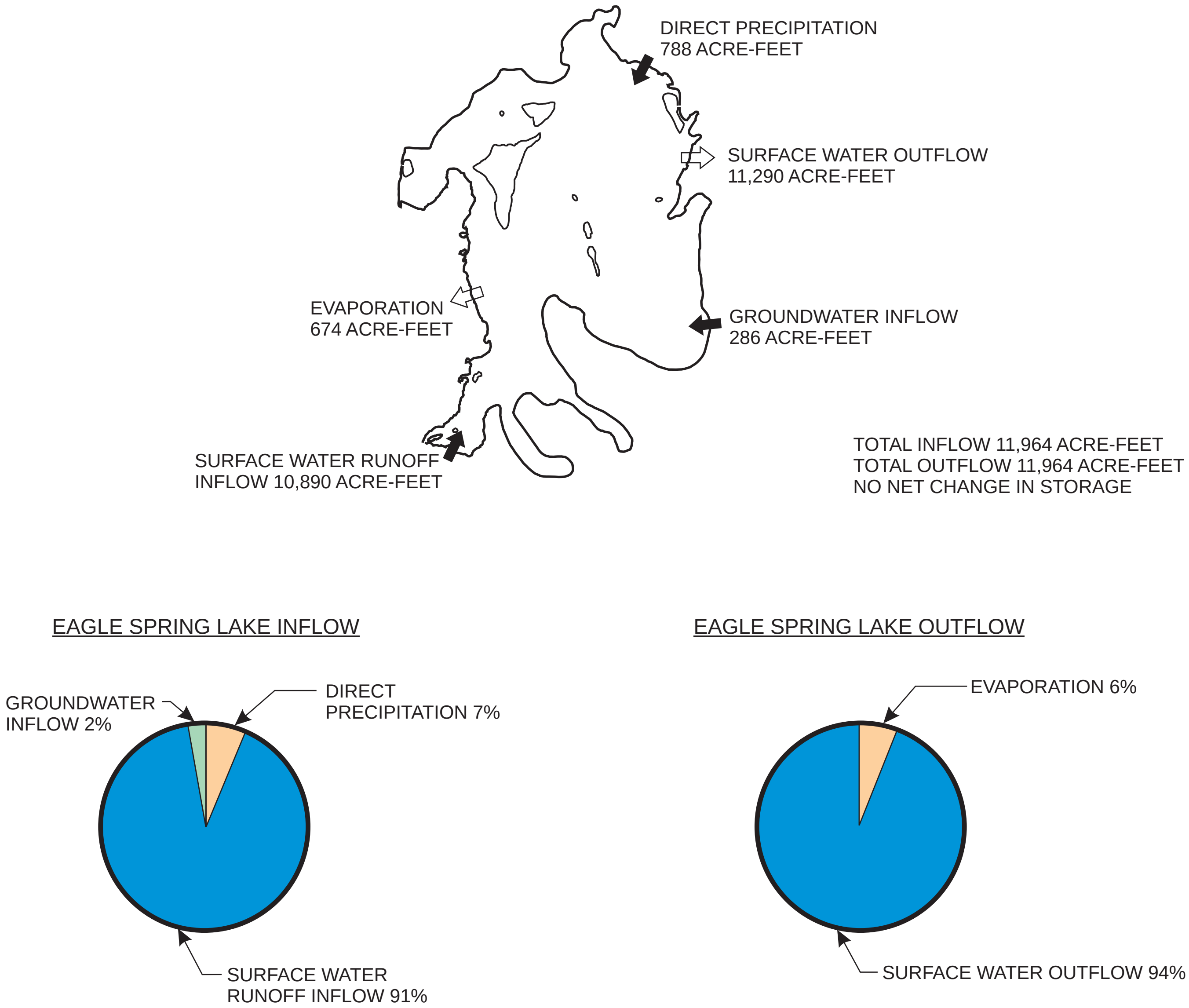
[a]*Data presented in initial SEWRPC report calculated a net outflow of groundwater from Eagle Spring Lake during the study year of 1993-1994 in the amount of 120 acre-feet. Refinements in the modeling technology used to determine tributary area boundaries and surface water size for Eagle Spring Lake led to determinations of net groundwater inflow to the Lake during 2008 and over the long-term.*

Source: National Oceanic and Atmospheric Administration and SEWRPC.

nutrients for many years, recycling them each year during the periods spring and fall overturn, with the result that the effects of tributary area protection may not be immediately apparent. The relatively short water residence times estimated for Eagle Spring Lake are indicative of a well-flushed waterbody that should respond relatively quickly to changes in the external nutrient and contaminant loads.

Figure 13

LONG-TERM HYDROLOGIC BUDGET FOR EAGLE SPRING LAKE



Source: U.S. Geological Survey and SEWRPC.

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Chapter III

LAND USE REGULATIONS AND HISTORICAL, EXISTING, AND FORECAST LAND USE AND POPULATION

INTRODUCTION

Water pollution problems, and the ultimate solution of those problems, are primarily a function of the human activities within the tributary area to a waterbody, and of the ability of the underlying natural resource base to sustain those activities. This is especially true in an area directly tributary to a lake because lakes are highly susceptible to water quality degradation attendant to human activities in this area. Lake water quality degradation arising from human activities in the shoreland zone is more likely to interfere with desired water uses, and is often difficult and costly to correct. Accordingly, the land uses and population levels in the direct tributary area of a lake are important considerations in lake water quality management. In addition, in the case of drainage or through-flow lakes having both an inlet and an outlet, human activities in the larger tributary watershed also can influence the nature of potential water quality concerns and the nature of community responses to observed water quality conditions. Hence, consideration should also be given to the human activities in the wider watershed.

As noted in Chapter II, since the publication of the initial comprehensive lake management plan for Eagle Spring Lake,[1] there has been a significant advance in topographic mapping capability, with the advent of two-feet contour interval digital terrain maps (DTMs) that allow significant refinement of the drainage area tributary to specific waterbodies. Consequent to this, the actual drainage area tributary to Eagle Spring Lake has been refined with a reduction in the areal extent of both the drainage area and Lake surface area. Several portions of the watershed have been defined as internally-drained, which effectively removes these areas from the surface drainage contributing to Eagle Spring Lake in all but the most extreme precipitation events. Notwithstanding, while these areas rarely contribute surface flows to Eagle Spring Lake, they may play a role in groundwater recharge, which in some cases may make its way into the surface water system through springs and other groundwater discharge points in the watershed. Numerous such groundwater discharge points have been identified, as summarized by the Wisconsin Conservation Department,[2] and as updated during the formulation of the Mukwonago River protection plan by the Southeastern Wisconsin Regional Planning Commission (SEWRPC)

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[1]*SEWRPC Community Assistance Planning Report No. 226,* A Lake Management Plan for Eagle Spring Lake, Waukesha County, Wisconsin, *October 1997.*

[2]*Wisconsin Conservation Department,* 1958 Spring Area Survey, Waukesha County, *December 1958.*

staff.[3] These observations were further refined through both a Regional groundwater assessment conducted by the Commission,[4] an area-specific detailed groundwater model developed for the Village of Eagle and environs,[5] and a number of studies that have investigated various aspects of the groundwater system tributary to the Mukwonago River watershed draining to Eagle Spring Lake.[6] As a result of these investigations, the area tributary to Eagle Spring Lake is defined as inclusive of the internally drained areas for purposes of evaluating civil division jurisdictions, population, and land use, documented in this chapter, that potentially affect the hydrology of Eagle Spring Lake; however, these internally drained areas are excluded for the contaminant loading assessments set forth in Chapter IV.

CIVIL DIVISIONS

The geographic distribution and functional jurisdictions of the general- and special-purpose units of government also are important factors which must be considered in lake water quality management, since these local units of government provide the basic structure of the decision-making framework within which intergovernmental environmental problems must be addressed. Superimposed on the irregular tributary area of Eagle Spring Lake are the local civil division boundaries, shown on Map 12. These governmental units include: portions of the Village of Eagle and the Town of Eagle, both in Waukesha County; the Towns of LaGrange and Troy in Walworth County; and, the Town of Palmyra in Jefferson County. Jefferson, Walworth and Waukesha Counties administer a number of programs and administrative functions which also relate directly to lake and tributary area management in the Eagle Spring Lake area, as does the Wisconsin Department of Natural Resources (WDNR).

LAND USE REGULATIONS

The comprehensive zoning ordinance represents one of the most important and significant administrative and regulatory tools available to local units of government for directing the use of lands within their areas of jurisdiction. Table 4 shows the land use regulations in effect in the civil divisions within the area tributary to Eagle Spring Lake, which are further summarized below.

General Zoning

Villages in Wisconsin are granted comprehensive, or general, zoning powers under Section 61.35 of the *Wisconsin Statutes*. Counties also are granted general zoning powers within their unincorporated areas under Section 59.69 of the *Wisconsin Statutes*. However, a county zoning ordinance becomes effective only in those towns that ratify the county ordinance. Towns that have not adopted a county zoning ordinance may adopt village powers, and subsequently utilize the village zoning authority conferred in Section 62.23, subject, however, to

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[3]*See SEWRPC Community Assistance Planning Report No. 309,* Mukwonago River Watershed Protection Plan, *June 2010.*

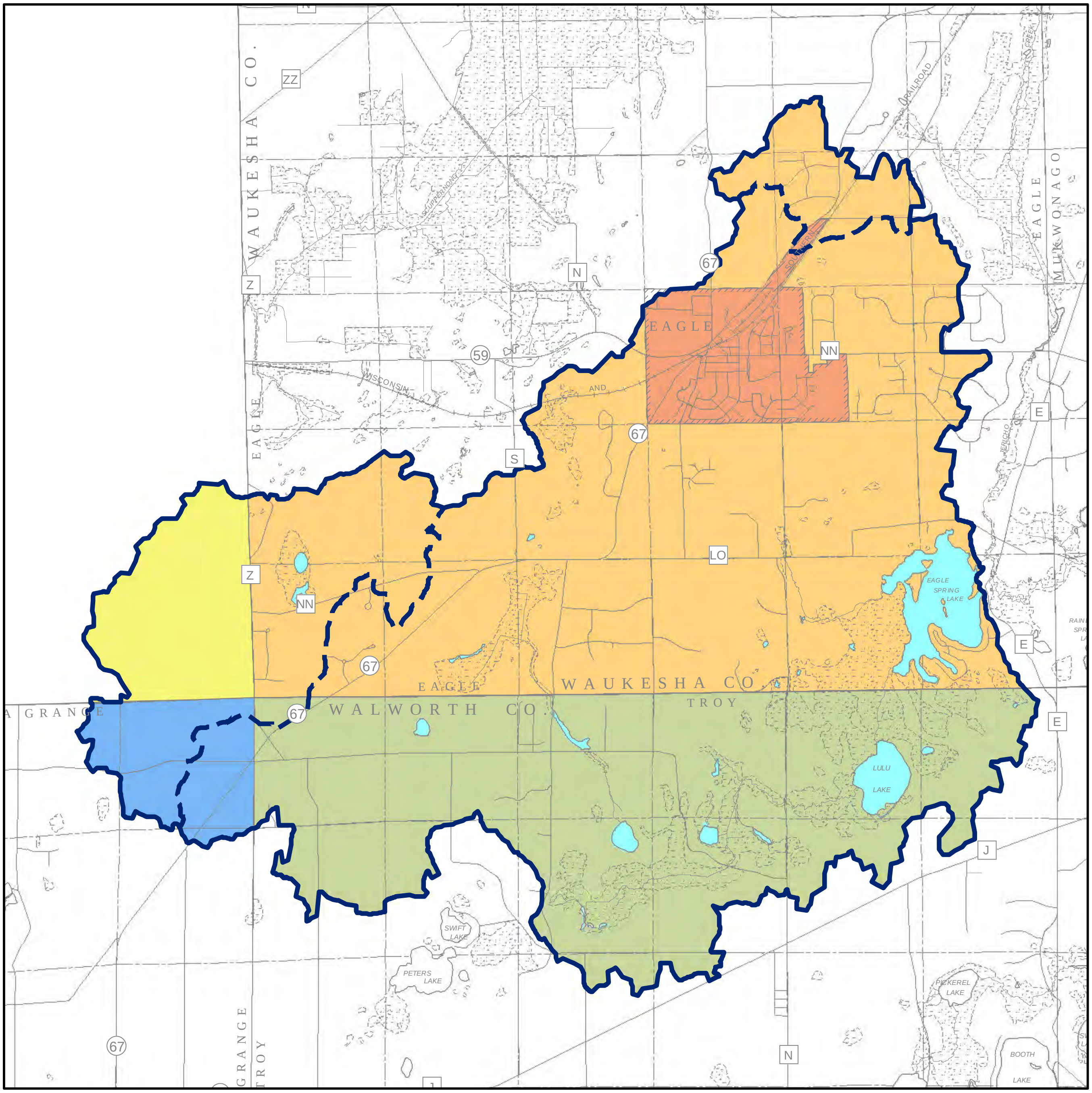
[4]*SEWRPC Technical Report No. 37,* Groundwater Resources of Southeastern Wisconsin, *June 2002.*

[5]*SEWRPC Memorandum Report No. 167,* Simulation of Shallow Groundwater Flow in the Vicinity of the Village of Eagle, Waukesha County, Wisconsin, *2004.*

[6]*See, for example, Todd Shoemaker, "Evaluation of the Hydrology and Hydraulics of Eagle Spring Lake, Eagle Wisconsin," Master of Science Thesis submitted to the Department of Civil and Environmental Engineering at the University of Wisconsin-Madison, May 2002; Hilary Erin Gittings, "Hydrogeologic Controls on Springs in the Mukwonago River Watershed, SE Wisconsin," Master of Science Thesis submitted to the University of Wisconsin-Madison, 2005; Karin Marie Hollister, "Hydrologic Modeling of the Upper Mukwonago River: An Investigation of the Effects of Urban Development and an Evaluation of Mitigation Schemes, Southeastern Wisconsin," Master of Science Thesis submitted to the University of Wisconsin-Madison, May 2006.*

Map 12

CIVIL DIVISION BOUNDARIES WITHIN THE TOTAL TRIBUTARY AREA TO EAGLE SPRING LAKE



Town of Eagle	Total Tributary Area Boundary
Town of LaGrange	Internally Drained Area Boundary Where Not Coincident with the Total Tributary Area Boundary
Town of Palmyra	
Town of Troy	
Village of Eagle	

N

0 3,000 6,000 Feet

Source: SEWRPC.

Table 4

LAND USE REGULATIONS WITHIN THE TOTAL AREA TRIBUTARY TO EAGLE SPRING LAKE BY CIVIL DIVISION

Community	Type of Ordinance: General Zoning	Floodland Zoning	Shoreland or Shoreland-Wetland Zoning	Subdivision Control	Construction Site Erosion Control and Stormwater Management
Jefferson County................	Adopted	Adopted	Adopted	Adopted	None
Town of Palmyra	County	County	County	County	None
Walworth County	Adopted	Adopted	Adopted and Wisconsin Department of Natural Resources-approved	Adopted	Adopted
Town of LaGrange..........	County	County	County	Adopted	Adopted
Town of Troy	County	County	County	Adopted	County
Waukesha County	Adopted	Adopted	Adopted and Wisconsin Department of Natural Resources-approved	Floodland and shoreland only	Adopted
Town of Eagle	Adopted	County	County	Adopted	Adopted
Village of Eagle	Adopted	None[a]	Not required	Adopted	Adopted

[a]*Flood hazard areas have been identified or mapped on year 2008 FEMA digital flood insurance maps.*

Source: SEWRPC.

county board approval where a general-purpose county zoning ordinance exists. Alternatively, a town may adopt a zoning ordinance under Section 60.61 of the *Wisconsin Statutes* where a general-purpose county zoning ordinance has not been adopted, but only after the county board fails to adopt a county ordinance at the petition of the governing body of the town concerned. General zoning is in effect in all communities within the Mukwonago River watershed.

Zoning is a tool used to regulate the use of land in Walworth and Waukesha Counties in a manner that serves to promote the general welfare of its citizens, the quality of the environment, and the conservation of its resources, as well as implement a land use plan. Zoning is the delineation of areas or zones into specific districts which provides uniform regulations and requirements that govern the use, placement, spacing, and size of land and buildings. The Planning and Zoning Division of the Waukesha County Department of Parks and Land Use administers the zoning maps and the zoning ordinance for portions of the unincorporated areas of Waukesha County, and the Land Use and Resource Management Division of Walworth County administers the zoning maps and zoning ordinance for portions of the unincorporated areas of Walworth County. The Basic Zoning Code was adopted in 1959 and last updated in May of 2005. Within the watershed, that code applies only to the Towns of LaGrange, Troy, and Palmyra. The code is designed to provide standards for land development to provide for adequate sanitation, drainage, safety, convenience of access, the preservation and promotion of the environment, property values, and general attractiveness. The Town of Eagle has its own zoning code pursuant to Section 60.61 of the *Wisconsin Statutes*.

Floodland Zoning

Section 87.30 of the *Wisconsin Statutes* requires that villages and counties, with respect to their unincorporated areas, adopt floodland zoning to preserve the floodwater conveyance and storage capacity of floodplain areas and to prevent the location of new flood-damage-prone development in flood hazard areas. The minimum standards which such ordinances must meet are set forth in Chapter NR 116, "Wisconsin's Floodplain Management Program," of the *Wisconsin Administrative Code*. The required regulations govern filling and development within a regulatory floodplain, which is defined as the area which has a 1-percent-annual-probability of being inundated. Under Chapter NR 116, local floodland zoning regulations must prohibit nearly all forms of development within the floodway, which is that portion of the floodplain required to convey the 1-percent-annual-probability peak flood flow. Local regulations must also restrict filling and development within the flood fringe, which is that portion of the floodplain located outside the floodway that would be covered by floodwater during the 1-percent-annual-probability flood. Permitting the filling and development of the flood fringe area, however, reduces the floodwater storage capacity of the natural floodplain, and may, thereby, increase downstream flood flows and stages.

The Waukesha and Walworth County ordinances related to shoreland and floodland protection recognize existing uses and structures and regulates them in accordance with sound floodplain management practices while protecting the overall water quality of stream systems. These ordinances are intended to: 1) regulate and diminish the proliferation of nonconforming structures and uses in floodplain areas; 2) regulate reconstruction, remodeling, conversion and repair of such nonconforming structures with the overall intent of lessening the public responsibilities attendant to the continued and expanded development of land and structures which are inherently incompatible with natural floodplains; and, 3) lessen the potential danger to life, safety, health, and welfare of persons whose lands are subject to the hazards of floods. Floodland zoning is in place for all of the towns in Walworth and Waukesha County. The Village of Eagle had flood hazard areas identified and mapped on year 2008 FEMA digital flood insurance rate maps, but has not adopted a floodland ordinance at this time.

Shoreland Zoning

Shoreland zoning regulations play an important role in protecting water resources. Under Section 59.692 of the *Wisconsin Statutes*, within their unincorporated areas, counties in Wisconsin are required to adopt zoning regulations within statutorily defined shoreland areas, which are defined as those lands within 1,000 feet of a navigable lake, pond, or flowage; 300 feet of a navigable stream; or to the landward side of the floodplain, which-ever distance is greater.[7]

Minimum standards for county shoreland zoning ordinances are set forth in Chapter NR 115, "Wisconsin's Shoreland Management Program."[8] Chapter NR 115 of the *Wisconsin Administrative Code* sets forth minimum requirements regarding lot sizes and building setbacks; restrictions on cutting of trees and shrubbery; and restrictions on filling, grading, lagooning, dredging, ditching, and excavating that must be incorporated into county shoreland zoning regulations. Because these are minimum requirements, counties may enact more restrictive ordinance provisions as are appropriate. In addition, Chapter NR 115 requires that counties place all wetlands five acres or larger and within the statutory shoreland zoning jurisdiction area into a wetland conservancy zoning district to ensure their preservation after completion of appropriate wetland inventories by the WDNR. However, the rules regarding minimum lots sizes, building setbacks, and cutting of trees and shrubbery established in Chapter NR 115 for counties do not apply to villages, except for newly annexed areas. Minimum standards for village shoreland-wetland zoning ordinances are set forth in Chapter NR 117 of the *Wisconsin Administrative Code*, "Wisconsin's City and Village Shoreland-Wetland Protection Program."

The basis for identification of wetlands to be protected under Chapters NR 115 and NR 117 is the Wisconsin Wetlands Inventory. Mandated by the State Legislature in 1978, that inventory resulted in the preparation of wetland maps covering each U.S. Public Land Survey township in the State. The inventory was completed for counties in southeastern Wisconsin in 1982, with the wetlands being delineated by SEWRPC on its 1980, one

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[7]*Determination of navigability and location of the ordinary high water mark on a case-by-case basis is the responsibility of the Wisconsin Department of Natural Resources.*

[8]*As of June 2009, a refined Chapter NR 115 of the* Wisconsin Administrative Code *was approved by the Wisconsin Natural Resources Board. These refinements, in part, provided for limitation of impervious surface areas in the shoreland zone.*

inch-equals-2,000-feet-scale aerial photography. SEWRPC staff, working in conjunction with the WDNR, recently completed updating that wetland inventory based on interpretation of 2005 color digital orthophotography and field verification of selected wetland boundaries.

County shoreland zoning ordinances are in effect in all unincorporated areas of Walworth and Waukesha Counties. All of the incorporated municipalities within the Mukwonago River watershed have adopted shoreland wetland zoning ordinances except for the Village of Eagle where shoreland-wetland zoning is not required. It should be noted that county shoreland zoning regulations remain in effect in areas which are annexed by a city or village after May 7, 1982, or for a town which incorporates as a city or village after April 30, 1994, according to Section 59.692(7)(a) of the *Wisconsin Statutes*, unless the ordinance requirements of the annexing or incorporating city or village are at least as stringent as those of the county. The only exception to this condition is if, after annexation, the annexing municipality requests the county to amend the county ordinance to delete or modify provisions that establish specified land uses or requirements associated with those uses. In such a situation, stipulations regarding land uses or requirements may be amended by the county.

Wetland Regulations

The determination of permissible, or potentially permissible, activities in wetlands within the Mukwonago River watershed may involve shoreland-wetland regulations as administered by the counties and villages, all under the oversight of the WDNR, pursuant to authorities set forth in Chapter 30 of the *Wisconsin Statutes*. Wetland water quality standards are set forth in Chapter NR 103, “Wetland Water Quality Standards,” of the *Wisconsin Administrative Code*. The procedures and criteria for the application, processing, and review of State water quality certifications are set forth in Chapter NR 299, “Water Quality Certification.” Chapter NR 103 applies to the discharge of dredged or fill materials to wetlands, among other provisions. These regulations are administered by the WDNR and in some cases through delegated authority from the U.S. Army Corps of Engineers (USCOE) pursuant to Section 404 of the Federal Clean Water Act. As a result of the January 9, 2001, ruling by the U.S. Supreme Court in the matter of *Solid Waste Agency of Northern Cook County* v. *U.S. Army Corps of Engineers*, No. 99-1178 (“SWANCC”), certain isolated, nonnavigable, intrastate wetlands/waters are not under USCOE regulatory jurisdiction. However, such wetlands may be regulated under complementary State regulations. In addition to the State standards noted above, the U.S. Department of Agriculture (USDA) implements policies and programs regarding wetland protection and preservation that benefit farmers and the environment.

Chapters 23 and 330 of the *Wisconsin Statutes* require that counties regulate the use of all wetlands five acres or larger in shoreland zones of unincorporated areas. Wetland maps for Waukesha and Walworth Counties that were originally prepared for the WDNR by SEWRPC in 1981 and 1982 were recently updated. In accordance with Chapter NR 115 of the *Wisconsin Administrative Code*, Waukesha and Walworth Counties have updated their shoreland zoning regulations and attendant maps to preclude further loss of wetlands in the shoreland areas. For development adjacent to statutory wetlands, Waukesha and Walworth County ordinances specify a minimum setback. The minimum developable lot sizes for parcels that include wetlands are regulated by the various jurisdictions that have general zoning authority within the watershed in Waukesha County. There is currently no specified limit on the maximum area of impervious surface for development adjacent to statutory wetlands.

The Waukesha County Wetland and Shoreland Zoning Ordinance provisions apply to the Town of Eagle, while the Towns of LaGrange and Troy are under the jurisdiction of the Walworth County General Zoning Ordinance. The Village of Eagle administers its own zoning ordinance. The existing zoning in the Waukesha County portion of the watershed would permit far more urban development than is envisioned in the adopted regional land use plan. In addition to the comprehensive zoning ordinances administered in the Eagle Spring Lake watershed, both the Waukesha County and Walworth County Boards of Supervisors exercise special-purpose shoreland and floodland zoning. These special-purpose zoning ordinances, prepared pursuant to the requirements of the Wisconsin Water Resources Act of 1965, codified as Chapter 30 of the *Wisconsin Statutes*, impose special land use regulations on unincorporated lands in the shoreland zone, which is defined as all lands located within 1,000 feet of any navigable lake, pond, or flowage, and within 300 feet of the ordinary high water mark of any navigable river or stream, or to the landward side of the floodplain, whichever is greater. The shoreland and floodland protection zoning ordinances are similar in content to the Waukesha and Walworth County Zoning Ordinances, but include additional regulations intended to protect waterways and the attendant shorelines.

The existing zoning ordinances have proven to be relatively effective in protecting the wetlands and water resources of the Walworth County portion of Eagle Spring Lake watershed, but not in the Waukesha County portion. If continued, current trends will result in the loss of a considerable amount of the open space in the area tributary to Eagle Spring Lake. Concern has been expressed by residents of the area over the widespread development of urban and suburban development on former agricultural lands in the vicinity of the Lake in Waukesha County. In addition, infilling and replacement of existing housing with larger structures, especially within the shoreland surrounding Eagle Spring Lake has, to a limited extent, taken place. Such redevelopment of the watershed and lakefront may be undesirable from the point of view of water quality protection as it generally results in a greater area of impervious surface, increased runoff, and increased pollutant loading. This may be accompanied by the year-round use of formerly seasonal lakefront properties potentially resulting in an over-loading of onsite sewage disposal systems. Control of shoreland redevelopment, and the related intensification of use, is not specifically addressed in the existing zoning codes, although new construction must meet specific compliance and inspection requirements for onsite sewage disposal systems. All onsite sewage disposal systems serving the Eagle Spring Lake community are inspected on a rotating two-year cycle by a licensed septage hauler and reported to Waukesha County using a mail-in card, pursuant to the Eagle Spring Lake Management District (ESLMD) septic inspection ordinance.

Subdivision Regulations

Chapter 236 of the *Wisconsin Statutes* requires the preparation of a subdivision plat whenever five or more lots of 1.5 acres or less in area are created, either at one time, or by successive divisions within a period of five years. The *Wisconsin Statutes* set forth requirements for surveying lots and streets, for plat review and approval by State and local agencies, and for recording approved plats. Section 236.45 of the *Wisconsin Statutes* allows any city, village, town, or county that has established a planning agency to adopt a land division ordinance, provided the local ordinance is at least as restrictive as the State platting requirements. Local land division ordinances may include the review of other land divisions not defined as "subdivisions" under Chapter 236, *Wisconsin Statutes*, such as when fewer than five lots are created or when lots larger than 1.5 acres are created.

The subdivision regulatory powers of towns and counties are confined to unincorporated areas. City and village subdivision control ordinances may be applied to extraterritorial areas, as well as to the incorporated areas. It is possible for both a county and a town to have concurrent jurisdiction over land divisions in unincorporated areas, or for a city or village to have concurrent jurisdiction with a town or county in the city or village extraterritorial plat approval area. In the case of overlapping jurisdictions, the most restrictive requirements apply.[9]

Within the total tributary area to Eagle Spring Lake, Walworth and Waukesha Counties have each adopted a countywide subdivision zoning ordinance with respect to floodlands and shorelands. Each community within the Mukwonago River watershed has adopted its own subdivision ordinance, except for the Town of Palmyra, which has adopted those subdivision control ordinances adopted and administered by Jefferson County. The subdivision control ordinances adopted and administered by Waukesha County apply only to the unincorporated statutory shoreland areas of the County. However, the Waukesha County Storm Water Management and Erosion Control Ordinance also contains certain cross-compliance provisions that directly affect the subdivision plat review and approval process in all unincorporated areas.

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[9]*Under Section 236.02 of the* Wisconsin Statutes, *the extraterritorial plat approval jurisdiction is the area within three miles of the corporate limits of a first-, second-, or third-class city and within 1.5 miles of a fourth-class city or a village. Within the Mukwonago River watershed, the Villages of Eagle, East Troy, Mukwonago, and North Prairie are fourth-class villages. Consequently, extraterritorial zoning applies within 1.5 miles of each of the Villages within the Mukwonago River watershed.*

Construction Site Erosion Control Regulations

Stormwater management and erosion control ordinances help minimize water pollution, flooding, and other negative impacts of urbanization on downstream water resources (lakes, streams, wetlands, and groundwater) and property owners, both during and after construction activities. These ordinances are an important tool for accomplishing watershed protection goals because they apply to the whole watershed, not just a certain distance from the water resource.

The *Wisconsin Statutes* grant authority to counties, pursuant to Section 59.693; villages, pursuant to Section 61.354; and, towns, pursuant to Section 60.627, in Wisconsin to adopt ordinances for the prevention of erosion from construction sites and the management of stormwater runoff, which generally apply to new development from lands within their jurisdictions.[10] A county ordinance would apply to all unincorporated areas and newly annexed lands, unless the annexing city or village enforces an ordinance at least as restrictive as the county ordinance. Towns may adopt village powers pursuant to Section 60.10 of the *Wisconsin Statutes* and subsequently utilize the authority conferred on villages to adopt their own erosion control and stormwater management ordinances. Pursuant to Section 60.627 of the *Wisconsin Statutes*, town construction site erosion control and stormwater management zoning requirements adopted under this section supersede county ordinances.

Specific construction site and erosion control requirements for unincorporated areas of Walworth County have been promulgated under Chapter 26, Environment, of the County Code of Ordinances. In Waukesha County, similar provisions are set forth in Chapter 14, Parks and Land Use, of the County Code of Ordinances. It should be noted that local erosion control ordinances do not apply to one- and two-family home construction as these are regulated under Chapter Comm 21 of the *Wisconsin Administrative Code*. Since the early 1990s, the Wisconsin Uniform Dwelling Code, set forth in Chapter Comm 21 of the *Wisconsin Administrative Code*, has included erosion control requirements for one- and two-family homes that apply statewide. Chapter Comm 21 supersedes all local ordinances.

Stormwater Management Regulations

In 1998, Waukesha County adopted an erosion control and post-construction stormwater management ordinance consistent with the state model ordinance and many local communities followed. Subsequently, beginning in August 2004, the Waukesha County Department of Parks and Land Use worked with the Waukesha County Storm Water Advisory Committee over the period of seven months to rewrite the County ordinance to reflect new performance standards set forth in Chapter NR 151, "Runoff Management," of the *Wisconsin Administrative Code* and to address a number of other implementation issues identified by the Waukesha County Department of Parks and Land Use. In March of 2005, the Waukesha County Board adopted Chapter 14, Article VIII, "Storm Water Management and Erosion Control Ordinance of the Waukesha County Code."[11] Enforcement of this ordinance currently represents the largest workload for the Waukesha County Department of Parks and Land Use staff.

Under the Waukesha County ordinance, there are a series of triggers that require a Storm Water Permit from the Waukesha County Department of Parks and Land Use. "Land disturbing activities" of a certain size require the preparation of an erosion control plan, aimed to reduce soil erosion and sedimentation during the construction and landscaping phases of a development. "Land development activities" generally result in the addition of

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[10]*The Village of Mukwonago's "Chapter 34, Division 4: Stormwater Management and Erosion Control Ordinance," effective January 6, 2009, is based on the WDNR model ordinance.*

[11]*A copy of the ordinance is available on the Waukesha County Department of Parks and Land Use web page at:* http://www.waukeshacounty.gov/uploadedFiles/Media/PDF/Parks_and_Land_Use/Land_Conservation/Stormwater/Index_Docs/Final%202005%20Storm%20Water%20Ordinance%20-%20Waukesha%20Co%20Web%20Version.pdf.

impervious surfaces to the land (i.e., rooftops and pavement of at least one-half acre in size), which requires the preparation of a stormwater management plan to control post-construction stormwater runoff. Either one requires a Storm Water Permit. The ordinance establishes a series of technical design standards intended to maintain predevelopment runoff patterns, peak flows, infiltration, water quality and the general hydrology of the site. While these standards may vary slightly between communities, the general intent and resulting best management practices on the landscape are usually similar.

Because stormwater management planning has a significant effect on onsite planning and land divisions, several provisions have been incorporated into the County ordinance to better coordinate stormwater planning with these other planning processes. One requires a “Preliminary Review Letter” from the Waukesha County Department of Parks and Land Use before certain zoning decisions or preliminary plat approval can be completed by the Planning and Zoning Division. Another requires a “Certification of Compliance” with the ordinance from the Waukesha County Department of Parks and Land Use before a Plat or Certified Survey Map can be approved for recording with the County Registrar of Deeds. These provisions have proved invaluable in avoiding conflicts between regulatory review processes and in promoting environmentally sound site planning for new developments.

Waukesha County has incorporated several standards into their stormwater ordinance that are intended to prevent basement wetness and flooding in newly developed areas, even if they are outside of zoned floodplains. For buildings designed for human occupation, these standards address flooding from surface water and wetness caused by groundwater seepage. For surface water, the standards use the peak water surface elevation produced by a 100-year recurrence interval, 24-hour design storm as a benchmark, requiring a 50-foot horizontal setback and a minimum two feet vertical separation from this elevation to the ground surface at the lowest exposed portion of the building. For groundwater, the standards generally do not allow inhabitable buildings on hydric soils and require a minimum one-foot vertical separation between the seasonal high groundwater table and the proposed basement floor surface. These standards apply to all the unincorporated areas of the County. Requiring buildings to meet these standards helps protect the large investments of local homebuyers, while avoiding potential nuisance drainage issues and costly publicly funded solutions in the future. These restrictions have also become more important in recent years as the living spaces of homes are often extended to a finished lower level.

The Walworth County stormwater management ordinances apply to residential lands of five acres or more in areal extent, residential lands of between three and five acres where there is at least 1.5 acres of impervious surface, nonresidential lands of two acres, where there is at least one acre of impervious surface, or other lands on which development activities may result in stormwater runoff likely to harm public property or safety. The stormwater management ordinances establish performance standards to manage both rate and volume of stormwater flows from regulated sites, and water quality.

Stormwater Discharge Permit System

The 1987 amendments to the Federal Clean Water Act established a Federal program for permitting stormwater discharges. The State of Wisconsin obtained certification from the U.S. Environmental Protection Agency which enabled the State to administer a stormwater discharge permitting program as an extension of the existing Wisconsin Pollution Discharge Elimination System (WPDES) program. Section 283.33 of the *Wisconsin Statutes* provides authority for the issuance of stormwater discharge permits by the State. The administrative rules for the State stormwater discharge permit program are set forth in Chapter NR 216, “Storm Water Discharge Permits,” of the *Wisconsin Administrative Code*, which took effect on November 1, 1994, and was most recently updated effective December 2009. Within the total area tributary to Eagle Spring Lake, Waukesha County is the only unit of government that is required to have a stormwater discharge permit under Chapter NR 216 unless they receive exemptions.

In addition, the State Legislature required the WDNR and the Wisconsin Department of Agriculture, Trade and Consumer Protection (WDATCP) to develop performance standards for controlling nonpoint source pollution from agricultural and nonagricultural land and from transportation facilities.[12] Chapter NR 216 identifies several categories of municipalities, industries, and construction sites that must obtain permits. The permit requirements are based on the performance standards set forth in Chapter NR 151 of the *Wisconsin Administrative Code*, which became effective on October 1, 2002. These latter standards were revised in December 2010. These standards are summarized below.

Agricultural Performance Standards and Prohibitions

Performance standards relate to four areas of agriculture: cropland soil erosion control, soil loss from riparian lands, manure management, and nutrient management.

The agricultural performance standards are:

- Soil erosion rates on all cropland (and pastures beginning on July 1, 2012) must be maintained at or below "T" (Tolerable Soil Loss);

- Starting in 2005 for high priority areas such as impaired waters, outstanding or exceptional resource waters, or source water protection areas, and 2008 for all other areas, application of manure or other nutrients to croplands must be done in accordance with a nutrient management plan, designed to meet state standards for limiting the entry of nutrients into groundwater or surface water resources (this standard does not apply to applications of industrial waste, municipal sludge, or septage regulated under other WDNR programs, provided that the material is not comingled with manure prior to application);

- Clean water runoff must be diverted away from contacting feedlots, manure storage facilities, and barnyards in water quality management areas (areas within 300 feet of a stream, 1,000 feet from a lake, or areas susceptible to groundwater contamination); and

- All new or substantially altered manure storage facilities must meet current engineering design standards and margin of safety requirements to prevent surface or groundwater pollution.

The manure management prohibitions are:

- No direct runoff from animal feedlots to "waters of the state,"

- No overflowing manure storage facilities,

[12]*The State performance standards are set forth in the Chapter NR 151, "Runoff Management," of the* Wisconsin Administrative Code. *Additional* Wisconsin Administrative 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," Chapter NR 153, "Runoff Management Grant Program," Chapter NR 154, "Best Management Practices, Technical Standards and Cost-Share Conditions," and Chapter NR 155 "Urban Nonpoint Source Water Pollution Abatement and Stormwater Management Grant Program." Those chapters of the* Wisconsin Administrative Code *became effective during 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. The Wisconsin Department of Agriculture, Trade, and Consumer Protection revised Chapter ATCP 50, "Soil and Water Resource Management," to incorporate the changes required under* 1997 Wisconsin Act 27.

- No unconfined manure piles in shoreland areas (areas within 300 of a stream, 1,000 feet from lakes), and

- No unlimited livestock access to “waters of the state” where the livestock prevent sustaining an adequate vegetative cover.

In general, for land that does not meet the NR 151 standards and that was cropped or enrolled in the U.S. Department of Agriculture Conservation Reserve or Conservation Reserve Enhancement Programs as of October 1, 2002, agricultural performance standards are only required to be met if cost sharing funds are available. Existing cropland that met the standards as of October 1, 2002, must continue to meet the standards. New cropland must meet the standards, regardless of whether cost share funds are available.

The 2010 revision to NR 151 adds new agricultural performance standards. The new performance standards include:

- A five- to 20-foot setback from the top of a surface water channel in agricultural fields within which no tillage is allowed for the purpose of maintaining streambank integrity and avoiding soil deposits into State waters;

- A limit on the amount of phosphorus that may run off croplands as measured by a phosphorus index;

- A prohibition against significant discharge of process water from milk houses, feedlots, and other similar sources; and

- A standard that requires crop and livestock producers to reduce discharges if necessary to meet a load allocation specified in an approved Total Maximum Daily Load (TMDL) by implementing targeted performance standards specified for the TMDL area using best management practices, conservation practices, and performance standards specified in Chapter ATCP 50 of the *Wisconsin Administrative Code*.

Under Chapter NR 216 of the *Wisconsin Administrative Code*, agriculture is not exempt from the requirement to submit a notice of intent (NOI) for one or more acres of land disturbance for the construction of structures such as barns, manure storage facilities or barnyard runoff control systems. Construction of an agricultural building or facility must follow an erosion and sediment control plan consistent with Section NR 216.46 of the *Wisconsin Administrative Code*, including meeting the performance standards of Section NR 151.11 of the *Wisconsin Administrative Code*. Agriculture is exempt from this requirement for activities such as planting, growing, cultivating and harvesting crops for human or livestock consumption and pasturing of livestock as well as for sod farms and tree nurseries. NR 216 establishes the criteria and procedure for issuance of stormwater discharge permits to limit the discharge of pollutants carried by stormwater runoff into waters of the State.

Nonagricultural (Urban) Performance Standards

The nonagricultural performance standards set forth in Chapter NR 151 encompass two major types of land management. The first includes standards for areas of new development and redevelopment and the second includes standards for developed urban areas. The performance standards address the following areas:

- Construction sites for new development and redevelopment,

- Post construction stormwater runoff for new development and redevelopment,

- Developed urban areas, and

- Nonmunicipal property fertilizing.

Chapter NR 151 requires counties and local units of government in urbanized areas, which are identified based on population density, to obtain a WPDES stormwater discharge permit as required under Chapter NR 216.02. Chapter NR 151 requires permit holders to reduce the amount of total suspended solids in stormwater runoff from areas of existing development that were in place as of October 2004 to the maximum extent practicable, according to the following standards:

- By March 10, 2008, the NR 151 standards call for a 20 percent reduction, and
- By October 1, 2013, the standards call for a 40 percent reduction; however, the 2010 revisions to Chapter NR 151 provide for a process for permitted municipalities to follow if they are unable to meet the required 40 percent reduction by 2013. The process identifies the stormwater management plan submittal process, the Departmental review process, and an allowance for up to 10 additional years to comply with the standard, as long as the stormwater management plan is followed.

Permitted municipalities are required to implement the following: 1) public information and education programs relative to specific aspects of nonpoint source pollution control; 2) municipal programs for collection and management of leaf and grass clippings; and 3) site-specific programs for application of lawn and garden fertilizers on municipally controlled properties with over five acres of pervious surface. Under the requirements of Chapter NR 151, by March 10, 2008, incorporated municipalities with average population densities of 1,000 people or more per square mile that were not required to obtain municipal stormwater discharge permits were required to have implemented those same three programs.

In addition, regardless of whether a municipality is required to have a stormwater discharge permit under Chapter NR 216, Chapter NR 151 requires that all construction sites that have one acre or more of land disturbance must discharge no more than five tons per acre per year.[13] With certain limited exceptions, those sites required to have construction erosion control permits must also have post-development stormwater management practices to reduce the total suspended solids (sediment) that would otherwise run off the site by 80 percent for new development, 40 percent for redevelopment, 40 percent for infill development of less than five acres occurring prior to October 1, 2012, and 80 percent for infill development of five acres or greater. After October 1, 2012, all eligible infill development will be required to achieve an 80 percent reduction. If it can be demonstrated that the solids reduction standard cannot be met for a specific site, total suspended solids must be controlled to the maximum extent practicable.

Section NR 151.124 of the *Wisconsin Administrative Code* requires infiltration of post-development runoff from areas developed on or after October 1, 2004, subject to certain specific exclusions and exemptions. For development with less than 40 percent connected imperviousness (“low imperviousness”), 90 percent of the annual predevelopment infiltration volume is required to be infiltrated. However, no more than 1 percent of the area of the project site is required to be used as an effective infiltration area. For development with connected imperviousness ranging from more than 40 percent up to 80 percent (“moderate imperviousness”), 75 percent of the annual predevelopment infiltration volume is required to be infiltrated. For development with connected imperviousness greater than 80 percent (“high imperviousness”), 60 percent of the annual predevelopment infiltration volume is required to be infiltrated. In the case of moderate and high imperviousness areas, no more than 2 percent of the project site is required to be used as effective infiltration area.

The 2010 revisions of NR 151 also changed the nonagricultural performance standards that address construction site erosion control, post-construction stormwater management, and developed urban areas. These changes include:

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[13]*This revised sediment reduction standard set forth in the 2010 revision of NR 151 has a two year delayed implementation to allow development of a model to measure compliance. During that two-year time period, the existing standard of an 80 percent reduction in the amount of sediment that runs off the site will still be in effect.*

- Modification of the construction site performance standard to apply prescriptive standards to construction sites of less than one acre,[14]

- Incorporation of nonnumeric effluent limits promulgated by the USEPA, effective February 1, 2010,

- Removal of the exemption from the total suspended solids performance standards of redevelopment sites with no increase in exposed parking or roads,

- Addition of the one-year, 24-hour design storm for the peak flow control performance standard,[15]

- Revision of the definition of a highly susceptible wetland that requires a 75-foot protective area standard, and

- Clarification of when best management practices may or may not be located in navigable waters.

In addition to these provisions, Section NR 151.13 of the *Wisconsin Administrative Code* requires municipalities to implement informational and educational programming to promote good housekeeping practices in developed urban areas, as well as related operational programs in those municipalities subject to stormwater permitting requirements pursuant to Chapter NR 216 of the *Wisconsin Administrative Code*.

Buffer Standards

Riparian buffers help to slow the velocity of water, allowing the settling of suspended soil particles, infiltration of runoff and soluble pollutants, adsorption of pollutants on soil and plant surfaces, and uptake of soluble pollutants by plants. The 2010 revisions to NR 151 create section NR 151.03 which requires that no tillage operations be conducted within five feet of the top of the channel of surface waters. This section also indicates that tillage setbacks greater than five feet but no more than 20 feet may be required to meet this standard. It also requires that crop producers shall maintain the area within the tillage setback in adequate sod or self-sustaining vegetative cover that provides a minimum of 70 percent coverage.

It is important to note that nonagricultural performance standards set forth in section NR 151.12 (post-construction performance standard for new development and redevelopment) also generally require impervious area setbacks of 50 feet from streams, lakes, and wetlands. This setback distance is increased to 75 feet to protect Chapter NR 102-designated Outstanding or Exceptional Resource Waters or Chapter NR 103-designated wetlands of special natural resource interest. Reduced setbacks of not less than 10 feet from less susceptible wetlands and drainage channels may be allowed. Under the 2010 revisions of NR 151, these performance standards are set forth in NR 151.125.

Stormwater Facility Operation and Maintenance

As stormwater facilities become more complex, they will require more attention by the end users. This is especially true for infiltration practices. Establishing an ongoing operation and maintenance program is critical to successful stormwater management. Waukesha County has developed a stormwater facility database that serves as a repository of design, construction, and maintenance information for stormwater best management practices under County jurisdiction. This database is being populated with new projects as they are permitted under the County ordinance. In addition, a process has been developed to populate the database with historical information

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[14]*This change was made to accommodate the transfer of Chapter Comm 60 of the* Wisconsin Administrative Code *to the jurisdiction of the WDNR, effective January 1, 2010.*

[15]*The original peak flow control performance standard calling for control of the two-year, 24-hour design storm peak flow remains in the rule.*

about previously permitted projects. This database is also accessible to municipal engineers around the County and will serve as a source of information for the continued maintenance of stormwater facilities into the future.

POPULATION

The resident population of the area tributary to Eagle Spring Lake has increased steadily since 1960, as shown in Table 5. The 1990 resident population of the watershed, estimated at about 3,470 persons, was almost twice the estimated 1960 population. Population forecasts, prepared by SEWRPC as a basis for the preparation of the regional land use plan, indicated that the resident population of the total area tributary to Eagle Spring Lake will increase to between 3,500 and 5,800 persons. Under the County development plan, a considerably higher resident population could be anticipated in the area tributary to Eagle Spring Lake. As of 2000, the population was estimated to be about 3,320 persons or approximately unchanged from the 1990 estimate.

The number of resident households in the area tributary to Eagle Spring Lake has also increased steadily since 1960, as shown in Table 5. Based upon forecasts developed for the regional land use plan, the number of resident households in the area would increase from about 1,120 in 1990 to between about 1,230 and 1,900 in the year 2010. Under the County development plan, a higher number of households also would be anticipated under buildout conditions in the area tributary to Eagle Spring Lake. In similar fashion as the population estimates, the numbers of housing units tabulated through the year 2000 Census was approximately 1,200 housing units.

In addition to the year-round resident population and households, there were, as of 1990, about 265 seasonal residents and 100 seasonal housing units within the area tributary to Eagle Spring Lake. The number of seasonal housing units had decreased to about 70 housing units at the time of the 2000 Census.

As development in the local area continues, the population of the area tributary to Eagle Spring Lake may be expected to continue to increase over the next two decades. This population growth may be expected to place continuing stress on the natural resource base in the Eagle Spring Lake tributary area, and both water resource demands and use conflicts may be expected to increase.

LAND USE

The type, intensity, and spatial distribution of the various land uses within the area tributary to Eagle Spring Lake are important determinants of lake water quality and recreational use demands. The existing land use pattern placed in the context of the historical development of the area, therefore, is an important consideration in any lake management planning effort for Eagle Spring Lake.

The movement of European settlers into the Southeastern Wisconsin Region began in about 1830. Completion of the U.S. Public Land Survey of southeastern Wisconsin in 1836, and the subsequent sale of the public lands, brought a rapid influx of settlers into the area. Map 13 shows an 1873 plat of the U.S. Public Land Survey for the Eagle Spring Lake area. Historical urban growth patterns in the total tributary area to the Lake since 1880 are shown on Map 14 and are tabulated in Table 6. Significant urban development began to occur within the area tributary to Eagle Spring Lake shortly after the completion of the U.S. Public Land Survey, with the earliest development occurring within the current Village of Eagle area. Development around Eagle Spring Lake itself began to occur in the early 1900s. The most rapid increase in urban land use development in the tributary area occurred between 1975 and 1990, when 1,280 acres of the area were converted from rural to urban land uses. However, the most extensive urban development of lands surrounding Eagle Spring Lake largely occurred between 1900 and 1940.

Table 5

POPULATION AND HOUSEHOLDS WITHIN THE TOTAL AREA TRIBUTARY TO EAGLE SPRING LAKE: 1960-2000

Year	Population	Households
1960	1,800	450
1970	1,990	550
1980	2,930	920
1985	3,050	990
1990	3,470	1,120
2000	3,320	1,190

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

In the initial comprehensive lake management plan,[16] the existing 1990 land uses in the total tributary area were presented. At that time, rural land uses constituted about 88 percent of the land uses in the tributary area, with agricultural uses comprising about 70 percent of rural land uses, and 62 percent of the land use overall. Urban land uses at that time occupied about 12 percent of the total tributary area, with residential uses comprising the major portion of urban uses. Residential land uses accounted for about 59 percent of all urban land uses and 7 percent of land uses overall.

During the current study period, the existing land uses in the area tributary to Eagle Spring Lake are shown on Map 15 and quantified in Table 7. About 2,677 acres, or about 17 percent of the area tributary to Eagle Spring Lake, including the internally drained areas, were devoted to urban land uses in 2000. The dominant urban land use was residential, encompassing 1,663 acres, or about 62 percent, of the total area in urban use. About 13,396 acres, or about 83 percent of the Eagle Spring Lake drainage area, including the internally drained areas, were still devoted to rural land uses. About 6,752 acres, or about 50 percent of the rural area, were in agricultural land uses. Woodlands, wetlands, and surface water, including the surface area of Eagle Spring Lake, accounted for approximately 5,345 acres, or about 40 percent of the area in rural uses.

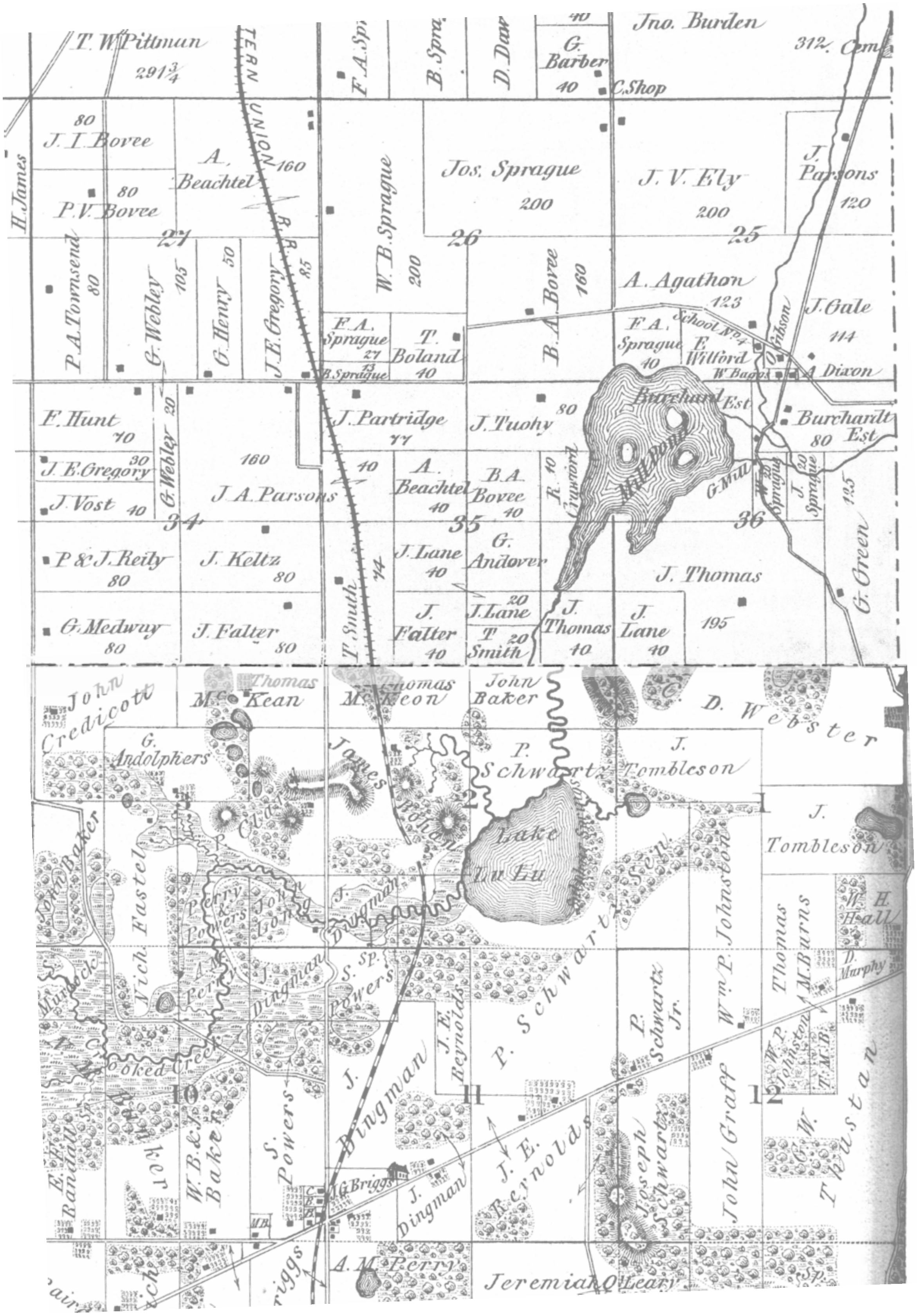
Under year 2035 conditions, as shown in Map 16 and quantified in Table 7, no significant changes in land use conditions within the Eagle Spring Lake subwatershed are envisioned in the regional land use plan, although some infilling of existing platted lots and some backlot development may be expected to occur. In addition, the redevelopment of properties and the reconstruction of existing single-family homes also may be expected on lakeshore properties. Under the full buildout condition envisioned under the Waukesha County development plan,[17] most of the undeveloped lands outside the environmental corridors and other environmentally sensitive areas could potentially be developed for low-density urban uses. This development should occur in the form of residential clusters on smaller lots, thereby preserving portions of the remaining open space and, thus, reducing the impacts on the Lake. In addition, such future development would be subject to the numerous construction site and runoff management ordinances, identified above, that would be applicable to such development. It is envisioned that the application of such measures will further moderate any impacts arising from future development.

[16]*SEWRPC Community Assistance Planning Report No. 226,* op. cit.

[17]*SEWRPC Community Assistance Planning Report No. 209,* A Development Plan for Waukesha County, Wisconsin, *August 1996, as refined.*

Map 13

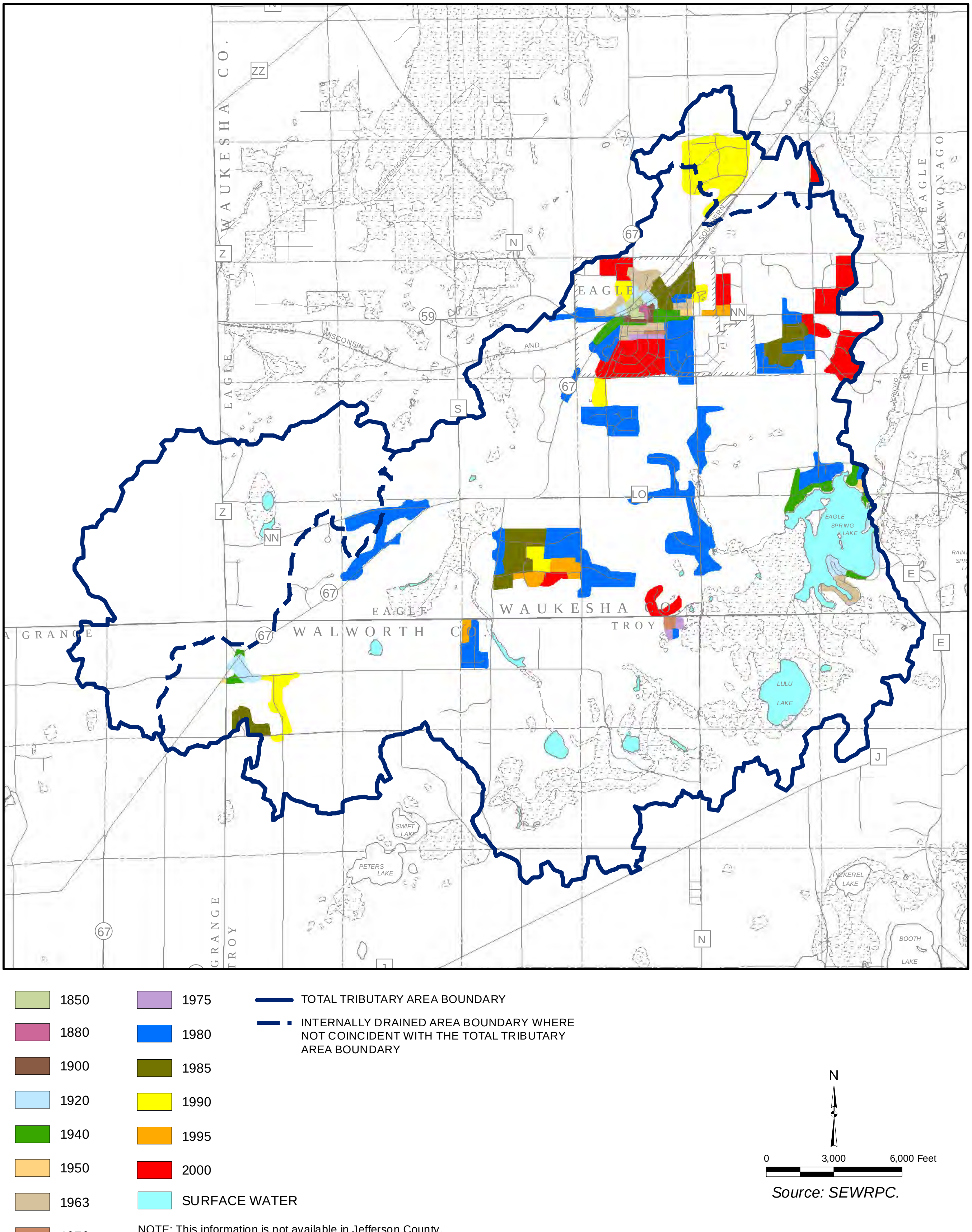
HISTORIC PLAT MAP FOR EAGLE SPRING AND LULU LAKES AREA: 1873



Source: Waukesha County 1873 Plat Book by Worley and Bracher and Walworth County 1873 Plat Book by Everts, Baskin, and Stewart.

Map 14

HISTORIC URBAN GROWTH WITHIN THE TOTAL TRIBUTARY AREA TO EAGLE SPRING LAKE



NOTE: This information is not available in Jefferson County.

Source: SEWRPC.

Table 6

EXTENT OF HISTORIC URBAN GROWTH IN THE TOTAL TRIBUTARY AREA OF EAGLE SPRING LAKE: 1880-2000

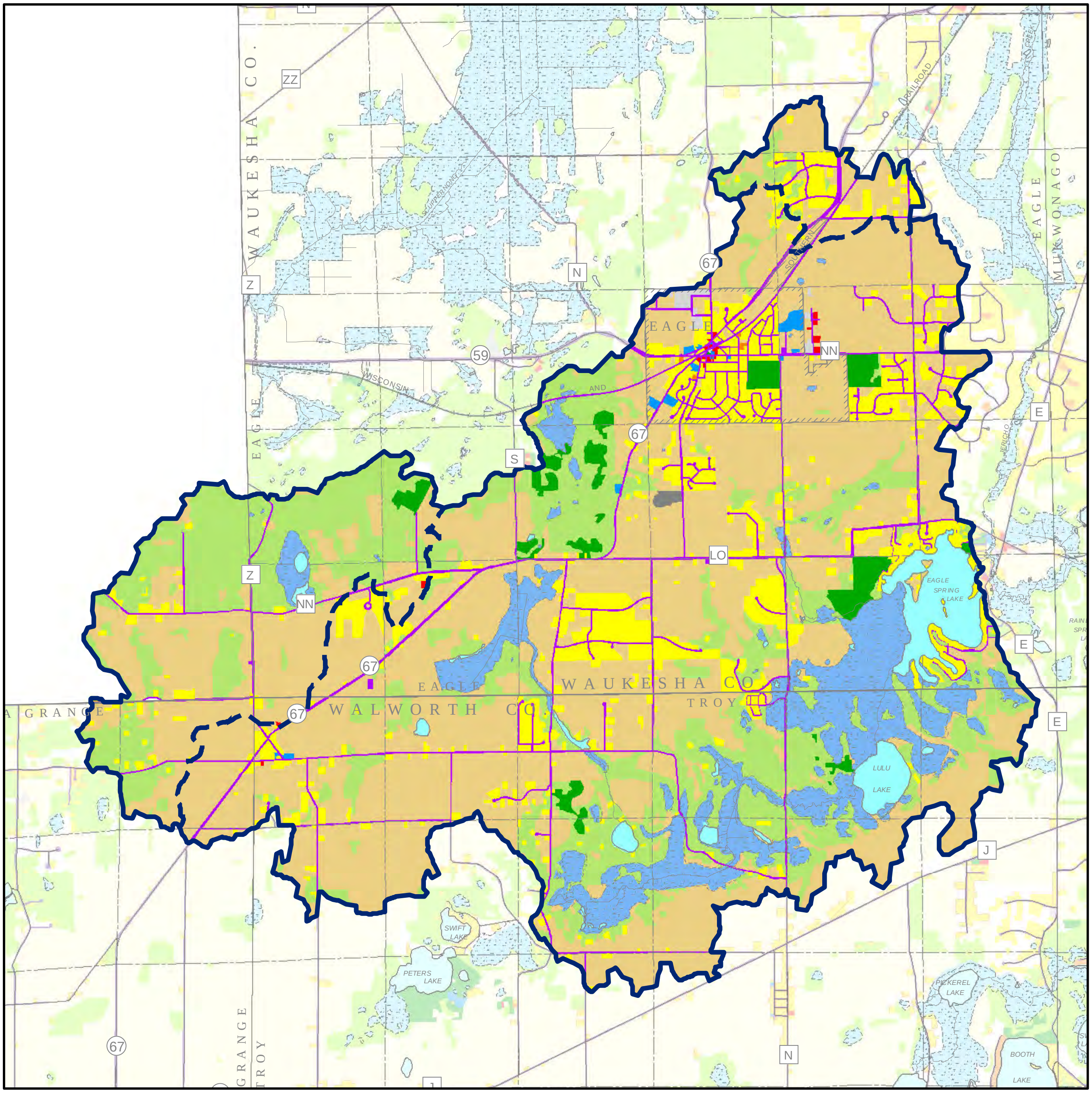
	Tributary Area	
Year	Extent of New Urban Development Occurring Since Previous Period (acres)[a]	Cumulative Extent of Urban Development (acres)[a]
1880	15	15
1900	22	37
1920	9	46
1940	65	111
1950	93	204
1963	13	217
1970	88	305
1975	11	316
1980	16	332
1985	782	1,114
1990	228	1,342
1995	271	1,613
2000	161	1,774

[a]*Urban development, as defined for the purposes of this discussion, includes those areas within which houses or other buildings have been constructed in relatively compact groups, thereby indicating a concentration of urban land uses. Scattered residential developments were not considered urban in this analysis.*

Source: SEWRPC.

Map 15

EXISTING LAND USE WITHIN THE TOTAL TRIBUTARY AREA TO EAGLE SPRING LAKE: 2000



SUBURBAN-DENSITY SINGLE-FAMILY RESIDENTIAL
LOW-DENSITY SINGLE-FAMILY RESIDENTIAL
MEDIUM-DENSITY SINGLE-FAMILY RESIDENTIAL
HIGH-DENSITY SINGLE-FAMILY RESIDENTIAL
COMMERCIAL
INDUSTRIAL
GOVERNMENTAL
TRANSPORTATION: MOTOR VEHICLE RELATED
TRANSPORTATION: RAIL RELATED
COMMUNICATIONS AND UTILITIES
RECREATION

WETLANDS
WOODLANDS
AGRICULTURAL
OPEN LANDS
SURFACE WATER
STREAM
TOTAL TRIBUTARY AREA BOUNDARY
INTERNALLY DRAINED AREA BOUNDARY WHERE NOT COINCIDENT WITH THE TOTAL TRIBUTARY AREA BOUNDARY

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

N

0 3,000 6,000 Feet

Source: SEWRPC.

Table 7

EXISTING AND PLANNED LAND USE WITHIN THE AREA TRIBUTARY TO EAGLE SPRING LAKE: 2000 AND 2035

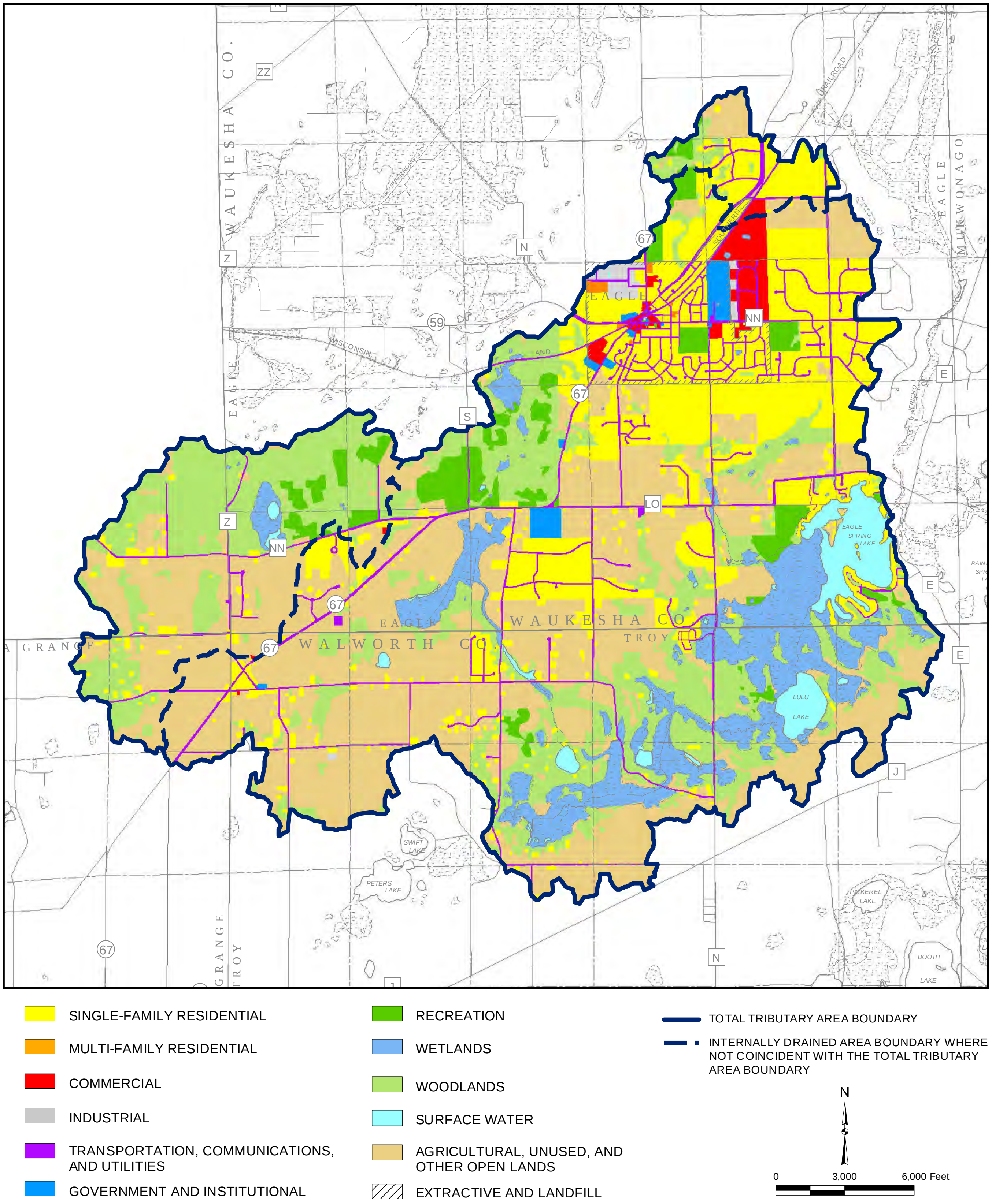
	2000				2035			
Land Use Categories[a]	Eagle Spring Lake (acres)	Internally Drained Area 5 (acres)	Internally Drained Area 6 (acres)	Total (acres)	Eagle Spring Lake (acres)	Internally Drained Area 5 (acres)	Internally Drained Area 6 (acres)	Total (acres)
Urban								
Residential	1,454	82	127	1,663	2,849	93	247	3,188
Commercial	9	2	0	11	194	2	15	210
Industrial	29	0		029	65	0	0	65
Governmental and Institutional	32	0	0	32	117	0	0	117
Transportation, Communication, and Utilities	567	65	40	671	585	68	39	692
Recreational	252	20	0	272	469	114	23	606
Subtotal	2,341	170	166	2,677	4,278	277	323	4,878
Rural								
Agricultural	5,571	937	244	6,752	4,817	934	102	5,853
Wetlands	1,368	57	0	1,425	1,367	57	0	1,424
Woodlands	2,236	1,164	76	3,476	2,234	1,165	76	3,474
Water	430	14	0	444	431	14	0	444
Open Lands	1,181	104	15	1,300	0	0	0	0
Subtotal	10,786	2,274	336	13,396	8,849	2,169	178	11,196
Total	13,128	2,444	502	16,074	13,127	2,446	501	16,074

[a]*Parking included in associated use.*

Source: SEWRPC.

Map 16

PLANNED LAND USE WITHIN THE TOTAL TRIBUTARY AREA TO EAGLE SPRING LAKE: 2035



Source: SEWRPC.

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Chapter IV

WATER QUALITY

INTRODUCTION

The Eagle Spring Lake community has a long history of efforts by the residents to protect and improve the Lake's water quality. Previous planning and monitoring of the Lake have been carried out by the U.S. Geological Survey (USGS),[1] the Wisconsin Department of Natural Resources (WDNR),[2] and the Eagle Spring Lake Management District (ESLMD).[3] These data were summarized in the initial comprehensive lake management plan for Eagle Spring Lake,[4] for the period through 1994.

Although the ESLMD discontinued its participation in the USGS Trophic State Index (TSI) monitoring program in 2003,[5] the District continued to participate actively in the University of Wisconsin-Extension (UWEX) Citizen Lake Monitoring Network (CLMN), formerly the WDNR Self-Help Monitoring Program, through 2005. The ESLMD also participated in the Expanded Self-Help Monitoring Program, which includes the collection of TSI data, during this period. These data form the basis of the analysis of the current water quality conditions in Eagle Spring Lake, with the data presented in the initial comprehensive lake management plan being used in this second

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[1]*U.S. Geological Survey Water-Data Reports WI-91-1 through WI-93-2*, Water Resources Data–Wisconsin, Water Year 1991 *through* Water Year 1993, *published annually, March 1992 through March 1994; U.S. Geological Survey Open-File Reports No. 95-190 through 04-1087,* Water Quality and Lake-Stage Data for Wisconsin Lakes, Water Year 1994 *through* Water Year 2003, *published annually 1995 through 2004.*

[2]*Wisconsin Department of Natural Resources Lake Use Report No. FX-19,* Eagle Spring Lake, Waukesha County, Wisconsin, *1969; see also Wisconsin Department of Natural Resources Lake Use Report No. FX-39,* Lulu Lake, Walworth County, Wisconsin, *1969.*

[3]*SEWRPC Community Assistance Planning Report No. 226,* A Lake Management Plan for Eagle Spring Lake, Waukesha County, Wisconsin, *1997.*

[4]Ibid.

[5]*U.S. Geological Survey Water-Data Reports WI-91-1 through WI-93-2,* op. cit.; *U.S. Geological Survey Open-File Reports No. 95-190 through 04-1087,* op. cit.

edition plan as a basis for assessing water quality trends in Eagle Spring Lake. In addition, the results of sediment studies and loading analyses completed since 1997 are summarized herein.[6]

HISTORICAL WATER QUALITY CONDITIONS

For purposes of the initial comprehensive lake management plan for Eagle Spring Lake, data collected between 1991 and 1994 were used to determine water quality conditions in the Lake and to characterize the suitability of the Lake for recreational use and for the support of fish and aquatic life. Water quality samples were taken seasonally from the main basin of the Lake during this monitoring period. The sampling station was located at the deepest point in the Lake, as shown on Map 5 in Chapter II. These data suggested that Eagle Spring Lake was a mesotrophic, or moderately enriched, waterbody, with "good" water quality compared to other lakes in the Southeastern Wisconsin Region.

For the purposes of this study, water quality data gathered primarily by the citizen lake monitoring network volunteer from the ESLMD from 1991 through 2005 are used to characterize the water quality of Eagle Spring Lake. These data were acquired from the deep hole sampling site used by the USGS for acquisition of water quality data presented in the initial comprehensive lake management plan. Thermal profile and dissolved oxygen profile data for the current study period were not collected as part of the CLMN sampling program; however, the data acquired during the initial comprehensive lake management plan formulation are reviewed.

Both water temperature and dissolved oxygen concentrations are important ecological "drivers" that define the biological response of lakes to the input of nutrients and other contaminants. In the case of Eagle Spring Lake, because it can be classified as a shallow lake in terms of its response to storm events and other external conditions, the patterns of circulation noted below may occur more frequently than on the annual basis described. Notwithstanding, the consequences of mixing are similar to those described, even though they may occur on a more frequent basis. It is not unusual for such lakes, referred to as polymictic waterbodies, to remain in a mixed condition for much of the year, stratifying only occasionally. Even though shallow lakes may weakly stratify, as documented in the initial comprehensive lake management plan—see Figure 3 of that document—such stratification may not be a barrier to fishes and other aquatic organisms provided that sufficient dissolved oxygen is present in the various layers of lake water; on the other hand, such mixing may contribute to higher surface water nutrient concentrations than would otherwise be expected and hence contribute to higher levels of productivity that would otherwise be expected.

Thermal Stratification

Thermal stratification is the result of the differential heating of lake water, and the resulting water temperature-density relationships at various depths within the lake water column. Water is unique among liquids because it reaches its maximum density, or mass per unit of volume, at about 39°F. The development of summer thermal stratification begins in early summer, reaches its maximum in late summer, and disappears in the fall. Stratification may also occur during winter under ice cover, as illustrated diagrammatically in Figure 14. In shallow lakes, wind-induced mixing may occur more frequently than in deeper lakes; however, the essential processes are the same even if occurring more frequently in shallow lakes.

As summer begins, lakes absorb solar energy at the surface. Wind action and, to some extent, internal heat transfer mechanisms transmit this energy to the underlying portions of the waterbodies. As the upper layer of water is heated by solar energy, a physical barrier, created by differing water densities between warmer and cooler water, begins to form between the warmer surface water and the colder, heavier bottom water, as shown in Figure 15. This "barrier" is marked by a sharp temperature gradient known as the thermocline—also called the

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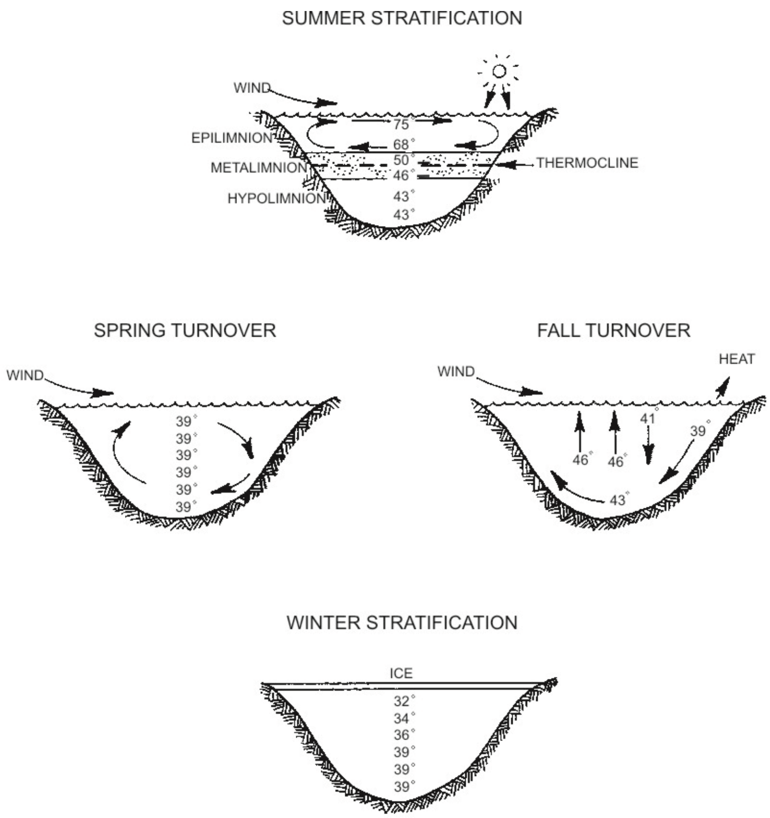
[6]*See,* inter alia, *Hey and Associates, Inc.,* Eagle Spring Lake Water Quality Summary and Management Report, *January 2005.*

Figure 14

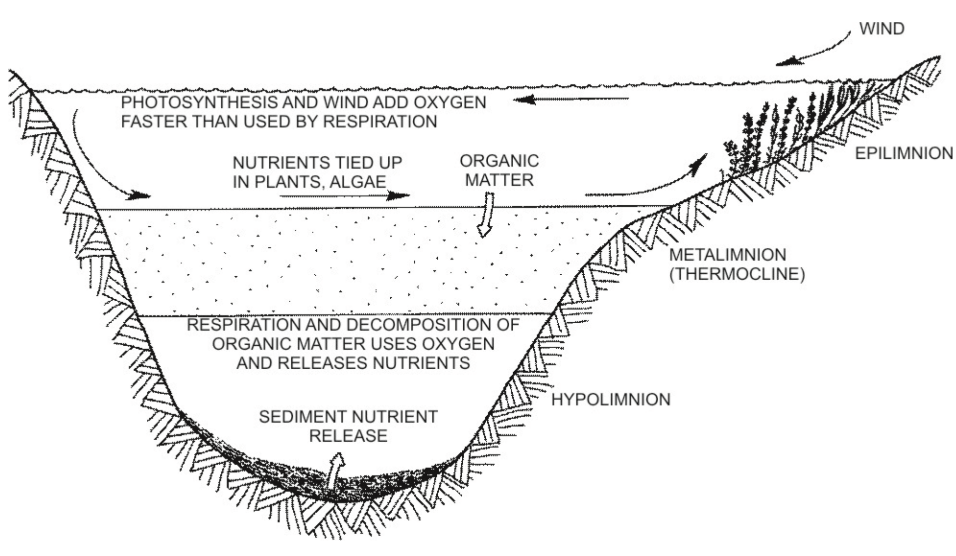
THERMAL STRATIFICATION OF LAKES



Source: University of Wisconsin-Extension and SEWRPC.

Figure 15

LAKE PROCESSES DURING SUMMER STRATIFICATION



Source: University of Wisconsin-Extension and SEWRPC.

metalimnion—which is characterized by a 1°C drop in temperature per one meter (or about a 2°F drop in temperature per three feet) of depth. This zone or layer of rapid temperature change separates the warmer, lighter, upper layer of water—called the epilimnion—from the cooler, heavier, lower layer—called the hypolimnion—as shown in Figure 15. Although this barrier can be readily crossed by fish, provided sufficient oxygen exists, it essentially prohibits the exchange of water between the two layers. This condition has a major impact on both the chemical and biological activity in a lake.

The autumnal mixing period occurs when air temperatures cool the surface water and wind action results in the erosion of the thermocline: as the surface water cools, it becomes heavier, sinking and displacing the now relatively warmer water below. The colder water sinks and mixes under wind action until the entire column of water is of uniform temperature, as shown in Figure 14. This action, which follows summer stratification, is known as "fall turnover."

From fall turnover until freeze-up, surface waters continue to cool in response to the decline in ambient air temperatures. Once the temperature of the water at the surface drops to the point of maximum water density, these waters become denser than the warmer waters below them, and, as a consequence of this density difference, the surface waters begin to "sink" to the bottom. Eventually, the entire water column is cooled to the point of maximum density. The surface waters continue to cool until they reach about 32°F, and are, once again, less dense than the waters below which remain at about 39°F. At 32°F, the lake surface may then become ice covered, isolating the lake water from the atmosphere for a period of up to four months. As shown in Figure 14, winter stratification then can occur as the colder, lighter water and ice remains at the surface and is separated from the relatively warmer, heavier water near the bottom of the lake.

Spring brings a reversal of the process of lake stratification. Once the surface ice has melted, the upper layer of water continues to warm until it reaches 39°F, the maximum density point of water and, coincidentally, the temperature of the deeper waters below this surface layer. At this point, the entire water column is, once again, the same temperature (and density) from surface to bottom, and wind action results in a mixing of the entire lake. This is referred to as "spring turnover" and usually occurs within weeks after the ice goes out, as shown in Figure 14. After spring turnover, the water at the surface continues to warm and become less dense, causing it to float above the colder, deeper water. Wind and resulting waves carry some of the energy of the warmer, lighter water to lower depths, but only to a limited extent. Thus begins the formation of the thermocline and another period of summer thermal stratification.

During the formulation of the initial comprehensive lake management plan, thermal and dissolved oxygen profiles indicated that water temperatures ranged from approximately 40°F during the winter to approximately 80°F in the summer. For this reason, complete mixing of Eagle Spring Lake was not seriously restricted by thermal stratification in the summer or by ice cover in the winter.

Dissolved Oxygen

Dissolved oxygen levels are one of the most critical factors affecting the living organisms in a lake ecosystem, since most organisms require oxygen to survive. Generally, dissolved oxygen concentrations are greatest in the surface waters 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 at the bottom of a lake, where decomposer organisms and chemical oxidation processes utilize oxygen in the decay process.

In shallow lakes, as shown in the initial comprehensive lake management plan, frequent mixing of the water column by wind action can result in dissolved oxygen concentrations being relatively uniform throughout the water column. Stratification can occur; however, it is generally short-lived, with the next wind episode mixing the lake waters. In the case of Eagle Spring Lake, this frequent mixing of the water column can be seen in the dissolved oxygen profiles published in the initial comprehensive lake management plan for the Lake. During the initial comprehensive lake management planning period, when dissolved oxygen concentration gradients were observed in the Lake, such as in June and August 1991, dissolved oxygen levels were generally highest on the bottom of the Lake, where photosynthetic production of oxygen by benthic (bottom-dwelling) plants elevated the concentrations of this element. Only rarely, such as in August 1992, was the inverse situation true, as is more common in other, deep water lakes. Even then, there were no recorded incidents of hypolimnetic anoxia—or the lack of dissolved oxygen in the bottom waters of the Lake—in the main basin of the Lake.

When a lake does become thermally stratified, as described above, the surface supply of dissolved oxygen to the hypolimnion is cut off. Gradually, if there is not enough dissolved oxygen to meet the total demands from the bottom dwelling aquatic life and decaying organic material, the dissolved oxygen levels in the bottom waters may be reduced, even to zero, a condition known as anoxia or anaerobiasis, as shown in Figure 15.

Fall turnover, between September and October in most years, naturally restores the supply of oxygen to the bottom water, although hypolimnetic anoxia can be reestablished during the period of winter thermal stratification. Winter anoxia is more common during years of heavy snowfall, when snow covers the ice, reducing the degree of light penetration, and reducing algal photosynthesis that takes place under the ice. Under these conditions, anoxia can contribute to the winter-kill of fish. At the end of winter, dissolved oxygen concentrations in the bottom waters of the Lake are restored during the period of spring turnover, which generally occurs between March and May. In Eagle Spring Lake, during the formulation of the initial comprehensive lake management plan, hypolimnetic anoxia was not observed during winter stratification and dissolved oxygen levels at all depths were found to be adequate for the support of fish throughout the winter.

Hypolimnetic anoxia, common in many of the lakes in southeastern Wisconsin during summer stratification, can have biological consequences, especially for the lake fisheries. Depleted oxygen levels in the hypolimnion may cause fish to move upward, nearer to the surface of the lakes, where higher dissolved oxygen concentrations exist. This migration, when combined with temperature, can select against some fish species that prefer the cooler water temperatures that generally prevail in the lower portions of the lakes. When there is insufficient oxygen at these depths, these fish are susceptible to summer-kills, or, alternatively, are driven into the warmer water portions of the lake where their condition and competitive success may be severely impaired. As in the case of dissolved oxygen stratification during the winter months, hypolimnetic anoxia was rarely observed during summer stratification and dissolved oxygen levels at all depths were found to be generally adequate for the support of fish throughout the summer.

In addition to the biological consequences, the lack of dissolved oxygen at depth can enhance the development of chemoclines, or chemical gradients, with an inverse relationship to the dissolved oxygen concentration. For example, the sediment-water exchange of elements such as phosphorus, iron, and manganese is increased under anaerobic conditions, resulting in higher hypolimnetic concentrations in these elements. Under anaerobic conditions, iron and manganese change oxidation states enabling the release of phosphorus from the iron and manganese complexes to which they are bound under aerobic conditions. This “internal loading” can affect water quality significantly if these nutrients and salts are mixed into the epilimnion, especially during early summer when these nutrients can become available for algal and rooted aquatic plant growth. These mixing events can be caused by severe weather, which both has the potential to cool the surface waters and decrease or eliminate the surface-to-bottom thermal gradients as a result of wind action associated with storms. While shallow lakes and/or embayments are frequently subject to these multiple mixing events, the phenomenon of internal loading was not observed with any frequency in Eagle Spring Lake during the study period associated with the formulation of the initial comprehensive lake management plan. The likely import of internal loading to the nutrient budget of Eagle Spring Lake is discussed further below.

Specific Conductance

Specific conductance, the ability of water to conduct an electric current, is an indicator of the concentration of dissolved solids in the water; as the amount of dissolved solids increases, the specific conductance increases. As such, specific conductance is often useful as an indication of possible pollution in a lake’s waters. Freshwater lakes commonly have a specific conductance range of from 10 to 1,000 microSiemens per centimeter (µS/cm), although measurements in polluted waters or in lakes receiving large amounts of land runoff can sometimes exceed 1,000 μS/cm.[7] Additionally, during periods of thermal stratification, specific conductance can increase at the lake bottom due to an accumulation of dissolved materials in the hypolimnion. This is a consequence of the "internal loading" phenomenon noted above.

During the formulation of the initial comprehensive lake management plan, specific conductance in the main lake basin ranged from 411 μS/cm to 474 μS/cm, which is within the normal range for lakes in southeastern Wisconsin.[8] No significant surface to bottom conductivity gradients were observed, with the exception of the summer period during 1993, when specific conductance increased with depth from between 475 and 516 μS/cm at the surface to over 710 μS/cm at about seven feet of depth.

Specific conductivity data for the current study period were not available.

Regionwide, increases in specific conductance over the years appear to be associated with increases in the chloride concentrations in lakes. Long-term continued increases of specific conductance can serve as an indicator of increasing contamination of the Region's lakes with concomitant deleterious effects on the plants and animals inhabiting those environments.

Chloride

Underlying the phenomenon of increasing conductivity is the increasing concentrations of chloride in the surface waters of southeastern Wisconsin. At high concentrations, chloride can directly affect aquatic plant growth and pose a threat to aquatic organisms. The effects of chloride contamination begin to manifest at about 250 milligrams per liter (mg/l) and become severe at concentrations in excess of 1,000 mg/l.[9] Natural chloride concentrations in lake water are directly affected by leaching from underlying bedrock and soils, and by deposition from precipitation events. Higher concentrations can reflect pollution. Lakes in southeastern Wisconsin typically have very low natural chloride concentrations due to the limestone bedrock found in the Region. Limestone is primarily composed of calcium carbonate and magnesium carbonate, and, as such, is rich in carbonates rather than chlorides. Consequently, the sources of chloride in southeastern Wisconsin are largely anthropogenic, including sources such as salts used on streets and highways for winter snow and ice control, salts discharged from water softeners, and salts from sewage and animal wastes.

The significance of human-originated chlorides is reflected in the chloride concentrations found in lakes in the different regions of Wisconsin, where geological sources of the element are rare. Chloride concentrations in the more populated and urban southeastern region average about 19 mg/l as contrasted with about 2.0 mg/l in the northeastern and northwestern regions of the State, about 4.0 mg/l in the central region, and about 7.0 mg/l in the southwestern region.[10] During the formulation of the initial comprehensive lake management plan, chloride concentrations in the main basin of the Lake ranged from 11 mg/l to 13 mg/l during the spring of 1991 and 1994, which placed Eagle Spring Lake within the normal range for lakes in southeastern Wisconsin.[11] The most

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[7]*Deborah Chapman,* Water Quality Assessments, second edition, *E&FN Spon, 1996.*

[8]*R.A. Lillie and J.W. Mason, Wisconsin Department of Natural Resources Technical Bulletin No. 138,* Limnological Characteristics of Wisconsin Lakes, *1983.*

[9]*Frits van der Leeden, Fred L. Troise and David Keith Todd,* The Water Encyclopedia, Second Edition, *Lewis Publishers 1990.*

[10]*R.A. Lillie and J.W. Mason, Wisconsin Department of Natural Resources Technical Bulletin No. 138,* op. cit.

[11]Ibid.

important anthropogenic sources of chloride to Eagle Spring Lake were believed to be the salts used on streets and highways for winter snow and ice control,[12] and salts used in water softening appliances. No chloride concentration data were available for the current study period.

Alkalinity and Hardness

Alkalinity is an index of the buffering capacity of a lake, or the ability of a lake to absorb and neutralize acids. Lakes having a low alkalinity and, therefore, a low buffering capacity, may be more susceptible to the effects of acidic atmospheric deposition. The alkalinity of a lake depends on the levels of bicarbonate, carbonate, and hydroxide ions present in the water. Due, in large part, to the deposits of limestone and dolomite that make up much of the bedrock underlying many of the lakes and their associated tributary areas, lakes in southeastern Wisconsin typically have a high alkalinity, with an average concentration of about 173 milligrams per liter (mg/l) expressed as calcium carbonate.[13] During the initial comprehensive lake management plan study period, Eagle Spring Lake alkalinity averaged 207 mg/l between 1991 and 1994, which was slightly above this average value.[14]

In contrast to alkalinity, water hardness is a measure of the multivalent metallic ion concentrations, such as those of calcium and magnesium, present in a lake. Generally, lakes with high levels of hardness produce more fish and aquatic plants than lakes whose water is "soft" or comprised of lower concentrations of multivalent metallic ions.[15] Hardness is usually reported as an equivalent concentration of calcium carbonate ($CaCO_3$). During the initial comprehensive lake management plan study period, hardness in Eagle Spring Lake averaged 232 mg/l, which is within the normal range for lakes in southeastern Wisconsin.[16] There were no data for alkalinity or hardness acquired during the current study.

Applying these measures to Eagle Spring Lake, the Lake may be classified as a hard-water alkaline lake, which is typical of most lakes in southeastern Wisconsin.

Hydrogen Ion Concentration (pH)

The pH is a logarithmic measure of hydrogen ion concentration on a scale of 0 to 14 standard units, with 7 units indicating neutrality. A pH above 7 units indicates basic (or alkaline) water, and a pH below 7 units indicates acidic water. The pH of lake water influences many of the chemical and biological processes that occur there. Even though moderately low/high pH may not directly harm fish or other organisms, as pH nears the ends of the scale, such values can have adverse effects on the organisms living in a lake. Additionally, under conditions of very low (acidic) pH, certain metals, such as aluminum, zinc, and mercury, can become soluble if present in a lake's bedrock or tributary area soils, leading to an increase in concentrations of such metals in a lake's waters

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[12]*The major sources of chlorides to lakes in the Southeastern Wisconsin Region include both road salt applications during winter months and salts discharged from water softeners year-round. In the case of those communities served by public sanitary sewerage systems, the softener salts are conveyed away from the lakes to the wastewater treatment plant.*

[13]*R.A. Lillie and J.W. Mason, Wisconsin Department of Natural Resources Technical Bulletin No. 138,* op. cit.

[14]Ibid.

[15]*Byron Shaw, Lowell Klessig, and Christine Mechenich,* Understanding Lake Data, *University of Wisconsin-Extension Publication No. G3582, 2004.*

[16]*R.A. Lillie and J.W. Mason, Wisconsin Department of Natural Resources Technical Bulletin No. 138,* op. cit.

with subsequent potentially harmful effects to not only the fish but also to those organisms, including humans, who eat them.[17] In general, the pH for most natural waterbodies, however, is within the range of about 6.0 to about 8.5.[18]

As in the case of alkalinity, the chemical makeup of the underlying bedrock has a great influence on the pH of lake waters. In the case of lakes in the Southeastern Wisconsin Region, where the bedrock is comprised largely of limestone and dolomite, the pH typically is in the alkaline range, above a pH value of 7 units, even though the pH of rain in the Southeastern Wisconsin Region is typically on the order of 4.4.[19] Data collected as part of the National Atmospheric Deposition Program (NADP) indicate that there has been a gradual upward trend in the pH of precipitation at the City of Lake Geneva monitoring station, from about 4.4 in 1984 to about 5.0 in 2005.[20]

During the studies associated with the formulation of the initial comprehensive lake management plan study, pH values in Eagle Spring Lake ranged from 7.36 to 8.5, annually. Since Eagle Spring Lake has a high alkalinity or buffering capacity, and because the pH does not fluctuate below 7.0, the Lake was not considered to be susceptible to the harmful effects of acidic deposition.

EXISTING WATER QUALITY CONDITIONS

As noted above, water quality data used in the formulation of the current lake management plan are based primarily on data gathered under the auspices of the CLMN program by a citizen lake monitoring volunteer from the Eagle Spring Lake Management District. TSI data on the Lake were collected by the volunteer monitor between 1991 and 2005 from the deep hole sampling site used by the USGS for acquisition of water quality data presented in the initial comprehensive lake management plan. These data, which focus on water clarity, chlorophyll-*a* concentration, and total phosphorus concentration in the surface waters of Eagle Spring Lake, are discussed below, and summarized in Table 8.

Water Clarity

Water clarity, or transparency, provides an indication of overall water quality; clarity may decrease because of turbidity caused by high concentrations of organic and inorganic suspended materials, such as algae and zooplankton, and suspended sediment, and/or because of color caused by high concentrations of dissolved organic substances. Water clarity is measured with a Secchi-disk, a black-and-white, eight-inch-diameter disk, which is lowered into the water until a depth is reached at which the disk is no longer visible. This depth is known as the "Secchi-disk reading." Such measurements comprise an important part of the UWEX CLMN Program in which citizen volunteers assist in lake water quality monitoring efforts.

Water clarity generally varies throughout the year as algal populations increase and decrease in response to changes in weather conditions and nutrient loadings. But, water clarity can also vary from region to region in the State as a reflection of regional differences in lake biogeochemistry. Lakes in the northeastern Wisconsin region generally have low levels of turbidity, as indicated by the region's average Secchi-disk reading of 8.9 feet, compared to the average in the Southeastern Wisconsin Region of 4.9 feet.[21]

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[17] *See National Atmospheric Deposition Program, http://nadp.sws.uiuc.edu,* op. cit.

[18] *Deborah Chapman,* op. cit.

[19] Ibid.

[20] *National Atmospheric Deposition Program,* http://nadp.sws.uiuc.edu, op. cit.

[21] Ibid.

Table 8

SUMMER WATER QUALITY CONDITIONS IN EAGLE SPRING LAKE: 1991-2005

Year	Secchi Disk Reading (feet)	Total Phosphorus (mg/l)	Chlorophyll-*a* (µg/l)
1991			
Range	6.75-11.25	- -	- -
Mean	8.6	- -	- -
Number of Samples	N = 6	- -	- -
1992			
Range	5.5-13.0	- -	- -
Mean	7.0	- -	- -
Number of Samples	N = 14	- -	- -
1993			
Range	5.25-6.5	- -	3.1-10.7
Mean	6.0	- -	6.5
Number of Samples	N = 25	- -	N = 3
1994			
Range	4.5-6.5	0.011-0.021	2.8-8.3
Mean	5.8	0.015	6.5
Number of Samples	N = 27	N = 5	N = 5
1995			
Range	4.0-6.25	- -	- -
Mean	5.4	- -	- -
Number of Samples	N = 6	- -	- -
1996			
Range	3.6-8.9	0.010-0.019	3.2-8.7
Mean	5.4	0.013	6.2
Number of Samples	N = 12	N = 4	N = 4
1997			
Range	4.75-6.5	0.029	5.7-7.8
Mean	5.9	0.029	6.8
Number of Samples	N = 14	N = 1	N = 2
1998			
Range	4.0-6.5	0.018	6.6
Mean	5.3	0.018	6.6
Number of Samples	N = 13	N = 1	N = 1
1999			
Range	5.0-6.5	0.021	2.8
Mean	5.7	0.021	2.8
Number of Samples	N = 10	N = 1	N = 1
2000			
Range	4.3-6.5	0.017 -0.0 28	3.7-7.0
Mean	5.8	0.022	5.3
Number of Samples	N = 12	N = 2	N = 2
2001			
Range	3.9-6.5	0.020 -0.0 22	5.4-6.0
Mean	5.3	0.021	5.7
Number of Samples	N = 13	N = 2	N = 2
2002			
Range	5.0-6.0	- -	- -
Mean	5.4	- -	- -
Number of Samples	N = 10	- -	- -

Table 8 (continued)

Year	Secchi Disk Reading (feet)	Total Phosphorus (mg/l)	Chlorophyll-*a* (μg/l)
2003			
Range	3.9-6.5	0.020 -0.0 37	6.4
Mean	5.5	0.028	6.4
Number of Samples	N = 24	N = 2	N = 1
2004			
Range	4.2-4.9	0.016-0.018	6.6
Mean	4.5	0.017	6.6
Number of Samples	N = 2	N = 2	N = 1
2005			
Range	5.0-5.75	- -	- -
Mean	5.25	- -	- -
Number of Samples	N = 10	- -	- -

Source: Wisconsin Department of Natural Resources Self-Help Monitoring program, University of Wisconsin-Extension Citizen Lake Monitoring Network, and SEWRPC.

During the initial comprehensive lake management planning studies, Secchi-disk measurements taken by USGS ranged from about three feet to about 7.5 feet, with an average of about five feet, which depths were close to, or coincident with, the lake bottom. These values indicated fair to poor water quality compared to other lakes in southeastern Wisconsin.

As shown in Figure 16, during the current study period, Secchi-disk readings for Eagle Spring Lake were between about four feet and about eight feet, which was consistent with other shallow lakes within the Region. These values also are similar to the median values for the Region and indicate generally fair water quality compared to other lakes in southeastern Wisconsin.[22] Generally, seasonality in Secchi-disk measurements follow a trend of gradually diminishing Secchi-disk depths as the seasons progress from winter, when Secchi-disk readings are typically highest, through spring and summer. Lower Secchi-disk readings in spring are not unusual for lakes in the region, and reflect the growths of algae and zooplankton during the warmer months, as well as the effects of surface runoff from the tributary area and inflows into the Lakes.

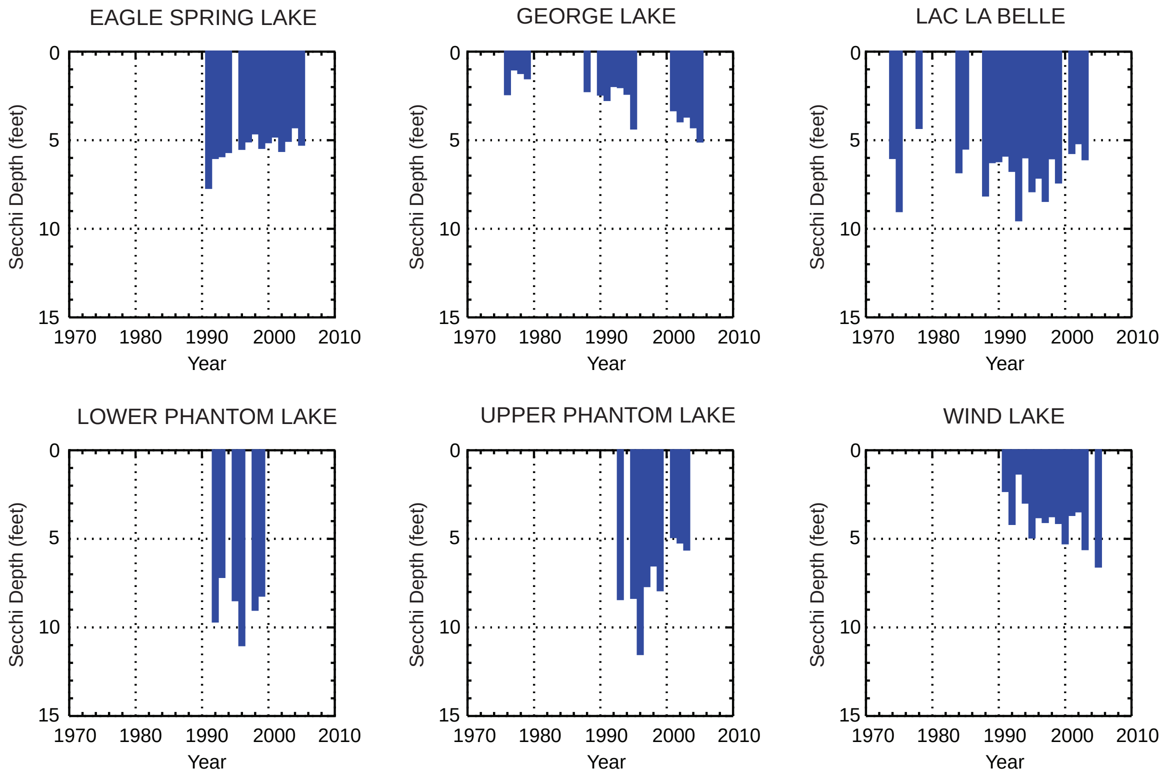
In recent years, some lakes in southeastern Wisconsin have experienced improved water clarity that may be related to the presence of the zebra mussel, *Dreissena polymorpha,* an invasive, nonnative filter feeding mollusk known to impact water clarity in inland lakes. The WDNR lists Eagle Spring Lake as having had an established population of this species since 2005.

The Environmental Remote Sensing Center (ERSC), established during 1970 on the University of Wisconsin-Madison campus, was one of the first remote sensing facilities in the United States. Using data gathered by satellite remote sensing over a three-year period, the ERSC generated a map based on a mosaic of satellite images showing the estimated water clarity of the largest 8,000 lakes in Wisconsin. The WDNR, through its volunteer-based Self-Help Monitoring Program (now the CLMN), was able to gather clarity measurements from Secchi-disk readings for about 800 lakes, or about 10 percent of Wisconsin's largest lakes; the satellite remote sensing technology utilized by ERSC was able to accurately estimate clarity for the remaining 90 percent. ERSC remote sensing for Eagle Spring Lake estimated average water clarity at 4.9 feet, which is consistent with the observed data.

[22]Ibid.

Figure 16

ANNUAL MEAN SUMMER (JUNE 15-SEPTEMBER 15) SECCHI DEPTH AMONG SHALLOW LAKES IN SOUTHEAST WISCONSIN: 1970-2008



Source: U.S. Geological Survey and SEWRPC.

Chlorophyll-*a*

Chlorophyll-*a* is the major photosynthetic ("green") pigment in algae. The amount of chlorophyll-*a* present in the water is an indication of the amount of algae in the water, and its level of concentration is useful in determining the trophic status of lakes and hence the suitability of a lake for certain uses. The median chlorophyll-*a* concentration for lakes in the Southeastern Wisconsin Region is about 9.9 μg/l.[23] Chlorophyll-*a* levels above about 10 μg/l range result in a green coloration of the water that may be severe enough to impair recreational activities such as swimming and skiing.[24]

During the initial comprehensive lake management plan study period, chlorophyll-*a* concentrations in the main basin of Eagle Spring Lake ranged from a low of four micrograms per liter (μg/l) in June 1994, to a high of 10 μg/l in July 1991, which were within the range of values recorded in other lakes in the Region at the time.[25] These concentrations indicated good water quality.

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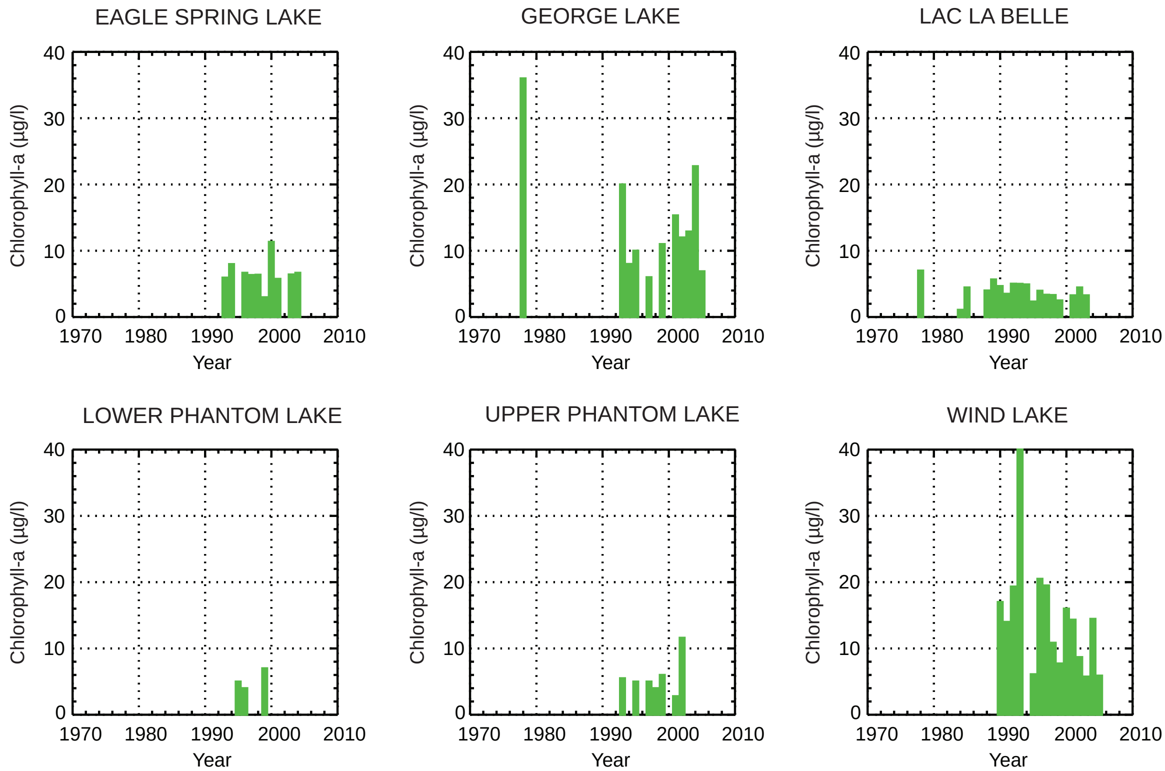
[23]Ibid.

[24]*J.R. Vallentyne, "The Process of Eutrophication and Criteria for Trophic State Determination," in* Modeling the Eutrophication Process—Proceedings of a Workshop at St. Petersburg, Florida, *November 19-21, 1969, pp. 57-67.*

[25]Ibid.

Figure 17

ANNUAL MEAN SUMMER (JUNE 15-SEPTEMBER 15) CHLOROPHYLL-*a* AMONG SHALLOW LAKES IN SOUTHEAST WISCONSIN: 1970-2008



Source: U.S. Geological Survey and SEWRPC.

During the current study period, the chlorophyll-*a* concentrations in Eagle Spring Lake remained within this range. Chlorophyll-*a* concentrations ranged from about 4.0 µg/l to about 12 µg/l in the main lake basin. As shown in Figure 17, compared to George and Wind Lakes (two other shallow lakes within the Southeastern Wisconsin Region), algal populations in Eagle Spring Lake, as reflected by the observed chlorophyll-*a* concentrations, have remained at relatively low levels over the 10-year period of record. Although algal blooms have occurred on Eagle Spring Lake, as indicated by chlorophyll-*a* concentrations in excess of 20 µg/l, such blooms have not been perceived as a major problem to date, and the range of values remains within the range of chlorophyll-*a* concentrations indicative of good water quality.

Nutrient Characteristics

Aquatic plants and algae require nutrients such as phosphorus and nitrogen for growth. In hard-water alkaline lakes, most of these nutrients are generally found in concentrations that exceed the needs of growing plants. However, in lakes where the supply of one or more of these nutrients is limited, plant growth is limited by the amount of that nutrient available. During the studies associated with the formulation of the initial comprehensive lake management plan, the nitrogen-to-phosphorus ratios in samples collected from Eagle Spring Lake following spring turnover were always greater than 14:1, indicating that plant production was most likely consistently limited by phosphorus.

Phosphorus can exist in a lake in several forms. Soluble phosphorus, being dissolved in the water column, is readily available for plant growth. However, its concentration can vary widely over short periods of time as plants take up and release this nutrient. Therefore, total phosphorus, which includes both dissolved and particulate phosphorus, is usually considered a better indicator of nutrient status. Total phosphorus includes the phosphorus contained in plant and animal fragments suspended in the lake water, phosphorus bound to sediment particles, and phosphorus dissolved in the water column.

The recommended regional water quality guideline for phosphorus, set forth for lakes in the adopted regional water quality management plan, is 0.020 milligrams per liter (mg/l) of total phosphorus or less during spring turnover. This is the level considered in the regional plan as necessary to limit algal and aquatic plant growth to levels consistent with the recreational and warmwater fishery and other aquatic life water use objectives. Statewide standards for phosphorus concentrations in lakes were adopted during November 2010. The Statewide phosphorus standard supersedes the regional guideline value. Pursuant to Section NR 102.06, "Phosphorus," of the *Wisconsin Administrative Code*, Eagle Spring Lake would be considered to be a nonstratified drainage lake,[26] and subject to a 0.040 mg/l total phosphorus criterion, above which value the lake would be considered to be impaired with respect to phosphorus.[27]

During the formulation of the initial comprehensive lake management plan, total phosphorus concentrations were generally found to be less than 0.020 mg/l, with an average total phosphorus concentration in the surface waters of Eagle Spring Lake of 0.013 mg/l, indicating good water quality. During the current study period, as shown in Figure 18, total phosphorus concentrations in Eagle Spring Lake ranged from about 0.012 mg/l to about 0.030 mg/l, with an average of about 0.018 mg/l. These values, while remaining consistent with the relatively low chlorophyll-*a* concentrations presented above, may indicate a slight deterioration in water quality in recent years, although the total phosphorus concentrations measured in the Lake do not exceed the State threshold value for nonstratified drainage lakes.

Seasonal gradients in phosphorus concentration between the epilimnion and hypolimnion reflect the biogeochemistry of this growth element. In stratified lakes, nutrients can become depleted in the upper waters as plants utilize them for growth during the growing season. When aquatic organisms die, they usually sink to the bottom of the lake, where they are decomposed, releasing the nutrients back into solution. Phosphorus from these organisms may then be either stored in the bottom sediments or recirculated back into the water column. Under conditions of oxygen depletion, the phosphorus that is stored in the lake sediments can be released into the water column through the phenomenon mentioned above as "internal loading."[28] Internal loading can occur under aerobic conditions, but generally at a slower rate than under anaerobic conditions.

As the waters mix, this phosphorus may be widely dispersed throughout the lake waterbody and become available for algal growth. When the mixing process is relatively slow, on the order of days to weeks, minerals and nutrients released from the sediments into the hypolimnion of the lake tend to recombine with the multivalent cations in the lake sediments and precipitate out of the water column; if the mixing process is relatively rapid, on

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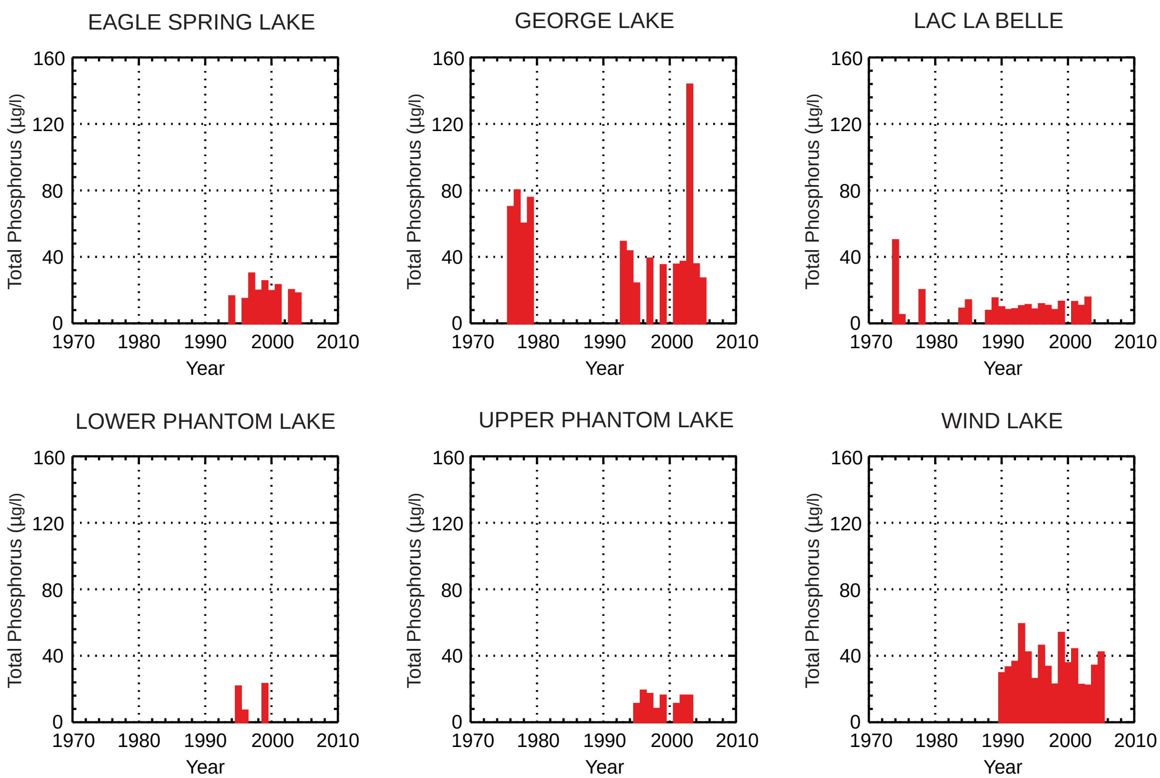
[26]*Pursuant to Paragraph NR 102.06(2)(g) of the* Wisconsin Administrative Code, *the morphological characteristics of Eagle Spring Lake would result in a value of 3.6, which does not exceed the Statutory value of 3.8 which would place the Lake into the stratified lake or reservoir category.*

[27]*See Paragraph NR 102.06(4)(b)3. of the* Wisconsin Administrative Code.

[28]*Because phosphorus is not highly soluble in water, it readily forms insoluble precipitates with calcium, iron, and aluminum under aerobic conditions and accumulates, predominantly, in the lake sediments. If the bottom waters become depleted of oxygen during stratification, however, certain chemical changes occur, especially in the oxidation state of iron from the insoluble Fe^{3+} state to the more soluble Fe^{2+} state. The effect of these chemical changes is that the phosphorus becomes soluble again and is released from the sediments.*

Figure 18

ANNUAL MEAN SUMMER (JUNE 15-SEPTEMBER 15) TOTAL PHOSPHORUS
AMONG SHALLOW LAKES IN SOUTHEAST WISCONSIN: 1970-2008



Source: U.S. Geological Survey and SEWRPC.

the order of hours to days, as may occur due to the passage of an intense storm, the minerals and nutrients may be mixed upward into the epilimnion or surface waters where they are available for plant growth.[29] The magnitude of this release and its concomitant effects in contributing to algal growth in the surface waters of the Lake, therefore, may be moderated by a number of circumstances, including the rate of mixing during the spring and fall overturn events. In shallow lakes, like Eagle Spring Lake, the more frequent and rapid mixing of the water column can inject surface waters with a constant infusion of dissolved phosphorus. However, during the initial study, the data indicated there was little internal loading of phosphorus for the bottom sediments of Eagle Spring Lake. This was confirmed through the phosphorus loading analyses summarized below, which resulted in a forecast in-lake surface water phosphorus concentration that was not dissimilar to the observed concentration, suggesting that all of the phosphorus present in the lake water column could be accounted for through external phosphorus sources.

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[29]*See, for example, R.D. Robarts, P.J. Ashton, J.A. Thornton, H.J. Taussig, and L.M. Sephton, "Overturn in a hypertrophic, warm, monomictic impoundment (Hartbeespoort Dam, South Africa),"* Hydrobiologia, *Volume 97, 1982, pp. 209-224.*

CONTAMINANT LOADINGS AND SOURCES

Contaminant loads to a lake are generated by various natural processes and human activities that take place in the area tributary to a lake.[30] These loads are transported to the lake through the atmosphere, across the land surface, and by way of inflowing streams. Contaminants transported by the atmosphere are deposited onto the surface of the lake as dry fallout and direct precipitation. Contaminants transported across the land surface enter the lake as direct runoff and, indirectly, as groundwater inflows, including drainage from onsite wastewater treatment systems. Contaminants transported by streams enter a lake as surface water inflows. In through-flow lakes, like Eagle Spring Lake, contaminant loads transported across land surfaces and inflowing streams, in the absence of identifiable or point source discharges from industries or wastewater treatment facilities, comprise the principal routes by which contaminants enter a waterbody.[31] Currently, there are no significant point source discharges of contaminants to Eagle Spring Lake or to the surface waters tributary to Eagle Spring Lake. For this reason, the discussion that follows is based upon nonpoint source contaminant loads to Eagle Spring Lake.

The initial comprehensive lake management plan included estimated nonpoint source loads from the area tributary to Eagle Spring Lake. These sources included urban sources, such as runoff from residential, commercial, transportation, construction, and recreational activities, including onsite sewage disposal systems, and rural sources, such as runoff from agricultural lands. Estimates were made of the phosphorus and suspended solids loads to the Lake from the tributary area, based upon surface runoff and atmospheric contributions. Losses through the outlet also were estimated during the study year.

During the current study, nonpoint-sourced phosphorus, suspended solids, and urban-derived metals input to Eagle Spring Lake were estimated using the Wisconsin Lake Model Spreadsheet (WILMS version 3.0),[32] and unit area load-based (UAL) models developed for use within the Southeastern Wisconsin Region. These estimates are contrasted with the nutrient and sediment load estimates set forth in the initial plan. The WILMS and UAL models were used to forecast nutrient, sediment, and metals loads to Eagle Spring Lake based upon year 2000 land use and planned year 2035 land use conditions.[33] The forecast contaminant loads to Eagle Spring Lake are set forth in Table 9.

Phosphorus Loading

Phosphorus has been identified as the factor generally limiting aquatic plant growth in Eagle Spring Lake. Thus, excessive levels of phosphorus in the lake are likely to result in conditions that interfere with the desired use of the lake. Consequently, knowledge of, and managing the mass of, phosphorus entering Eagle Spring Lake is a critical element in restoring and maintaining acceptable water quality in this waterbody. Phosphorus loads to the

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[30]*Water, as the "universal solvent," rarely occurs in a pure form in nature. It almost always exists as a dilute solution comprised of a mixture of various elements. Unless the levels of these solutes exceed a pre-determined or legal threshold value, they can be termed "contaminants." Beyond a specified threshold value, however, such contaminants are termed "pollutants" as a consequence of their impact on human use of the waters.*

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

[32]*Wisconsin Department of Natural Resources Publication No. PUBL-WR-363-94,* Wisconsin Lake Modeling Suite Program Documentation and User's Manual, Version 3.3 for Windows, *August 2002.*

[33]*The Village of Eagle is currently exempted from the stormwater management permitting requirements set forth in Chapter NR 216 of the* Wisconsin Administrative Code *pursuant to the provisions of Section NR 216.023.*

Table 9

ESTIMATED CONTAMINANT LOADS FROM THE TOTAL AREA, EXCLUDING INTERNALLY DRAINED AREAS, TRIBUTARY TO EAGLE SPRING LAKE: 2000 AND 2035

Land Use	2000					2035				
	Sediment (tons)	Phosphorus (pounds)	Copper (pounds)	Zinc (pounds)	Cadmium (pounds)	Sediment (tons)	Phosphorus (pounds)	Copper (pounds)	Zinc (pounds)	Cadmium (pounds)
Residential	14.5	292.7[a]	0.4	16.9	<0.1	29.7	581.5[a]	2.1	42.9	0.2
Commercial	3.5	10.8	2.0	13.4	0.1	76.0	232.8	42.7	289.1	1.9
Industrial	10.9	33.9	6.3	43.2	0.3	24.4	76.1	14.3	96.8	0.6
Communications, Transportation, and Utilities	0.1	2.5	- -	- -	- -	- -	- -	- -	- -	- -
Governmental	8.2	43.2	2.2	25.6	- -	- -	- -	8.2	93.6	- -
Recreational	3.0	68.0	- -	- -	- -	5.6	126.6	- -	- -	- -
Subtotal	40.2	451.1	10.9	99.1	0.4	165.6	1,174.9	67.3	522.4	2.7
Water	40.4	55.9	- -	- -	- -	40.4	55.9	- -	- -	- -
Wetlands	2.5	54.7	- -	- -	- -	2.5	54.7	- -	- -	- -
Woodlands	4.1	89.4	- -	- -	- -	4.1	89.4	- -	- -	- -
Open Lands	5.6	129.9	- -	- -	- -	- -	- -	- -	- -	- -
Agricultural	1,253.4	4,791.1	- -	- -	- -	1,083.8	4,142.6	- -	- -	- -
Subtotal	1,306.0	5,121.0	- -	- -	- -	1,130.8	4,342.6	- -	- -	- -
Total	1,346.2	5,572.1	10.9	99.1	0.4	1,296.4	5,517.5	67.3	522.4	2.7

[a]*Onsite sewage disposal systems are estimated to contribute between 40 pounds of phosphorus and 290 pounds of phosphorus per year.*

Source: SEWRPC.

Lake were estimated in the initial comprehensive lake management plan for existing 1990 land use conditions using land use data derived from the then-current regional land use plan.[34] This analysis updated the initial estimates of phosphorus loadings to Eagle Spring Lake set forth in the regional water quality management plan.[35]

The regional water quality management plan estimated the phosphorus load to Eagle Spring Lake based upon 1975 land use conditions as approximately 8,190 pounds of phosphorus per year. The major portion of this load was estimated to have been derived from animal operations in the watershed, which delivered more than 75 percent of the phosphorus entering the Lake, about 6,250 pounds. Other rural land operations contributed a large percentage of the remaining load, or about 1,335 pounds per year to the Lake. Urban density lands and atmospheric deposition each provided about 150 pounds of phosphorus per year, while onsite sewage disposal systems were estimated to contribute the balance of the total load, or about 300 pounds of phosphorus per year. No changes in this load were forecast for year 2000 conditions.

The initial comprehensive lake management plan for Eagle Spring Lake refined these loads based upon 1990 land use conditions. In the initial comprehensive lake management plan, a total annual phosphorus load to Eagle Spring Lake based upon 1990 land use conditions was estimated to be 4,520 pounds per year.[36] While rural agricultural land uses remained the largest source of phosphorus to the Lake, contributing about 2,515 pounds of phosphorus per year, or just over one-half of the total load to the Lake, urban density land uses were estimated to contribute one-quarter of the load, with the balance of the total load being contributed from direct deposition onto the Lake surface and from runoff from woodlands and wetlands. Based upon 1990 conditions, onsite sewage disposal systems were estimated to contribute 370 pounds of phosphorus or less than 10 percent of the total annual load.

For the purposes of this plan, the current phosphorus load to Eagle Spring Lake was estimated based upon observed year 2000 land use conditions. Under year 2000 conditions, it was estimated that 5,570 pounds of phosphorus were delivered to Eagle Spring Lake annually. Of this total, approximately 8 percent of the load is generated from urban lands, about 86 percent from agricultural lands within the tributary area, and about 1 percent by direct deposition into the Lake surface. The balance of the annual phosphorus load arises from rural density lands, including woodlands and wetlands within the tributary area. These loads reflect the changes in land use that occurred within the tributary area that were not foreseen at the time of formulation of the 1979 regional water quality management plan. As noted above, the phosphorus load estimated to be delivered to Eagle Spring Lake in the initial regional water quality management plan was assumed to remain unchanged from 1975 land use conditions. However, there was considerable conversion of agricultural lands that occurred during the period between 1975 and 2000, with a corresponding reduction in the estimated nutrient load generated from agricultural operations in the watershed. It should also be noted that the State of Wisconsin has adopted a turf management standard limiting the application of lawn fertilizers containing phosphorus within the State.[37]

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[34]*SEWRPC Planning Report No. 40,* A Regional Land Use Plan for Southeastern Wisconsin—2010, *January 1992, as refined by SEWRPC Community Assistance Planning Report No. 209,* A Development Plan for Waukesha County, Wisconsin, *August 1996.*

[35]*SEWRPC Planning Report No. 30,* A Regional Water Quality Management Plan for Southeastern Wisconsin: 2000, *Volume Two,* Alternative Plans, *February 1979.*

[36]*The initial comprehensive lake management plan reported the total annual phosphorus load to Eagle Spring to be about 2,000 pounds per year; this value, set forth in Table 12 of the initial plan, should have been reported in kilograms of phosphorus per year, or 4,520 pound per year.*

[37]*On April 14, 2009,* 2009 Wisconsin Act 9 *created Section 94.643 of the* Wisconsin Statutes *relating to restrictions on the use and sale of fertilizer containing phosphorus in urban areas throughout the State of Wisconsin.*

Further conversion of agricultural lands to nonagricultural land uses is anticipated under planned year 2035 conditions. Under planned year 2035 conditions, the annual external phosphorus load to Eagle Spring Lake is expected to continue to decline slightly, to about 5,520 pounds of phosphorus. The urban-sourced phosphorus is expected to increase to about 21 percent of the total annual phosphorus load, with this increase primarily arising as a result of additional residential and commercial development in the tributary area. Rural contributions to the total annual phosphorus load to Eagle Spring Lake are expected to continue to decline. Agriculturally derived phosphorus entering Eagle Spring Lake is expected to decrease to about 4,140 pounds annually, or to about 75 percent of the total annual phosphorus load, primarily as a result of the conversion of rural agricultural lands to urban land uses.

In-Lake Phosphorus Sources
Phosphorus release from the lake bottom sediments, or "internal loading," may also contribute phosphorus to the Lake. In the initial comprehensive lake management plan for Eagle Spring Lake, internal loading was not considered to be a significant component of the phosphorus budget of the Lake due to the polymictic nature of the Lake. This is consistent with the water column of Eagle Spring Lake remaining oxygenated for much of the year. During the current study, based upon the observed total phosphorus concentration in the Lake—averaging 0.020 mg/l—and the forecast total phosphorus concentration based upon the anticipated total phosphorus loading to the Lake—estimated at 0.020 mg/l—it can again be concluded that internal loading of phosphorus within Eagle Spring Lake is negligible.

In-Lake Phosphorus Sinks
During the formulation of the initial comprehensive lake management plan for Eagle Spring Lake, it was estimated that 23 percent of the annual total phosphorus load entering Eagle Spring Lake of the total phosphorus load was retained within the Lake.[38] This mass of phosphorus was used either by the biomass within the Lake or deposited in the lake sediments. The balance of the phosphorus entering the Lake was transported downstream. During the current study period, it was estimated that a similar percentage of the phosphorus load was retained within Eagle Spring Lake.

Sediment Loading
Sediment loads to Eagle Spring Lake were estimated during the current study based upon year 2000 and forecast year 2035 land use conditions. These data, shown in Table 9, suggest an annual sediment load to the Lake of about 1,350 tons under year 2000 land use conditions, and of about 1,300 tons under planned year 2035 land use conditions. Of the likely annual sediment load delivered to the Lake under year 2000 land use conditions, it was estimated that 1,250 tons per year, or 93 percent of the total loading, was contributed by runoff from agricultural land. About 40 tons of sediment per year were estimated to be contributed from urban lands with an equivalent mass of sediment being contributed by direct precipitation onto the lake surface. Under planned year 2035 conditions, as set forth in the Waukesha County development plan and adopted regional land use plan, the annual sediment load to the Lake from the total tributary area is anticipated to decrease by about 4 percent. The distribution of the sources of the sediment load to the Lake also are expected to change, with an increased mass of sediment being contributed from urban lands, which are estimated to contribute 166 tons of sediment per year, and less sediment being contributed from agricultural lands, estimated to contribute 1,084 tons of sediment per year. It is estimated that 56 tons of sediment per year would to be contributed by direct precipitation onto the lake surface under year 2035 conditions.

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[38]*D.P. Larsen and H.T. Mercier, "Phosphorus retention capacity of lakes,"* Journal of the Fisheries Research Board of Canada, *Volume 33, 1976, pp. 1742-1750.*

Urban Heavy Metals Loadings
Urbanization brings with it increased use of metals and other materials that contribute pollutants to aquatic systems.[39] The majority of these metals become associated with sediment particles,[40] and is likely to be encapsulated into the bottom sediments of the Lake. Estimated loadings of copper, zinc, and cadmium likely to be contributed to Eagle Spring Lake from the total tributary area are shown in Table 9. Under existing year 2000 conditions, it was estimated that 11 pounds of copper, 99 pounds of zinc, and 0.4 pound of cadmium were contributed to Eagle Spring Lake from urban lands annually. Under year 2035 conditions, based upon forecast land use as set forth in the Waukesha County development plan and adopted regional land use plan, the annual heavy metal loads to the Lake are anticipated to generally increase. The annual loads to the Lake under buildout conditions are estimated to be 67 pounds of copper, 522 pounds of zinc, and three pounds of cadmium.

Groundwater Quality
Hilary Erin Gittings also indicated that flow in the Mukwonago River system is dependent upon groundwater discharges from multiple aquifers, including the surficial shallow sand and gravel aquifer and the shallow bedrock aquifer.[41] Of the groundwater contributed to the spring complex upstream of Lulu Lake, about 15 to 100 percent was discharged through "boils" from a bedrock source, entering the springs through preferential flow paths within the fractured bedrock; the sand and gravel aquifer was estimated to contribute from 0 to 20 percent to this flow, between the spring complex and the TNC foot bridge—total groundwater inputs during any given year could equal up to 100 percent of the inflow to Lulu Lake, with the ratio of shallow bedrock aquifer to surficial shallow sand and gravel aquifer flows varying as a function of rainfall, runoff, and degree of aquifer recharge experienced during a specific year. A similar relationship was reported for the Lake Beulah area which also received a small contribution of groundwater from the deep aquifer. Gittings further reported high levels of chloride in water samples obtained from the open water and shallow groundwater sites upstream of Lulu Lake. This is consistent with findings reported by the Eagle Spring Lake Management District's August 2008 report entitled "Mukwonago River-Watershed Nutrient Study: August 2004-October 2008."

Groundwater inflows within the Eagle Spring Lake and Lulu Lake basins have a direct effect on the thermal structure of the Lakes. During the summer of 2007, SEWRPC staff deployed continuous monitoring devices at 42 locations, 18 of which were either upstream of or within Eagle Spring Lake, in the Mukwonago River Basin to measure water temperatures and one additional site to monitor air temperatures. Some of these locations were monitored continuously over this three year time period and other sites were only monitored in one or two years. These devices were programmed to record temperature in hourly increments. In addition, there also was a weather station on Eagle Spring Lake where daily mean, minimum, and maximum temperatures were recorded along with additional variables such as precipitation, wind speed, and direction.

Average summer daily maximum air temperatures for the Eagle Spring Lake weather station were 26.7 degrees Celsius (ºC) in 2007, 25.7 ºC in 2008, and 24.3 ºC in 2009, as shown in Figure 19. This indicates that the summers have decreased in temperature on average during the study period. However, Figure 19 also indicates that there is a considerable range in maximum daily summer temperatures from about 17 ºC to more than 32 ºC, which reflects variability generated by cloud cover and storm systems. Since air temperatures are major determinants of water temperatures, these differences in air temperature have important implications for water temperature changes. For example, although the year 2009 was the coldest summer on average, the warmest maximum daily water temperature recorded over the entire sampling period throughout the entire Mukwonago River system occurred on

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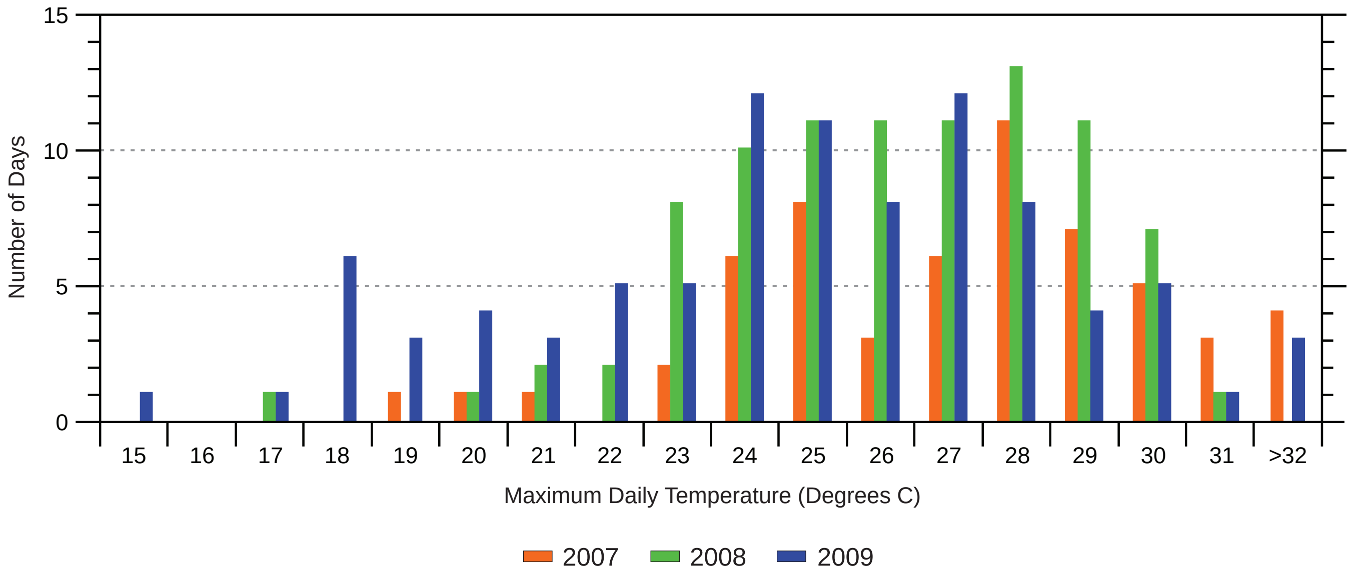
[39] *Jeffrey A. Thornton, et al.,* op. cit.

[40] *Werner Stumm and James J. Morgan,* op. cit.

[41] *Hilary Erin Gittings, "Hydrogeologic Controls on Springs in the Mukwonago River Watershed, SE Wisconsin," Master of Science Thesis submitted to the University of Wisconsin-Madison, 2005.*

Figure 19

MAXIMUM DAILY SUMMER (JUNE-AUGUST) AIR TEMPERATURE
AT THE EAGLE SPRING LAKE WEATHER STATION: 2007-2009



NOTE: Average summer daily maximum air temperatures for the Eagle Spring Lake Weather Station were 26.7 degrees Celsius (°C) for 2007, 25.7 °C for 2008, and 24.3 °C for 2009.

Source: SEWRPC.

June 26, 2009, as shown on Figure 20. This occurred due to approximately seven straight days and nights of increasing air temperatures driving increasing water temperatures. Figure 20 shows several important features: 1) daily fluctuations that reflect the diurnal increase in temperature during the day and cooling at night; 2) the influence of groundwater discharge on the daily fluctuations and maximum temperatures which are reduced in sections of stream with increased volumes of groundwater discharge; and, 3) the dependency of water temperature on both the current and preceding daily air temperatures.

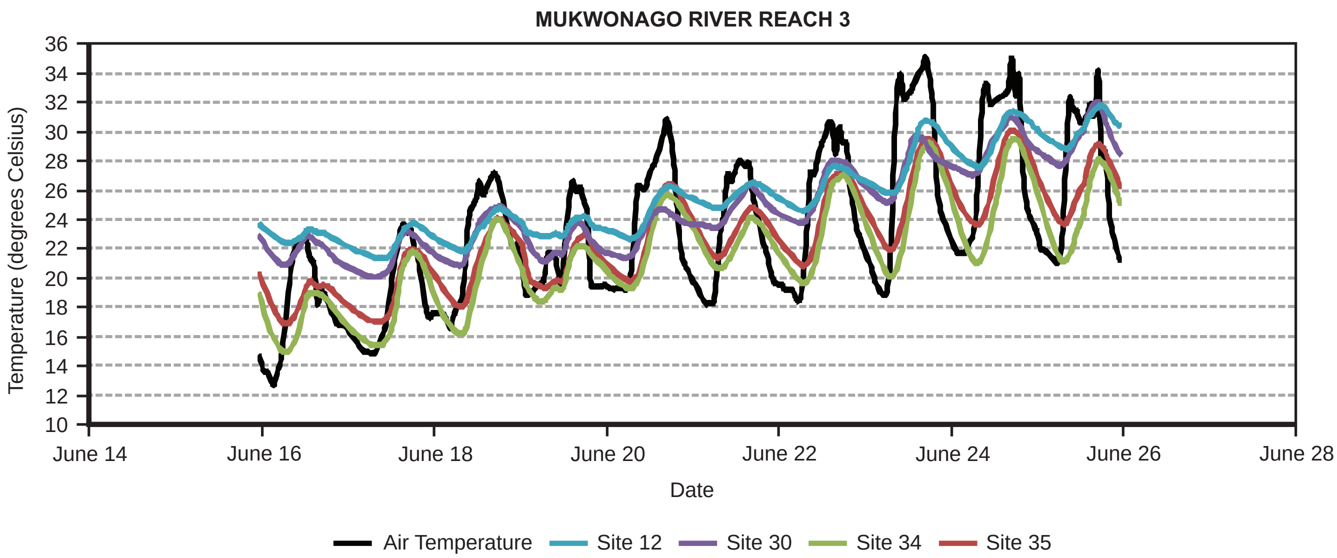
Figure 21 shows how water temperatures upstream of Eagle Spring Lake at the TNC bridge (Site 34) were much cooler than surface water temperatures within Eagle Spring Lake. However, this figure also shows that daily temperatures can be much more variable and in some cases much warmer upstream of Eagle Spring Lake than within the Lake, itself, particularly before the summer. Further, Figure 21 shows that groundwater inflows within Eagle Spring Lake have a direct effect on the thermal structure of the Lake by significantly decreasing water temperatures in the northwestern portions of the Lake. The temperature data also show that the eastern portions of the lake are warmer than the western portions, due to prevailing winds, which seem to have important implications for stratification. This east-west phenomenon was also observed to occur within Lulu Lake. This indicates that the southern bays are likely to be less well mixed and more susceptible to heating than other areas within Eagle Spring Lake. Therefore, although water temperatures tended to increase in Eagle Spring Lake during June 2009, the actual water temperature variations within the Lake can be very complex.

RATING OF TROPHIC CONDITION

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 to the degree of nutrient enrichment which has occurred. There are three terms generally used to describe the trophic status of a lake: oligotrophic, mesotrophic, and eutrophic.

Figure 20

HOURLY WATER AND AIR TEMPERATURES AMONG SITES AND REACHES WITHIN THE MUKWONAGO RIVER WATERSHED: JUNE 16-26, 2009



NOTE: Air temperature data are from the Eagle Spring Lake Weather Station, Eagle, Wisconsin; Site 12 is located downstream of the Wambold Dam, Site 30 is located in the channel between Lulu and Eagle Spring Lakes, Site 34 is located upstream of The Nature Conservancy bridge, and Site 35 is located upstream of Bluff Road in the Town of Troy, Walworth County, Wisconsin.

Source: SEWRPC.

Oligotrophic lakes are nutrient-poor lakes. These lakes characteristically support relatively few aquatic plants and often do not contain very productive fisheries. Oligotrophic lakes may provide excellent opportunities for swimming, boating, and waterskiing. Because of the naturally fertile soils and the intensive land use activities, there are relatively few oligotrophic lakes in southeastern Wisconsin.

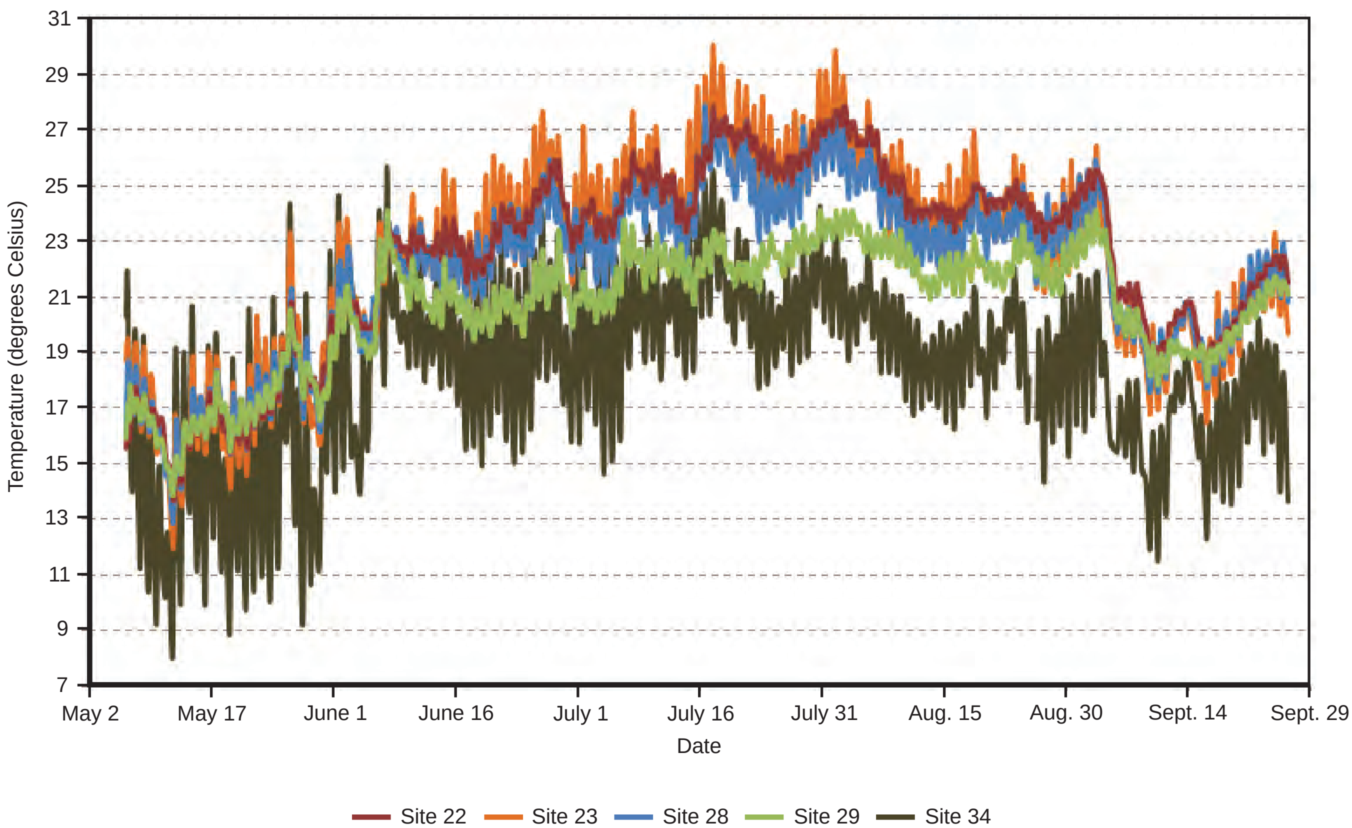
Mesotrophic lakes are moderately fertile lakes which may support abundant aquatic plant growths and productive fisheries. However, nuisance growths of algae and macrophytes are usually not exhibited by mesotrophic lakes. These lakes may provide opportunities for all types of recreational activities, including boating, swimming, fishing, and waterskiing. Many lakes in southeastern Wisconsin are mesotrophic.

Eutrophic lakes are nutrient-rich lakes. These lakes often exhibit excessive aquatic macrophyte growths and/or experience frequent algae blooms. If the lakes are shallow, fish winterkills may be common. While portions of such lakes are not ideal for swimming and boating, eutrophic lakes may support very productive fisheries.

Several numeric “scales,” based on one or more water quality indicators, have been developed to define the trophic condition of a lake. Because trophic state is actually a continuum from very nutrient poor to very nutrient rich, a numeric scale is useful for comparing lakes and for evaluating trends in water quality conditions. Care must be taken, however, that the particular scale used is appropriate for the lake to which it is applied. In this case, two indices appropriate for Wisconsin lakes have been used; namely, the Vollenweider-OECD open-boundary

Figure 21

HOURLY SURFACE WATER TEMPERATURES AT ONE SITE UPSTREAM OF EAGLE SPRING LAKE VERSUS SEVERAL SITES IN THE LAKE: MAY-SEPTEMBER 2008



NOTE: Sites 22 to 29 are within Eagle Spring Lake and Site 34 is upstream of Eagle Spring and Lulu Lakes.

Source: SEWRPC.

trophic classification system,[42] and the Carlson Trophic State Index (TSI).[43] In addition, the Wisconsin Trophic State Index value (WTSI) is presented.[44] The WTSI is a refinement of the Carlson TSI designed to account for the greater humic acid content—brown water color—present in Wisconsin lakes, and has been adopted by the WDNR for use in lake management investigations.

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[42]*Organization for Economic Cooperation and Development (OECD),* Eutrophication of Waters: Monitoring, Assessment, and Control, *Paris, 1982; see also H. Olem and G. Flock, U.S. Environmental Protection Agency Report EPA-440/4-90-006,* The Lake and Reservoir Restoration Guidance Manual, Second Edition, *Washington, D.C., August 1990.*

[43]*R.E. Carlson, "A Trophic State Index for Lakes,"* Limnology and Oceanography, *Vol. 22, No. 2, 1977.*

[44]*See R.A. Lillie, S. Graham, and P. Rasmussen, "Trophic State Index Equations and Regional Predictive Equations for Wisconsin Lakes,"* Research and Management Findings, *Wisconsin Department of Natural Resources Publication No. PUBL-RS-735 93, May 1993.*

OECD Trophic State Classification
The OECD open-ended trophic state classification system assigns a trophic condition rating based on the ratio of mean lake depth to hydraulic residence time and phosphorus loading per unit of lake surface. Using the OECD trophic system and applying the current data in Table 8, Eagle Spring Lake would be classified as having about a 60 percent probability of being mesotrophic based upon phosphorus levels, as shown in Figure 22. The Lake also would have about a 30 percent probability of being oligotrophic, and about a 10 percent probability of being eutrophic, based upon mean annual phosphorus concentrations.

Based upon chlorophyll-*a* levels, the Lake would be classified as having about a 45 percent probability of being either mesotrophic or eutrophic, with about a 5 percent probability of being either hypereutrophic or oligotrophic, as shown in Figure 22.

Based upon Secchi-disk readings, the Lake would be classified as having a 50 percent probability of being eutrophic, with a 35 percent probability of being hypertrophic, and about a 15 percent probability of being mesotrophic, as shown in Figure 22.

While these indicators result in slightly differing lake trophic state classifications, it may be concluded that Eagle Spring Lake should be classified as a mesotrophic lake, or a lake with acceptable water quality for most uses. In the initial comprehensive lake management plan, Eagle Spring Lake also was considered to be mesotrophic, using the open-ended OECD trophic state classification system.

Trophic State Index
The Trophic State Index (TSI) assigns a numerical trophic state condition rating based on Secchi-disk transparency, and total phosphorus and chlorophyll-*a* concentrations. The original Trophic State Index developed by Professor Robert E. Carlson has been modified for Wisconsin lakes by the WDNR using data on 184 lakes throughout the State.[45] Based on the Wisconsin Trophic State Index ratings derived during the formulation of the initial comprehensive lake management plan, Eagle Spring Lake was classified as mesotrophic with a WTSI rating of about 52. Remote sensing data gathered as part of the aforementioned ERSC program, estimated a Carlson TSI rating of 54 for Eagle Spring Lake, which places Eagle Spring Lake in the upper mesotrophic to eutrophic category. The slightly lower Wisconsin Trophic State Index (WTSI) rating for Eagle Spring Lake is consistent with the corrections included in the WTSI calculations for the humic coloration of Wisconsin Lakes. Based on current data set forth in Table 8, Eagle Spring Lake may be classified as mesotrophic, with a WTSI rating of about 50, as summarized in Figure 23.

SUMMARY

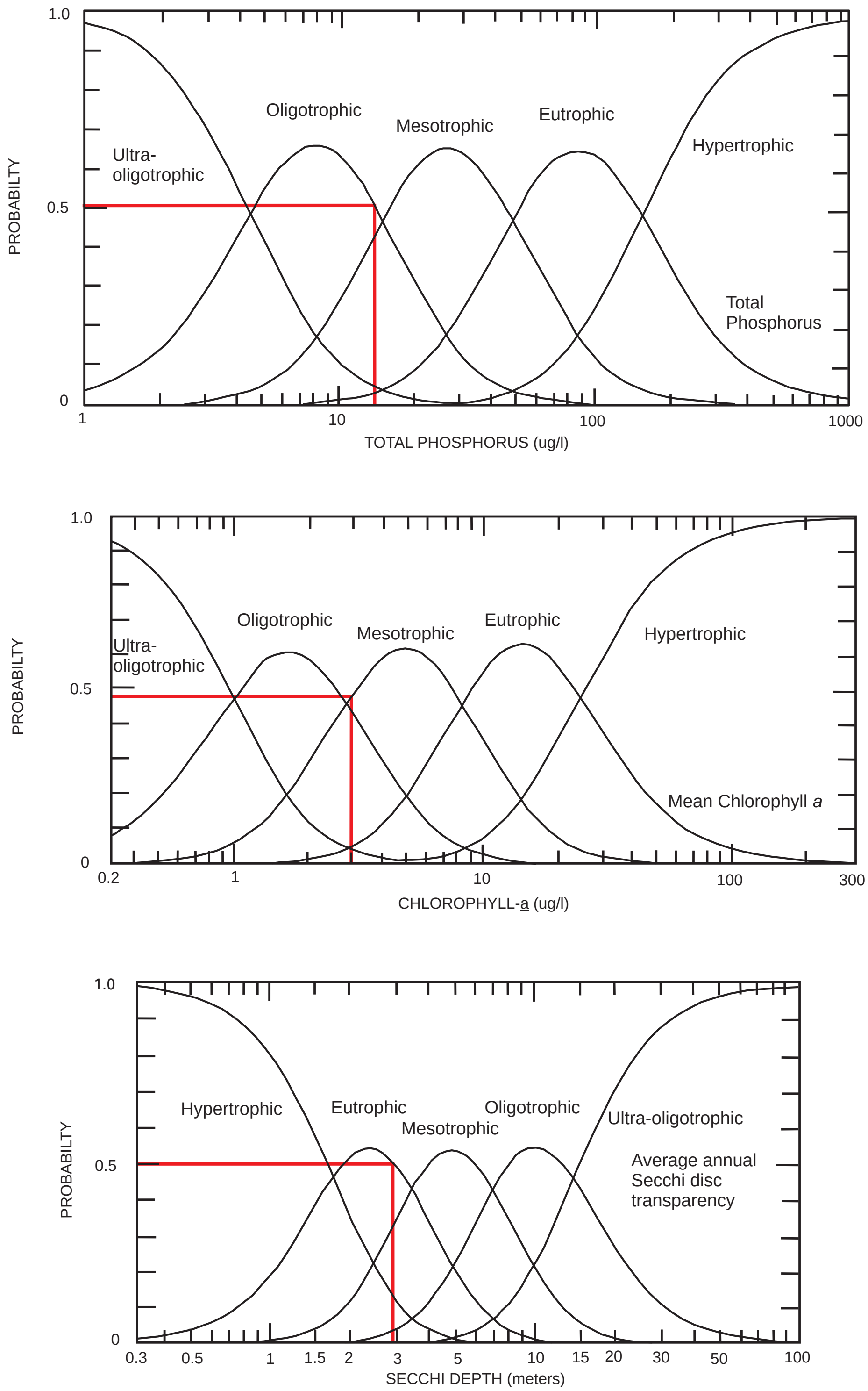
Eagle Spring Lake represents a typical hard-water, alkaline lake that is considered to have relatively good water quality. Total phosphorus levels were found to be generally below the level considered to cause nuisance algal and macrophytic growths. Summer stratification has not been commonly observed in Eagle Spring Lake and the surface waters of the Lake have historically been well oxygenated and supportive of a healthy fish population. Winterkill has not been a problem in Eagle Spring Lake because of the substantial volume of the Lake that provides an adequately oxygenated water volume for the support of fish throughout the winter.

There were no significant point sources of pollutants in the Eagle Spring Lake tributary area. Nonpoint sources of pollution included stormwater runoff from urban and agricultural areas. Based upon year 2000 land use conditions, the total annual phosphorus load to Eagle Spring Lake was estimated to be 5,600 pounds. Runoff from the rural lands contributed the largest amount of phosphorus, about 90 percent of the total phosphorus load, with

[45]*R.A. Lillie, S. Graham, and P. Rasmussen*, op. cit.

Figure 22

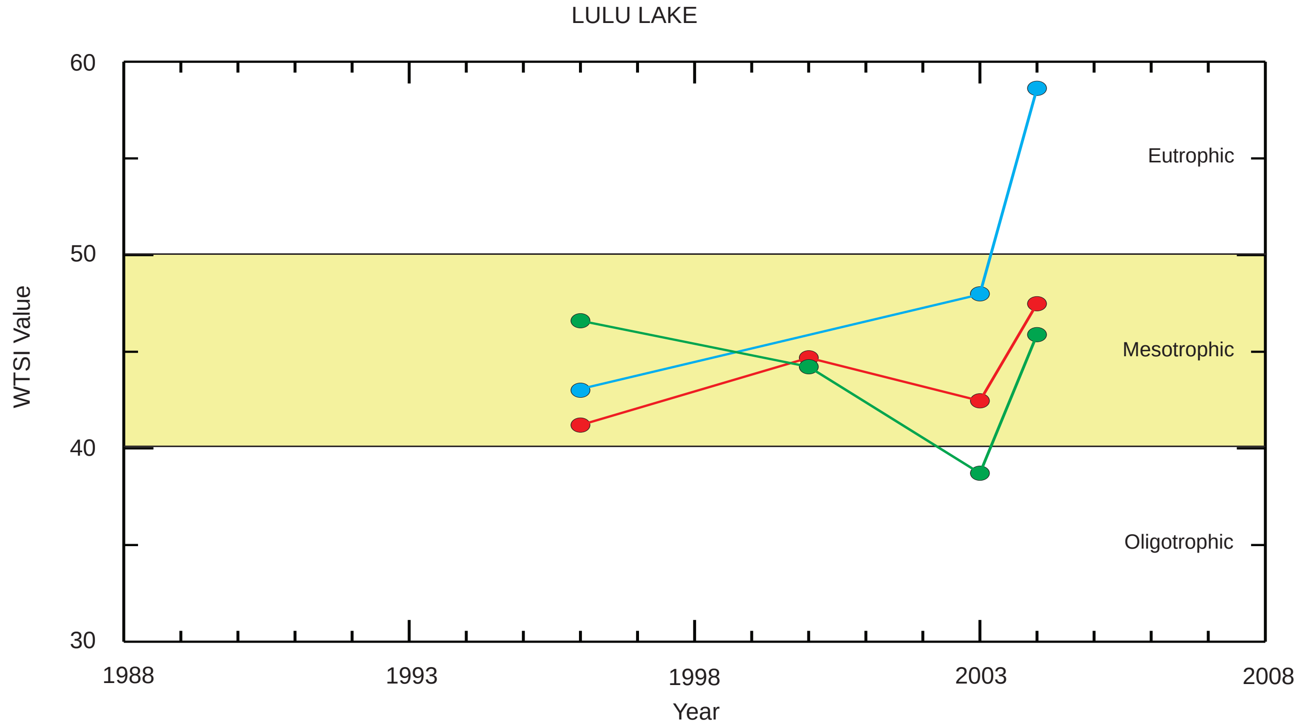
TROPHIC STATE CLASSIFICATION OF EAGLE SPRING LAKE BASED UPON THE OECD OPEN-ENDED CLASSIFICATION SYSTEM: 2009

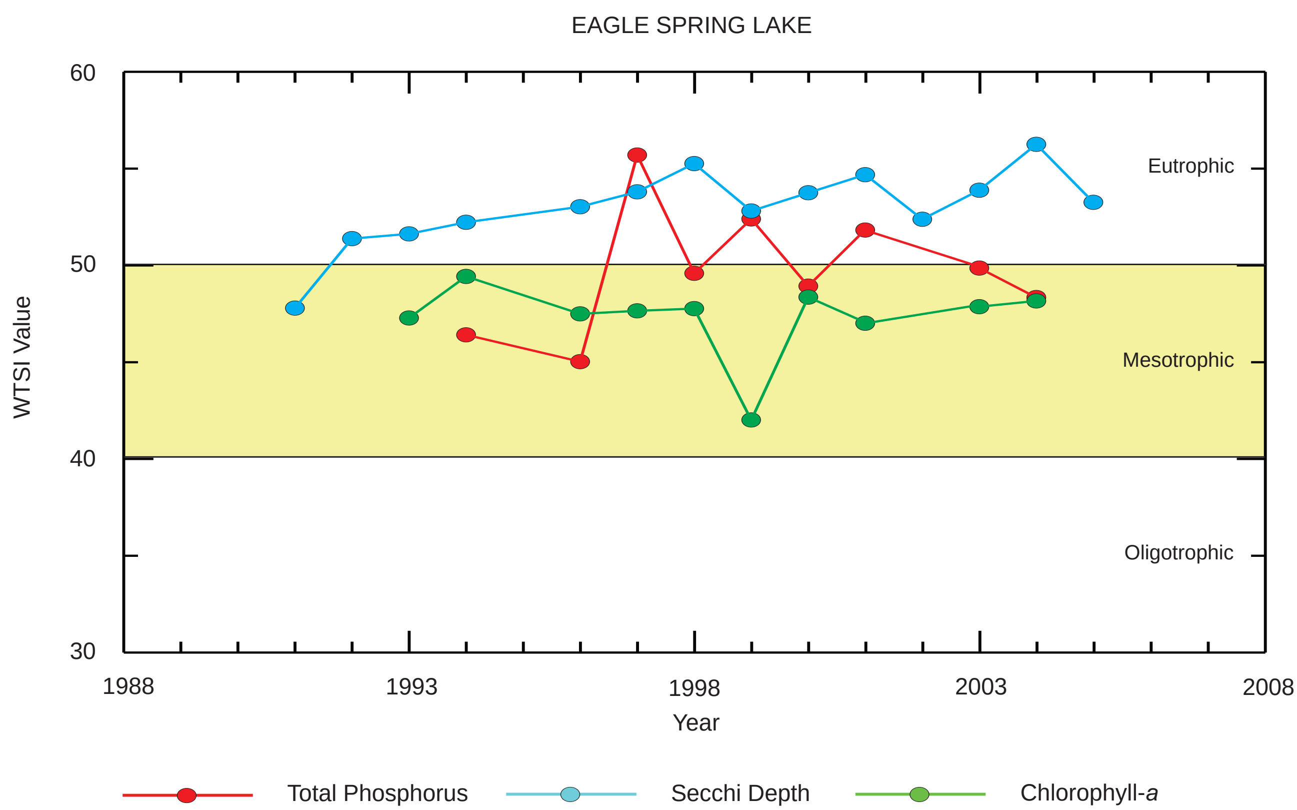


Source: University of Wisconsin-Extension Citizen Lake Monitoring Network and SEWRPC.

Figure 23

WISCONSIN TROPHIC STATE INDICES FOR EAGLE SPRING AND LULU LAKES: 1988-2008





Source: University of Wisconsin-Extension Citizen Lake Monitoring Network and SEWRPC.

the runoff from urban lands contributing about 8 percent, and direct precipitation onto the lake surface contributing about 2 percent of the total phosphorus load, or a relatively minor amount of phosphorus, to the Lake. Under forecast buildout conditions, the phosphorus load to the Lake is expected to decrease slightly to about 5,500 pounds per year, primarily as a result of a decrease in the load generated from rural lands. Approximately 25 percent of the total phosphorus loading is estimated to remain in the Lake by conversion to biomass or through sedimentation; however, internal releases of phosphorus from the bottom sediments were not considered to be a problem in Eagle Spring Lake.

Based on the OECD open-ended trophic state classification system and the Wisconsin Trophic State Index ratings of about 50 calculated from Eagle Spring Lake data, Eagle Spring Lake may be classified as a mesotrophic lake. This trophic status is unchanged from that determined in the initial comprehensive lake management plan.

Chapter V

AQUATIC BIOTA AND ECOLOGICALLY VALUABLE AREAS

INTRODUCTION

Eagle Spring Lake is an important element of the natural resource base of Waukesha County. The Lake and the Mukwonago River that flows through it contribute to the quality of life of the residential community in the area, and to the quality experiences of area visitors. In urban settings, natural resource features such as lakes and wetlands typically are subjected to extensive recreational use pressures and high levels of pollutant discharges. These common forms of stress to aquatic systems may result in the deterioration of the natural resource features, altering the nature and quality of the experiences of residents and visitors alike, and modifying the species compositions in both terrestrial and aquatic ecosystems. For this reason, the formulation of sound management strategies must be based on a thorough knowledge of the pertinent characteristics of the individual resource features, as well as of the urban development in the area concerned. Accordingly, this chapter provides information on the natural resource features of the Eagle Spring Lake tributary area, including data on aquatic macrophytes, fish, wildlife, wetlands and woodlands, and environmental corridors. Water quality conditions have been described in Chapter IV, while recreational activities are described and quantified in Chapter VI.

AQUATIC PLANTS

Aquatic plants include larger plants, or macrophytes, and microscopic algae, or phytoplankton. These plants form an integral part of the aquatic food web, converting inorganic nutrients present in the water and sediments into organic compounds that are directly available as food for other aquatic organisms. In the process known as photosynthesis, plants utilize energy from sunlight and release oxygen also required by other aquatic life forms. These plants form both the food stocks for, and habitat of, the larger aquatic animals present in the Lake and associated stream systems.

To document the types, distribution, and relative abundance of the aquatic plants in Eagle Spring Lake, the initial planning report compiled by the Southeastern Wisconsin Regional Planning Commission (SEWRPC) presented data from surveys conducted by commission staff during July 1994.[1] As part of the current planning effort, the Commission staff conducted a further aquatic plant survey during the summer of 2008. Data from these aquatic macrophyte surveys are summarized below.

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[1]*SEWRPC Community Assistance Planning Report No. 226*, A Lake Management Plan for Eagle Spring Lake, Waukesha County, Wisconsin, *October 1997.*

Phytoplankton

Phytoplankton or algae are small, generally microscopic, plants that are found in all lakes and streams. They occur in a wide variety of forms, as single cells or as multiple-celled colonies or filaments, and can be either attached or free floating. Algae are primary producers that form one of the bases of the aquatic food web. As primary producers, they utilize the process of photosynthesis to convert energy and nutrients to the compounds necessary to support life in the aquatic system. Oxygen, which is vital to higher forms of life in a lake or stream, also is produced during the photosynthetic process.

Algae are generally classified according to their dominant pigment; for example, green, blue-green, yellow-brown, and golden brown. Green algae (Chlorophyta) are the most important sources of food for zooplankton, or microscopic animals, in the lakes of southeastern Wisconsin. Blue-green algae (Cyanophyta) are not ordinarily utilized by zooplankton or fish populations, and may become over-abundant and out of balance with the organisms that feed on them. Dramatic population increases, or "blooms," of blue-green algae may occur when excessive nutrient supplies are available, optimum sunlight and temperature conditions exist, and there is a lack of competition from other aquatic plant species and insufficient grazing by zooplankton. In contrast, yellow-brown algae and golden-brown algae are adapted to growth under low-light conditions and cooler water temperatures.

Phytoplankton communities and abundances vary seasonally with fluctuations in solar irradiance, turbulence due to prevailing winds, and nutrient availability. In temperate lakes, there is a typical seasonal succession of algae, beginning with a spring diatom maximum and progressing through a period of green algal and blue-green algal dominance during the summer months. Chrysophyta, or yellow-brown algae, tend to dominate during the autumn and winter months. In lakes with high nutrient levels, heavy growths of phytoplankton, or algal blooms, may occur. Algal blooms may reach nuisance proportions in fertile, or eutrophic-lakes, resulting in the accumulation of surface scums or slimes. In some cases, heavy concentrations of wind-blown algae accumulate on shorelines, where they die and decompose, causing noxious odors and unsightly conditions. The decaying algae consume oxygen, sometimes depleting available supplies and resulting in fish kills. Also, certain species of decomposing blue-green algae may release toxic materials into the water. Algal blooms have occurred on Eagle Spring Lake, but have not been perceived to be a major problem.

Data on the types and concentrations of algae found in Eagle Spring Lake were not collected during either the initial or the current study periods. Rather, the density of algal populations was evaluated based upon the concentrations of the green algal pigment, chlorophyll-*a*. Chlorophyll-*a* concentrations above the threshold level of about 10 μg/l generally indicate that algal populations are at densities that result in a green coloration of the water that may be severe enough to impair recreational activities such as swimming and waterskiing.[2] The chlorophyll-*a* concentrations reported in Table 8 in Chapter IV of this plan are generally below the threshold value, indicating relatively low populations of algae and good water quality.

Aquatic Macrophytes

Aquatic macrophytes play an important role in the ecology of southeastern Wisconsin lakes. Depending on their type, distribution, and abundance, they can be either beneficial or a nuisance. Macrophytes growing in the locations and in densities that do not significantly interfere with human access to the water and recreational uses, such as boating and swimming, are beneficial in maintaining lake fisheries and wildlife populations. Macrophytes provide habitat for other forms of aquatic life and may remove nutrients from the water that otherwise could contribute to excessive algal growth. These positive ecological benefits are summarized in Table 10, which is based upon the species recorded as being present in Eagle Spring Lake and Lulu Lake during either the 1994 survey or the 2008 aquatic plant survey conducted by Commission staff. The Commission staff conducted both

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[2]*J.R. Vallentyne, 1969 "The Process of Eutrophication and Criteria for Trophic State Determination" in* Modeling the Eutrophication Process—Proceedings of a Workshop at St. Petersburg, Florida, *November 19-21, 1969, pages 57-67.*

Table 10

AQUATIC PLANT SPECIES PRESENT IN EAGLE SPRING LAKE AND THEIR POSITIVE ECOLOGICAL SIGNIFICANCE: 1994 AND 2008

Aquatic Plant Species Present	Ecological Significance[a]
Ceratophyllum demersum (coontail)	Provides good shelter for young fish and supports insects valuable as food for fish and ducklings
Chara vulgaris (muskgrass)	Excellent producer of fish food, especially for young trout, bluegills, and small and largemouth bass; stabilizes bottom sediments; and has softening effect on the water by removing lime and carbon dioxide
Elodea canadensis (waterweed)	Provides shelter and support for insects which are valuable as fish food
Eleocharis acicularis (needle spikerush)	Food for waterfowl and muskrats
Lemna minor (lesser duckweed)	Provides important food for wildfowl and attracts small aquatic animals
Myriophyllum spp. (native milfoil)	Provides valuable food and shelter for fish; fruits eaten by many wildfowl
Myriophyllum spicatum (Eurasian water milfoil)	None known
Najas flexilis (bushy pondweed)	Stems, foliage, and seeds important wildfowl food and produces good food and shelter for fish
Najas marina (spiny naiad)	Provides good food and shelter for fish and food for ducks
Nuphar sp. (yellow water lily)	Leaves, stems, and flowers are eaten by deer; roots eaten by beavers and porcupines; seeds eaten by wildfowl; leaves provide harbor to insects, in addition to shade and shelter for fish
Nymphaea tuberosa (white water lily)	Provides shade and shelter for fish; seeds eaten by wildfowl; rootstocks and stalks eaten by muskrats; roots eaten by beaver, deer, moose, and porcupine
Potamogeton crispus (curly-leaf pondweed)	Provides food, shelter, and shade for some fish and food for wildfowl
Potamogeton foliosis (leafy pondweed)	Provides important food for wildfowl and food and shelter for fish
Potamogeton gramineus (variable pondweed)	Provides food important to ducks and food and cover for fish
Potamogeton illinoensis (Illinois pondweed)	Provides some food for ducks and shelter for fish
Potamogeton natans (floating-leaf pondweed)	Provides good food for ducks late in the season
Potamogeton pectinatus (Sago pondweed)	This plant is the most important pondweed for ducks, in addition to providing food and shelter for young fish
Potamogeton pusillus (small pondweed)	Provides food important to ducks and food and cover for fish
Potamogeton richardsonii (Richardson's pondweed)	Provides good food and cover for fish and supports insects
Potamogeton zosteriformis (flat-stemmed pondweed)	Provides some food for ducks
Ranunculus longirostris (water crowfoot)	Provides food important to ducks and food and cover for fish
Ranunculus sp. (water buttercup)	Provides food for trout, upland game birds, and wildfowl
Typha latifolia (cattail)	Supports insects; stalks and roots important food for muskrats and beavers; attracts marsh birds, wildfowl, and songbirds, in addition to being used as spawning grounds by sunfish and shelter for young fish
Utricularia sp. (bladderwort)	Provides good food and cover for fish
Vallisneria americana (wild celery/eel grass)	Provides good shade and shelter, supports insects, and is valuable fish food
Zosterella dubia (water stargrass)	Provides food important to ducks and food and cover for fish

[a]*Information obtained from* A Manual of Aquatic Plants *by Norman C. Fassett, the* Guide to Wisconsin Aquatic Plants by the *Wisconsin Department of Natural Resources, and* Through the Looking Glass: A Field Guide to Aquatic Plants *by the University of Wisconsin-Extension.*

Source: SEWRPC.

aquatic plant surveys utilizing the same transects for the two surveys. A comparison of the species found during each survey is set forth in Table 11. Representative illustrations of these aquatic plants can be found in Appendix A.

Notwithstanding, when the densities of aquatic plants become so great as to interfere with swimming and boating activities, when their growth forms limit habitat diversity, and when the plants reduce the aesthetic appeal of the resource, some form of control may be required to ensure the ongoing multiple-purpose use of the Region's lakes. Many factors, including lake shape, depth, water clarity, nutrient availability, bottom substrate composition, wave action, and the type and size of fish populations present, determine the distributions and abundance of aquatic macrophytes in a lake.

During July 1994, 20 species of plants were identified in Eagle Spring Lake, many of which were reported to be common to abundant, as shown in Table 12. Plant growth occurred throughout the Lake. Species that interfere with the recreational and aesthetic use of the Lake, such as Eurasian water milfoil (*Myriophyllum spicatum*), coontail (*Ceratophyllum demersum*), and curly-leaf pondweed (*Potamogeton crispus*), were found to be present in the Lake. All but the latter were found to be common. Muskgrass (*Chara* spp.) and wild celery (*Vallisneria americana*) were the dominant species in many areas of the main basin, and were especially abundant in the southern portion of the main lake basin at depths of up to six feet. Coontail and Sago pondweed (*Potamogeton pectinatus*) were common in the northern portion of the main lake basin at depths of four to six feet. Eurasian water milfoil was largely confined to the southeastern embayment.

Due to the navigable connection between Eagle Spring Lake and Lulu Lake, a survey of aquatic plant communities in Lulu Lake also was conducted by SEWRPC staff during July 1994. Table 12 also shows the results of that survey. Species that interfere with the recreational and aesthetic use of that Lake, such as Eurasian water milfoil, coontail, and curly-leaf pondweed, were found to be present in Lulu Lake. All were found to be scarce. Plant growth occurred primarily along the periphery of Lulu Lake at water depths of up to 15 feet. Muskgrass, bushy pondweed (*Najas flexilis*), and spiny naiad (*Najas marina*) were the dominant species in many areas of the main basin, at depths of up to 15 feet. Coontail occurred in the vicinity of the Mukwonago River inlet to the Lake. Eurasian water milfoil was largely confined to the northern shores adjacent to the Mukwonago River outlet from Lulu Lake to Eagle Spring Lake, appearing to have been introduced to Lulu Lake from Eagle Spring Lake by the boat traffic that routinely traverses the short section of river between the two Lakes.

During the 2008 survey, as shown in Table 13, 21 species of plants were identified in Eagle Spring Lake, many of which were considered to be common to abundant; Table 14 shows the results of the 2008 Lulu Lake survey wherein a total of 18 species of submerged aquatic plants were observed. Maps 17 and 18 show the distributions of aquatic plants in Eagle Spring Lake and Lulu Lake, respectively. The aquatic plant communities of both Lakes were similar, although a greater range in diversity of aquatic plant community types was present within Eagle Spring Lake. In Eagle Spring Lake, northern water milfoil (*Myriophyllum* spp.) was the dominant submersed aquatic plant, with bushy pondweed, muskgrass, and wild celery comprising the other commonly occurring aquatic plant species. The major aquatic plant species present in Lulu Lake included Eurasian water milfoil and muskgrass. Bushy pondweed and coontail also were common.

Invasive Aquatic Plant Species

Eurasian water milfoil is one of eight milfoil species found in Wisconsin and the only one known to be an exotic or nonnative plant as defined pursuant to Chapter NR 109 of the *Wisconsin Administrative Code*. Chapter NR 40 of the *Wisconsin Administrative Code* subsequently designated this species as an aquatic invasive species. Consequently, the presence of Eurasian water milfoil in lakes is a reason for concern. Because of its nonnative nature, Eurasian water milfoil has few natural enemies that can control its potentially explosive growth, which the plant typically exhibits in lakes with organic-rich sediments or where the lake bottom has been disturbed. In such cases, the Eurasian water milfoil populations can displace native plant species. This, in turn, can lead to the loss of plant diversity, degradation of water quality, and reduction in habitat value for fish, invertebrates, and wildlife. The plant has been known to cause severe aesthetic and recreational use problems in lakes in southeastern Wisconsin.

Table 11

AQUATIC PLANT SPECIES OBSERVED IN EAGLE SPRING AND LULU LAKES: JULY 1994 AND AUGUST 2008

Common Name	Scientific Name	Eagle Spring Lake		Lulu Lake	
		1994	2008	1994	2008
Coontail	*Ceratophyllum demersum*	X	X	X	X
Muskgrass	*Chara vulgaris*	X	X	X	X
Elodea	*Elodea canadensis*	X	X	X	X
Needle Spikerush	*Eleocharis acicularis*	- -	X	- -	X
Eurasian Water Milfoil	*Myriophyllum spicatum*	X	X	X	X
Native Water Milfoil	*Myriophyllum spp.*	X	X	X	X
Bushy Pondweed	*Najas flexilis*	X	X	X	X
Spiny Naiad	*Najas marina*	X	X	X	X
Nitella	*Nitella spp.*	- -	- -	- -	X
Curly-Leaf Pondweed	*Potamogeton crispus*	X	X	X	- -
Leafy Pondweed	*Potamogeton foliosis*	- -	X	X	- -
Variable Pondweed	*Potamogeton gramineus*	X	X	X	- -
Illinois Pondweed	*Potamogeton illinoensis*	X	X	X	X
Floating-Leaf Pondweed	*Potamogeton natans*	X	X	X	X
Sago Pondweed	*Potamogeton pectinatus*	X	X	X	X
Small Pondweed	*Potamogeton pusillus*	- -	X	- -	- -
Clasping-Leaf Pondweed	*Potamogeton richardsonii*	- -	X	X	X
Flat-Stem Pondweed	*Potamogeton zosteriformis*	X	X	X	X
Water Crowfoot	*Ranunculus longirostris*	X	X	-	X
Bladderwort	*Utricularia vulgaris*	X	X	X	X
Eel Grass/Wild Celery	*Vallisneria Americana*	X	X	X	X
Water Stargrass	*Zosterella dubia*	- -	X	- -	X

Source: SEWRPC.

Table 12

AQUATIC PLANT SPECIES OBSERVED IN EAGLE SPRING AND LULU LAKES: JULY 1994

Common Name	Scientific Name	Eagle Spring Lake[a]	Lulu Lake[a]
Coontail	*Ceratophyllum demersum*	Common	Scarce
Muskgrass	*Chara vulgaris*	Abundant	Abundant
Elodea	*Elodea canadensis*	Common	Scarce
Eurasian Water Milfoil	*Myriophyllum spicatum*	Common	Scarce
Native Water Milfoil	*Myriophyllum spp.*	Common	Scarce
Bushy Pondweed	*Najas flexilis*	Common	Abundant
Spiny Naiad	*Najas marina*	Common	Abundant
Curly-Leaf Pondweed	*Potamogeton crispus*	Scarce	Scarce
Leafy Pondweed	*Potamogeton foliosis*	- -	Scarce
Variable Pondweed	*Potamogeton gramineus*	Scarce	Scarce
Illinois Pondweed	*Potamogeton illinoensis*	Scarce	Scarce
Floating-Leaf Pondweed	*Potamogeton natans*	Common	Scarce
Sago Pondweed	*Potamogeton pectinatus*	Common	Scarce
Clasping-Leaf Pondweed	*Potamogeton richardsonii*	- -	Scarce
Flat-Stem Pondweed	*Potamogeton zosteriformis*	Scarce	Scarce
Water Crowfoot	*Ranunculus longirostris*	Scarce	- -
Bladderwort	*Utricularia vulgaris*	Common	Scarce
Eel Grass/Wild Celery	*Vallisneria Americana*	Abundant	Scarce

[a]*Plant abundance during the 1994 survey was rated as abundant, common, or scarce; these ratings are approximately consistent with the four-point numerical rating scale subsequently adopted by the Wisconsin Department of Natural Resources, wherein the maximum density possible of 4.0 is assigned to plants that occur at all four points sampled at a given depth. A rating of abundant would be approximately equal to 4.0; common, 3.0; and, scare 1.0 to 2.0.*

Source: SEWRPC.

Table 13

AQUATIC PLANT SPECIES OBSERVED IN EAGLE SPRING LAKE: AUGUST 2008

Common Name	Scientific Name	Number of Sites Found	Frequency of Occurrence[a]	Relative Density[b]	Importance Value[c]
Coontail	*Ceratophyllum demersum*	12	21.82	2.67	58.18
Muskgrass	*Chara vulgaris*	32	58.18	2.28	132.73
Needle Spikerush	*Eleocharis acicularis*	7	12.73	2.00	25.45
Elodea	*Elodea canadensis*	8	14.55	1.50	21.82
Eurasian Water Milfoil	*Myriophyllum spicatum*	24	43.64	179	78.18
Native Water Milfoil	*Myriophyllum spp.*	43	78.18	2.67	209.09
Bushy Pondweed	*Najas flexilis*	40	72.73	2.73	198.18
Spiny Naiad	*Najas marina*	20	36.36	1.45	52.73
Curly-Leaf Pondweed	*Potamogeton crispus*	3	5.45	2.00	10.91
Leafy Pondweed	*Potamogeton foliosis*	7	12.73	2.29	29.09
Variable Pondweed	*Potamogeton gramineus*	2	3.64	1.00	3.64
Illinois Pondweed	*Potamogeton illinoensis*	1	1.82	2.00	3.64
Floating-Leaf Pondweed	*Potamogeton natans*	4	7.27	1.75	12.73
Sago Pondweed	*Potamogeton pectinatus*	16	29.09	1.44	41.82
Small Pondweed	*Potamogeton pusillus*	3	5.45	1.00	5.45
Clasping-Leaf Pondweed	*Potamogeton richardsonii*	10	18.18	1.10	20.00
Flat-Stem Pondweed	*Potamogeton zosteriformis*	7	12.73	1.86	23.64
Water Crowfoot	*Ranunculus longirostris*	9	16.36	2.11	34.55
Bladderwort	*Utricularia vulgaris*	15	27.27	2.13	58.18
Eel Grass/Wild Celery	*Vallisneria Americana*	27	49.09	2.56	125.45
Water Stargrass	*Zosterella dubia*	2	3.64	3.50	12.73

NOTE: Sampling occurred at 55 sites along 19 transects.

[a]*The percent frequency of occurrence is the number of occurrences of a species divided by the number of samplings with vegetation, expressed as a percentage. It is the percentage of times a particular species occurred when there was aquatic vegetation present, and is analogous to the Jesson and Lound point system.*

[b]*The average density is the sum of density ratings for a species divided by the number of sampling points with vegetation. The maximum density possible of 4.0 is assigned to plants that occur at all four points sampled at a given depth and is an indication of how abundant a particular plant is throughout a lake.*

[c]*The importance value is the product of the relative frequency of occurrence and the average density, expressed as a percentage. This number provides an indication of the dominance of a species within a community.*

Source: SEWRPC.

Similarly, curly-leaf pondweed has been identified in Chapters NR 40 and NR 109 of the *Wisconsin Administrative Code* as an aquatic invasive plant species. While this plant has somewhat greater ecological value than Eurasian water milfoil, it too is an aggressive colonizer and capable of degrading the aquatic habitat of a lake or waterway.

Both Eurasian water milfoil and curly-leaf pondweed are present in both Eagle Spring Lake and Lulu Lake.

Eagle Spring Lake as a Shallow Lake Ecosystem

The high diversity and abundance of aquatic macrophytes within Eagle Spring Lake is largely an artifact of being a shallow lake with an extensive littoral zone. In addition to the submerged aquatic macrophytes, Eagle Spring Lake also contains significant amounts of floating and emergent macrophytes particularly within the western and southwestern portion of the lake. The physical structure established by aquatic macrophytes provides fisheries

Table 14

AQUATIC PLANT SPECIES OBSERVED IN LULU LAKE: AUGUST 2008

Common Name	Scientific Name	Number of Sites Found	Frequency of Occurrence[a]	Relative Density[b]	Importance Value[c]
Coontail	*Ceratophyllum demersum*	9	22.5	2.56	57.5
Muskgrass	*Chara vulgaris*	17	42.5	2.59	110.0
Needle Spikerush	*Eleocharis acicularis*	1	2.5	4.00	10.0
Elodea	*Elodea canadensis*	2	5.0	2.00	10.0
Eurasian Water Milfoil	*Myriophyllum spicatum*	22	55.0	2.14	117.5
Native Water Milfoil	*Myriophyllum spp.*	4	10.0	1.50	15.0
Bushy Pondweed	*Najas flexilis*	12	30.0	2.50	75.0
Spiny Naiad	*Najas marina*	4	10.0	1.25	12.5
Nitella	*Nitella spp.*	1	2.5	2.00	5.0
Illinois Pondweed	*Potamogeton illinoensis*	7	17.5	1.71	30.0
Floating-Leaf Pondweed	*Potamogeton natans*	1	2.5	2.00	5.0
Sago Pondweed	*Potamogeton pectinatus*	6	15.0	1.17	17.5
Clasping-Leaf Pondweed	*Potamogeton richardsonii*	1	2.5	1.00	2.5
Flat-Stem Pondweed	*Potamogeton zosteriformis*	4	10.0	2.25	22.5
Water Crowfoot	*Ranunculus longirostris*	1	2.5	1.00	2.5
Bladderwort	*Utricularia vulgaris*	2	5.0	1.00	5.0
Eel Grass/Wild Celery	*Vallisneria Americana*	1	2.5	2.00	5.0
Water Stargrass	*Zosterella dubia*	2	5.0	1.00	5.0

NOTE: Sampling occurred at 40 sites along 10 transects.

[a]*The percent frequency of occurrence is the number of occurrences of a species divided by the number of samplings with vegetation, expressed as a percentage. It is the percentage of times a particular species occurred when there was aquatic vegetation present, and is analogous to the Jesson and Lound point system.*

[b]*The average density is the sum of density ratings for a species divided by the number of sampling points with vegetation. The maximum density possible of 4.0 is assigned to plants that occur at all four points sampled at a given depth and is an indication of how abundant a particular plant is throughout a lake.*

[c]*The importance value is the product of the relative frequency of occurrence and the average density, expressed as a percentage. This number provides an indication of the dominance of a species within a community.*

Source: SEWRPC.

habitat within the littoral zones of lakes for foraging, spawning, shade, and protective cover.[3] Recent research by the Wisconsin Cooperative Fisheries Research Unit has shown that the characteristics and composition of macrophyte beds significantly influences fish community structure in littoral zones of north temperate lakes.[4] This and other research has shown that macrophytes are important to fish abundance and diversity; however, relations between specific macrophyte characteristics and fish communities are not consistent, which indicates that lake-specific differences are more important than applying across-lake strategies for managing macrophyte communities in lakes.[5]

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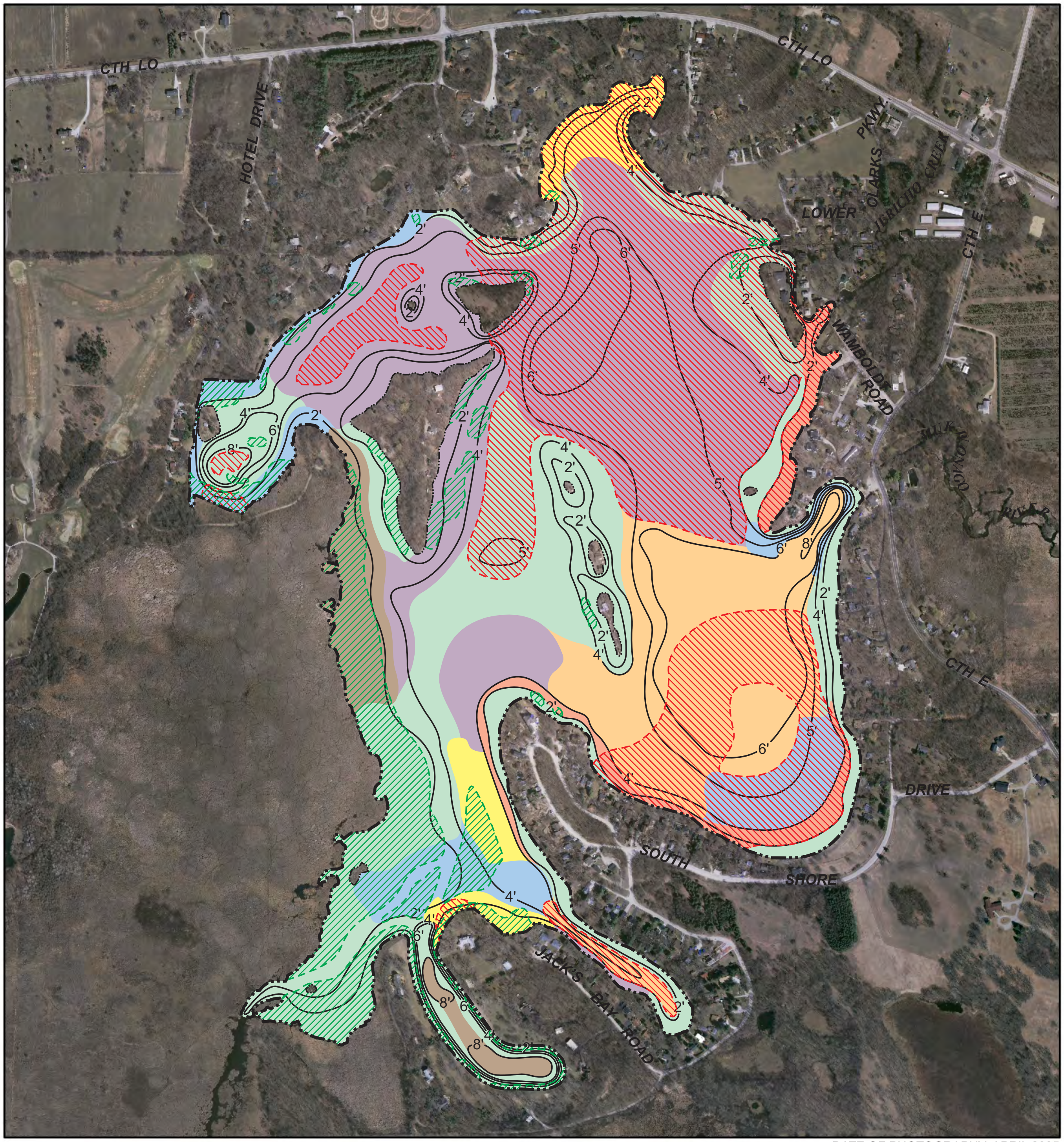
[3]*See M.J. Weaver, J.J. Magnuson, and M.K. Clayton, "Distribution of Littoral Zone Fishes in Structurally Complex Macrophytes,"* Canadian Journal of Fisheries and Aquatic Sciences, *Volume 54, pages 2,277-2,289, 1997; see also, E.D. Dibble, K.J. Killgore, and G.O. Dick, "Measurement of Plant Architecture in Seven Aquatic Plants,"* Journal of Freshwater Ecology, *Volume 11, pages 311-318, 1996.*

[4]*K.M. Carden, "Macrophytes as Fish Habitat: The Role of Macrophyte Morphology and Bed Complexity in Fish Species Distributions," Master of Science Thesis, University of Wisconsin-Stevens Point, December 2002.*

[5]Ibid.

Map 17

AQUATIC PLANT COMMUNITY DISTRIBUTION IN EAGLE SPRING LAKE: 2008



4' WATER DEPTH CONTOUR IN FEET

WATER LILIES

EURASIAN WATER MILFOIL

SPINY NAIAD, SMALL PONDWEED, NATIVE MILFOIL, WILD CELERY, BLADDERWORT, NEEDLE SPIKE RUSH, COONTAIL, BUSHY PONDWEED, WATERWEED, FLAT-STEM PONDWEED, LEAFY PONDWEED, AND SAGO PONDWEED

BUSHY PONDWEED, SAGO PONDWEED, NATIVE MILFOIL, SPINY NAIAD, MUSKGRASS, BLADDERWORT, SMALL PONDWEED, WILD CELERY, FLOATING-LEAF PONDWEED, NEEDLE SPIKE RUSH, CLASPING-LEAF PONDWEED, LEAFY PONDWEED, FLAT- STEM PONDWEED, WATERWEED, AND COONTAIL

MUSKGRASS, SPINY NAIAD, NATIVE MILFOIL, BLADDERWORT, AND FLOATING-LEAF PONDWEED

COONTAIL, MUSKGRASS, WATERWEED, BUSHY PONDWEED, SPINY NAIAD, SAGO PONDWEED, CURLY-LEAF PONDWEED, NATIVE MILFOIL, WATER STAR GRASS, WILD CELERY, BLADDERWORT, CLASPING-LEAF PONDWEED, AND NEEDLE SPIKE RUSH

MUSKGRASS, BUSHY PONDWEED, SPINY NAIAD, SAGO PONDWEED, CURLY-LEAF PONDWEED, NATIVE MILFOIL, ILLINOIS PONDWEED, VARIABLE PONDWEED, BLADDERWORT, CLASPING-LEAF PONDWEED, AND NEEDLE SPIKE RUSH

COONTAIL, MUSKGRASS, BUSHY PONDWEED, FLAT-STEM PONDWEED, LEAFY PONDWEED, SAGO PONDWEED, CURLY-LEAF PONDWEED, NATIVE MILFOIL, BLADDERWORT, AND CLASPING-LEAF PONDWEED

COONTAIL, MUSKGRASS, WATERWEED, BUSHY PONDWEED, SPINY NAIAD, FLAT-STEM PONDWEED, LEAFY PONDWEED, SAGO PONDWEED, NATIVE MILFOIL, WATER STAR GRASS, WILD CELERY, BLADDERWORT, CLASPING-LEAF PONDWEED, AND NEEDLE SPIKE RUSH

DATE OF PHOTOGRAPHY: APRIL 2005

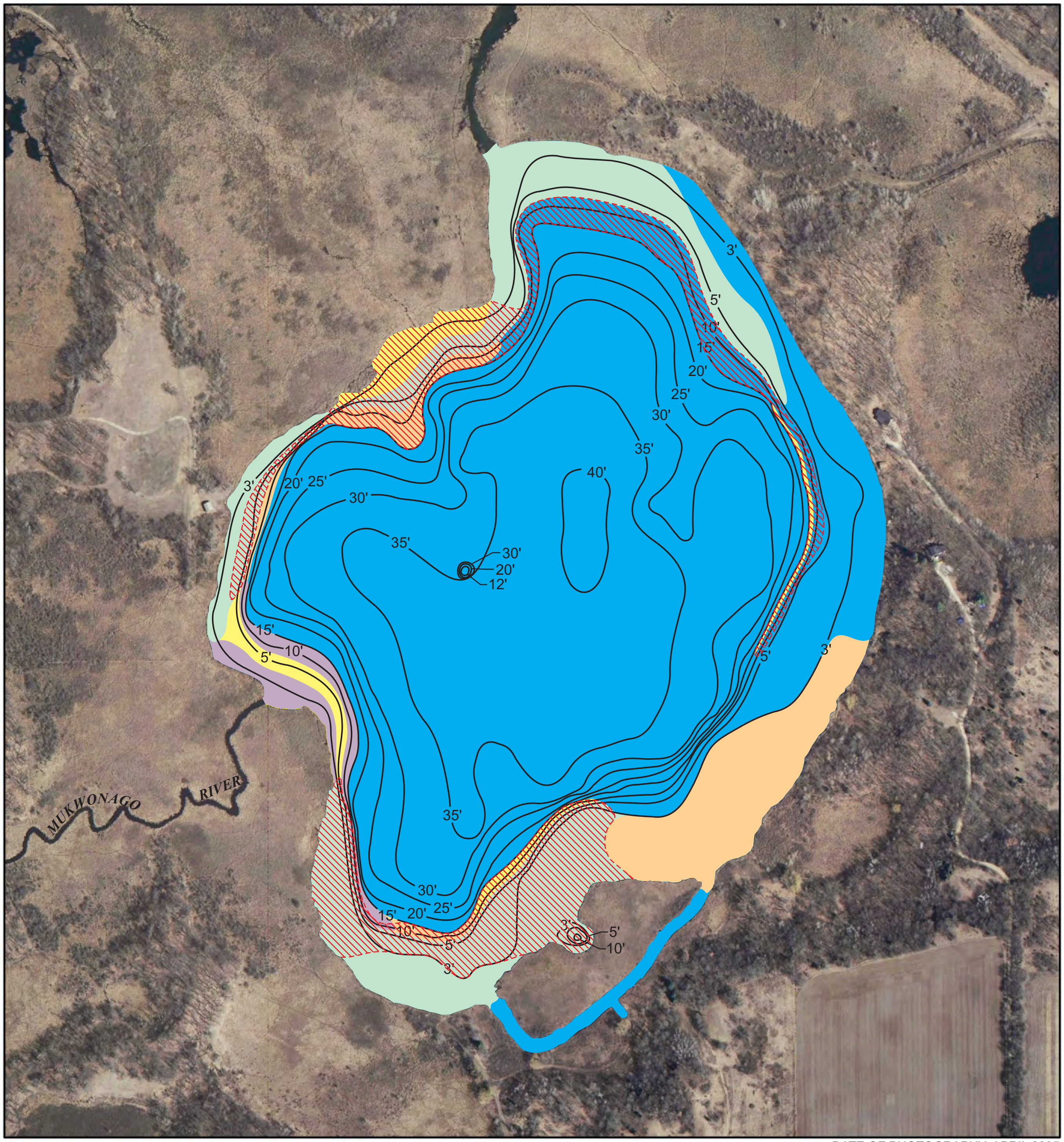
GRAPHIC SCALE

0 250 900 FEET

Source: SEWRPC.

Map 18

AQUATIC PLANT COMMUNITY DISTRIBUTION IN LULU LAKE: 2008



—20'— WATER DEPTH CONTOUR IN FEET

OPEN WATER

WATER LILIES

EURASIAN WATER MILFOIL

COONTAIL

COONTAIL, MUSKGRASS, SAGO PONDWEED, SPINY NAIAD, NATIVE MILFOIL, AND NITELLA

COONTAIL, MUSKGRASS, SAGO PONDWEED, NATIVE MILFOIL, WATERWEED, AND BUSHY PONDWEED

COONTAIL, MUSKGRASS, SAGO PONDWEED. WATERWEED, BUSHY PONDWEED, SPINY NAIAD, FLAT-STEM PONDWEED, NATIVE MILFOIL, WATER STAR GRASS, ILLINOIS PONDWEED, WILD CELERY, BLADDERWORT, FLOATING-LEAF PONDWEED, WHITE WATER CROWFOOT, CLASPING-LEAF PONDWEED, AND NEEDLE SPIKE RUSH

DATE OF PHOTOGRAPHY: APRIL 2005

GRAPHIC SCALE

0 250 500 FEET

Source: SEWRPC.

Based upon the information above, Eagle Spring Lake can be considered to be a macrophyte dominated, clear-water, shallow lake system as opposed to a turbid water ecosystem with few submerged plants, which is based upon the theoretical alternative stable states classification system of Scheffer and others.[6] Research has shown that, in general, both clear-water and turbid states can be stabilized by a number of mechanisms such as nutrient loading, water level changes, biotic manipulations, and severe weather.[7] The theoretical model that leads to the alternative states is based upon a "critical turbidity" level and three assumptions: 1) vegetation disappears when a critical turbidity is exceeded, 2) vegetation reduces turbidity, and 3) turbidity increases with the nutrient level due to increased phytoplankton growth.[8] Therefore, this model shows that over an intermediate range of nutrient levels two alternatives exist: a highly turbid one without vegetation and a clear water state dominated by submerged macrophytes.

It is important to note that there are many factors that can affect critical nutrient levels and the consequent equilibrium state such as lake depth, lake size, and climate.[9] Higher water levels can lead to loss of submerged aquatic plants causing a shift to the turbid equilibrium state.[10] Nevertheless, Eagle Spring Lake has remained in a clear water macrophyte dominated state despite being allegedly maintained at 0.56 foot above its then permitted level, as demonstrated through comparison of Maps 19 and 20. Alternatively, low water levels may have more complicated effects on a lake system. For example, low water levels can lead to freezing of lake bottom sediments and in some cases cause enough damage to the submerged vegetation to move the lake from a clear water to a turbid state.[11] Low water levels may also increase the risk of fish kills due to anoxic conditions in summer and/or winter.[12] Lake size has been shown to be an important factor in determining whether a lake is clear versus

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[6]*See M. Scheffer*, Ecology of Shallow Lakes, *Chapman and Hall, London, 1998; M. Scheffer, and E.H. van Nes, "Shallow Lakes Theory Revisited: Various Alternative Regimes Driven by Climate, Nutrients, Depth and Lake Size,"* Hydrobiologia*, Volume 584, pages 455-466, 2007; and, M. Scheffer, S.H. Hosper, M.L. Meijer, and B. Moss, "Alternative Equilibria in Shallow Lakes,"* Trends in Ecology and Evolution*, Volume 8, pages 275-279, 1993.*

[7]*See B. Moss,* Ecology of Freshwaters: Man and Media, Past to Future, *Third Edition, Blackwells, Oxford, 1998; E. Jeppesen,* The Ecology of Shallow Lakes—Trophic Interactions in the Pelagial, *University of Copenhagen Press, Silkeborg, 358 pages, 1998; E. Jeppesen, E.M. Sondergaard, M. Sondergaard, and K. Kristoffersen,* Structuring Role of Submerged Macrophytes in Lakes, *Springer-Verlag, New York, 1998; and, M. Scheffer,* op. cit.*, 1998.*

[8]*See M. Scheffer, and others,* op. cit.*, 1993; and, M. Scheffer, and E.H. van Nes,* op. cit.*, 2007.*

[9]*M. Scheffer, and E.H. van Nes,* op. cit.*, 2007.*

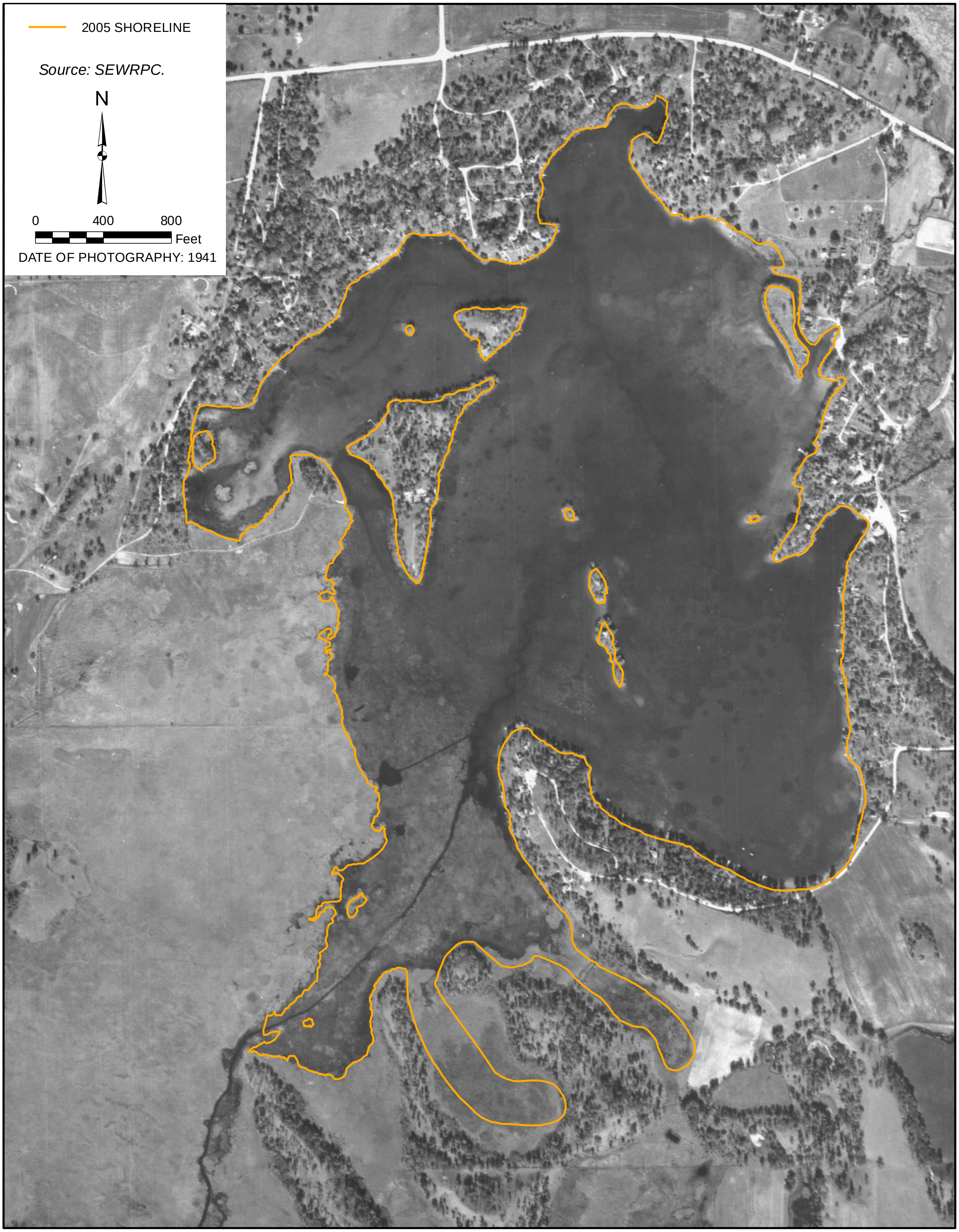
[10]*See M. Wallsten, and P.O. Forsgren, "The Effects of Increased Water Level on Aquatic Macrophytes,"* Journal of Aquatic Plant Management*, Volume 27, pages 32-37, 1989; and A. Engel, and S.A. Nichols, "Aquatic Macrophyte Growth in a Turbid Windswept Lake,"* Journal of Freshwater Ecology*, Volume 9, pages 97-109, 1994.*

[11]*I. Blindow, G. Andersson, A. Hargeby, and S. Johansson, "Long-Term Patterns of Alternative Stable States in Two Shallow Eutrophic Lakes,"* Freshwater Biology*, Volume 30, pages 159-167, 1993.*

[12]*G.J. Van Geest, F.C.J.M. Roozen, H. Coops, R.M.M. Roijackers, A.D. Buijse, E.T. Peeters, and M. Scheffer, "Vegetation Abundance in Lowland Flood Plain Lakes Determined by Surface Area, Age and Connectivity,"* Freshwater Biology*, Volume 48, Number 3, pages 440-454, 2003.*

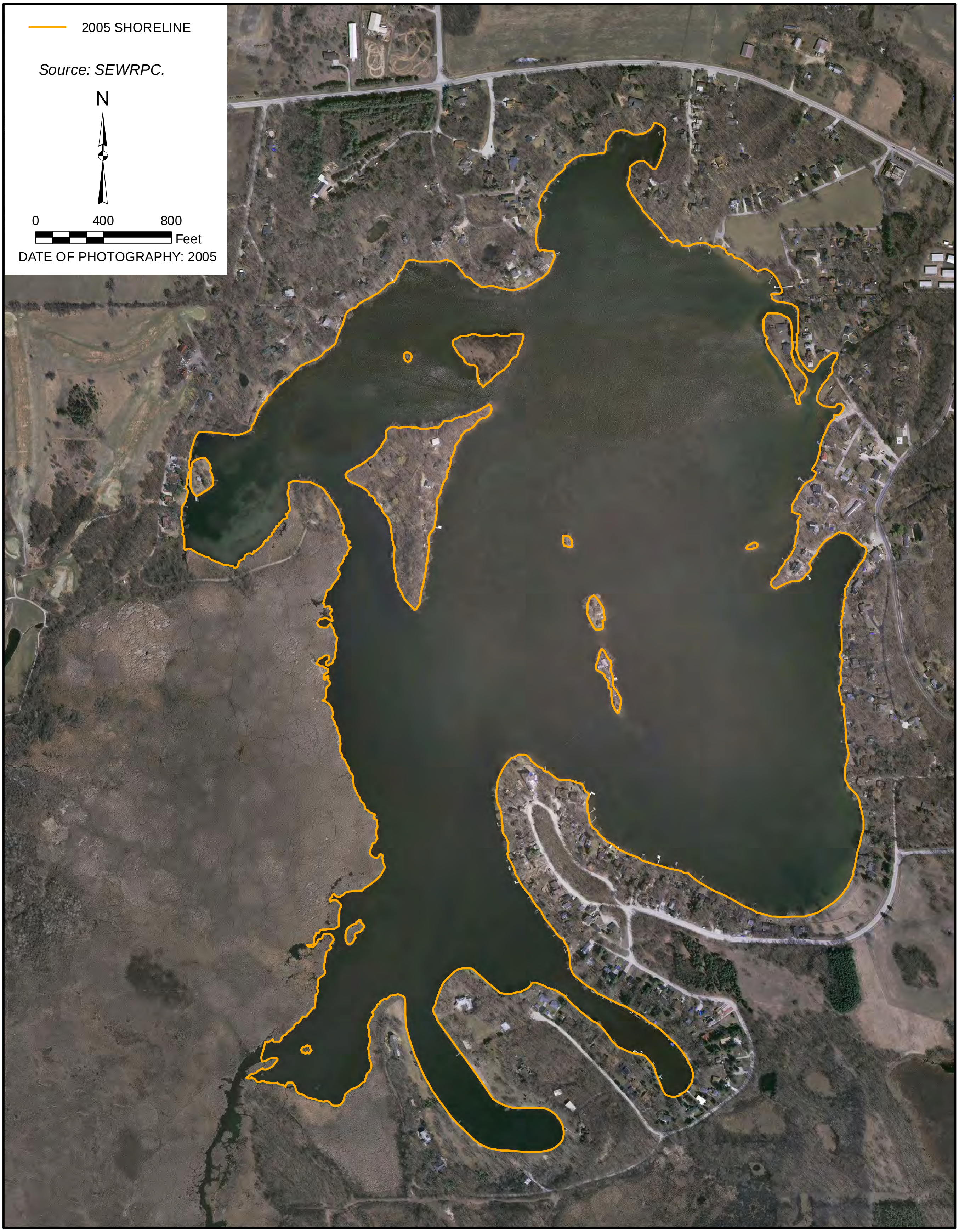
Map 19

EAGLE SPRING LAKE: 1941



Map 20

EAGLE SPRING LAKE: 2005



turbid.[13] Eagle Spring Lake is a relatively large lake; therefore, based upon lake size, this means that it is more likely to contain abundant fish, which increases the likelihood of the unvegetated turbid-water state. Finally, moderate warming caused by climate change, which has been well documented to be occurring in Wisconsin,[14] might promote the turbid state, although it also could promote the growth of submerged aquatic vegetation and a clear water state.[15] In conclusion, research has shown that there is no single critical nutrient level for maintaining a clear state, as factors such as lake size, depth and climate can significantly affect the threshold.[16] "In principle, the list of factors that may influence the probability that a lake turns to the turbid state is almost endless."[17]

Aquatic Plant Management
Records of aquatic plant management efforts on Wisconsin lakes were not maintained by the Wisconsin Department of Natural Resources (WDNR) prior to 1950. Thus, while previous interventions were likely, the recorded efforts to manage the aquatic plants in Eagle Spring Lake have taken place since 1950. Aquatic plant management activities in Eagle Spring Lake can be categorized as primarily mechanical harvesting with supplemental chemical control focused on nonnative invasive species, primarily Eurasian water milfoil. Currently, all forms of aquatic plant management are subject to permitting by the WDNR pursuant to authorities granted the Department under Chapters NR 107 and NR 109 of the *Wisconsin Administrative Code*. In addition, Chapter NR 40 of the *Wisconsin Administrative Code* designates aquatic invasive species and specifically prohibits the introduction and transportation of designated invasive species in the State of Wisconsin.

Chemical Controls
Perceived excessive growths of macrophytes in Eagle Spring Lake have generally resulted in the application of chemical controls. Recorded herbicide treatments that have been applied to Eagle Spring Lake are set forth in Table 15. In Wisconsin, the use of chemicals to control aquatic plants and algae has been regulated since 1941, even though records of aquatic herbicide applications have only been maintained by the WDNR since 1950.

In 1926, sodium arsenite, an agricultural herbicide, was first applied to lakes in the Madison area, and, by the 1930s, sodium arsenite was widely used throughout the State for aquatic plant control. No other chemicals were applied in significant amounts to control macrophytes until recent years, when a number of organic chemical herbicides came into general use. The amounts of sodium arsenite applied to Eagle Spring Lake, and years of application during the period 1950 through 1969, are listed in Table 15. The total amount of sodium arsenite applied over this period was about 4,360 pounds.

Sodium arsenite was typically sprayed onto the surface of Eagle Spring Lake within an area up to 200 feet from the shoreline. Treatment typically occurred between mid-June and mid-July. The amount of sodium arsenite used was calculated to result in a concentration of about 10 milligrams per liter (mg/l) sodium arsenite (about five mg/l arsenic) in the treated lake water. The sodium arsenite typically remained in the water column for less than 120 days. Although the arsenic residue was naturally converted from a highly toxic form to a less toxic and less biologically active form, much of the arsenic residue was deposited in the lake sediments. When it became

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[13]*Van Geest and others,* op. cit*., 2003.*

[14]*J.J. Magnuson, J. Krohelski, K. Kunkel, and D. Robertson, "Wisconsin's Waters and Climate: Historical Changes and Possible Futures," In: Wisconsin's Waters: A Confluence of Perspectives,* Transactions of the Wisconsin Academy of Sciences, Arts and Letters*, Volume 90, 2003.*

[15]*M. Scheffer, and E.H. van Nes,* op. cit*., 2007.*

[16]Ibid.

[17]Ibid.*, page 459.*

Table 15

CHEMICAL CONTROL OF AQUATIC PLANTS IN EAGLE SPRING LAKE: 1950-2009

Year	Total Acres Treated	Algal Control		Macrophyte Control				
		Copper Sulfate (pounds)	Cutrine or Cutrine-+ (pounds)	Sodium Arsenite (pounds)	2,4-D (pounds)	2,4-D (gallons)	Diquat (gallons)	Aquathol (gallons)
1950-1969	- -	250.0	- -	4,360	- -	- -	3	- -
1973	- -	- -	- -	- -	- -	- -	- -	25
1974	- -	15.0	- -	- -	- -	- -	- -	20
1975	- -	39.3	11.5 gal.	- -	- -	- -	- -	23
1978	- -	- -	8.5 gal.	- -	- -	- -	- -	9
1980	- -	- -	- -	- -	50	- -	- -	- -
1981	- -	- -	- -	- -	40	- -	- -	- -
1982	- -	- -	- -	- -	40	- -	- -	- -
1999	5.00	- -	- -	- -	- -	500	- -	- -
2001	52.00	- -	- -	- -	5,200	- -	- -	- -
2002	4.64	- -	- -	- -	725	- -	- -	- -
2003	8.75	- -	- -	- -	890	- -	- -	- -
2004	5.00	- -	- -	- -	500	- -	- -	- -
2005	12.20	- -	- -	- -	1,175	- -	- -	- -
2006	21.65	- -	- -	- -	2,200	- -	- -	- -
2007	9.00	- -	- -	- -	900	- -	- -	- -
2008	13.00	- -	- -	- -	1,300	- -	- -	- -
2009	4.00	- -	- -	- -	400	- -	- -	- -
Total	- -	304.3	20.0 gal.	4,360	13,420	500	3	77

NOTE: During years not included, either no chemical controls were used or records of such are not available for this time period.

Source: Wisconsin Department of Natural Resources and SEWRPC.

apparent that arsenic was accumulating in the sediments of treated lakes and that the accumulations of arsenic were found to present potential health hazards both to humans and aquatic life, the use of sodium arsenite was discontinued in the State in 1969. Proposed State sediment quality criteria relating to arsenic are set forth in Table 16.

As shown in Table 15, the aquatic herbicides Aquathol and 2,4-D also have been applied to Eagle Spring Lake to control aquatic macrophyte growths. Diquat and endothall (Aquathol®) are contact herbicides that kill aquatic plant parts exposed to the active ingredient. Diquat use is restricted to the control of duckweed (*Lemna* sp.), milfoil (*Myriophyllum* spp.), and waterweed (*Elodea* sp.). However, this herbicide is nonselective and will kill many other aquatic plants, such as pondweeds (*Potamogeton* spp.), bladderwort (*Utricularia* sp.), and naiads (*Najas* spp.). Endothall primarily kills pondweeds, but does not control other potentially nuisance species, such as Eurasian water milfoil (*Myriophyllum spicatum*). The herbicide 2,4-D is a systemic herbicide that is absorbed by the leaves and translocated to other parts of the plant; it is more selective than the other herbicides listed above and is generally used to control Eurasian water milfoil. However, it will also kill beneficial species, such as water lilies (*Nymphaea* sp. and *Nuphar* sp.). The present restrictions on water use after application of these herbicides are given in Table 17.

In addition to the chemical herbicides used to control large aquatic plants, algicides have been applied to Eagle Spring Lake. As shown in Table 15, copper sulfate and Cutrine®, a copper-based product, have been applied to Eagle Spring Lake, on occasion, between 1950 and 1978. Like arsenic, copper, the active ingredient in many

Table 16

WISCONSIN DEPARTMENT OF NATURAL RESOURCES DRAFT SEDIMENT SCREENING CRITERIA[a]

Chemical	Lowest Effect Level (LEL)	Medium Effect Level (MEL)	Severe Effect Level (SEL)
Arsenic	6.00	33.0	85.0
Copper	25.00	110.0	390.0
Lead	31.00	110.0	250.0
Mercury	0.15	0.2	1.3
Ammonia-Nitrogen	75.00	- -	- -

[a]*Units are in milligrams of contaminant per kilogram of dry sediment.*

Source: Wisconsin Department of Natural Resources.

Table 17

RESTRICTIONS ON WATER USES AFTER APPLICATION OF AQUATIC HERBICIDES[a]

	Days after Application					
Use	Copper Sulfate	Diquat	Glyphosate	Endothall	2,4-D	Fluridone
Drinking	- -[b]	14	- -[c]	7-14	- -[d]	- -[f]
Fishing	0	14	0	3	0	0
Swimming	0	1	0	- -	0[e]	0
Irrigation	0	14	0	7-14	- -[d]	7-30

[a]*The U.S. Environmental Protection Agency has indicated that, if these restrictions are observed, pesticide residues in water, irrigated crops, or fish will not pose an unacceptable risk to humans and other organisms using or living in the treatment zone.*

[b]*According to the Wisconsin Department of Natural Resources, if water is to be used as potable water, the residual copper content cannot exceed one part per million (ppm).*

[c]*According to the Wisconsin Department of Natural Resources, if water is to be used as potable water, the drinking water tolerance of glyphosate (Rodeo®) is one part per million (ppm).*

[d]*2,4-D products are not to be applied to waters used for irrigation, animal consumption, drinking, or domestic uses, such as cooking and watering vegetation, for two weeks following the date of application.*

[e]*Swimming is not advisable within 24 hours of the time of application of 2,4-D products.*

[f]*According to the Wisconsin Department of Natural Resources, if water is to be used as potable water, the drinking water tolerance of fluridone (Sonar®) is 0.15 parts per million (ppm).*

Source: Wisconsin Department of Natural Resources and SEWRPC.

algicides, including Cutrine Plus®, may accumulate in the bottom sediments. Excessive levels of copper may be toxic to fish and benthic organisms, but, generally, have not been found to be harmful to humans.[18] As reported in the initial comprehensive lake management plan,[19] no significant copper concentrations were reported by Swanson Environmental, Inc., under contract to the Eagle Spring Lake Management District (ESLMD) during their 1990 survey. Restrictions on water uses after application of Cutrine Plus® and other copper-containing compounds are also given in Table 17, and proposed State sediment quality criteria relating to copper are set forth in Table 16.

Macrophyte Harvesting

Excessive macrophyte growths in Eagle Spring Lake have resulted in a combination-approach nuisance and invasive aquatic plant control program based upon chemical treatments targeting Eurasian water milfoil together with mechanical harvesting. Manual harvesting of aquatic plants around piers and docks also is practiced. Currently, permits are required for the removal of aquatic plants pursuant to Chapter NR 109 of the *Wisconsin Administrative Code*, which came into effect during 2003. However, a general, statewide permit allows riparian owners to clear a 30-foot-wide corridor along their shorelines; outside of the 30-foot-wide linear shoreland corridor, a specific permit is required under Chapter NR 109. No data on manual harvesting permits issued to Eagle Spring Lake residents are available, although riparian property owners and residents report periodic utilization of manual harvesting techniques along portions of the shoreline of the Lake.

Insofar as the mechanical control of aquatic plant growth in the Lake is concerned, the ESLMD holds the requisite Chapter NR 109 mechanical harvesting permit for their operations on the Lake. During the 2010 open water harvesting period, the ESLMD reported cutting approximately 30 acres of the total 225-acre area identified in the initial comprehensive lake management plan as being potentially harvestable;[20] in other words, areas where there was a high probability of Eurasian water milfoil and curly-leaf pondweed growth, areas of greater than three feet of water depth, and areas associated with recreational boating traffic utilizing the Lake.[21] Approximately 6,170 tons wet weight of aquatic plant material was harvested, the vast majority of which was noted to be “floaters” or aquatic plant material that was broken loose from the lakebed as a result of wind wave action or boating activities. Almost one-half of this material (45 percent of the total) was collected during the month of August 2010 (August 5 through September 2, 2010). The harvester operator noted that this material was comprised primarily of eel grass (*Vallisneria americana*), which naturally up-roots in the early autumn as part of its over-wintering survival mechanism. The ESLMD also noted that they made a special cutting between September 27 and October 11, 2010, for the expressed purpose of cutting back Eurasian water milfoil in order for the District to evaluate the efficacy of a late fall cutting in reducing Eurasian water milfoil growth during the following (2011) growing season.

Biological and Physical Controls

The use of physical control measures, such as placement of bottom barriers, pea gravel blankets, or surface water colorants, has not been reported from Eagle Spring Lake.

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[18] *Jeffrey A. Thornton and Walter Rast, “The Use of Copper and Copper Compounds as Algicides,” in H. Wayne Richardson,* Handbook of Copper Compounds and Applications, *Marcel Dekker, New York, 1997, pages 123-142.*

[19] *SEWRPC Community Assistance Planning Report No. 226,* op. cit.

[20] *Eagle Spring Lake Management District,* in litt., *to the Wisconsin Department of Natural Resources, dated November 2, 2010.*

[21] *SEWRPC Community Assistance Planning Report No. 226,* op. cit.

Biological control agents have been used to control the growths of purple loosestrife in the wetlands surrounding Eagle Spring Lake. The purple loosestrife beetles, *Galerucella* spp. and *Hylobius* sp., have proven very effective in this role throughout southeastern Wisconsin. Biological control agents also were used experimentally in Eagle Spring Lake to manage Eurasian water milfoil growths, although in common with most other large lakes subject to motorized boat traffic in the Region the experiment was less than successful, most likely because the weevils were washed off the host plants by boat wakes and consumed by bass and other fishes. The use of grass carp, *Ctenopharyngodon idella*, to control aquatic plant growths is expressly prohibited in Wisconsin.

AQUATIC ANIMALS

Aquatic animals include microscopic zooplankton; benthic, or bottom-dwelling, invertebrates; fish and reptiles; amphibians; mammals; and waterfowl and other birds that inhabit the Lake and its shorelands. These make up the primary and secondary consumers of the Lake's food web.

Zooplankton

Zooplankton are microscopic animals which inhabit the same environment as phytoplankton, the microscopic plants. An important link in the food chain, crustacean zooplankton feed mostly on algae, and, in turn, are a good food source for fish. Zooplankton populations in Eagle Spring Lake have not been sampled either during the initial or current planning programs, so no records of zooplankton numbers and species composition are available, and the current state of the zooplankton community is not known. However, given the composition and condition of the fish community in Eagle Spring Lake, it may be assumed that the zooplankton population is sufficiently robust and diverse to support a relatively healthy fishery.

Benthic Invertebrates

The benthic, or bottom dwelling, macroinvertebrate communities of lakes include such organisms as sludge worms, midges, and caddis fly larvae. These organisms are frequently used to assess the existing and recent past water quality of a lake. In addition, these organisms form an important part of the food web, acting as processors of the organic material that accumulates on the lake bottom and frequently being grazed, in turn, by bottom feeding fishes. Some benthic macroinvertebrate organisms are opportunistic in their feeding habits, while others are openly predaceous. The diversity of the benthic community reflects the trophic status of a lake, with less enriched lakes typically having a greater diversity. Nevertheless, there is no single "indicator organism" that determines the trophic status, or level of enrichment of a lake; rather the entire community must be assessed. The time of year for this assessment consequently becomes an important consideration, since these populations fluctuate widely during the summer months as a result of life stage of the organisms, climatic variability, and localized water quality changes. An early spring or winter sampling is considered to be the best opportunity for making an overall assessment of the benthic community composition. As was the case with zooplankton, there are no data available regarding benthic populations in Eagle Spring Lake.

Zebra mussels, *Dreissenia polymorpha*, a nonnative species of shellfish with known negative impacts on native benthic populations, are currently spreading into inland lakes from the Laurentian Great Lakes system where they are considered to be an invasive species. This mollusk, originally introduced into the Great Lakes in ballast water carried by ships from Europe, is now widespread in southeastern Wisconsin inland waters. According to WDNR records, Eagle Spring Lake has been listed as an inland lake with an established community of zebra mussels since 2005.

Zebra mussels are having a varied impact on inland lakes in the Upper Midwest. They disrupt the food chain by removing significant amounts of phytoplankton which serve as food, not only for themselves, but also for larval and juvenile fish and many forms of zooplankton. However, many lakes experience improved water clarity as a result of the filter feeding proclivities of these mollusks. This improved clarity has led to increased growths of rooted aquatic plants, including Eurasian water milfoil. Curiously, within the Southeastern Wisconsin Region, zebra mussels have been observed attaching themselves to the stalks of the Eurasian water milfoil plants, dragging these stems out of the zone of light penetration, due to the weight of the zebra mussel shells, and interfering with

Table 18

FISH SPECIES COMPOSITION BY PHYSIOLOGICAL TOLERANCE IN THE EAGLE SPRING WATERSHED: 1958-2008

Species According to Their Relative Tolerance to Pollution	1958-1989	1990-2005
Intolerant		
Blackchin Shiner	X	- -
Blacknose Darter	X	X
Least Darter[a]	X	- -
Iowa Darter	X	- -
Rainbow Darter	X	- -
Rock Bass	X	X
Smallmouth Bass	- -	X
Tolerant		
Bluntnose Minnow	X	X
Brook Stickleback	X	- -
Brown Bullhead	- -	X
Central Mudminnow	X	X
Common Carp	X	X
Creek Chub	X	- -
Fathead Minnow	- -	X
Golden Shiner	X	X
Green Sunfish	X	X
White Sucker	X	X
Yellow Bullhead	X	X
Intermediate		
Banded Killifish[a]	X	- -
Black Crappie	X	X
Blackside Darter	- -	X
Bluegill	X	X
Bowfin	- -	X
Brook Silverside	X	X
Common Shiner	X	X
Emerald Shiner	X	- -
Fantail Darter	X	- -
Grass Pickerel	X	X
Johnny Darter	X	X
Lake Chubsucker[a]	X	X
Largemouth Bass	X	X
Northern Pike	- -	X
Pumpkinseed	X	X
Warmouth	X	X
White Crappie	- -	X
Yellow Perch	X	X
Total Number of Species	30	27

[a]*State-designated species of special concern.*

Source: Wisconsin Department of Natural Resources and SEWRPC.

the competitive strategy of the Eurasian water milfoil plants. This, in turn, has contributed to improved growths of native aquatic plants, in some cases, and to the growths of filamentous algae too large to be ingested by the zebra mussels, in others. Regardless as to the seeming beneficial impacts of these mollusks, the overall effect is that, as zebra mussels and other invasive species spread to inland lakes and rivers, so do the environmental, aesthetic, and economic costs to water users.

Fishes of Eagle Spring Lake

In Wisconsin, high-quality warmwater streams are characterized by many native species including cyprinids, darters, suckers, sunfish, and percids that typically dominate the fish assemblage. Intolerant species—species that are particularly sensitive to water pollution and habitat degradation—are common in high-quality warmwater systems. Tolerant fish species—species that are capable of persisting under a wide range of degraded conditions—also are typically present within high-quality warmwater streams, but they do not dominate. Insectivores—fish that feed primarily on small invertebrates—and top carnivores—fish that feed on other fish, vertebrates, or large invertebrates—are generally common. Omnivores—fish that feed on both plant and animal material—also are generally common, but do not dominate. In addition, simple lithophilous spawners—fish species that lay their eggs directly on large substrate, such as clean gravel or cobble, without building a nest or providing parental care for the eggs—are generally common.

Review of the fishery data collected upstream of the Wambold Dam inclusive of Eagle Spring Lake, Lulu Lake, and the Mukwonago River between 1958-1989 and 1990-2005 indicates that the historic and recent fishery are similar and contain nearly 30 species as shown in Table 18. Two species, the least darter and banded killifish, which are species of special concern in the State of Wisconsin, have not been observed in this watershed since 1989. However, the lake chubsucker, which also is a species of special concern in the State of Wisconsin, continues to be present in the Lakes.

Eagle Spring Lake contains a moderately diverse fishery community, is known for its fishing, and is the site of numerous fishing-related community events, such as the community “carp out” that was conducted annually between 1990 and 2001. There have been no known fish kills reported by WDNR for Eagle Spring Lake. However, this lake has suffered from an unbalanced fishery community in terms of a disproportionately high proportion of bass with low average size, an abundance of small predatory fishes, and low numbers of large predatory fishes;

Table 19

FISH STOCKING REPORT FOR EAGLE SPRING LAKE: 1992-2006

Year	Species	Strain	Age Class	Number Stocked	Average Length (inches)
1992	Northern Pike	Unspecified	Fingerling	307	8.00
1993	Northern Pike	Unspecified	Fingerling	500	8.00
1994	Northern Pike	Unspecified	Fingerling	3,110	5.75
1996	Northern Pike	Unspecified	Fingerling	1,820	4.30
1998	Northern Pike	Unspecified	Small fingerling	1,500	- -
1999	Northern Pike	Unspecified	Small fingerling	1,740	2.40
2000	Northern Pike	Unspecified	Small fingerling	1,600	3.45
2001	Northern Pike	Lake Puckaway	Small fingerling	3,620	2.60
2002	Northern Pike	Lake Puckaway	Small fingerling	1,555	3.10
2005	Northern Pike	Lake Puckaway	Small fingerling	1,555	2.20
2006	Northern Pike	Lake Puckaway	Small fingerling	1,250	6.00

Source: Wisconsin Department of Natural Resources.

Table 20

FISHING REGULATIONS APPLICABLE TO EAGLE SPRING LAKE: 2010-2011

Species	Open Season	Daily Limit	Minimum Size
Northern Pike	May 1 to March 6	2	26 inches
Walleyed Pike	May 1 to March 6	5	15 inches
Largemouth and Smallmouth Bass	May 1 to March 6	3 in total	None[a]
Rock, Yellow and White Bass	Open all year	None	None
Bluegill, Pumpkinseed (sunfish), Crappie, and Yellow Perch	Open all year	10 in total	None
Bullhead and Rough Fish	Open all year	None	None

[a]*There is no minimum size limit on largemouth and smallmouth bass in Eagle Spring Lake; but, bass from 14 inches through 18 inches may not be kept, and only one fish over 18 inches is allowed with a daily bag limit of three in total.*

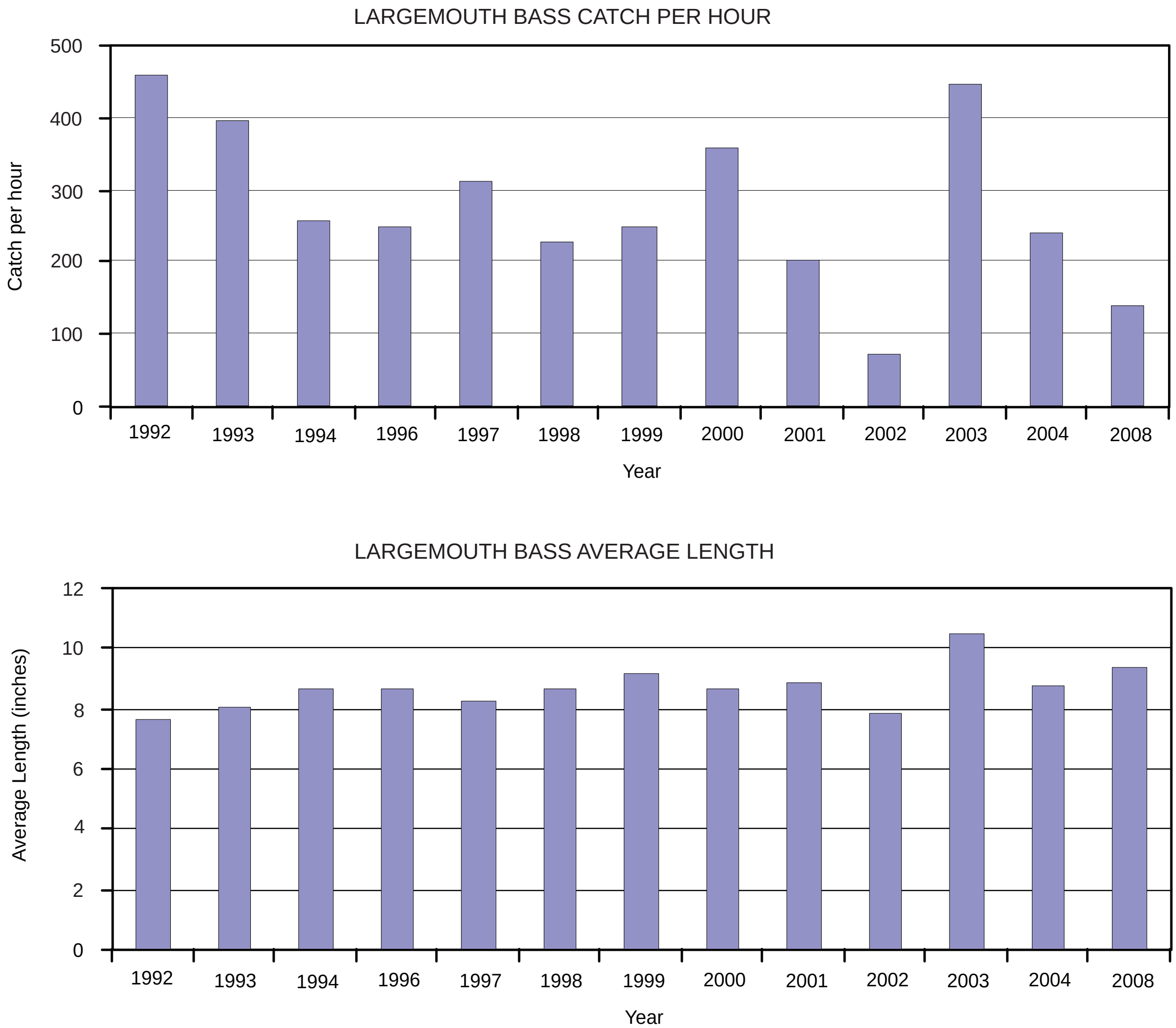
Source: Wisconsin Department of Natural Resources Publication No. PUBL-FH-301 2010, Guide to Wisconsin Hook and Line Fishing Regulations 2010-2011*, January 2010; and SEWRPC.*

namely, largemouth bass and northern pike. Northern pike fingerlings were annually stocked in Eagle Spring Lake from 1992 to 2006 in an effort to establish a larger population of this gamefish species, as shown in Table 19. However, the northern pike fishery continues to remain limited in this system. For example, only eight total northern pike were collected during the 2008 survey. In addition, mandatory slot size regulations excluding 14- to 18-inch largemouth bass from the harvest have recently been established by WDNR to protect and enhance this species. There are no minimum size limits for largemouth bass of less than 14 inches and a bag limit of one of largemouth bass greater than 18 inches, with a maximum of three largemouth bass in total. These management measures, summarized in the fishing regulations set forth in Table 20, are geared toward reversing the unbalanced fishery that has existed within Eagle Spring Lake and recent data suggest that this has begun to occur.

Based upon surveys conducted by WDNR staff, as shown Figure 24, overall abundances of largemouth bass have decreased and average lengths have slowly increased between 1992 and the present. Since the largemouth bass populations in 1992 contained numerous small-sized fishes, the trend toward a lower abundance and larger average fish length is a sign that this predatory species is developing a more balanced proportion of larger, higher quality fishes. This trend is supported by the most recent 2008 size frequency distribution, shown in Figure 25, which contained the highest proportions of largemouth bass greater than 14 inches recorded in recent years. In

Figure 24

CATCH PER HOUR AND AVERAGE LENGTH OF LARGEMOUTH BASS IN EAGLE SPRING LAKE: 1992-2008



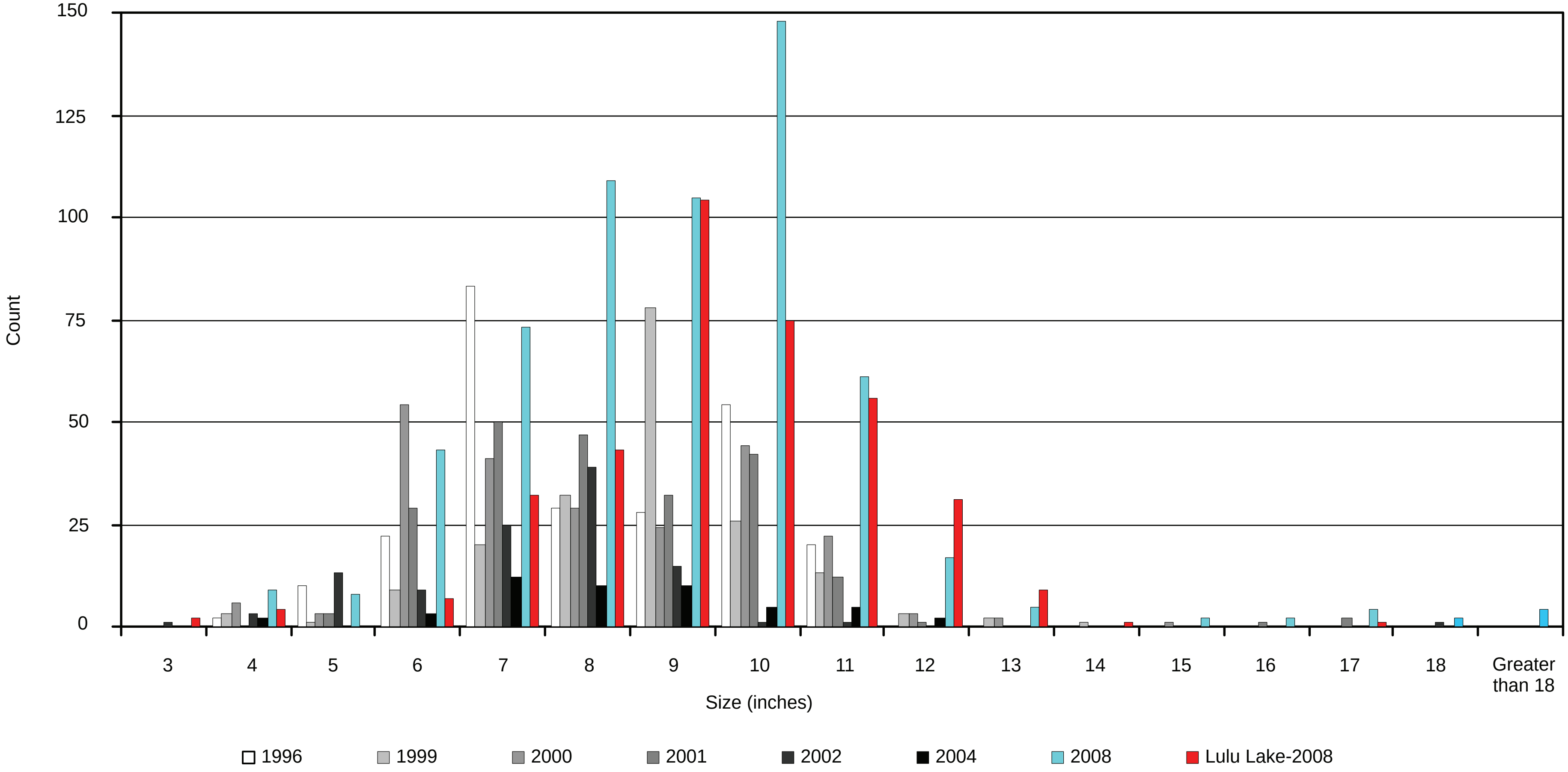
Source: Wisconsin Department of Natural Resources.

addition, the 2008 survey of Lulu Lake showed that this basin also contained a similar size structure to that reported from Eagle Spring Lake. WDNR population estimates in the 2008 mark-recapture survey indicated a mean population size of approximately 3,450 total largemouth bass in Eagle Spring Lake and 1,691 total largemouth bass in Lulu Lake. The 2008 survey indicated that the recent slot length size management measures seem to be having the desired effect on the population size structure in Eagle Spring Lake. However, the size-at-age data for largemouth bass reported between 1996 and 2004 indicate that the largemouth bass population grows more slowly and achieves smaller than average sizes per age class compared to regional average largemouth bass growth rates for lakes in southeastern Wisconsin as shown in Figure 26. It is possible that the size-at-age data for 2008 may show better growth rates than previously recorded years, but those data have not yet been compiled.

Although the bluegill population abundance has been much more variable than the largemouth bass abundance, since 1999 the bluegill abundances have continued to decrease with a concomitant increase in average size as shown in Figure 27. This is likely to be a result of the catch limits of 10 panfish that recently have been instituted

Figure 25

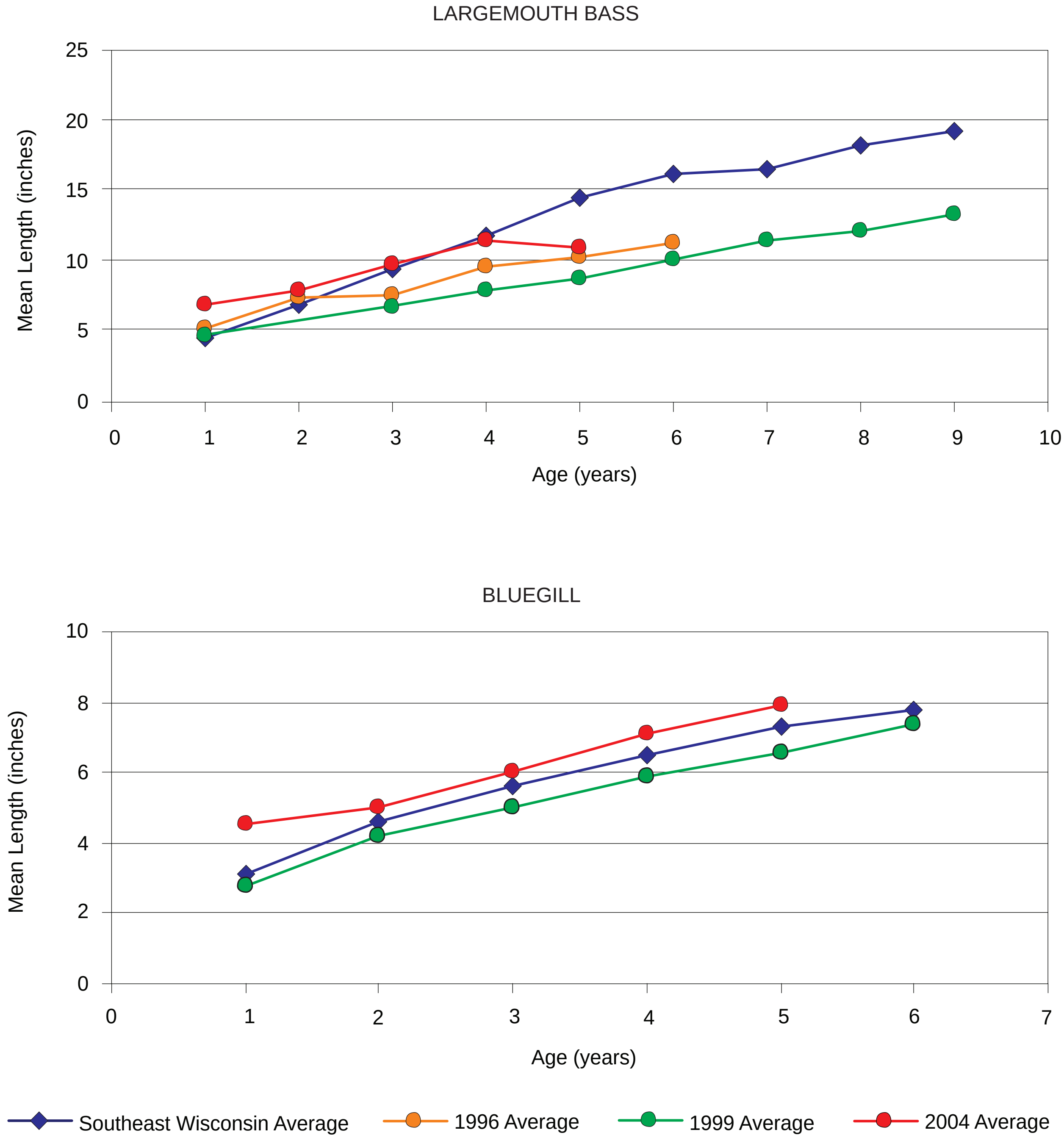
SIZE FREQUENCY DISTRIBUTION OF LARGEMOUTH BASS IN EAGLE SPRING AND LULU LAKES: 1996-2008



Source: Wisconsin Department of Natural Resources.

Figure 26

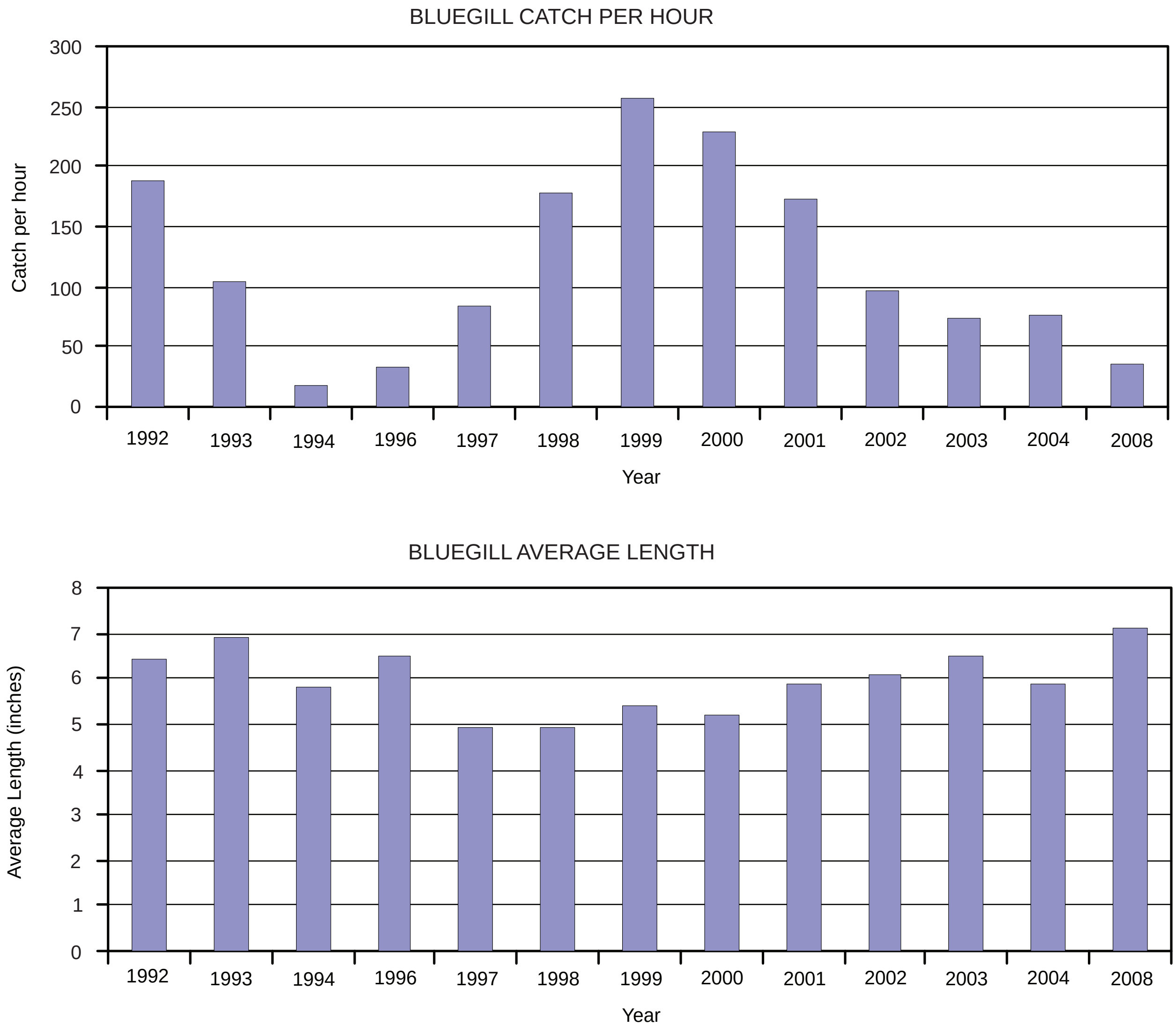
LARGEMOUTH BASS AND BLUEGILL SIZE-AT-AGE WITHIN EAGLE SPRING LAKE COMPARED TO THE SOUTHEASTERN WISCONSIN LAKES AVERAGE GROWTH RATES: 1996-2008



Source: Wisconsin Department of Natural Resources.

Figure 27

CATCH PER HOUR AND AVERAGE LENGTH OF BLUEGILL IN EAGLE SPRING LAKE: 1992-2008

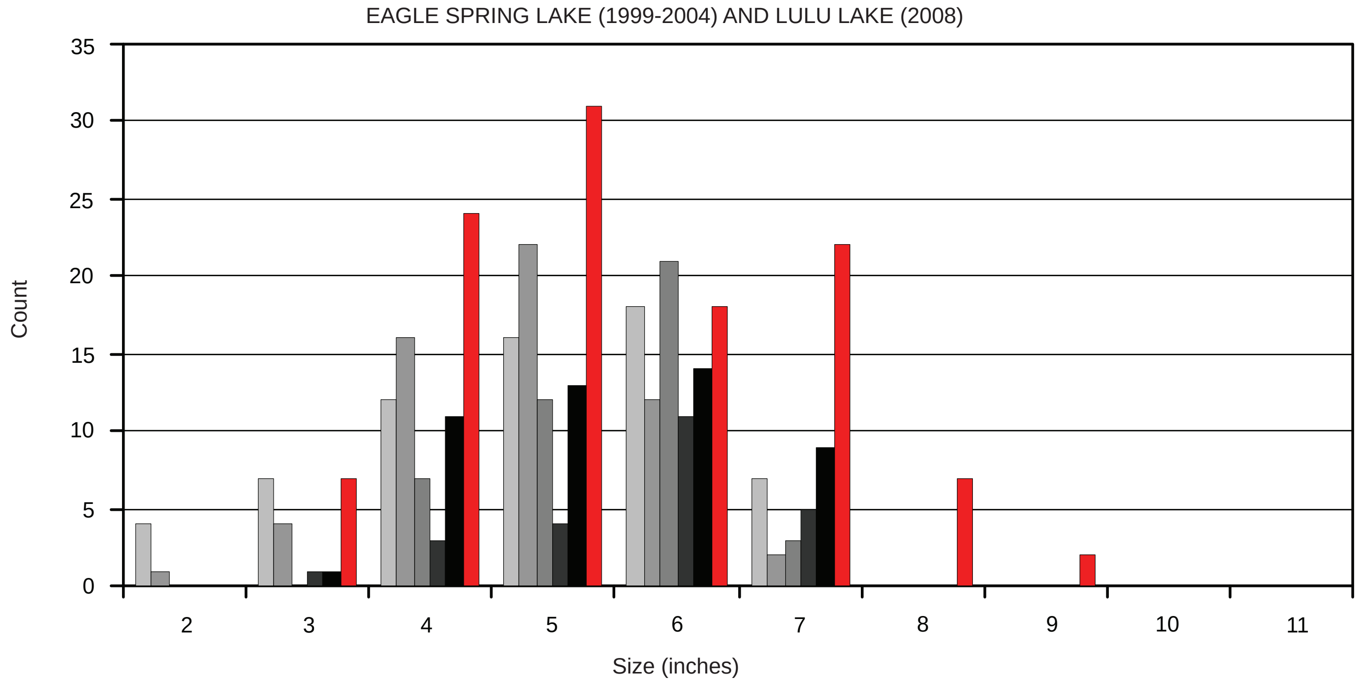


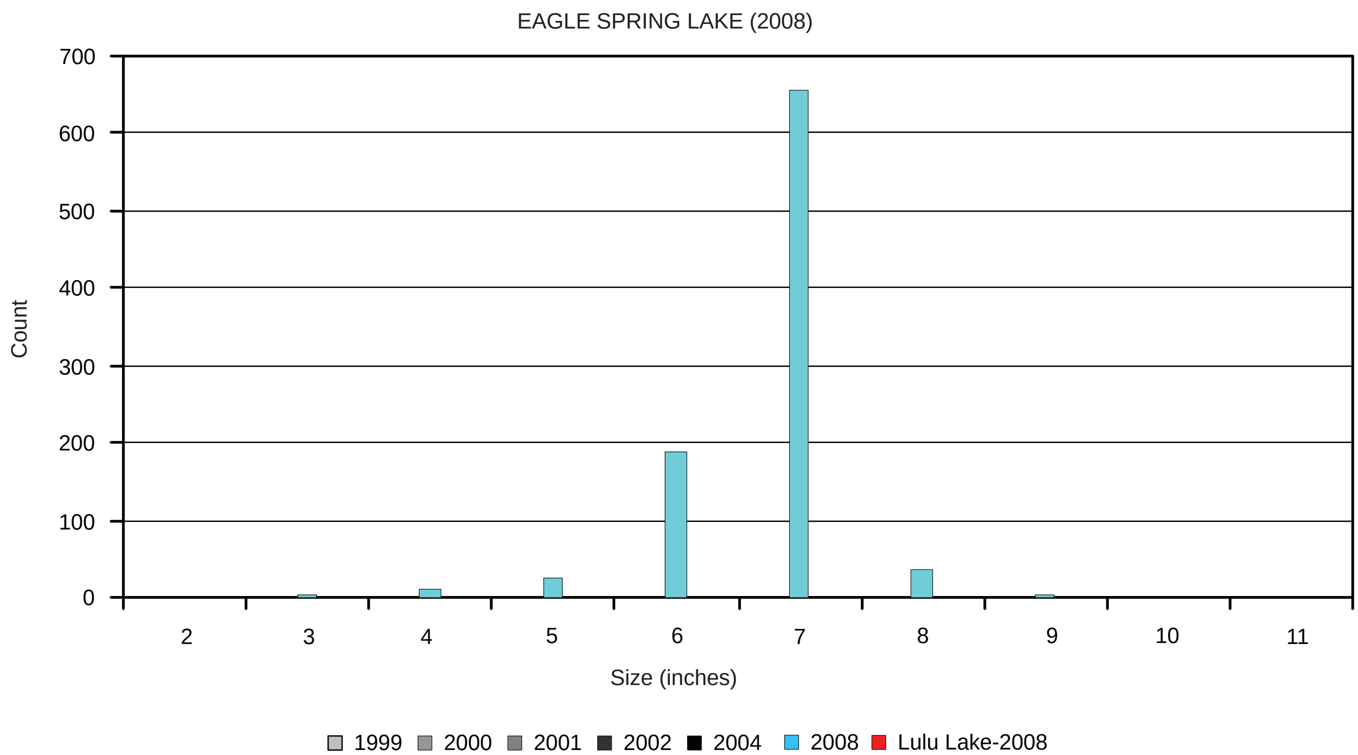
Source: Wisconsin Department of Natural Resources.

to protect these species from overharvesting. Like largemouth bass, the trend of increasing abundance and larger average size is a sign that bluegill are developing a more balanced population. In 2008, bluegill achieved the largest average size compared to the previous 16 years of surveys. The size frequency analysis, set forth in Figure 28, also showed a dominant seven-inch size class in 2008. Like Eagle Spring Lake, the 2008 size frequency distribution of bluegill in Lulu Lake indicated a significant proportion of bluegill greater than seven inches in length, which has not been recorded previously. It is important to note that the 2008 fish survey results may be biased due to differences in gear compared to previous surveys; fyke nets were used in combination with electrofishing during the 2008 survey. Fyke nets are very effective at collecting bluegill, and a large proportion of the bluegill catch were collected in the fyke nets. Nevertheless, the 2004 growth rates, as shown in Figure 26, indicate that bluegill are achieving a larger size-at-age class than the regional average bluegill growth rates, which is a good sign of a recovering fishery.

Figure 28

SIZE FREQUENCY DISTRIBUTION OF BLUEGILL IN EAGLE SPRING AND LULU LAKES: 1992-2008





Source: Wisconsin Department of Natural Resources.

Nonnative Species

Carp have been a part of the fishery within Eagle Spring Lake for a long time; it is considered to be an "established nonnative fish species" pursuant to Chapter NR 40 of the *Wisconsin Administrative Code*, whose distribution within Wisconsin is restricted to capture and transport for harvest, research, or other authorized purpose. The reintroduction of these fishes into other waters of the State is prohibited.

While these fish have a long association with Eagle Spring Lake, this species has not been a dominant component of the fishery historically. Carp are a tolerant fish species that can significantly degrade water quality and habitat conditions for other fish species when they become dominant; hence, they are considered an injurious species in lakes. The catch per unit effort for carp has generally remained below 10 per hour of electrofishing between 1992 and 2008, indicating that their abundance has remained consistently low, as suggested by the data shown in Figure 29. In general, average carp length has remained high during this period, indicating that the population has been dominated by large adults with limited recruitment. This latter fact is likely to be the reason why the population has not become a dominant component of the fishery. The size frequency distribution of carp in Eagle Spring Lake in 2002 and 2008 indicates a similar pattern among size classes; however, the 2008 survey indicates that there were significantly more fishes overall, as shown in Figure 30. There also seems to be a greater proportion of smaller fishes, which is a troubling sign, indicating that recruitment may be more successful and carp may become a more dominant part of the fishery. Recent population estimates based upon the 2008 survey show that there are 4,264 carp in Eagle Spring Lake, suggesting that they are a significant component of the fishery within the Lake.

Carp can be extremely disruptive to the aquatic vegetation that provides habitat and shelter for more desirable species of fishes,[22] as well as increase lake turbidity levels through resuspension of sediments when carp densities get high enough.[23] Carp are benthivorous fish and ingest sediment to obtain food particles by filtering material through their gill rakers.[24] Carp can process up to five times their body weight per day and the fine particles that are not retained by the fish become suspended in the water. Recent studies have shown that the small pits on the sediment surface that are left over from feeding fishes greatly reduce the erosion resistance, which makes the sediment more susceptible to resuspension through wind and/or motor boat activity.[25] Since shallow lakes are naturally much more susceptible to increased turbidity levels from wind and motor boat activity than deep lakes, carp potentially have a much greater synergistic impact on water quality within the shallow Eagle Spring Lake.

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[22]*G.W. Becker,* Fishes of Wisconsin*, University of Wisconsin Press, Madison, 1983.*

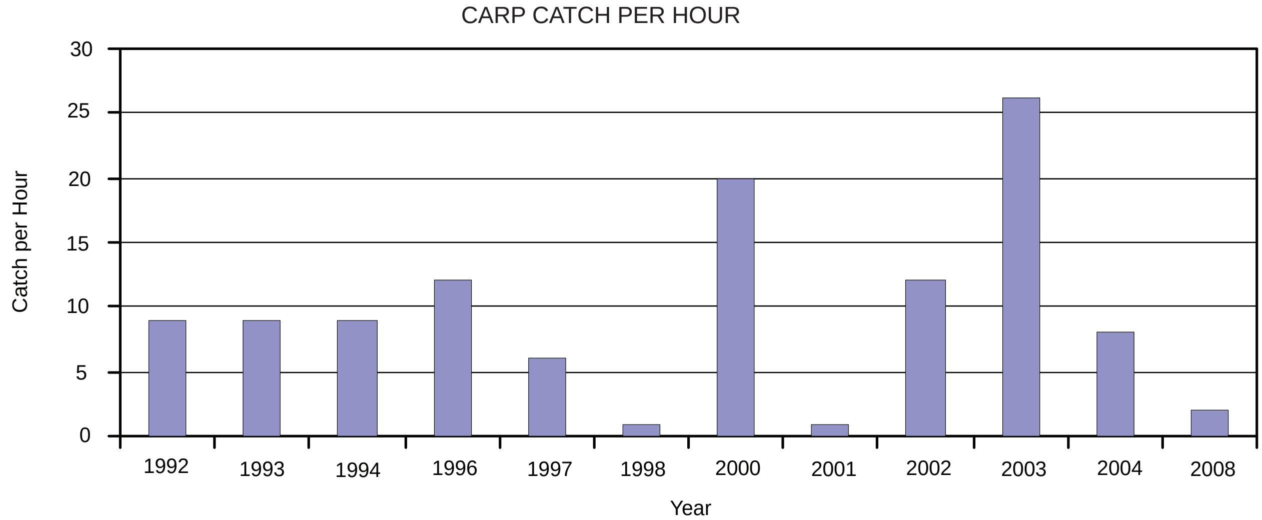
[23]*A.W. Breukelaar, E.H.R.R. Lammens, J.G.P. Lein Breteler, and I. Taltrai, "Effect of Benthivorous Bream (*Abamis brama*) and Carp (*Cyprinus carpio*) on Resuspension,"* Internationale Vereinigung für Theoretische und Angewandte Limnologie: Verhandlungen*, Volume 25, Number 4, pages 2144-2147, 1994.*

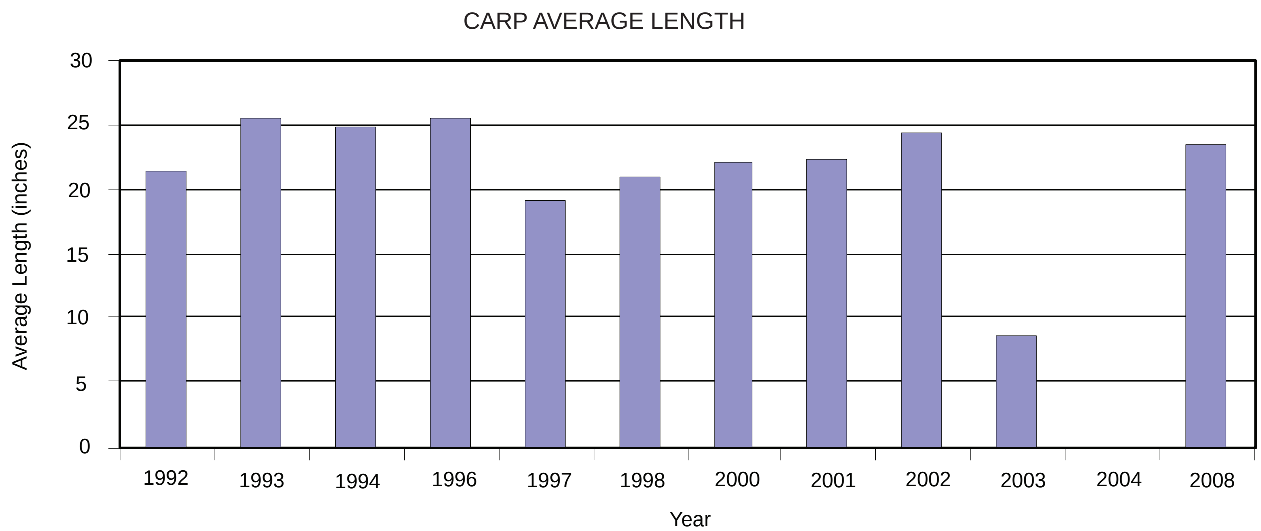
[24]*E.H.R.R. Lammens, and W. Hoogenboezem, "Diets and Feeding Behaviour," In: I.J. Winfield and J.S. Nelson, editors*, Cyprinid Fishes: Systematics, Biology, and Exploitation*, Chapman and Hall, New York, pages 353-376, 1991.*

[25]*M. Scheffer, S. Szabo, A. Gragnani, E. van Nes, S. Rinaldi, N. Kautsky, J. Norberg, R.M.M. Roijackers, and R.J.M. Franken, "Floating Plant Dominance as a Stable State,"* Proceedings of the National Academy of Sciences*, Volume 100, Number 7, pages 4040-4045, 2003.*

Figure 29

CATCH PER HOUR AND AVERAGE LENGTH OF CARP IN EAGLE SPRING LAKE: 1992-2008





Source: Wisconsin Department of Natural Resources.

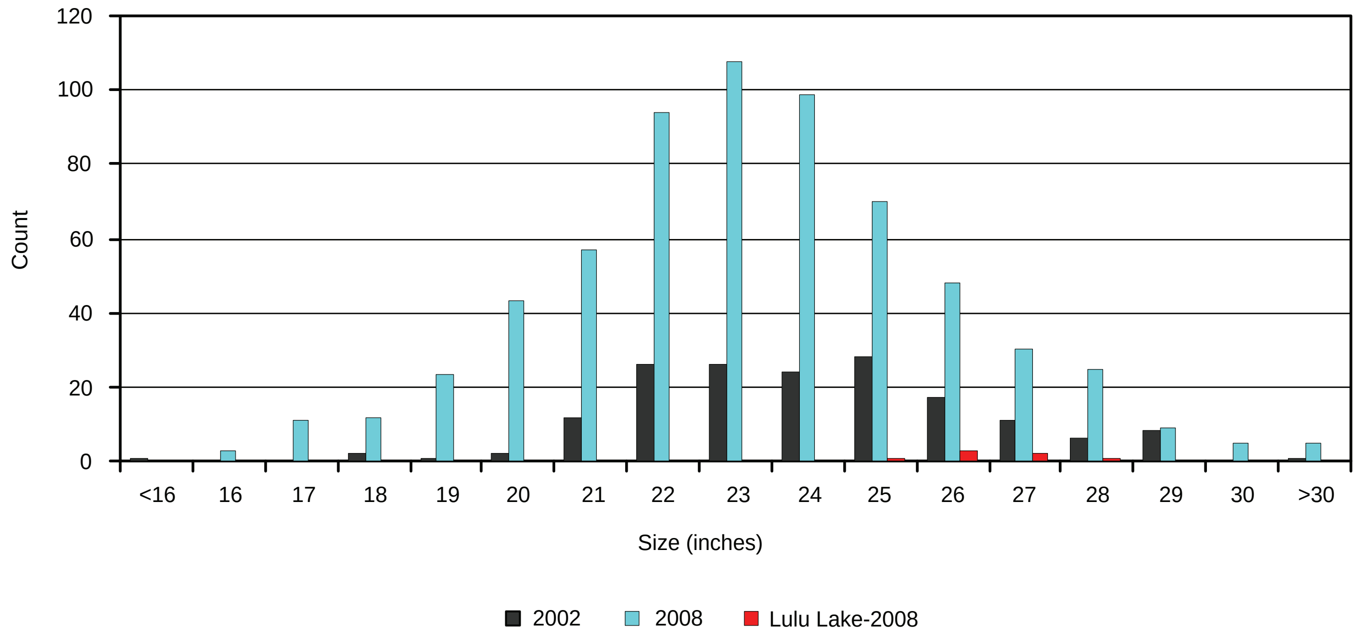
Fisheries Management

Loss of habitat is a primary concern of a fisheries management program, and it has become well understood that littoral zone habitat and fishery degradation is highly associated with lake shore residential development.[26] Eagle Spring Lake's shoreline is largely developed, which puts significant pressure on protecting the remaining highest

[26]*J.J. Jennings, E. Emmons, G. Hatzenbeler, C. Edwards, and M. Bozek, "Is Littoral Habitat Affected by Residential Development and Land Use in Watersheds of Wisconsin Lakes?,"* Lake and Reservoir Management, *Volume 19, Number 3, pages 272-279, 2003; J.J. Jennings, M. Bozek, G. Hatzenbeler, E. Emmons, and M. Staggs, "Cumulative Effects of Incremental Shoreline Habitat Modification on Fish Assemblages in a North Temperate Lake,"* North American Journal of Fisheries Management, *Volume 19, pages 18-27, 1999; and, D.E. Schindler, S. Geib, and M. Williams, "Patterns of Fish Growth along a Residential Development Gradient in North Temperate Lakes,"* Ecosystems, *Volume 3, pages 229-237, 2000.*

Figure 30

SIZE FREQUENCY DISTRIBUTION OF CARP IN EAGLE SPRING AND LULU LAKES: 2002-2008



Source: Wisconsin Department of Natural Resources.

quality natural shoreline in the western portion of the Lake. Since the types and quality of habitat for bluegill, largemouth, and northern pike have not been quantified within Eagle Spring Lake, it is not known if a particular habitat type is limiting one or more of these species or one or more parts of their life history—i.e., spawning, egg development, fry, juvenile, adults—within the Lake. To complicate matters, it is also not known how much the fishery within Eagle Spring Lake depends upon Lulu Lake. It has been well documented in the mark-recapture surveys that limited numbers of marked largemouth bass and carp in Eagle Spring Lake were also found in Lulu Lake and vice versa. The distances within, and between, these lakes are well within the documented normal movement ranges of bluegill,[27] largemouth bass,[28] and northern pike.[29] In addition, size frequency distributions of bluegill and largemouth bass as noted above were very similar between Eagle Spring and Lulu Lakes, which seems to support the idea that these species may be readily immigrating and emigrating between these lakes.

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[27]*C.P. Paukert, D.W. Willis, and M.A. Bouchard, "Movement, Home Range, and Site Fidelity of Bluegills in a Great Plains Lake,"* North American Journal of Fisheries Management*, Volume 24, pages 154-161, 2004.*

[28]*K.C. Hanson, and others, "Assessment of Largemouth Bass (*Micropterus salmoides*) Behaviour and Activity at Multiple Spatial and Temporal Scales Utilizing a Whole-Lake Telemetry Array,"* Hydrobiologia*, Volume 58, pages 243-256, 2007.*

[29]*A. Kobler, T. Klefoth, C. Wolter, F. Fredrich, and R. Arlinghaus, "Contrasting Northern Pike (*Esox lucius *L.) Movement and Habitat Choice between Summer and Winter in a Small Lake,"* Hydrobiologia*, Volume 601, Number 1, pages 17-27, 2008; and, T. Vehanen, P. Hyvarinen, K. Johansson, and T. Laaksonen, "Patterns of Movement of Adult Northern Pike (*Esox lucius *L.) in a Regulated River,"* Ecology of Freshwater Fish*, Volume 15, Number 2, pages 154-160, 2006.*

Based upon known habitat requirements for bluegill, largemouth bass, and northern pike, each of which is an important recreational species, Eagle Spring Lake seems to qualitatively contain an adequate amount of vegetative cover, depth, and substrate habitat for fishes. However, recruitment and/or population sizes are limited in Eagle Spring Lake for bluegill, largemouth bass, and northern pike species compared to other lakes in the Region and the reasons for this are not known. Overharvest or exploitation from anglers is likely to be a major factor affecting these species; however, there has not been a creel survey to quantify this impact. Based upon sediment observations taken during the aquatic plant survey on Eagle Spring Lake in 2008, it seems that gravel substrates may be limiting the amount of available spawning substrates for largemouth bass.[30] The observed substrates of Eagle Spring Lake are comprised of approximately 30 percent silt/sand, 29 percent marl, 23 percent silt, 8 percent sand, 6 percent silt/sand, and 4 percent sand/gravel. Gravel or sand/gravel combination substrates were only identified at four of the 19 locations within Eagle Spring Lake, and no gravel substrates were found among 10 locations on Lulu Lake, although a sandy area is reported on the northeastern side of the Lake by the ESLMD Commissioners. Gravel or sand/gravel substrates were only recorded at the nearest-shore lake depth of 1.5 feet with one exception where sand/gravel substrates were found at the 3.0 feet depth.

Qualitative observations of Eagle Spring Lake on May 6, 2008, indicated that nesting largemouth bass were at the shoreline in waters of less than 1.5 feet depth overlying gravel substrates. Bluegills also generally spawn on sand or gravel in water depths of 1.0 foot to 2.5 feet. Eagle Spring Lake seems to contain adequate amounts of sand substrate, and bluegills have been observed to spawn adjacent to a large proportion of shoreline within the Lake.[31] In contrast, northern pike have never been observed to spawn within Eagle Spring Lake. Northern pike require emergent shoreline vegetation and sufficient depth and time of flooding inundation for successful spawning.[32] There appears to be plenty of emergent vegetation for northern pike spawning on the western and southwestern shoreline; however, this vegetation might not be inundated for long enough periods of time to promote successful northern pike spawning and egg development within Eagle Spring Lake, given the current static water level management—i.e., generally plus or minus three inches around a mean stage of 820.69 feet National Geodetic Vertical Datum of 1929 (NGVD29)—that occurs within this Lake, as shown in Figure 4 in Chapter II if this report.

The Lake is judged to have a good fishery. Currently, the WDNR manages Eagle Spring Lake as a warmwater sportfishery. Fisheries management efforts have included passive maintenance through compliance with State of Wisconsin fishing regulations, with the following modifications: the combined daily bag limit on panfish is 10 in total; and, there is no minimum length limit on largemouth or smallmouth bass, but bass from 14 inches through 18 inches may not be kept, and only one fish over 18 inches is allowed with a daily bag limit of three in total.[33] The 2010-2011 regulations governing the harvest of fishes from the waters of the State, as amended to include Eagle Spring Lake, are summarized in Table 20.

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[30]*C. Annett, J. Hunt, and E. Dibble, " The Complete Bass: Habitat Use Patterns of all Stages of the Life Cycle of Largemouth Bass,"* Proceedings of the American Fisheries Society Symposium, *Volume 16, pages 306-314, 1996.*

[31]*Thomas A. Day, Commissioner, Eagle Spring Lake Management District, personal communication.*

[32]*J.M. Casselman and C.A. Lewis, "Habitat Requirements of Northern Pike (*Esox lucius*),"* Canadian Journal of Fisheries and Aquatic Sciences, *Volume 53, Supplement 1, pages 161-174, 1996.*

[33]*Wisconsin Department of Natural Resources Publication No. PUBL-FH-301 2010,* Guide to Wisconsin Hook and Line Fishing Regulations 2010-2011, *2010.*

Other Wildlife

The complete spectrum of wildlife species originally native to Waukesha County has, along with its habitat, undergone significant change in terms of diversity and population size since the European settlement of the area. This change is a direct result of the conversion of land by the settlers from its natural state to agricultural and urban uses, beginning with the clearing of the forest and prairies, the draining of wetlands, and ending with the development of extensive urban areas. Successive cultural uses and attendant management practices, both rural and urban, have been superimposed on the land use changes and have also affected the wildlife and wildlife habitat. In agricultural areas, these cultural management practices include draining land by ditching and tiling and the expanding use of fertilizers, herbicides, and pesticides. In urban areas, cultural management practices that affect wildlife and their habitat also include the use of fertilizers, herbicides, and pesticides, as well as the use of road salt for snow and ice control; the presence of heavy motor vehicle traffic that produce disruptive noise levels and air pollution; nonpoint source water pollution from human activities on the landscape; and the introduction of domestic pets.

Although a quantitative field inventory of amphibians, reptiles, birds, and mammals was not conducted as a part of the Eagle Spring Lake study, a field reconnaissance was undertaken by the WDNR during July 1992. The technique used in compiling the wildlife data involved obtaining lists of those amphibians, reptiles, birds, and mammals known to exist, or known to have existed in the Eagle Spring Lake area; associating these lists with the historic Lake area as inventoried; and projecting the appropriate amphibian, reptile, bird, and mammal species into the Eagle Spring Lake area. The net result of the application of this technique is a listing of those species which were probably once present in the subwatershed; those species which may be expected to still be present under currently prevailing conditions; and those species which may be expected to be lost or gained as a result of urbanization within the area.

Amphibians and Reptiles

Amphibians and reptiles are vital components of the ecosystem in an environmental unit like the Eagle Spring Lake subwatershed. Examples of amphibians native to the area include frogs, toads, and salamanders. Turtles and snakes are examples of reptiles common to the Eagle Spring Lake area. Blanding’s turtle, a threatened species, is resident in Lulu and Eagle Spring Lakes. A total of 15 amphibian and 17 reptile species are normally expected to be present in the Eagle Spring Lake area. Most amphibians and reptiles have definite habitat requirements which are adversely affected by advancing urban development as well as by certain agricultural land management practices. The major detrimental factors affecting the maintenance of amphibians in a changing environment is the destruction of breeding ponds, urban development occurring in migration routes, and changes in food sources brought about by urbanization. Table 21 lists those amphibians and reptiles whose ranges are known to extend into the area.

Birds

A large number of birds, numbering about 190 species ranging in size from large game birds to small songbirds, are found in the Eagle Spring Lake area. The Eagle Spring Lake subwatershed supports a significant population of waterfowl, with mallards, wood duck, and blue-winged teal being the most numerous waterfowl known to nest in the area. Larger numbers of birds move through the subwatershed during migrations when most of the regional species may also be present. Because of the mixture of lowland and upland woodlots, wetlands, and agricultural lands still present in the area, along with the favorable summer climate, the area supports many other species of birds. Many game birds, songbirds, waders, and raptors also reside or visit the Lake and its environs. Hawks and owls function as major rodent predators within the ecosystem. Swallows, whippoorwills, woodpeckers, nuthatches, and flycatchers, as well as several other species, serve as the major insect predators. In addition to their ecological roles, birds such as robins, red-winged blackbirds, orioles, cardinals, kingfishers, and mourning doves serve as subjects for bird watchers and photographers. Sandhill cranes and loons are notable migratory visitors, and a small population of Sandhill cranes have been reported to be resident on the Lake year-round. Bald eagles, osprey, black terns, Forster’s terns, loggerhead shrikes, peregrine falcons, barn owls, and Cooper’s hawks—all threatened or endangered species—have been reported to have been seen in the vicinity of Eagle Spring and Lulu Lakes. Table 22 lists bird species expected to be found within the Eagle Spring Lake area.

Table 21

AMPHIBIANS AND REPTILES OF THE EAGLE SPRING LAKE AREA

Scientific (family) and Common Name	Scientific Name	Species Reduced or Dispersed with Full Area Urbanization	Species Lost with Full Area Urbanization
Amphibians			
Proteidae			
Mudpuppy	*Necturus maculosus maculosus*	X	- -
Ambystomatidae			
Blue-Spotted Salamander	*Ambystoma laterale*	- -	X
Spotted Salamander	*Ambystoma maculatum*		
Eastern Tiger Salamander	*Ambystoma tigrinum tigrinum*	X	- -
Salamandridae			
Central Newt	*Notophthalmus viridescens louisianensi*	X	- -
Bufonidae			
American Toad	*Bufo americanus americanus*	X	- -
Hylidae			
Western Chorus Frog	*Pseudacris triseriata triseriata*	X	- -
Blanchard's Cricket Frog[a,b]	*Acris crepitans blanchardi*	X	- -
Northern Spring Peeper	*Hyla crucifer crucifer*	- -	X
Gray Tree Frog	*Hyla versicolor*	- -	X
Ranidae			
Bull Frog[c]	*Rana catesbeiana*	- -	X
Green Frog	*Rana clamitans melanota*	X	- -
Northern Leopard Frog	*Rana pipiens*	- -	X
Pickerel Frog[c]	*Rana palustris*	- -	X
Reptiles			
Chelydridae			
Common Snapping Turtle	*Chelydra serpentina serpentina*	X	- -
Kinosternidae			
Musk Turtle (stinkpot)	*Sternotherus odoratus*	X	- -
Emydidae			
Western Painted Turtle	*Chrysemys picta belli*	X	- -
Midland Painted Turtle	*Chrysemys picta marginata*	X	- -
Blanding's Turtle[d]	*Emydoidea blandingii*	- -	X
Trionychidea			
Eastern Spiny Softshell	*Trionyx spiniferus spiniferus*	X	- -
Colubridae			
Northern Water Snake	*Nerodia sipedon sipedon*	X	- -
Midland Brown Snake	*Storeria dekayi wrightorum*	X	- -
Northern Red-Bellied Snake	*Storeria occipitomaculata occipitomaculata*	X	- -
Eastern Garter Snake	*Thamnophis sirtalis sirtalis*	X	- -
Chicago Garter Snake	*Thamnophis sirtalis semifasciata*	X	- -
Butler's Garter Snake[d]	*Thamnophis butleri*	X	- -
Eastern Hognose Snake	*Heterodon platyrhinos*	- -	X
Smooth Green Snake	*Opheodrys vernalis vernalis*	- -	X
Eastern Milk Snake	*Lampropeltis triangulum triangulum*	- -	X

[a]*Likely to be extirpated from the watershed.*

[b]*State-designated endangered species.*

[c]*State-designated special concern species.*

[d]*State-designated threatened species.*

Source: Gary S. Casper, Geographical Distribution of the Amphibians and Reptiles of Wisconsin*, 1996, Wisconsin Department of Natural Resources, Kettle Moraine State Forest, Lapham Peak Unit; and SEWRPC.*

Table 22

BIRDS KNOWN OR LIKELY TO OCCUR IN THE EAGLE SPRING LAKE AREA

Scientific (family) and Common Name	Breeding	Wintering	Migrant
Gaviidae			
Common Loon[a]	- -	- -	X
Podicipedidae			
Pied-Billed Grebe	X	- -	X
Horned Grebe	- -	- -	X
Phalacrocoracidae			
Double-Crested Cormorant	- -	- -	X
Ardeidae			
American Bittern[a]	X	- -	X
Least Bittern[a]	X	- -	X
Great Blue Heron[a]	X	R	X
Great Egret[b]	- -	- -	X
Cattle Egret[a,c]	- -	- -	R
Green Heron	X	- -	X
Black-Crowned Night Heron[a]	- -	- -	X
Anatidae			
Tundra Swan	- -	- -	X
Mute Swan[c]	X	X	X
Snow Goose	- -	- -	X
Canada Goose	X	X	X
Wood Duck	X	- -	X
Green-Winged Teal	- -	- -	X
American Black Duck[a]	- -	X	X
Mallard	X	X	X
Northern Pintail[a]	- -	- -	X
Blue-Winged Teal	X	- -	X
Northern Shoveler	- -	- -	X
Gadwall	- -	- -	X
American Widgeon[a]	- -	- -	X
Canvasback[a]	- -	- -	X
Redhead[a]	- -	- -	X
Ring-Necked Duck	- -	- -	X
Lesser Scaup[a]	- -	- -	X
Greater Scaup	- -	- -	R
Common Goldeneye[a]	- -	X	X
Bufflehead	- -	- -	X
Red-Breasted Merganser	- -	- -	X
Hooded Merganser[a]	R	- -	X
Common Merganser[a]	- -	- -	X
Ruddy Duck	- -	- -	X
Cathartidae			
Turkey Vulture	X	- -	X
Accipitridae			
Osprey[a]	- -	- -	X
Bald Eagle[a,d]	- -	- -	R
Northern Harrier[a]	X	R	X
Sharp-Shinned Hawk	X	X	X
Cooper's Hawk[a]	X	X	X

Table 22 (continued)

Scientific (family) and Common Name	Breeding	Wintering	Migrant
Accipitridae (continued)			
Northern Goshawk[a]	- -	R	X
Red-Shouldered Hawk[b]	R	- -	X
Broad-Winged Hawk	R	- -	X
Red-Tailed Hawk	X	X	X
Rough-Legged Hawk	- -	X	X
American Kestrel	X	X	X
Merlin[a]	- -	- -	X
Phasianidae			
Grey Partridge[c]	R	R	- -
Ring-Necked Pheasant[c]	X	X	- -
Wild Turkey	X	X	- -
Rallidae			
Virginia Rail	X	- -	X
Sora	X	- -	X
Common Moorhen	X	- -	X
American Coot	X	R	X
Gruidae			
Sandhill Crane	X	- -	X
Charadriidae			
Black-Bellied Plover	- -	- -	X
Semi-Palmated Plover	- -	- -	X
Killdeer	X	- -	X
Scolopacidae			
Greater Yellowlegs	- -	- -	X
Lesser Yellowlegs	- -	- -	X
Solitary Sandpiper	- -	- -	X
Spotted Sandpiper	X	- -	X
Upland Sandpiper[a]	R	- -	X
Semi-Palmated Sandpiper	- -	- -	X
Pectoral Sandpiper	- -	- -	X
Dunlin	- -	- -	X
Common Snipe	R	- -	X
American Woodcock	X	- -	X
Wilson's Phalarope	- -	- -	X
Laridae			
Ring-Billed Gull	- -	- -	X
Herring Gull	- -	X	X
Common Tern[e]	- -	- -	R
Caspian Tern[e]	- -	- -	R
Forster's Tern[e]	- -	- -	R
Black Tern[a]	X	- -	X
Columbidae			
Rock Dove[c]	X	X	- -
Mourning Dove	X	X	X
Cuculidae			
Black-Billed Cuckoo	X	- -	X
Yellow-Billed Cuckoo[a]	X	- -	X

Table 22 (continued)

Scientific (family) and Common Name	Breeding	Wintering	Migrant
Strigidae			
Eastern Screech Owl	X	X	- -
Great Horned Owl	X	X	- -
Snowy Owl	- -	R	- -
Barred Owl	X	X	- -
Long-Eared Owl[a]	- -	X	X
Short-Eared Owl[a]	- -	R	X
Northern Saw-Whet Owl	- -	- -	X
Caprimulgidae			
Common Nighthawk	X	- -	X
Whippoorwill	- -	- -	X
Apodidae			
Chimney Swift	X	- -	X
Trochilidae			
Ruby-Throated Hummingbird	X	- -	X
Alcedinidae			
Belted Kingfisher	X	X	X
Picidae			
Red-Headed Woodpecker[a]	X	R	X
Red-Bellied Woodpecker	X	X	- -
Yellow-Bellied Sapsucker	- -	R	X
Downy Woodpecker	X	X	- -
Hairy Woodpecker	X	X	- -
Northern Flicker	X	R	X
Tyrannidae			
Olive-Sided Flycatcher	- -	- -	X
Eastern Wood Pewee	X	- -	X
Yellow-Bellied Flycatcher[a]	- -	- -	X
Acadian Flycatcher[b]	R	- -	X
Alder Flycatcher	R	- -	X
Willow Flycatcher	X	- -	X
Least Flycatcher	R	- -	X
Eastern Phoebe	X	- -	X
Great Crested Flycatcher	X	- -	X
Eastern Kingbird	X	- -	X
Alaudidae			
Horned Lark	X	X	X
Hirundinidae			
Purple Martin[a]	X	- -	X
Tree Swallow	X	- -	X
Northern Rough-Winged Swallow	X	- -	X
Bank Swallow	X	- -	X
Cliff Swallow	X	- -	X
Barn Swallow	X	- -	X
Corvidae			
Blue Jay	X	X	X
American Crow	X	X	X
Paridae			
Tufted Titmouse	R	R	- -
Black-Capped Chickadee	X	X	X

Table 22 (continued)

Scientific (family) and Common Name	Breeding	Wintering	Migrant
Sittidae			
Red-Breasted Nuthatch	R	X	X
White-Breasted Nuthatch	X	X	- -
Certhiidae			
Brown Creeper	- -	X	X
Troglodytidae			
Carolina Wren	- -	- -	R
House Wren	X	- -	X
Winter Wren	- -	- -	X
Sedge Wren[a]	X	- -	X
Marsh Wren	X	- -	X
Regulidae			
Golden-Crowned Kinglet	- -	X	X
Ruby-Crowned Kinglet[a]	- -	- -	X
Blue-Gray Gnatcatcher	X	- -	X
Eastern Bluebird	X	- -	X
Veery[a]	X	- -	X
Gray-Cheeked Thrush	- -	- -	X
Swainson's Thrush	- -	- -	X
Hermit Thrush	- -	- -	X
Wood Thrush[a]	X	- -	X
American Robin	X	X	X
Mimidae			
Gray Catbird	X	- -	X
Brown Thrasher	X	- -	X
Bombycillidae			
Bohemian Waxwing	- -	R	- -
Cedar Waxwing	X	X	X
Laniidae			
Northern Shrike	- -	- -	X
Loggerhead Shrike[e]	- -	- -	R
Sturnidae			
European Starling[c]	X	X	X
Vireonidae			
Bell's Vireo	- -	- -	R
Solitary Vireo	- -	- -	X
Yellow-Throated Vireo	X	- -	X
Warbling Vireo	X	- -	X
Philadelphia Vireo	- -	- -	X
Red-Eyed Vireo	X	- -	X
Parulidae			
Blue-Winged Warbler	X	- -	X
Golden-Winged Warbler[a]	R	- -	X
Tennessee Warbler[a]	- -	- -	X
Orange-Crowned Warbler	- -	- -	X
Nashville Warbler[a]	- -	- -	X
Northern Parula	- -	- -	X
Yellow Warbler	X	- -	X
Chestnut-Sided Warbler	- -	- -	X
Magnolia Warbler	- -	- -	X

Table 22 (continued)

Scientific (family) and Common Name	Breeding	Wintering	Migrant
Parulidae (continued)			
Cape May Warbler[a]	- -	- -	X
Black-Throated Blue Warbler	- -	- -	X
Yellow-Rumped Warbler	- -	R	X
Black-Throated Green Warbler	- -	- -	X
Cerulean Warbler[b]	R	- -	R
Blackburnian Warbler	- -	- -	X
Palm Warbler	- -	- -	X
Bay-Breasted Warbler	- -	- -	X
Blackpoll Warbler	- -	- -	X
Black-and-White Warbler	- -	- -	X
Prothonotary Warbler[a]	- -	- -	R
American Redstart	X	- -	X
Ovenbird	X	- -	X
Northern Waterthrush	- -	- -	X
Connecticut Warbler[a]	- -	- -	X
Mourning Warbler	R	- -	X
Common Yellowthroat	X	- -	X
Wilson's Warbler	- -	- -	X
Kentucky Warbler[b]	- -	- -	R
Canada Warbler	R	- -	X
Hooded Warbler[b]	R	- -	R
Thraupidae			
Scarlet Tanager	X	- -	X
Cardinalidae			
Northern Cardinal	X	X	- -
Rose-Breasted Grosbeak	X	- -	X
Indigo Bunting	X	- -	X
Emberizidae			
Dickcissel[a]	R	- -	X
Eastern Towhee	X	- -	X
American Tree Sparrow	- -	X	X
Chipping Sparrow	X	- -	X
Clay-Colored Sparrow	R	- -	X
Field Sparrow	X	- -	X
Vesper Sparrow[a]	X	- -	X
Savannah Sparrow	X	- -	X
Grasshopper Sparrow[a]	X	- -	X
Henslow's Sparrow[b]	R	- -	X
Fox Sparrow	- -	R	X
Song Sparrow	X	X	X
Lincoln's Sparrow	- -	- -	X
Swamp Sparrow	X	X	X
White-Throated Sparrow	- -	R	X
White-Crowned Sparrow	- -	- -	X
Dark-Eyed Junco	- -	X	X
Lapland Longspur	- -	R	X
Snow Bunting	- -	R	X
Icteridae			
Bobolink[a]	X	- -	X
Red-Winged Blackbird	X	X	X
Eastern Meadowlark[a]	X	R	X
Western Meadowlark[a]	R	- -	X

Table 22 (continued)

Scientific (family) and Common Name	Breeding	Wintering	Migrant
Icteridae (continued)			
Yellow-Headed Blackbird	X	- -	X
Rusty Blackbird	- -	R	X
Common Grackle	X	X	X
Brown-Headed Cowbird	X	R	X
Orchard Oriole[a]	R	- -	R
Baltimore Oriole	X	- -	X
Fringillidae			
Purple Finch	- -	X	X
Common Redpoll	- -	X	X
Pine Siskin[a]	- -	X	X
American Goldfinch	X	X	X
House Finch	X	X	X
Evening Grosbeak	- -	X	X
Passeridae			
House Sparrow[c]	X	X	- -

NOTE: Total number of bird species: 219
Number of alien, or nonnative, bird species: 7 (3 percent)

Breeding: Nesting species
Wintering: Present January through February
Migrant: Spring and/or fall transient

X - Present, not rare
R - Rare

[a]*State-designated species of special concern. Fully protected Federal and State laws under the Migratory Bird Act.*

[b]*State-designated threatened species.*

[c]*Alien, or nonnative, bird species.*

[d]*Federally designated threatened species.*

[e]*State-designated endangered species.*

Source: Samuel D. Robbins, Jr., Wisconsin Birdlife, Population & Distribution, Past and Present*, 1991; John E. Bielefeldt, Racine County Naturalist; Zoological Society of Milwaukee County and Birds Without Borders-Aves Sin Fronteras,* Report for Landowners on the Avian Species Using the Pewaukee, Rosendale and Land O'Lakes Study Sites*, April-August, 1998; Wisconsin Department of Natural Resources; and SEWRPC.*

Mammals

Given the rural nature of all but the immediate shoreline area of Eagle Spring Lake, many animals and numbers of waterfowl commonly inhabit areas of the subwatershed, especially in the still undeveloped areas southwest of the Lake and upstream of the Lake. A variety of mammals, ranging in size from large animals like the white-tailed deer to small animals like the pygmy shrew, are found in the Eagle Spring Lake area. Some 37 mammals have ranges that are known to extend into the area, as noted in Table 23. Mink, muskrat, beaver, white-tailed deer, red and grey fox, grey and fox squirrel, and cottontail rabbits, among others, are mammals reported to frequent the area.

Table 23

MAMMALS OF THE EAGLE SPRING LAKE AREA

Scientific (family) and Common Name	Scientific Name
Didelphidae	
Virginia Opossum	*Didelphis virginiana*
Soricidae	
Cinereous Shrew	*Sorex cinereus*
Short-Tailed Shrew	*Blarina brevicauda*
Least Shrew	*Cryptotis parva*
Vespertilionidae	
Little Brown Bat	*Myotis lucifugus*
Silver-Haired Bat	*Lasisoncteris octivagans*
Big Brown Bat	*Eptesicus fuscus*
Red Bat	*Lasiurus borealus*
Hoary Bat	*Lasiurus cinereus*
Leporidae	
Cottontail Rabbit	*Sylvilgus floridanus*
Sciuridae	
Woodchuck	*Marmota monax*
Thirteen-lined Ground Squirrel (gopher)	*Spermophilus tridencemilineatus*
Eastern Chipmunk	*Tamias striatus*
Grey Squirrel	*Sciurus carolinensis*
Western Fox Squirrel	*Sciurus niger*
Red Squirrel	*Tamiasciurus hudsonicus*
Southern Flying Squirrel	*Glaucomys volans*
Castoridae	
American Beaver	*Castor canadensis*
Cricetidae	
Woodland Deer Mouse	*Peromyscus maniculatus*
Prairie Deer Mouse	*Peromyscus leucopus bairdii*
White-Footed Mouse	*Microtus pennsylvanicus*
Meadow Vole	*Microtus ochrogaster*
Common Muskrat	*Ondatra zibethicus*
Muridae	
Norway Rat (introduced)	*Rattus norvegicus*
House Mouse (introduced)	*Mus musculus*
Zapodidae	
Meadow Jumping Mouse	*Zapas hudonius*
Canidae	
Coyote	*Canis latrans*
Eastern Red Fox	*Vulpes vulpes*
Gray Fox	*Urocyon cinereoargenteus*
Procyonidae	
Raccoon	*Procyon lotor*
Mustelidae	
Least Weasel	*Mustela nivalis*
Short-Tailed Weasel	*Mustela erminea*
Long-Tailed Weasel	*Mustela frenata*
Mink	*Mustela vison*
Badger (occasional visitor)	*Taxidea taxus*
Striped Skunk	*Mephitis mephitis*
Otter (occasional visitor)	*Lontra canadensis*
Cervidae	
White-Tailed Deer	*Odecoileus virginianus*

Source: H.T. Jackson, Mammals of Wisconsin*, 1961, U.S. Department of Agriculture Integrated Taxonomic Information System, National Museum of Natural History, Smithsonian Institute, and SEWRPC.*

Threatened, Endangered and Special Concern Species

Eagle Spring Lake and its environs contain a number of State-listed special concern, threatened, and endangered species of plants and animals. Most of these species are listed as species of special concern, including two mammal species, 14 species of birds, five species of reptiles and amphibians, three fishes, one mussel, and 22 plants, including both terrestrial and wetland aquatic species.[34] An additional four species of birds, one reptile, one mussel, and six plants are considered to be threatened. Of the State-listed endangered species, one bird—Foster's Tern, two reptiles and amphibians—Blanchard's Cricket Frog and the Western Ribbon Snake, and one mussel—the Rainbow Shell, have been noted as being present in the study area. No endangered fishes or plants were reported. The combined presence of this number of State-listed special concern, threatened and endangered species is consistent with the Outstanding and Exceptional Resource Waters classifications applied to Lulu Lake and the portion of the Mukwonago River downstream of Eagle Spring Lake and the Wambold Dam.

WETLANDS

Wetlands are defined by SEWRPC as, "areas that have a predominance of hydric soils and that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and under normal circumstances do support, a prevalence of hydrophytic vegetation typically adapted for life in saturated soil conditions." This definition, which is also used by the U.S. Army Corps of Engineers (USACE) and the U.S. Environmental Protection Agency (USEPA), is essentially the same as the definition used by the U.S. Natural Resources Conservation Service (NRCS).[35]

Another definition, which is applied by the WDNR and which is set forth in Chapter 23 of the *Wisconsin Statutes*, defines a wetland as "an area where water is at, near, or above the land surface long enough to be

[34]*Wisconsin Department of Natural Resources Bureau of Endangered Resources, personal communication.*

[35]*Lands designated as prior converted cropland, that is, lands that were cleared, drained, filled, or otherwise manipulated to make them capable of supporting a commodity crop prior to December 23, 1985, may meet the criteria of the NRCS wetland definition, but they would not be regulated under Federal wetland programs. If such lands are not cropped, managed, or maintained for agricultural production, for five consecutive years, and in that time the land reverts back to wetland, the land would then be subject to Federal wetland regulations.*

capable of supporting aquatic or hydrophytic vegetation, and which has soils indicative of wet conditions." In practice, the WDNR definition differs from that of SEWRPC in that the WDNR considers very poorly drained, poorly drained, and some of the somewhat poorly drained soils as wetland soils meeting the WDNR "wet condition" criterion. The SEWRPC definition only considers the very poorly drained and poorly drained soils as meeting the "hydric soil" criterion. Thus, the State definition, as actually applied, is more inclusive than the Federal and regional definitions, in that the WDNR may include some soils that do not show hydric field characteristics as wet soils capable of supporting wetland vegetation, a condition that may occur in some floodlands.[36]

As a practical matter, experience has shown that application of the WDNR, the USEPA and USACE, and the SEWRPC definitions produce reasonably consistent wetland identifications and delineations in the majority of situations within the Southeastern Wisconsin Region. That consistency is due, in large part, to the provision in the Federal wetland delineation manual that allows for the application of professional judgment in cases where satisfaction of the three criteria for wetland identification is unclear.

Wetlands in southeastern Wisconsin are classified predominantly as deep marsh, shallow marsh, southern sedge meadow, fresh (wet) meadow, shrub carr, alder thicket, low prairie, calcareous fen, bog, southern wet- and wet-mesic hardwood forest, and conifer swamp based upon their plant covers. Wetlands form an important part of the landscape in and adjacent to Eagle Spring Lake in that they perform natural functions that make them ecologically and environmentally invaluable resources. Wetlands affect the quality of water by acting as a filter or a buffer zone by utilizing some of the nutrients as well as allowing silt and sediments to settle out. They also influence the quantity of water by providing water during periods of drought and storing it during periods of flood and peak runoff. When located along shorelines of lakes and streams, wetlands help protect those shorelines from erosion. Wetlands also may serve as groundwater discharge and recharge areas, and they are important resources for overall ecological health and diversity that provide essential breeding and feeding grounds, shelter, and escape cover for many forms of fish and wildlife.

Wetlands are poorly suited to urban use. This is due to the high soil compressibility and instability, high water table, low load-bearing capacity, and high shrink-swell potential of wetland soils, and, in some cases, to the potential for flooding. In addition, metal conduits placed in some types of wetland soils may be subject to rapid corrosion. These constraints, if ignored, may result in flooding, wet basements and excessive operation of sump pumps, unstable foundations, failing pavements, broken sewer and water lines, and excessive infiltration of clear water into sanitary sewerage systems. In addition, there are significant onsite preparation and maintenance costs associated with the development of wetlands, particularly as they relate to roads, foundations, and public utilities.

SEWRPC maintains an inventory of wetlands within the Region which is updated periodically. In 2000, wetlands covered about 1,425 acres, or 9 percent, of the area tributary to Eagle Spring Lake, as shown on Map 21. The amount and distribution of wetlands in the area should remain relatively constant if the recommendations contained in the adopted regional land use plan are followed. About one-third of the Eagle Spring Lake shoreline is comprised of wetlands (not including the islands), which increase the Lake's ability to cope with nutrient loading and probably have contributed to the maintenance of the clear-water macrophyte dominated ecosystem state.[37] In addition, contiguous shoreline wetland acreages upstream of Eagle Spring Lake continue on for miles and represent a significant component of the overall land use adjacent to this portion of the Mukwonago River system.

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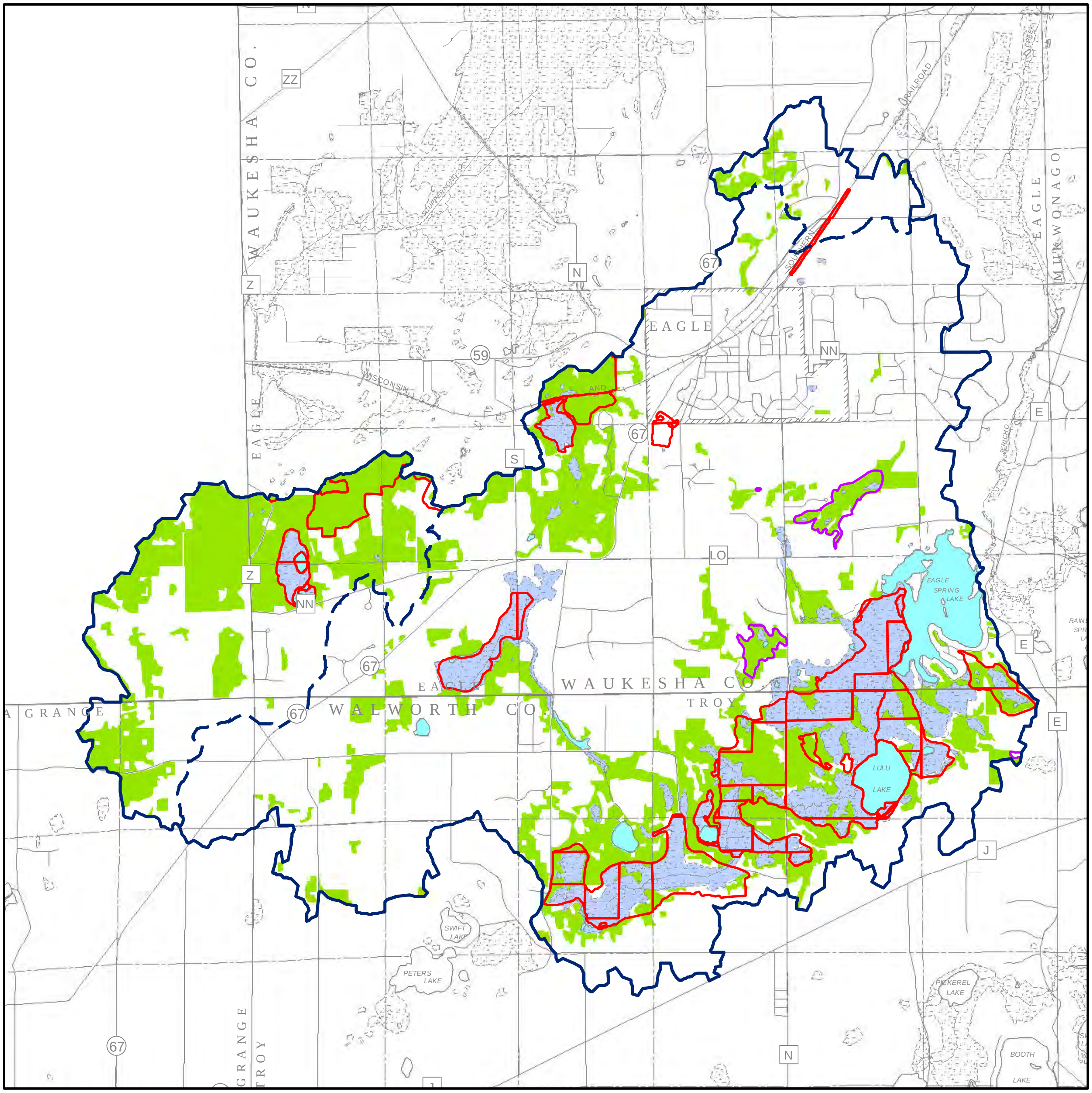
[36]*Although prior converted cropland is not subject to Federal wetland regulations unless cropping ceases for five consecutive years and the land reverts to a wetland condition, the State may consider prior converted cropland to be subject to State wetland regulations if the land meets the criteria set forth in the State wetland definition before it has not been cropped for five consecutive years.*

[37]*J.H. Janse, W. Ligtoet, S. Van Tol, and A.H.M Bresser, "A Model Study on the Role of Wetland Zones in Lake Eutrophication and Restoration,"* The Scientific World Journal*, Volume 1(S2), pages 605-614, 2001.*

Map 21

WETLANDS AND WOODLANDS WITHIN THE TOTAL TRIBUTARY AREA OF EAGLE SPRING LAKE



NOTE: Natural area and critical species habitat information is not available in Jefferson County.

Source: SEWRPC.

Based upon a recent survey of the riparian wetland areas around Eagle Spring Lake by Hey and Associates, Inc., entitled "Wetland Vegetation Survey at Eagle Spring Lake," dated January 2004, 19 wetland communities were identified ranging from moderate- to high-quality, as shown in Table 24. These wetlands were located along the western shoreline of Eagle Spring Lake. While the majority of species reported were native plants, a number of nonnative species including narrow-leaf cattail, purple loosestrife, phragmites, and buckthorn were reported. SEWRPC staff also observed all of these species adjacent to the upstream Lulu Lake during the 2008 field season.

WOODLANDS

Woodlands are defined by the Regional Planning Commission as those areas containing a minimum of 17 trees per acre with a diameter of at least four inches at breast height (4.5 feet above the ground). The woodlands are classified as dry, dry-mesic, mesic, wet-mesic, wet hardwood, and conifer swamp forests; the last three are also considered wetlands. SEWRPC maintains an inventory of woodlands within the Region which is updated periodically. Approximately 2,984 acres of woodland were inventoried during 2000 within the area tributary to Eagle Spring Lake. These woodlands covered about 19 percent of the tributary area, as shown on Map 21. The major tree species include the black willow (*Salix nigra*), cottonwood (*Populus deltoides*), green ash (*Fraxinus pennsylvanica*), silver maple (*Acer saccharinum*), American elm (*Ulmus americana*), basswood (*Tilia americana*), northern red oak (*Quercus borealis*), and shagbark hickory (*Carya ovata*). Some isolated stands of tamarack (Larix laricina) also exist in the tributary area, together with such other upland species as the white oak (*Quercus alba*), burr oak (*Quercus macrocarva*), black cherry (*Prunus serotina*), American beech (*Fagus grandifolia*), and paper birch (*Betula papyrifera*).

The amount and distribution of woodlands in the area should also remain relatively stable if the recommendations contained in the regional land use plan are followed. If, however, urban development is allowed to continue within the subwatershed much of the remaining woodland cover may be expected to be lost.

WILDLIFE HABITAT, NATURAL AREAS, AND ENVIRONMENTAL CORRIDORS

Wildlife Habitat

One of the key elements of the delineation of environmental corridors, natural areas, and critical species habitat was the identification of wildlife habitat areas within southeastern Wisconsin. These areas were initially inventoried by SEWRPC in cooperation with the WDNR during 1985. The five major criteria used to determine the value of these wildlife habitat areas are listed below:

1. Diversity: An area must maintain a high, but balanced, diversity of species for a temperate climate; balanced in that the proper predator-prey (consumer-food) relationships can occur. In addition, a reproductive interdependence must exist.

2. Territorial Requirements: The maintenance of proper spatial relationships among species which allows for a certain minimum population level can occur only if the territorial requirements of each major species within a particular habitat are met.

3. Vegetative Composition and Structure: The composition and structure of vegetation must be such that the required levels for nesting, travel routes, concealment, and protection from weather are met for each of the major species.

4. Location with Respect to Other Wildlife Habitat Areas: It is very desirable that a wildlife habitat maintain proximity to other wildlife habitat areas.

5. Disturbance: Minimal levels of disturbance by human activities are necessary (other than those activities of a wildlife management nature).

Table 24

EAGLE SPRING LAKE WETLAND COMPLEX PLANT COMMUNITY SUMMARY

Community	Floristic Quality Index	Vegetation Type	Dominant Vegetation	Total Species	Total Nonnative Species
1	33.4	Sedge meadow (on floating mat)	Long-bracted tussock sedge (*Carex aquatilis altior*) Common lake sedge (*Carex lacustris*)	31	0
2	15.0	Emergent marsh	Narrow-leaved cattail (*Typha angustifolia*)	9	0
3	15.6	Aquatic emergent	White water lily (*Nymphaea tuberosa*)	3	0
4	23.0	Sedge meadow (on floating mat) and alder thicket	Speckled alder (*Alnus rugosa*) Long-bracted tussock sedge	15	0
5	52.8	Emergent aquatic marsh, sedge meadow, fen, and open bog relic (on floating mat)	Long-bracted tussock sedge Hard-stemmed bulrush (*Scirpus acutus*)	55	1
6	55.0	Calcareous fen	Sedges (*Carex* spp.)	68	2
7	15.5	Emergent marsh (on floating mat)	Narrow-leaved cattail Hard-stemmed bulrush	10	0
8	21.7	Sedge meadow (on floating mat)	Long-bracted tussock sedge	12	0
9	18.0	Emergent marsh and shrubs	Sedges (*Carex* spp.)	9	0
10	15.5	Sedge meadow with tamaracks	Long-bracted tussock sedge Tamarack (*Larix laricina*)	6	0
11	27.9	Emergent marsh with a few widely scattered shrubs (portions of floating mat)	Narrow-leaved cattail	22	0
12	34.0	Sedge meadow, shrub-carr and wet to wet-mesic hardwoods	Common tussock sedge (*Carex stricta*) Quaking aspen (*Populus tremuloides*)	39	3
13	18.4	Sedge meadow (on floating mat)	Common lake sedge Common tussock sedge	14	0
14	25.6	Emergent marsh, sedge meadow	Narrow-leaved cattail Common tussock sedge	35	3
15	22.3	Aquatic emergent	White water lily	7	0
16	30.2	Sedge meadow and shrub-carr	Red-osier dogwood (*Cornus stolonifera*) Common tussock sedge	36	2
17	7.0	Aquatic emergent	White water lily	2	0
18	53.1	Sedge meadow and open bog relic (on floating mat)	Long-bracted tussock sedge Sphgagnum moss (*Sphagnum* spp.)	62	2
19	40.3	Emergent marsh/sedge meadow (on floating mat)	Narrow-leaved cattail Common tussock sedge	34	0

Source: Hey and Associates, Inc.

On the basis of these five criteria, the wildlife habitat areas were categorized as either Class I, High-Value; Class II, Medium-Value; or Class III, Good-Value, habitat areas. Class I wildlife habitat areas contain a good diversity of wildlife, are adequate in size to meet all of the habitat requirements for the species concerned, are generally located in proximity to other wildlife habitat areas, and meet all five criteria listed above. Class II wildlife habitat areas generally fail to meet one of the five criteria in the preceding list for a high-value wildlife habitat. However, they do retain a good plant and animal diversity. Class III wildlife habitat areas are remnant in nature in that they generally fail to meet two or more of the five criteria for a high-value wildlife habitat. Nevertheless, Class III habitat areas may be important if located in proximity to medium- or high-value habitat areas if they provide corridors linking wildlife habitat areas of higher value or if they provide the only available habitat in an area.

In the initial comprehensive lake management plan, it was determined that about 2,594 acres, or 16 percent, of the Eagle Spring Lake total tributary area were classified as Class I habitat; 2,008 acres, or 12 percent, were classified as Class II habitat; and, 1,488 acres, or 9 percent, were classified as Class III habitat. Wildlife habitat areas within the area tributary to Eagle Spring Lake are shown on Map 22.

Natural Areas

During the 1990s, the concept of land and wildlife management evolved into the delineation of natural areas which included critical species habitat among other attributes. This inventory process culminated in the publication of a regional natural areas and critical species habitat protection and management plan.[38] The total area tributary to Eagle Spring Lake contains several natural areas of local, countywide, and regional importance, due to the richness of its natural habitat and biota, as shown on Map 23. These areas included:

- Lulu Lake and Eagle Spring Lake Wetland Complex and Adjacent Uplands: The Lulu Lake State Natural Area, adjoining the southwestern shoreline of Eagle Spring Lake, is among the most valuable natural areas in the State, containing a portion of a 1,660 acre reserve comprised of oak openings, a leatherleaf bog, calcareous fen and sedge meadow wetland. It is proposed that this natural area be expanded to a total area of 2,310 acres through the purchase of additional lands by the WDNR and The Nature Conservancy (TNC);

- Upper Mukwonago River Wetland Complex: This 338-acre good quality wetland complex includes seepage springs, calcareous fen, sedge meadow, shrub-carr, shallow marsh, and tamarack relict. It is classified as NA-2, identifying it as a site of countywide or regional significance and contains rare species habitat;

- George Williams Sedge Meadow: This 27-acre sedge meadow-shallow marsh wetland is rated NA-3, identifying it as a site of local significance;

- Doyles Lake Wetlands: This privately owned 68-acre parcel contains an undeveloped lake containing a shallow marsh. It has received a rating of NA-3;

- Fur Farm Pond: Owned by the WDNR, this 69-acre site contains a deep and shallow marsh and sedge meadow community containing some bog-affiliated species. It is classified NA-2;

- STH 59 Oak Woods and Prairies: This 218-acre site is owned jointly by the WDNR, the Wisconsin Department of Transportation and private parties and is rated NA-3. It is a complex of dry prairie, dry oak woods, and shallow pond which contains significant amphibian populations;

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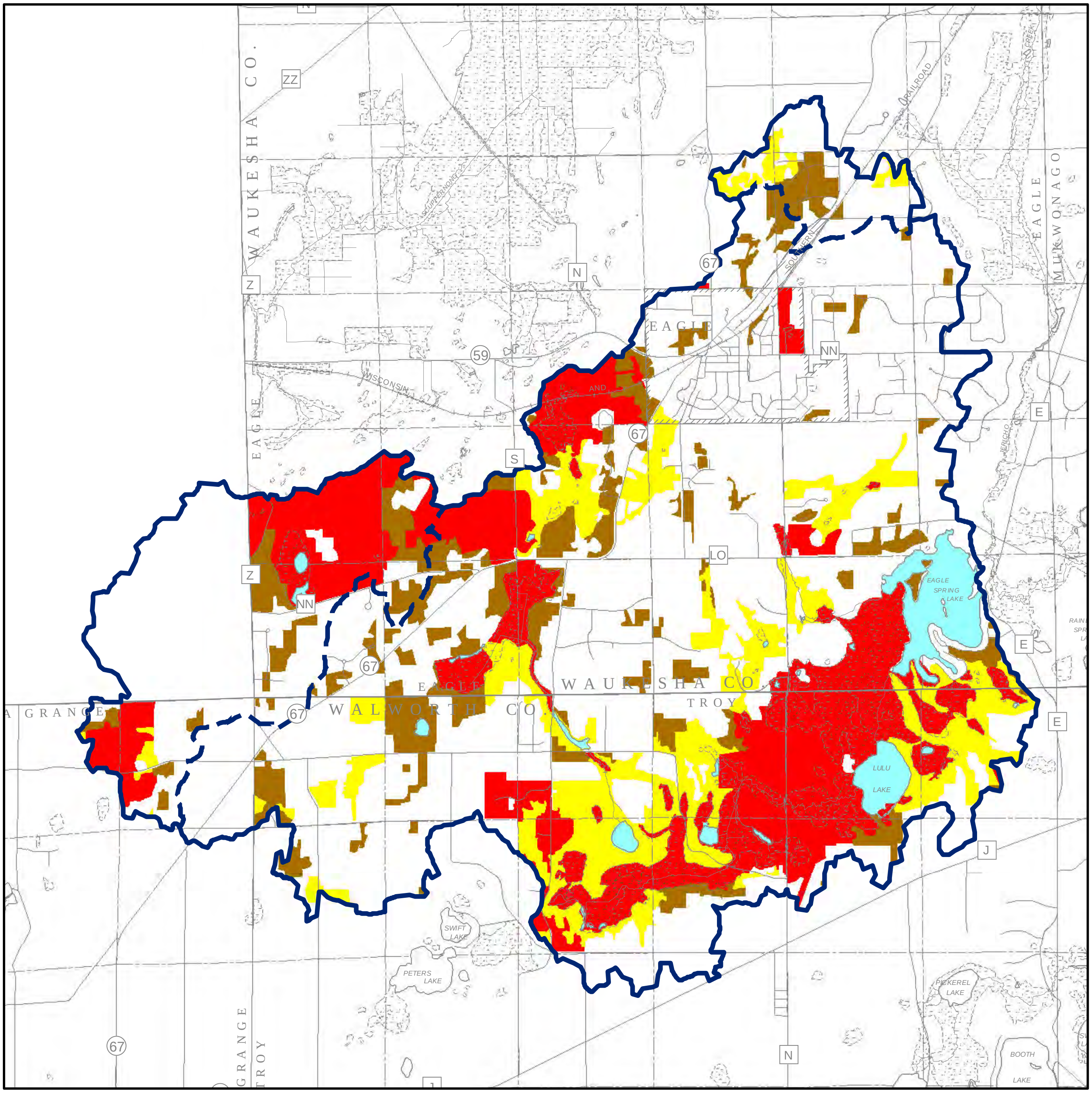
[38] *SEWRPC Planning Report No. 42,* A Regional Natural Areas and Critical Species Habitat Protection and Management Plan for Southeastern Wisconsin, *September 1997.*

Map 22

WILDLIFE HABITAT AREAS WITHIN THE TOTAL TRIBUTARY AREA TO EAGLE SPRING LAKE



Class I, High Value Habitat

Class II, Medium Value Habitat

Class III, Good Value Habitat

Surface Water

Total Tributary Area Boundary

Internally Drained Area Boundary Where Not Coincident with the Total Tributary Area Boundary

NOTE: This information is not available in Jefferson County.

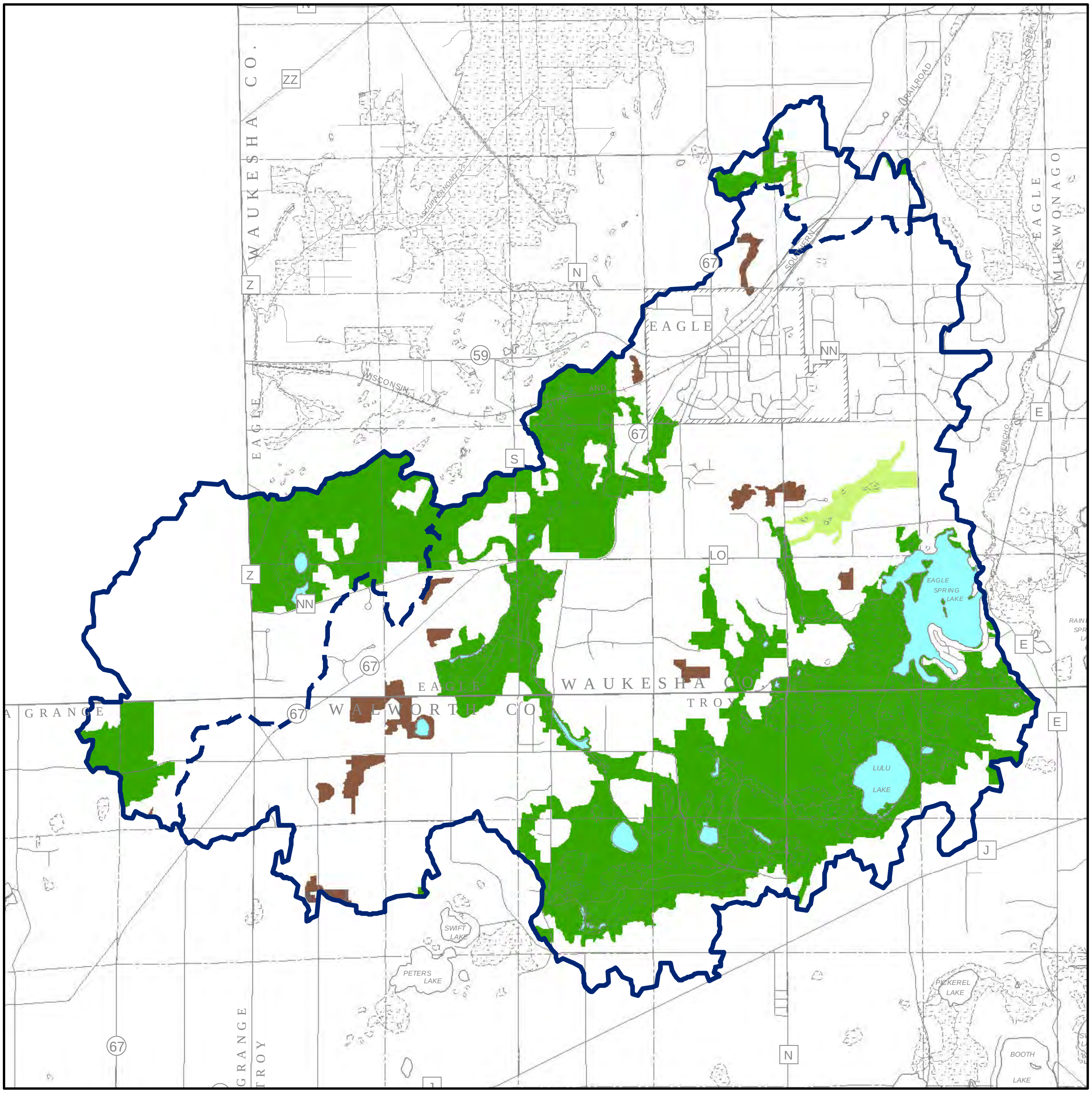
Source: SEWRPC.

N

0 3,000 6,000 Feet

Map 23

ENIRONMENTAL CORRIDORS AND ISOLATED NATURAL RESOURCE AREAS WITHIN THE TOTAL TRIBUTARY AREA TO EAGLE SPRING LAKE



Primary Environmental Corridor

Secondary Environmental Corridor

Isolated Natural Resource Area

Surface Water

Total Tributary Area Boundary

Internally Drained Area Boundary Where Not Coincident with the Total Tributary Area Boundary

NOTE: This information is not available in Jefferson County.

Source: SEWRPC.

- Eagle Center (Haffner) Oak Opening: This 20-acre privately owned parcel is rated NA-3 and contains a broken, gravelly interlobate moraine containing large, scattered, open-grown oaks above a weedy herb layer interspersed with dry prairie openings. It contains a large population of the State-designated threatened kittentails (*Besseva bullii*);

- Malek Wetland: This site is comprised of 94 acres of privately owned land that contains a large, generally good-quality wetland complex of sedge meadow, low prairie, deep and shallow marsh, and scattered shrub-carr.

WDNR-Delineated Sensitive Areas

Within lakes, the WDNR may identify sites that have special importance biologically, historically, geologically, ecologically, or even archaeologically, pursuant to authorities granted under Chapter NR 107 of the *Wisconsin Administrative Code* and/or Chapter 30 of the *Wisconsin Statutes*. Areas are identified as sensitive areas after comprehensive examination and study by WDNR staff from many different disciplines and fields of study. Currently, however, Eagle Spring Lake contains no WDNR-designated sensitive areas; Lulu Lake is classified by the WDNR as an Exceptional Water Resource.

The Environmental Corridor Concept

One of the most important tasks undertaken by SEWRPC as part of its work program was the identification and delineation of those areas of the Region having high concentrations of natural, recreational, historic, aesthetic, and scenic resources which should be preserved and protected in order to maintain the overall quality of the environment. Such areas normally include one or more of the following seven elements of the natural resource base which are essential to the maintenance of both the ecological balance and the natural beauty of the Region: 1) lakes, rivers, and streams and the associated undeveloped shorelands and floodlands; 2) wetlands; 3) woodlands; 4) prairies; 5) wildlife habitat areas; 6) wet, poorly drained, and organic soils; and, 7) rugged terrain and high-relief topography. While the foregoing seven elements constitute integral parts of the natural resource base, there are five additional elements which, although not a part of the natural resource base *per se*, are closely related to or centered on that base and therefore are important considerations in identifying and delineating areas with scenic, recreational, and educational value. These additional elements are: 1) existing outdoor recreation sites; 2) potential outdoor recreation and related open space sites; 3) historic, archaeological, and other cultural sites; 4) significant scenic areas and vistas; and, 5) natural and scientific areas.

The delineation of these 12 natural resource and natural resource-related elements on a map results in an essentially linear pattern of relatively narrow, elongated areas which have been termed “environmental corridors” by SEWRPC. Primary environmental corridors include a wide variety of the abovementioned important resource and resource-related elements and are, by definition, at least 400 acres in size, two miles in length, and 200 feet in width. The primary environmental corridors identified in the Eagle Spring Lake tributary area are, in some cases, contiguous with other environmental corridors and isolated natural resource areas lying outside the lake tributary area boundary and, consequently, meet these size and natural resource element criteria.

It is important to point out that, because of the many interlocking and interacting relationships between living organisms and their environment, the destruction or deterioration of one element of the total environment may lead to a chain reaction of deterioration and destruction. The drainage of wetlands, for example, may have far-reaching effects, since such drainage may destroy fish spawning grounds, wildlife habitat, groundwater recharge areas, and natural filtration and floodwater storage areas of interconnecting lake and stream systems. The resulting deterioration of surface water quality may, in turn, lead to a deterioration of the quality of the groundwater. Groundwater serves as a source of domestic, municipal, and industrial water supply and provides a basis for low flows in rivers and streams. Similarly, the destruction of woodland cover, which may have taken a century or more to develop, may result in soil erosion and stream siltation and in more rapid runoff and increased flooding, as well as destruction of wildlife habitat. Although the effects of any one of these environmental changes may not, in and of itself, be overwhelming, the combined effects may lead eventually to the deterioration of the underlying and supporting natural resource base, and of the overall quality of the environment for life. The need to protect and preserve the remaining environmental corridors within the Eagle Spring Lake tributary area, thus, becomes apparent.

Primary Environmental Corridors

Primary environmental corridors were first identified within the Region in 1963 as part of the original regional land use planning effort of SEWRPC and were subsequently refined under the Commission watershed studies and regional park and open space planning programs. The primary environmental corridors in southeastern Wisconsin generally lie along major stream valleys and around major Lakes and contain almost all the remaining high-value woodlands, wetlands, and wildlife habitat areas, and all the major bodies of surface water and related undeveloped floodlands and shorelands. As reported in the initial comprehensive lake management plan, primary environmental corridors in the Eagle Spring Lake tributary area, which have since been revised, comprised about 4,221 acres, or 25 percent, of the historical tributary area. Portions of this area are also included within the Lulu Lake State Natural Area boundary which currently encompasses about 1,660 acres. It is anticipated that this area will be increased to 2,310 acres based on proposed purchases by the WDNR and the TNC. An additional 114 acres, or 0.7 percent of the historical tributary area, were classed as secondary environmental corridor, while 303 acres, or 2 percent of the historical tributary area, were identified as isolated natural features. These refined environmental corridor lands and isolated natural resources areas are shown on Map 23.

Primary corridors may be subject to urban encroachment because of their desirable natural resource amenities. Unplanned or poorly planned intrusion of urban development into these corridors, however, not only tends to destroy the very resources and related amenities sought by the development, but tends to create severe environmental and development problems, as well. These problems include, among others, water pollution, flooding, wet basements, failing foundations for roads and other structures, and excessive infiltration of clear water into sanitary sewerage systems. The preservation of such corridors, thus, is one of the major ways in which the water quality of Eagle Spring Lake can be maintained and perhaps improved.

SUMMARY

Eagle Spring Lake is a reflection of its tributary area. As noted in Chapter IV, Eagle Spring Lake is a typical hard-water, alkaline lake that is considered to have good water quality. Total phosphorus levels were found to be generally below the level considered to cause nuisance algal and macrophytic growths, and chlorophyll-*a* concentrations were such in recent years as to suggest that algal growth was not an issue in the Lake during the study period. In contrast, the increasing abundance of rooted aquatic plants, especially Eurasian water milfoil, was remarked as an issue of concern. Nevertheless, the Lake provides suitable habitat for a self-sustaining game fish population.

The Eagle Spring Lake tributary area provides a range of habitats for birds, large and small mammals, and reptiles and amphibians, with about 35 percent of the total tributary area being considered to be valuable wildlife habitat. While the area of wildlife habitat has declined in the total tributary area since the initial delineation of habitat areas in 1985, about one-half of the area delineated as wildlife habitat is considered to be of very high value.

The primary environmental corridors contain almost all of the remaining high-value woodlands, wetlands, and wildlife habitat areas, as well as the major surface water resources and related undeveloped floodlands and shorelands. The preservation of such corridors, thus, is one of the major ways in which the water quality of Eagle Spring Lake can be maintained and perhaps improved.

Chapter VI

CURRENT WATER USES AND WATER USE OBJECTIVES

INTRODUCTION

Nearly all major lakes in the Southeastern Wisconsin Region serve multiple purposes, ranging from recreation to receiving waters for stormwater runoff. Recreational uses range from noncontact, passive recreational activities, such as picnicking and walking along the shoreline, to full-contact, active recreational activities, such as swimming, boating, and waterskiing. To accommodate this range of uses, the State of Wisconsin has developed water use objectives for the surface waters of the State, and has promulgated these objectives in Chapters NR 102 and NR 104 of the *Wisconsin Administrative Code*. Complementary water use objectives and supporting water quality guidelines have been adopted by the Southeastern Wisconsin Regional Planning Commission (SEWRPC), and set forth in the adopted regional water quality management plan for all major lakes and streams in the Region.[1] The current water uses, as well as the water use objectives and supporting water quality guidelines for Eagle Spring Lake, are discussed in this chapter.

RECREATIONAL USES AND FACILITIES

Eagle Spring Lake is located within about a one hour drive from much of the metropolitan area of Milwaukee. Its location, accessibility, and degree and type of shoreline development, contribute to a moderate degree of recreational usage by residents and nonresidents alike. The Lake supports a full range of lake uses, providing opportunities for a variety of water-based outdoor recreational activities, including fishing, boating, swimming, and nature studies. Winter recreational uses include cross-country skiing, ice skating, and snowmobiling. The scope of these recreational uses engaged in on Eagle Spring Lake is sufficiently broad to be consistent with the recommended water use objectives of full recreational use and the support of a healthy warmwater sportfishery, as set forth in the adopted regional water quality management plan. Seasonal community and private events and activities take advantage of the aesthetic qualities of the Lake, including events such as the Carp-Out Fisheree conducted annually between 1990 and 2001 which had an average attendance of 70 persons per event. In addition to summer or open water use, ice fishing is a popular winter pastime on Eagle Spring Lake.

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

Park and Open Space Sites

Eagle Spring Lake provides an ideal setting for the provision of parks and open space sites and facilities. There is a publicly-owned open space site—the northern portion of the Lulu Lake State Natural Area—and a publicly-owned lake access site along the Eagle Spring Lake shoreline. The public recreational boating lake-access site is located on the eastern shore of Eagle Spring Lake, and is considered to provide adequate public recreational boating access pursuant to Chapter NR 1 of the *Wisconsin Administrative Code*. This public recreational boating access site recently was upgraded by the WDNR.

Recreational Boating

Water-based outdoor recreational activities on Eagle Spring Lake include boating, fishing, swimming, and other active and passive recreational pursuits. Because of its size, Eagle Spring Lake receives some powerboat use. However, because of its limited depth and density of aquatic plant growth, the predominant use is fishing and pleasure boating. Boat surveys, conducted on June 25 and June 27, 1996, indicated that about 260 boats were moored on the Lake or stored on shore. Most of the watercraft not in use were powerboats, pontoon boats, and fishing boats, with lesser numbers of canoes, paddle boats, sailboats, and personal watercraft. Based upon the observations conducted at the time, it appeared that about 5 percent of these watercraft—about 13 watercraft—were in operation on the Lake at any given time.

A recreational watercraft count conducted on August 6, 2008, indicated a significant increase in the numbers of watercraft moored or stored on and around Eagle Spring Lake. A total of about 450 boats were observed to be moored on the Lake or stored on shore during the 2008 survey. This is an increase of approximately 73 percent in the numbers of boats on the Lake since 1996. This increase in the numbers of boats differs from recent lake recreational use patterns observed elsewhere in the Southeastern Wisconsin Region in recent years, which showed that there were slightly fewer boats in operation than during previous years, possibly due to the increase in motor boat fuel prices during this period. Nonetheless, given the increase in the total population of watercraft, it is likely that about 22 watercraft were in operation on the Lake at any given time. This likely increase in intensity of recreational watercraft usage is slightly above that suggested by the recreational boating access standards set forth in Chapter NR 1 of the *Wisconsin Administrative Code*, which provide for a minimum of nine parking spaces for trailered watercraft at the public recreational boating access site and a maximum of 18 spaces. While these standards do not exclude lake use by riparian owners, they do provide a guideline for boating use; guidelines set forth in the regional park and open space plan would suggest that the Lake could be safely used by about eight high speed recreational watercraft at any given time.[2] This latter guidance is essentially consistent with the minimum standards established in Chapter NR 1.

Recreational Boating Regulations

Recreational boating activities on Eagle Spring Lake are regulated by State boating and water safety laws, and by the specific provisions of the Town of Eagle Ordinance 93-02. The ordinance is summarized in Appendix B.

Angling

Eagle Spring Lake provides a high-quality habitat for gamefish, such as northern pike, smallmouth and largemouth bass, and panfish, as noted in Chapter V of this report. The sizes and the numbers of fish in the Lake provide a range of angling opportunities for both the lake residents and other lake users alike.

Wisconsin Department of Natural Resources Recreational Rating

In 1969, the WDNR used a rating technique to assess the recreational value of Eagle Spring Lake. At that time the Lake received 56 of a possible 72 points, indicating that moderately diverse recreational opportunities were provided by the Lake. In 1996, Commissioners of the ESLMD reassessed Eagle Spring Lake using the same guidelines as the earlier WDNR rating; as a result of the 1996 reassessment, the Lake received a score of 49

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[2]*SEWRPC Planning Report No. 27,* A Regional Park and Open Space Plan for Southeastern Wisconsin: 2000, *November 1977.*

points, indicating a slight decline in the intervening years since the original WDNR rating. In the 1996 assessment, favorable features included the boating and angling opportunities provided, while unfavorable features included variable water quality, primarily as a result of turbidity, and extensive aquatic macrophyte growth.

WATER USE OBJECTIVES

The regional water quality management plan recommended adoption of full recreational use and warmwater fisheries objectives for Eagle Spring Lake. The findings of the inventories of the natural resource base, set forth in Chapters III through V, indicate that the use of the Lake and the resources of the area are generally supportive of such objectives, although it is expected that remedial measures will be required if the Lake is to fully meet the objectives. The recommended warmwater fishery objective is supported in Eagle Spring Lake by a sport fishery based largely on largemouth bass and panfish. These fishes have traditionally been sought after in Eagle Spring Lake. Likewise, the range of recreational activities observed on and around the Lake by Commission staff suggest that the Lake is accommodating a full range of recreational uses, although such uses are dominated by recreational boating and angling.

WATER QUALITY STANDARDS AND GUIDELINES

The water quality guidelines supporting the warmwater fishery and full recreational use objectives, as established for planning purposes in the regional water quality management plan, are set forth in Table 25. These guidelines reflect the standards set forth in Chapters NR 102 and 104 of the *Wisconsin Administrative Code*, but were refined for planning purposes in terms of their application. Guidelines are recommended for pH and dissolved oxygen and fecal coliform concentrations. The guidelines set forth in Table 25 also reflect the recently established standards for temperature and phosphorus concentration adopted by the State of Wisconsin. These standards and guidelines apply to the epilimnion or surface waters of lakes and to streams. Other contaminants, such as oil, debris, and scums; odors, tastes, and color-producing substances; and toxins, are not permitted in waters of the State in concentrations harmful to the aquatic life, as set forth in Chapter NR 102 of the *Wisconsin Administrative Code*. These guidelines and standards serve as water quality objectives for Eagle Spring Lake.

The adoption of these standards and guidelines is intended to specify conditions in the waterways concerned that mitigate excessive macrophyte and algal growths, and promote all forms of recreational use, including angling, in these waters. Implementation of actions consistent with these guidelines will ensure that Eagle Spring Lake is maintained in a mesotrophic condition. As noted in Chapter IV of this report, such a condition is the likely natural state of the major lakes in the Southeastern Wisconsin Region and represents an achievable water quality goal for the Region’s lakes.

Table 25

RECOMMENDED WATER QUALITY STANDARDS TO SUPPORT RECREATIONAL AND WARMWATER FISH AND AQUATIC LIFE USE

Water Quality Parameter	Water Quality Standard
Maximum Temperature	80°F /87°F[a]
pH Range	6.0-9.0 standard units[b]
Minimum Dissolved Oxygen	4.0 mg/l[b]
Maximum Fecal Coliform	200/400 MFFCC/100 ml[c]
Maximum Total Residual Chlorine	0.01 mg/l[d]
Maximum Un-ionized Ammonia Nitrogen	0.02 mg/l[d]
Maximum Total Phosphorus	0.04 mg/l [e]
Other	- -[d,f]

[a]*The sublethal nonspecific (80°F) and acute (87°F) water temperature standards for inland lakes and impoundments in the State were adopted as Section NR 102.25(4)of the* Wisconsin Administrative Code *during September 2010. Temperatures of discharges and rates of temperature change must be such as not to cause harm to fish or aquatic life, as set forth in Sections NR 102.28 and NR 102.29.*

[b]*The pH range must be between 6 and 9 standard units, and the dissolved oxygen concentration must be greater than 4 mg/l, pursuant to Chapter NR 104 of the* Wisconsin Administrative Code*, if the waterbody is not to be classified as having water quality suitable for limited forage fish or limited aquatic life communities.*

[c]*The membrane filter fecal coliform count per 100 milliliters (MFFCC/100 ml) shall not exceed a monthly geometric mean of 200 per 100 ml based on not less than five samples per month, nor a level of 400 per 100 ml in more than 10 percent of all samples during any month.*

[d]*Unauthorized concentrations of substances are not permitted that alone or in combination with other material present are toxic to fish or other aquatic life. Standards for toxic substances are set forth in Chapter NR 105 of the* Wisconsin Administrative Code*.*

[e]*This standard for lakes that are drainage lakes but not stratified lakes is set forth in Section 102.06(4)(b)3, of the* Wisconsin Administrative Code*, adopted in November 2010.*

[f] *All waters shall meet the following minimum standards at all times and under all flow conditions: Substances that will cause objectionable deposits on the shore or in the bed of any body of water shall not be present in such amounts as to interfere with public rights in waters of the State. Floating or submerged debris, oil, scum, or other material shall not be present in such amounts as to interfere with public rights in the waters of the State. Materials producing color, odor, taste, or unsightliness shall not be present in amounts that are acutely harmful to animal, plant, or aquatic life.*

Source: SEWRPC.

Chapter VII

ALTERNATIVE LAKE MANAGEMENT MEASURES

INTRODUCTION

Based upon a review of the inventories and analyses set forth in Chapters II through VI, issues were identified that required consideration in the formulation of alternative and recommended lake management measures. These issues are related to: 1) land use; 2) pollution abatement; 3) water quality; 4) aquatic biota; and, 5) water uses. The management measures considered herein are focused primarily on those measures which are applicable to Eagle Spring Lake, the Town of Eagle, and Waukesha County, although larger-scale measures are noted where such drainage area measures may be applicable to the Lake. In this chapter, the full range of possible management measures is considered and reviewed for inclusion in the recommended lake management plan for Eagle Spring Lake, which is set forth in Chapter VIII.

TRIBUTARY AREA MANAGEMENT ALTERNATIVES

Land Use

A basic element of any water quality management effort for a lake is the promotion of sound land use development and management within the tributary area. The types and locations of future urban and rural land uses in the area tributary to Eagle Spring Lake will determine, to a large degree, the character, magnitude, and distribution of nonpoint sources of pollution; the practicality of, as well as the need for, stormwater management; and, to some degree, the water quality of the Lake. Additionally, the use of water within this drainage area, and especially of groundwater resources underlying the drainage basin, will affect the hydrology and physical limnology of the Lake and the Upper Mukwonago River basin.

Potentially applicable tributary area management measures start at the lake shore and extend into the tributary area surrounding the Lake, and into the larger watershed draining to Eagle Spring Lake. Interventions at each of these scales are outlined below, while in-lake management measures are reviewed in the later portions of this chapter.

Existing year 2000 and planned year 2035 buildout land use patterns and existing zoning regulations in the tributary area to Eagle Spring Lake have been described in Chapter II. If the recommendations set forth in the adopted Waukesha County development plan and the regional land use plan are followed, it may be expected that, under buildout conditions, some additional urban-density residential development would occur within the area directly tributary to Eagle Spring Lake.[1] Much of this residential development is likely to occur on agricultural lands, within the drainage area upstream of Eagle Spring Lake. Infilling of existing platted lots and some backlot development, as well as the redevelopment and reconstruction of existing single-family homes around the Lake itself, also may be expected to occur. It should be noted that further development in the total area tributary to Eagle Spring Lake is limited as a result of land acquisitions by the Wisconsin Department of Natural Resources (WDNR) within and adjacent to the Kettle Moraine State Forest, and land acquisitions by The Nature Conservancy (TNC). These acquisitions and associated conservancy zoning provide a degree of protection of the watershed from expansion of urban density land uses.

Within the area directly tributary to the Lake, however, recent surveillance indicates that some urban density development and redevelopment is currently occurring. Forecast changes in urban residential lands, for example, would suggest that the area of land occupied by single-family residential development will almost double between the year 2000 and the year 2035, increasing from about 1,450 acres in 2000 to about 2,850 acres in 2035. Accordingly, given the potential impact of lakeshore development on the lake resources, land use development or redevelopment proposals around the shoreline of Eagle Spring Lake and within the area tributary to the Lake should be evaluated for potential impacts on the Lake, as such proposals are advanced.

Development in the Shoreland Zone

Recent studies of the potential impact of riparian landscaping activities on the nutrient loadings to lakes in southeastern Wisconsin have suggested that urban residential lands can contribute up to twice the mass of phosphorus to a lake when subjected to an active program of urban lawn care than similar lands managed in a more natural fashion.[2] While the State of Wisconsin has subsequently adopted new turf management regulations pursuant to 2009 *Wisconsin Act* 9, the application of other agrochemicals to such lands in excess of the plant requirements is likely to continue to result in enhanced contaminant loadings directly to the adjacent waterbodies. For this reason, the Mukwonago River watershed protection plan recommends maintenance and expansion of riparian buffers around watercourses within the basin.[3] Such shoreland management measures complement other land management measures such as implementation to community-level land use plans and zoning regulations, and contribute to the protection and integrity of riparian corridors. Despite the considerable residential and other development that has occurred around Eagle Spring Lake, the wetland areas to the southeast of the main lake basin have remained largely undisturbed. Comparison of Maps 19 and 20 in Chapter V of this plan not only shows the extent of existing wetlands and shoreland buffers around the shorelands of Eagle Spring Lake in 1941 and 2005, but also reflect the presence of conservancy lands and the stewardship exercised by private landowners since the 1940s.

Development in the Tributary Area

The level of development envisioned in the Waukesha County development plan for the total area tributary to Eagle Spring Lake indicates continuing urban development, generally on large suburban-density lots. Careful review of applicable zoning ordinances, to incorporate levels and patterns of development consistent with the Mukwonago River protection plan within the area tributary to Eagle Spring Lake, is recommended. Changes in the zoning ordinances should be considered to better reflect the land use patterns recommended in the County

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[1]*See SEWRPC Community Assistance Planning Report No. 209,* A Development Plan for Waukesha County, Wisconsin, *August 1996; SEWRPC Planning Report No. 48,* A Regional Land Use Plan for Southeastern Wisconsin: 2035*, June 2006.*

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

[3]*SEWRPC Community Assistance Planning Report No. 309,* Mukwonago River Watershed Protection Plan, *June 2010.*

development plan, as refined through the River protection plan. For example, consideration should be given to minimizing the areal extent of future residential development by developing specific provisions and incentives to encourage cluster residential development, or conservation development, on smaller lots while preserving, to the greatest extent practicable, the open space on each property or group of properties considered for development.[4] In addition, consideration of other provisions to ensure appropriate monitoring and maintenance of onsite sewage disposal systems, where such systems exist, and effective stormwater and runoff control and management, is recommended. Each of these latter measures is addressed in greater detail below.

Wastewater Management
At the time of the current study, urban residential development located in some areas of the total area tributary to Eagle Spring Lake are included within public sanitary sewer service areas, as recommended in the adopted regional water quality management plan,[5] even though such lands continue to be served by onsite sewage disposal systems. Isolated development, lying outside these areas but within the total area tributary to Eagle Spring Lake, is expected to continue to be served by onsite sewage disposal systems. Recent land ownership changes, however, associated with the acquisition of the Rainbow Springs property by the State of Wisconsin, would suggest that the sewerage needs in the area be reevaluated, and the provision of wastewater management services modified accordingly.

As reported in Chapter IV, because total phosphorus loadings from onsite sewage disposal systems are estimated to contribute only a minor proportion, about 5 percent or less, of the total phosphorus load to the Lake, onsite sewage disposal is likely to remain the primary wastewater treatment method, it is recommended that an onsite sewage disposal system management program continue to be carried out, including the conduct of an ongoing informational and educational effort to enhance awareness of the need for regular maintenance of these systems. Homeowners should be advised of the rules, regulations, and system limitations governing onsite sewage disposal systems, and should be encouraged to undertake preventive maintenance programs.

Stormwater Management
With respect to stormwater management, Waukesha County adopted a stormwater management ordinance during 2000. The Town of Eagle utilizes this ordinance. The County ordinance reflects best practices insofar as the determination of stormwater flows, mitigation of flooding potential, and the control of contaminants from land use activities are concerned. Periodic review of this ordinance and its provisions for consistency with best practices, and to ensure its currency with the state-of-the-art, should be undertaken to facilitate control of urban-sourced contaminants that could potentially be delivered to the Lake. To this end, efficient use of stormwater management practices such as swales and rain gardens, protection of riparian buffers, and maintenance of wetlands and floodlands within the tributary area to absorb flood flows form effective management techniques.

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

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

[5]*See SEWRPC Memorandum Report No. 93,* A Regional Water Quality Management Plan for Southeastern Wisconsin: An Update and Status Report, *March 1995.*

Wetland protection can be accomplished through land use regulation and, in cases where land use regulations may not offer an adequate degree of protection, through public acquisition of sensitive sites. Many of the wetland areas are currently protected by zoning and regulatory programs administered by the U.S. Army Corps of Engineers (USACE), WDNR, and County and municipal authorities under one or more of the Federal, State, County, and local regulations. Additional protections may be warranted, as recommended, for example, in the regional natural areas and critical species habitat protection and management plan and watershed protection plan.

Pollution Abatement

All human activities upon the land surface result in some degree of mobilization of contaminants and modification of surface runoff patterns that can affect lakes and streams, their quality, and biotic condition. Many human activities can be mitigated to a large extent by the implementation of sound planning, appropriate nonpoint source pollution abatement measures, and the actions of an informed public. In the first instance, sound land use development and management in the tributary area, and protection of environmentally sensitive lands, are the fundamental building blocks for protecting lake and stream water quality and habitat, and preserving human use opportunities that will support a broadly based recreational and residential community. In addition, specific nonpoint source pollution control and abatement measures should be integrated into land use regulations and promoted by a far-reaching informational and educational program within the areas tributary to individual lakes and streams. These land-based regulations have been summarized to a large extent in the foregoing sections of this plan. This section discusses relevant pollution control and abatement measures that could be applicable to the tributary area of Eagle Spring Lake.

Nonpoint Source Pollution Abatement

Tributary area management measures may be used to minimize nonpoint source pollutant loadings from the tributary area by locating development within a tributary basin in accordance with sound land use planning practices. Beyond such actions, specific interventions may be required to control the mass of contaminants generated by various types of land use activity that are transported to the Lake. Rural sources of contaminants arise as pollutants transported by runoff from cropland and pastureland, while urban sources include contaminants transported by runoff from residential, commercial, industrial, transportation, and recreational land uses, and from construction activities. Within the area tributary to Eagle Spring Lake, the presence of significant areas of conservancy land and the extent of the riparian buffers surrounding the watercourses tributary to the Lake currently provide a significant degree of resource protection. Hence, it is possible to focus nonpoint source pollution abatement practices on specific areas of the watershed, primarily those areas immediately adjacent to the Lake. Within this area, application of nonpoint source pollution control measures based upon the recommendations set forth in the regional water quality management plan as refined,[6] and in the Waukesha County land and water resource management plan,[7] should continue to contribute to the reduction in nonpoint source pollutant loadings by up to 25 percent in both urban and rural areas of the watershed, recommended in the regional water quality management plan.

As described in Chapter IV, the most readily controllable loadings are associated primarily with runoff from urban lands within the area tributary to the Lake, and from urbanizing lands throughout the area tributary to the Lake, that are linked to the Lake by way of streams and stormwater drainage systems. These loadings constituted about 3 percent of the sediment load, 8 percent of the total phosphorus load, and 100 percent of the heavy metals load to Eagle Spring Lake, based upon year 2000 land use patterns. Phosphorus loadings from the remainder of

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

[7]*Waukesha County,* Waukesha County Land and Water Resource Management Plan: 2006-2010*, January 2006.*

the tributary area (about 81 percent), and from direct deposition onto the lake surface (about 8 percent), contributed the balance of the total load. The contributions of phosphorus and sediment from rural lands are expected to decrease as agricultural lands are progressively converted to urban uses, although heavy metals loads are likely to increase. While some proportion of these contaminant loads may be attenuated as a consequence of the extensive wetland areas within the tributary area, the ability of the wetlands to assimilate pollutants is wholly dependent upon the maintenance of the structure and function of their ecosystems. These features can be overwhelmed by inappropriate land uses that result in the degradation of the wetlands, diminishing their ability to capture contaminants or overloading the ability of the wetlands to assimilate contaminants. Thus, the control of nonpoint sources of water pollution at their sources is an important consideration. Properly applied, such controls can reduce the pollutant loadings to a lake by about 25 percent or more.

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

Rural Nonpoint Source Controls

Upland erosion from rural lands is a major contributor of sediment to streams and lakes. Estimated phosphorus and sediment loadings from rural lands in the area tributary to Eagle Spring Lake were presented in Chapter IV. These data were utilized in determining the pollutant load reduction that could be achieved, the types of practices needed, and the extent of the areas to which the practices need to be applied within the area tributary to Eagle Spring Lake. While agricultural land uses are anticipated to be a declining form of land usage within the area tributary to Eagle Spring Lake, the agricultural operations that remain within the tributary area will continue to contribute a significant proportion of the sediment load to the waterbody. Thus, detailed farm conservation plans are likely to continue to be required to adapt and refine erosion control and nutrient and pest management practices for individual farm units. Generally prepared with the assistance of staff from the U.S. Natural Resources Conservation Service (NRCS) and/or county land and water conservation departments, such plans identify desirable tillage practices, cropping patterns, and rotation cycles. The plans also consider the specific topography, hydrology, and soil characteristics of the farm; identify the specific resources of the farm operator; and, articulate the operator objectives of the owners and managers of the land. Similarly, master plans for the Southern Unit of the Kettle Moraine State Forest (including the recent Rainbow Springs acquisition), and the management plans of the TNC, should detail local level pollution abatement practices applicable in these areas.

Urban Nonpoint Source Controls

As of 2000, established urban land uses, excluding internally drained areas, comprised about 450 acres, or about 20 percent, of the total area tributary to Eagle Spring Lake. The annual phosphorus loading from these urban lands was estimated to be 450 pounds, or less than 10 percent of the total load of phosphorus to the Lake. This is anticipated to increase to about 20 percent of the total load of phosphorus under buildout conditions. Those urban-source pollutant loads that are most controllable include runoff from the residential lands adjacent to the Lake, and urban runoff from areas with a high proportion of impervious surface. The potential also exists within the Eagle Spring Lake tributary area for significant construction site erosion impacts if development continues in the tributary area as has been the recent trend.

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

Particular attention also should be given to reducing pollutant loadings from high pollutant loading areas, such as parking lots. To the extent practicable, parking lot stormwater runoff should be diverted to areas covered by pervious soils and appropriate vegetation, rather than being directly discharged to surface waters. Sweeping, increased catch basin cleaning, leaf litter and vegetation debris collection, and stormwater storage and infiltration measures can enhance the control of nonpoint-source pollutants from urban and urbanizing areas, and reduce urban nonpoint source pollution loads by up to about 50 percent. The proper design and application of such urban nonpoint source control measures is consistent with the Waukesha County stormwater ordinance provisions.

Developing Area Nonpoint Source Controls

Developing areas can generate significantly higher pollutant loadings, albeit for relatively short periods. Developing areas include a wide array of activities, including urban renewal projects, individual site development within the existing urban area, and new land subdivision development. The regional land use and county development plans envision some large-lot suburban-density development within the area tributary to Eagle Spring Lake, together with the redevelopment of existing, platted lakefront lots. Consequently, there is the potential for significant construction activity on lands within the total area tributary to the Lake.

Construction sites produce suspended solids and other contaminant loadings at rates several times higher than established urban land uses. Control of sediment loss from construction sites can be accomplished using the measures set forth in the model ordinance developed by the WDNR in cooperation with the Wisconsin League of Municipalities.[8] These controls include temporary measures that can be taken to reduce pollutant loadings from construction sites during stormwater runoff events. Construction erosion controls may be expected to reduce pollutant loadings from such sites by about 75 percent. While such controls may have only a minimal impact on the total pollutant loading to the Lake due to the relatively small amount of land being developed at any given time, such controls are important pollution control measures that can abate localized short-term loadings of phosphorus and sediment from the tributary area and the upstream tributary area. The control measures include such revegetation practices as temporary seeding, mulching, and sodding, and such runoff control measures as filter fabric fences, straw bale barriers, storm sewer inlet protection devices, diversion swales, sediment traps, and sedimentation basins.

The Waukesha County construction site erosion control ordinance is administered and enforced by the County in both the shoreland and nonshoreland areas of the unincorporated areas within the total tributary area of Eagle Spring Lake. The provisions of these ordinances apply to all development except single- and two-family residential construction. Single- and two-family construction erosion control practices are to be specified as part of the building permit process. Because of the potential for development, some of it albeit unplanned, in the area tributary to Eagle Spring Lake, it is important that adequate construction erosion control programs, including enforcement, be in place.

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[8]*Wisconsin League of Municipalities and Wisconsin Department of Natural Resources,* Wisconsin Construction Site Best Management Practices Handbook, *April 1994.*

IN-LAKE MANAGEMENT ALTERNATIVES

The reduction of external contaminant loads to Eagle Spring Lake that are likely to be achieved through the aforedescribed measures should help to prevent further deterioration of lake water quality conditions. These measures, however, may not completely eliminate existing water quality and lake-use concerns. In mesotrophic and eutrophic lakes, the nutrients previously delivered to, and retained in, such lakes can result in increased macrophyte growth that can result in restricted water use potentials, even after the implementation of tributary area-based management measures. Given that Eagle Spring Lake falls within the mesotrophic range, the consideration of in-lake rehabilitation techniques is likely to be of value.

The applicability of specific in-lake rehabilitation techniques is highly dependent on lake-specific characteristics. The success of any lake rehabilitation technique can seldom be guaranteed, and because of the relatively high cost of applying most techniques, a cautious approach to implementing in-lake rehabilitation techniques is generally recommended. Certain in-lake rehabilitation techniques should be applied only to lakes in which: 1) nutrient inputs have been reduced below the critical level; 2) there is a high probability of success in the applications of a particular technology in lakes of similar size, shape, and quality; and, 3) the possibility of adverse environmental impacts is minimal. Finally, it should be noted that many in-lake rehabilitation techniques require the issuance of permits from appropriate State and Federal agencies prior to implementation.

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

Water Quality Management

As discussed in Chapter IV, water quality information on Eagle Spring Lake was compiled from data gathered under the auspices of the U.S. Geological Survey (USGS) trophic state index (TSI) monitoring program during the process of formulating the initial comprehensive lake management plan for the Lake. Since that time, the Eagle Spring Lake Management District (ESLMD) has participated in the volunteer monitoring program formerly known as the WDNR Self-Help Monitoring Program and currently known as the University of Wisconsin-Extension (UWEX) Citizen Lake Monitoring Network (CLMN). Volunteers enrolled in this program gather data at regular intervals on water clarity using a Secchi disk. Because pollution tends to reduce water clarity, Secchi-disk measurements are generally considered one of the key parameters in determining the overall quality of a lake's water as well as a lake's trophic status. Secchi-disk measurement data are compiled in a WDNR-sponsored lake water quality data base, accessible online through the WDNR website at: *http://dnr.wi.gov/lakes/Projects/ByCounty.aspx*. The Expanded CLMN Monitoring Program involves the collecting of data on several key physical and chemical parameters in addition to the Secchi-disk measurements. Under this program, samples of lake water are collected by volunteers at regular intervals and are analyzed for total phosphorus and chlorophyll-*a* concentrations by the State Laboratory of Hygiene (SLOH). Although this more extensive data collection effort places more of a burden on the volunteers, these data provide greater insight into the water quality of a lake and thus provide more timely awareness of changing in-lake conditions.

This awareness is critical in determining the need for, and extent of, in-lake management practices that may be required to moderate potentially deleterious impacts on the lake ecosystem. Such practices include a variety of measures designed to directly modify the magnitude of either a water quality determinant or biological response. While specific measures aimed at managing aquatic plants and the fisheries are considered separately below, this section reviews possible in-lake measures to address nutrients, water residence times, and lake sediments.

In-Lake Nutrient Management by Phosphorus Precipitation and Inactivation

Nutrient inactivation is a restoration measure that is designed to limit the biological availability of phosphorus by chemically binding the element in the lake sediments using a variety of divalent or trivalent cations, highly positively charged elements. Aluminum sulfate (alum), ferric chloride, and ferric sulfate are commonly used cation sources. The use of these techniques to remove phosphorus from nutrient-rich lake waters is an extension of common water supply and wastewater treatment processes. Costs depend on the lake volume and type and dosage of chemical used. Approximately 100 tons of alum, costing about $200 per ton, can treat a lake area of about 40 acres. Effectiveness depends, in part, on the ability of the alum flocculent to form a stable “blanket” on the lakebed; to wit, on flushing time, turbulence, as a function of lake depth, lake water acidity (pH) and rate of continued sedimentation. Impacts can include the release of toxic quantities of free aluminum into the water. The resulting improved water clarity also can encourage the spread of rooted aquatic plants.

Because of the polymictic state of Eagle Spring Lake, as well as the relatively low levels of phosphorus in the Lake, nutrient inactivation through the employment of aluminum sulfate is not considered a viable option at this time.

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

Inlet/Outlet Control Operations
The inflow to Eagle Spring Lake is moderated to an extent by the presence of Lulu Lake immediately upstream of Eagle Spring Lake. While Lulu Lake does not have a control structure such as that at Eagle Spring Lake, the volume of that waterbody combined with the extensive wetland area between the two lakes and the channel dimensions between the Lake, can act to moderate flood flows into Eagle Spring Lake. In contrast, the outflow from Eagle Spring Lake is managed through two outlet structures locally known as the Wambold dam—a dam with a manually operated control gate—and Kroll dam—a former mill race—both located at the east side of Eagle Spring Lake just west of CTH E. These structures comprise a single impoundment referenced as Wambold dam in WDNR dam File #67.4 The Wambold dam is owned and operated by the ESLMD. The operating levels of the impoundment were re-established during 2010 by the WDNR in a refined operating permit for the dam. These elevations, ranging from 9.4 to 9.7 based upon a local datum, reflect the historic and actual operating levels of the impoundment, as can be seen on Maps 19 and 20 in Chapter V.[9] During this same period (2009-2010), the ESLMD completed required concrete work on the dam on July 16, 2009; submitted the remaining required information on the dam and its operations on January 11, 2010;[10] and, received WDNR after-the-fact approval of this work on February 17, 2010.[11]

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

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[9]*Reflecting SEWRPC Level 1 Certified Survey (11-28-2007 MMS).*

[10]*Repairs and modifications were undertaken by the Eagle Spring Lake Management District pursuant to plans and specifications developed by Ayres and Associates, dated January 11, 2010.*

[11]*Ms. Michelle Schneider of the WDNR staff,* in litt.*, dated February 17, 2010.*

Drawdown can affect the lake fisheries both indirectly, by reducing the numbers of food organisms, and directly, by reducing available habitat and desiccating (drying out) eggs and spawning habitat. In contrast, increasing water levels, especially during spring, can provide enhanced fish breeding habitat for some species, such as pike and muskellunge, and increase the food supply for opportunistic feeders, such as bass, by providing access to terrestrial insects, for example. Costs also are primarily associated with loss of use. Effectiveness is better than for aquatic plant control, but the potential for side effects remains high given that undesirable fish species may also benefit from water level changes.

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

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

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

Because of the unpredictability of the results, the impairment of recreational uses, and the temporary nature of the beneficial effects of a drawdown, drawdown is not considered a viable option for Eagle Spring Lake. That said, there may be some benefit to be gained by allowing a periodic increase in water level during the spring to flood riparian wetlands surrounding Eagle Spring Lake to encourage breeding of northern pike in these wetlands.

Water Level Stabilization

While water level management in a lake is a common technique for managing fish and aquatic macrophytes, the consequences of manipulating lake water levels can be both beneficial and deleterious. The major impacts from the riparian owners' standpoint is that the fluctuating water levels affect shoreline erosion, interfere with proper pier height and placement, as well as the correct placement of shoreline protection structures.

Periodic changes in precipitation and weather patterns between years often result in fluctuation of water loads to a lake. These fluctuations in turn can affect lake levels. Most plant and animal species can cope with this level of water surface fluctuation without experiencing the consequences, both positive and negative, noted above.

Nevertheless, while artificial stabilization of the water surface is not recommended for Eagle Spring Lake, it is desirable from the point of view of aquatic habitat that water level fluctuations be maintained within natural limits.

In-Lake Sediment Management

Nutrient Load Reduction

Nutrient diversion is a restoration measure, which is designed to reduce the trophic state or degree of over-feeding of a waterbody and thereby control the growth response of the aquatic plants in the system. Control of nutrients in surface water runoff in the tributary area, as described above under tributary area management measures, is generally preferable to attempting such control within a lake. That said, in-lake control of nutrients generally involves removal of contaminated sediments or encapsulation of nutrients by chemical binding, as in the case of the nutrient inactivation measures described above. Costs are generally high, involving an engineered design and usually some form of pumping or excavation. Effectiveness is variable, and impacts include the rerelease of nutrients into the environment. While some limited deepening of specific areas within the lake basin may be warranted for navigational purposes, the widespread use of in-lake nutrient load reduction measures is not warranted in Eagle Spring Lake. As noted in Chapter IV, the good agreement between predicted and observed phosphorus concentrations in the Lake strongly suggests that the external nutrient load to the Lake accounts for the major part of the observed phosphorus concentration in the lake water column. Consequently, in-lake nutrient load reduction is not considered to be a viable alternative in the case of Eagle Spring Lake.

Dredging

Sediment removal is a restoration measure that is carried out using a variety of techniques, both land-based and water-based, depending on the extent and nature of the sediment removal to be carried out. For larger-scale applications, a barge-mounted hydraulic or cutter-head dredge is generally used, while, for smaller-scale operations, a shore-based drag-line system is typically employed. Both methods are expensive, especially if a suitable disposal site is not located close to the dredge site. Costs for removal and disposal begin at between $10 and $25 per cubic yard, with the cost of sediment removal alone beginning at between $3.00 and $5.00 per cubic yard. Effectiveness of dredging varies with the effectiveness of tributary area controls in reducing or minimizing the sediment sources. Federal and State permits are required for use of this option.

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

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

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

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

In addition, while dredging can result in an immediate increase in lake depth, such increases may be short-lived if the sources of sediment being deposited in the lake are not controlled within the area tributary to the lake. The sediment load reaching Eagle Spring Lake comes from both urban and agricultural lands within the area tributary to Eagle Spring Lake. Sediment also may be generated from streambank and shoreland erosion. Many of these sources can be effectively controlled through the adoption, implementation, and maintenance of recommended control measures within the tributary area.

Objectives of Dredging in Eagle Spring Lake

The ESLMD property owners and electors, at their annual meeting held on August 8, 1998, instructed the Lake Management District Board of Commissioners to further investigate the conditions under which dredging could be pursued as a lake management measure and to generate an estimate of the costs associated with the selective deepening of the Lake. In response to this mandate, a facilitated discussion was convened at a meeting of the Eagle Spring Lake Management District Board of Commissioners held on November 5, 1998, to explore the feasibility of dredging within Eagle Spring Lake (See Appendix D-3). The Commissioners of the Eagle Spring Lake Management District, those electors of the District present, and Department of Natural Resources staff articulated the need for dredging based upon five principal uses of the waters of Eagle Spring Lake. A consensus was reached that the Lake should be a multiple purpose waterbody serving boating, swimming, fishing, and aesthetic purposes and contributing to the maintenance of property values in the Eagle Spring Lake community. It was further agreed that the latter two uses could be best served by achieving the first three uses identified. To this end, and citing data set forth in the initial comprehensive lake management plan, the participants identified the characteristics of a boatable, swimmable and fishable lake:

- For the Lake to be considered boatable, it would have to have adequate depth to permit the use of pontoon boats, ski-boats, and sailboats;

- For the Lake to be considered swimmable, it would have to have adequate depth and clarity for diving, swimming outside of aquatic plant beds, and good water quality;

- For the Lake to be considered fishable, it would have to have sufficient variation in depths to provide sand and gravel spawning areas, adequate and diverse (native) aquatic plant communities, deep water areas, shallow water areas, and marshlands.

Based upon these characteristics, the participants assigned water depths to each use. To be boatable with respect to ski-boats (and other high-speed watercraft), it was determined that the Lake should have between eight feet and 12 feet of depth in the boating area-based upon the estimated depth to which boat propellers create a disturbance of the Lake bottom which was approximated as five times the depth of the propeller shaft in the water. To be swimmable, the Lake should have at least six feet of depth for diving and about 12 feet of depth to create conditions that would limit the growth of aquatic plants. Thus, it was determined that the optimal depth to which portions of the lake should be dredged would be about 12 feet. It was also agreed that, in order to promote a diverse fishery, a variety of depths should be maintained within the Lake basin.

Additionally, the meeting participants indicated specific areas of the Lake where deepening would be appropriate, based upon the use patterns reported in the initial comprehensive lake management plan. To accommodate high-speed boating activities, the priority areas for sediment removal were identified as corridors within the main Lake basin of approximately 150 feet minimum width. This area is part of the recommended boating management zone identified in the initial comprehensive lake management plan. It also was proposed to connect the boating management zone serving the northwestern embayment of the Lake with the main Lake basin by deepening a boating lane through the demarcated habitat area to the west of the islands in that area of the Lake. However, to protect the extensive wetland complex that forms a significant portion of the western shoreline of the Lake, it was agreed that the area demarcated as a fishing management zone along this shoreline in the lake management plan be protected. Finally, in addition to the areas set forth above, it was suggested that certain other sites, primarily in the embayments to the north and south of the main Lake basin be selectively deepened. These areas in the southern portion of the Lake had been demarcated as access management zones in the lake management plan and as a fishing management zone in the northern portion of the Lake. To this end, a conceptual dredging scheme was agreed by the participants. Sixteen potential dredging project areas were identified, based upon the agreed conceptual dredging scheme. Sediment depths in these various project areas ranged from one to more than 12 feet of accumulated soft sediment. The estimated volume of material to be removed should the conceptual dredging project be fully executed was approximately 1,100,000 cubic yards of sediment.

Sediment samples obtained from Eagle Spring Lake suggested that any residual arsenic resulting from historic aquatic plant management practices employed at Eagle Spring Lake was below the proposed action level, although some localized high concentrations of lead and ammonia-nitrogen were observed along the wetland fringe that forms the western shores of the Lake.

DREDGING METHOD

While various means can be used to remove sediments from lakes, and especially from those lakes which have a water level control structure, such as Eagle Spring Lake, it was agreed among the participants in the discussion that the most acceptable means of removing accumulated soft sediments from Eagle Spring Lake would be by means of hydraulic dredging. This means of deepening the waterbody was determined to have the least impact not only on the recreational use of the Lake by riparians and visitors to Eagle Spring Lake, but also on the aquatic flora and fauna of the Lake, including fish populations. Hence, the use of drawdown followed by sediment removal using conventional drag-line or clamshell dredging techniques was discounted. The participants expressed interest in reviewing the experiences of the School Section Lake Management District in the conduct of their recent dredging project during which that District purchased and later resold an hydraulic dredger.

COST OF DREDGING AND SITUATION OF THE CONFINED DISPOSAL FACILITY

During follow-up discussions with the Lake Management District Commissioners at their meeting held on December 15, 1998, it was concluded that the cost of conducting a dredging project and the siting of a disposal facility for the dredge spoils would be assumed to be similar to those costs and locations identified during the dredging project completed by the Eagle Spring Lake Management District during 1995. Those costs and locations are summarized in the initial comprehensive lake management plan for Eagle Spring Lake. Based upon the previous experience of the Eagle Spring Lake Management District, it can be estimated that the overall project costs for completing the dredging program as outlined above would approach $5,000,000. Based upon experiences elsewhere in the Southeast Wisconsin Region, such costs could range from $5,000,000 to as high as $15,000,000.

OUTCOME OF THE DREDGING PROPOSALS

The dredging of lakebed material from navigable waters of the State requires a permit to be issued by the WDNR pursuant to Chapter 30 of the *Wisconsin Statutes* and by the U.S. Army Corps of Engineers pursuant to Chapter 404 of the *Code of Federal Regulations*. In addition, because current solid waste disposal regulations define dredged material as a solid waste, any dredging project of over 3,000 cubic yards requires solid waste licensing of the disposal site pursuant to Chapter NR 180 of the *Wisconsin Administrative Code*. The ESLMD application for the State Chapter 30 permit, submitted to the WDNR in response to the District's mandate from the electors and property owners of the District, was subsequently denied by the WDNR. Consequently, and given the additional consideration of the potential recreational use impacts of a drawdown during the summer and winter recreational seasons, extensive dredging of Eagle Spring Lake is not considered a viable alternative at this time.

Fisheries and Aquatic Plant Management

Fisheries Management Measures

Eagle Spring Lake provides a quality habitat for a healthy, warmwater fishery. Currently, adequate water quality, dissolved oxygen levels, bottom substrate materials along the shoreline, and a diverse aquatic plant community exist for the maintenance of a sportfish population in the Lake. Winterkill currently is not a problem. The Lake supports a gamefish-panfish fishery, with popular gamefish such as largemouth bass, smallmouth bass, walleye, and northern pike, being present in the Lake. In addition, the lake chubsucker, which is a species of special concern in the State of Wisconsin, is present in the Lake, as noted in Chapter V.

Habitat Protection

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

Loss of habitat should be a primary concern of any fisheries management program. Such environmentally valuable areas within the Lake and its tributary area are the most important areas to be protected. In addition, limiting or restricting certain activities in those areas of the Lake containing important fish habitat will minimize significant disturbance of fish activities and aquatic plant beds. Within these areas, aquatic plant management measures should be restricted, and dredging, filling, and the construction of piers and docks should be discouraged. It is especially important that habitat disturbances be limited during the breeding and spawning season, especially in those areas with suitable substrates for fish reproduction, such as the sand bar on the northeastern shoreline of Lulu Lake.

It also should be noted that water level fluctuations other than those consequent to natural climatic variability and water quality conditions can affect fish habitat and the breeding success of fishes. In this regard, the maintenance of lake water levels within natural limits, and the maintenance of good water quality, cannot be overemphasized as fish habitat protection measures.

Shoreline Maintenance

Shoreline maintenance refers to a group of measures designed to reduce and minimize shoreline loss due to erosion by waves, ice, or related actions of the water. Most of the shoreline of Eagle Spring Lake is protected by some type of structural measure. Four shoreline erosion control techniques were in use during 2008: natural vegetative buffer strips, rock and riprap revetments, wooden and concrete bulkheads, and beach. Maintenance of a vegetated buffer strip immediately adjacent to the Lake is the simplest, least costly, and most natural method of reducing shoreline erosion. This technique employs natural vegetation, rather than maintained lawns, within five to 10 feet of the lakeshore and the establishment of emergent aquatic vegetation from two to six feet lakeward of the shoreline. The use of vegetated buffer strips is encouraged by the WDNR for use on low to moderate energy shorelines, pursuant to Chapter NR 328 of the *Wisconsin Administrative Code*, which includes a worksheet for determining shoreline protection structures that can be permitted in lakes in Wisconsin.

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

Rock revetments, or riprap, are a highly effective method of shoreline erosion control applicable to high energy shorelines, as defined in Chapter NR 328 of the *Wisconsin Administrative Code*. The technique involves the shaping of the shoreline slope, the placement of a porous filter material, such as sand, gravel, or pebbles, on the slope and the placement of rocks on top of the filter material to protect the slope against the actions of waves and ice. The advantages of rock revetments are that they are highly flexible and not readily weakened by movements caused by settling or ice expansion, they can be constructed in stages, and they require little or no maintenance. The disadvantages of rock revetments are that they limit some uses of the immediate shoreline. The rough, irregular rock surfaces are unsuitable for walking; require a relatively large amount of filter material and rocks to be transported to the lakeshore; and can cause temporary disruptions and contribute sediment to the lake. If improperly constructed, revetments may fail because of washout of the filter material. A rock revetment is estimated to cost $25 to $35 per linear foot. While many of these structures are already in place at Eagle Spring Lake, future replacement of these structures with vegetated shoreline protection alternatives may be required in accordance with Chapter NR 328 requirements.

Natural vegetated buffer strips and riprap, as shown in Figure 31, are considered viable options, especially in those areas subject to significant wind-wave, boat wake, and ice scour erosion. In those portions of the Lake subject to direct action of wind waves and ice scour, the use of riprap would provide a more robust means of stabilizing shorelines, while elsewhere along the lakeshore creation of vegetated buffer strips would provide not only shoreline erosion protection but also enhanced shoreland habitat for fish and wildlife. In this regard, it should be noted that the selection of appropriate shoreland protection structures is subject to the provisions of Chapter NR 328 of the *Wisconsin Administrative Code*.

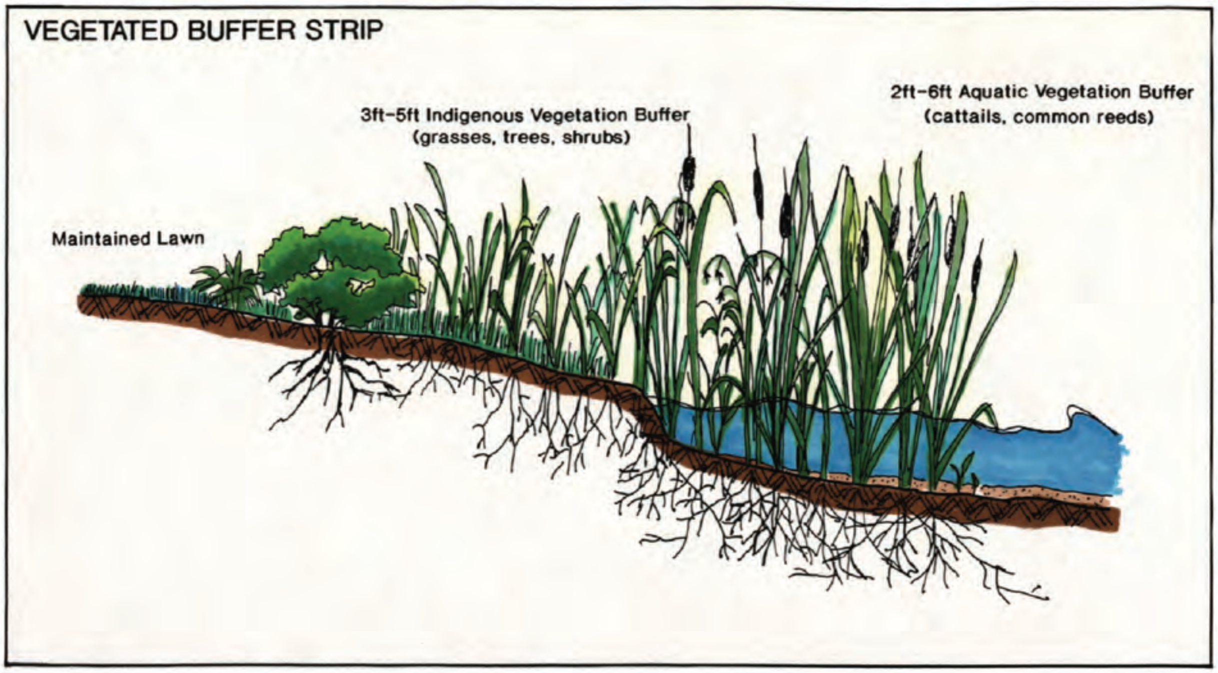
Modification of Species Composition

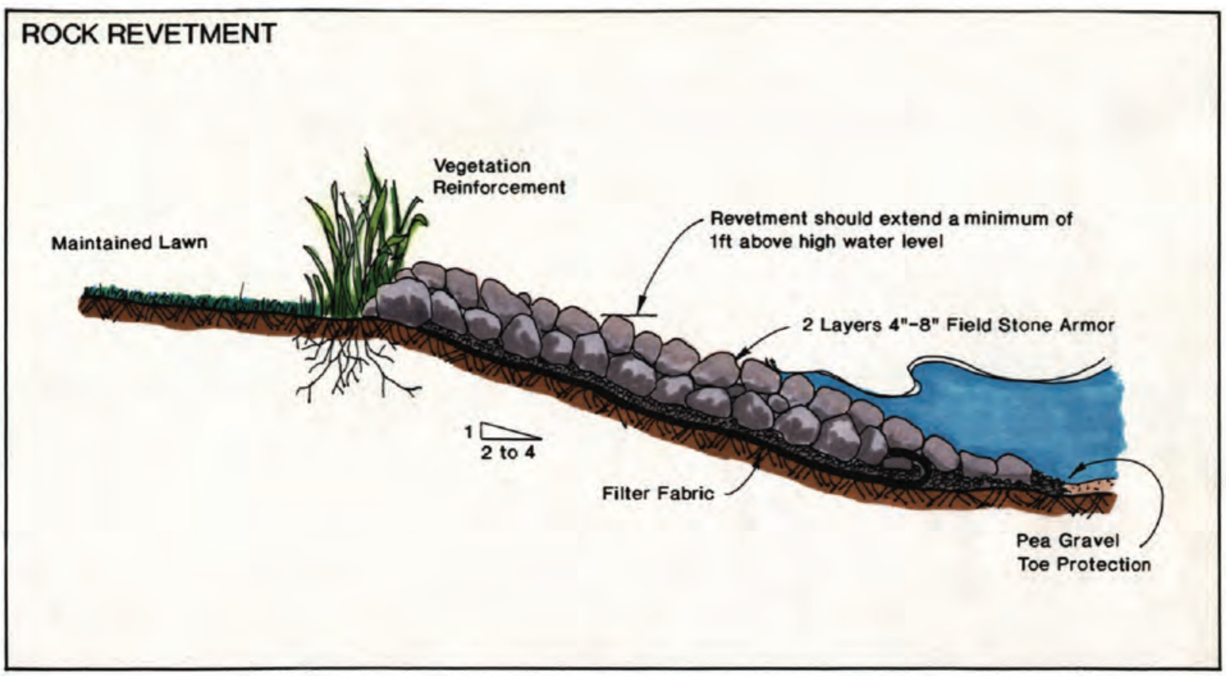
Species composition management refers to a group of conservation and restoration measures that include selective harvesting of undesirable fish species and stocking of desirable species designed to enhance the angling resource value of a lake. These measures also include water level manipulation both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

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

Figure 31

RECOMMENDED ALTERNATIVES FOR SHORELINE EROSION CONTROL





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

Source: SEWRPC.

As noted in Chapter V, Eagle Spring Lake is currently managed for warmwater sportfish, and selective stocking is undertaken primarily by the WDNR. Continued fish stocking by the WDNR is considered a viable option for Eagle Spring Lake, subject to monitoring and creel surveying data collected from the Lake by the WDNR. Additional fish population control measures do not appear to be warranted at this time, although roughfish populations should continue to be monitored.

Regulations and Public Information
To reduce the risk of overharvest, the WDNR has placed restrictions on the number and size of certain fish species caught by anglers. The open season, size limits, and bag limits for the fish species of Eagle Spring Lake are given in Table 20 in Chapter V of this report. Enforcement of these regulations is critical to the success of any sound fish management program.

Aquatic Plant Management Measures
Aquatic plant management refers to a group of management and restoration measures aimed at both removal of nuisance vegetation and manipulation of species composition in order to enhance and provide for recreational water use. Generally, aquatic plant management measures are classified into four groups: chemical measures, which include using aquatic herbicides; mechanical measures, which include harvesting and manual removal; biological measures, which include the use of various organisms, including insects; and physical measures, which include lake bottom coverings and water level management. All of these measures are stringently regulated and require a State permit under Chapters NR 107 or NR 109 of the *Wisconsin Administrative Code*.

The costs of aquatic plant management measures range from minimal for manual removal of plants using rakes and hand-pulling to upwards of $100,000 for the purchase of a mechanical plant harvester and ancillary equipment, the operational costs for which can approach $10,000 to $20,000 per year depending on staffing and operating policies. Harvesting is probably the measure best applicable to larger areas while chemical controls may be best suited to use in confined areas and for initial control of invasive plants. Planting of native plant species is largely experimental in lakes, but can be considered a specialized shoreland management zone at the water’s edge, where it has proven to be an effective means of mitigating the effects of runoff from residential and other properties and enhancing privacy. Physical controls and mechanical harvesting may have side effects in the expansion of plant habitat and the spread of reproductive vegetative fragments. Each of these groups of aquatic plant management measures is discussed in greater detail below.

Chemical Measures
Chemical treatment with aquatic herbicides is a short-term method of controlling heavy growths of aquatic macrophytes and algae. Chemicals are applied to the growing plants in either liquid or granular form. The advantages of using chemical herbicides to control aquatic macrophyte growth are the relative ease, speed, and convenience of application. Herbicides also offer a degree of selectivity, targeting specific types of aquatic plants. Over time, repeated applications of chemical herbicides can lead to a change in aquatic plant community composition. Such a change has been reported in the aquatic plant flora in Eagle Spring Lake by the ESLMD Board of Commissioners, and can be seen in Table 11 in Chapter V of this report, and by comparing the relative density of aquatic plants observed in the Lake during 1994 and 2008 (compare Tables 12 and 13 in Chapter V). Nevertheless, there can be disadvantages associated with chemical control of aquatic plants, including the following:

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

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

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

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

5. Adverse impacts on other aquatic organisms may be expected. At the concentrations used for macrophyte control, Diquat has been known to kill the zooplankton *Daphnia* and *Hyalella*, both important fish foods. *Daphnia* is the primary food for the young of nearly all fish species found in the Region's lakes.[12]

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

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

Action to control the growth of milfoil, especially Eurasian water milfoil and hybrid milfoil, is warranted in order to limit the spread of these plants to other portions of the Lake. To this end, early spring treatments using targeted herbicide applications offer the opportunity to minimize milfoil growth and reproduction prior to the recreational boating season, thereby addressing one of the mechanisms that drive the spread of these plants in lakes.[13]

With respect to the control of periodic algal blooms, the advantages and disadvantages of chemical control measures used to manage aquatic macrophyte also apply to the chemical control of algae. Copper, the active ingredient in algicides, can be an effective algicide. However, the copper may accumulate in the lake bottom sediments where excessive amounts are potentially toxic to fish and benthic animals. Fortunately, copper is rapidly eliminated from human systems and few cases of copper sensitivity among humans are known.[14] Since nuisance algae blooms have not been a major problem in the past, it is unlikely that chemical algaecide treatments would be necessary on Eagle Spring Lake at this time.

Costs of chemical treatments vary widely. Large, organized treatments are more efficient and tend to decrease unit costs for commercial applications compared to individual treatments. Other factors, such as the type of chemical used and the number of treatments needed, are also important. Estimated costs for lakes in southeastern

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

[13]*Eurasian water milfoil and its hybrids reproduce through autofragmentation of plants. This can be exacerbated by boating activity which can fragment the plants through propeller action and wind-wave action which fragments the plants as a consequence of water turbulence. Of these reproduction mechanisms, only boating traffic can be controlled by humans.*

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

Wisconsin range from $240 to $480 per acre. Chemical treatments must be permitted by the State under Chapter NR 107 of the *Wisconsin Administrative Code*.

In the future, should there be a demonstrated need to control aquatic plants in selected areas of Eagle Spring Lake, chemical treatment is considered to be a viable management option.

Manual and Mechanical Harvesting Measures

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

1. Harvesting removes the harvested plant biomass from the lake. The removal of this plant biomass decreases the rate of accumulation of organic sediment. A typical harvest of submerged macrophytes from eutrophic lakes in southeastern Wisconsin can yield between 140 and 1,100 pounds of biomass per acre per year.[15]

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

3. Repeated macrophyte harvesting may reduce the regrowth of certain aquatic macrophytes. The regrowth of milfoil has been reported to have decreased as harvesting frequency was increased.[16]

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

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

6. Selective macrophyte harvesting may reduce stunted populations of panfish in lakes where excessive cover has adversely influenced predator-prey relationships. By allowing an increase in predation on young panfish, both gamefish and the remaining panfish may show increased growth.[17]

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

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

[16]*See Appendix D of SEWRPC Memorandum Report No. 143, 2nd Edition*, An Aquatic Plan Management Plan for the Lauderdale Lakes, Walworth County, Wisconsin, *July 2010; compare also Maps 21 through 24 in SEWRPC Community Assistance Planning Report No. 58, 2nd Edition,* A Lake Management Plan for Pewaukee Lake, Waukesha County, Wisconsin, *May 2003.*

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

The disadvantages of macrophyte harvesting include the following:

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

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

3. Fish, especially young-of-the-year bluegills and largemouth bass, as well as fish-food organisms, are frequently caught in the harvester. As much as 5 percent of the juvenile fish population can be removed by harvesting. A WDNR study found that four pounds of fish were removed per ton of plants harvested.[18] To protect the fish community from excessive mortality from harvesting, the WDNR generally recommends harvesting be conducted in areas six feet in depth or greater. Additionally, it is generally recommended that harvesting activities not begin before June 15th in order to reduce disturbing fish spawning activities.

4. The reduction in aquatic macrophyte biomass by harvesting or chemical control can reduce the diversity and productivity of macroinvertebrate fish-food organisms feeding on the epibiota. Bluegills generally move into the shoreline area after sunset, where they consume these macroinvertebrates. After sunrise they migrate to open water, where they graze, primarily on zooplankton. If harvesting or chemical control shifts the dominance of the littoral macroinvertebrate fauna to sediment dwellers, the macroinvertebrate component of the bluegill diet could be restricted.[19] This would increase predation pressure on zooplankton and reduce the growth rate of the panfish; it could eventually lead to undesirable ramifications throughout the food web in a lake.

5. Macrophyte harvesting may influence the community structure of macrophytes by favoring such plants as milfoil (*Myriophyllum* spp.) that propagate from cut fragments created during the harvesting process. Because harvesting is not 100 percent effective in collecting all plant fragments,[20] this may allow some plant species to spread into new areas through the rerooting of the cut fragments, even when shoreline collection of such fragments is employed.

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

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

8. High capital and labor costs may be associated with harvesting programs. These costs are largely comprised of staff costs and operating costs such as the costs of fuel, oil, and maintenance. The cost of new harvesting equipment, when needed, can be up to about $300,000.

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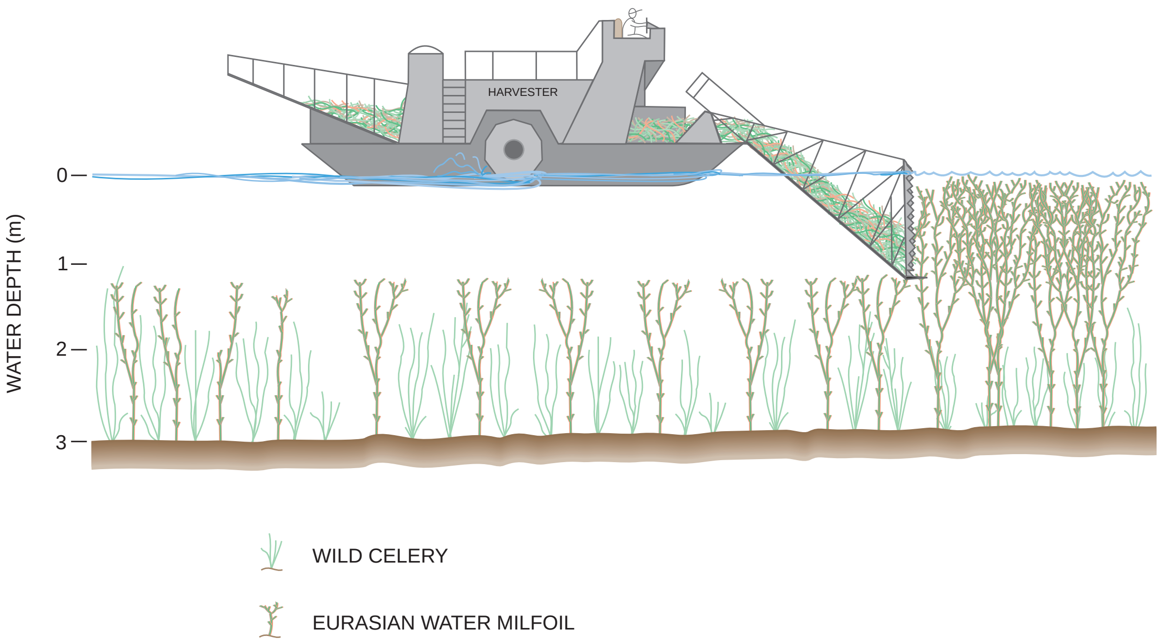
[18]*Wisconsin Department of Natural Resources,* Environmental Assessment Aquatic Nuisance Control (NR 107) Program*, 3rd Edition, 1990, 213 pp.*

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

[20]*It should be noted that some aquatic plants such as milfoil "autofragment" or create viable plant fragments as a reproductive strategy; also, aquatic plants may fragment for other reasons, such as disturbances caused by boat propellers and/or wind-induced turbulence.*

Figure 32

PLANT CANOPY REMOVAL WITH AN AQUATIC PLANT HARVESTER



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

Source: Wisconsin Department of Natural Resources and SEWRPC.

Harvesting programs should be designed to provide optimal benefits and minimal adverse impacts. Small fish are common in dense macrophyte beds, but larger fish, such as largemouth bass, do not utilize these dense beds.[21] Narrow channels may be harvested to provide navigational access and “cruising lanes” for predator fish to migrate into the macrophyte beds to feed on smaller fish. “Shared access” lanes may also be cut, allowing several residents to use the same lane. Increased use of these lanes should keep them open for longer periods than would be the case if a less directed harvesting program was followed. “Clear cutting” of aquatic plants and denuding the lake bottom of flora should be avoided. However, top cutting of plans such as Eurasian water milfoil, as shown in Figure 32, is suggested.

Water depth, numbers and arrangement of docks and moored boats, and nature of bottom substrate are important factors when considering mechanical harvesting. As explained above, most harvesting equipment is large and not well-suited to close operation around docks and moored boats where precise control of movement is needed. Areas of shallow depths, two to three feet or less, containing muck or other soft, loose bottom materials are generally not considered to be well suited to harvesting as the equipment tends to churn up these bottom materials, creating turbid water conditions, affecting established benthic communities and fragmenting rooted aquatic macrophytes. Plants such as Eurasian water milfoil, which propagate through the spread of plant fragments, may actually be at an advantage as a result of the chopping action of harvesting equipment. Mechanical harvesting is best suited to areas free of docks and moored watercraft or recreational equipment,

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

where lake bottom materials are firm and water is of sufficient depth to offer a degree of protection against potential lake bottom disruption by harvester equipment. The harvest of water lilies and emergent native plants should be avoided.

Protecting native aquatic plant communities from disturbances can help prevent Eurasian water milfoil from spreading within a lake. Recent studies show that native plants can effectively compete with Eurasian water milfoil. However, the exotic species tends to outcompete native plants when the lake's ecosystem is stressed.[22] Stress can be brought on by tributary area pollution, shoreline development, changing water levels, boating activity, and the presence of certain fishes such as carp that disturb the lake bottom sediments. This maintenance of a healthy aquatic plant community has been found to be the most efficient way of managing aquatic plants, as opposed to other means of managing problems once they occur. Furthermore, native aquatic plant communities contribute most effectively to the maintenance of good water quality by providing suitable habitat for desirable fish and other aquatic organisms which promote stable or increased property values and quality of life.[23]

Harvesting is a method that has been effectively utilized on Eagle Spring Lake and, because of the intermittent need for control of aquatic plants, harvesting should be considered to continue to be a viable option in areas of Eagle Spring Lake that are conducive to this method of management. Mechanical harvesting of aquatic plants must be permitted by the State under Chapter NR 109 of the *Wisconsin Administrative Code*.

Due to water depth limitations imposed by the size and maneuverability of the harvesters, it is not always possible for harvesters to reach the shoreline of every property. Likewise, because of the cost and other concerns relating to the use of chemical herbicides, alternative measures for the control of aquatic plant growth in specific areas of the Lake should be considered. A number of specially designed rakes are available from commercial outlets to assist lakefront homeowners in manually removing aquatic plants from the shoreline area. The advantages of these rakes are that they are easy and quick to use, and result in an immediate result, in contrast to chemical treatments that involve a waiting period. This method also removes the plants from the lake, thereby avoiding the accumulation of organic matter on the lake bottom. Unfortunately, manual harvesting is feasible in only very limited areas and is not practical for large-scale use. Nevertheless, manual harvesting does offer a reasonable level of aquatic plant control in the vicinity of docks and piers, and is therefore considered a viable option. Manual harvesting beyond a 30-foot-wide recreational corridor, or within a WDNR-delineated environmentally sensitive area, must be permitted by the State under Chapter NR 109 of the *Wisconsin Administrative Code*. Pursuant to the provision of this chapter, piers and other recreational areas must be placed within the 30-foot-wide recreational corridor.

Biological Measures

Another alternative approach to controlling nuisance weed conditions, in this particular case Eurasian water milfoil, is biological control. Classical biological control has been successfully used to control both weeds and herbivorous insects.[24] Recent documentation states that *Eurhychiopsis lecontei*, an aquatic weevil species, has the potential as a biological control agent for Eurasian water milfoil. In 1989, the weevil was discovered during a study investigating a decline of Eurasian water milfoil growth in a Vermont pond. *Eurhychiopsis* proved to have

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

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

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

significant negative effects on Eurasian water milfoil in the field and in the lab. The adult weevil feeds on the milfoil causing lesions which make the plant more susceptible to pathogens, such as bacteria or fungi, while the weevil larvae burrows in the stem of the plant causing enough tissue damage for the plant to lose buoyancy and collapse.[25] The few studies that have been done since that time have indicated the following potential advantages to use of this weevil as a means of Eurasian water milfoil control:

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

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

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

The potential disadvantages of using *Eurhychiopsis lecontei* include:

1. The studies done on *Eurhychiopsis* are very recent and more tests are necessary to determine if there are significant adverse effects.[26]

2. Since the upper portion of the Eurasian water milfoil plant is preferred by the weevil, harvesting would have to be extremely limited or not used at all in conjunction with this type of aquatic plant management control.

Relatively few studies concerning the use of *Eurhychiopsis lecontei* as a means of aquatic plant management control have been completed. Such cases have resulted in variable levels of control, and, although priced competitively with aquatic herbicides, the use of *Eurhychiopsis lecontei* is not considered a viable option for Eagle Spring Lake at this time. Use of biological control agents must be permitted by the State under Chapter NR 109 of the *Wisconsin Administrative Code*. While the use of biological control agents such as the Eurasian water milfoil weevil and the beetles, *Hylobius transversovittatus*, *Galerucella pusilla*, *Galerucella calmariensis*, *Nanophyes brevis*, and *Nanophyes marmoratus*, used to control infestations of purple loosestrife in wetlands and along shorelands has been shown to be beneficial in certain circumstances, including use at Eagle Spring Lake, the use of other biological control agents is prohibited in Wisconsin; the use of the grass carp, *Ctenopharyngodon idella*, for aquatic plant control is expressly prohibited.

Physical Measures

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

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

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

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

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

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

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

Public Informational Programming

Aquatic plant management usually centers on the eradication of nuisance aquatic plants for the improvement of recreational lake use. The majority of the public views all aquatic plants as “weeds” and residents often spend considerable time and money removing desirable plant species from a lake without considering their environmental impacts. As shown in Table 10 in Chapter V of this report, many aquatic plants have positive ecological value within the lake ecosystem, and most native aquatic plants rarely interfere with human water uses. Thus, public information is an important component of an aquatic plant management program and should include informational programming on:

1. The types of aquatic plants in Eagle Spring Lake and their value to water quality, fish, and wildlife.

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

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

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

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

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

To prevent unwanted introductions of plants and invasive aquatic animals into lakes, boaters should remove all plant fragments from their boats and trailers when exiting a lake, and allow wet wells, engine water jackets, and bilges to dry thoroughly for up to one week. Alternatively, boaters can run their vessels through a car wash, where high pressure, high temperature water sprays can remove and destroy organisms such as the zebra mussel juveniles (veligers).[27] Providing the opportunity for the removal of plant fragments at the boat landing on Eagle Spring Lake, and provision of signage at the boat landing, including provision of disposal containers at the boat landing, may help motivate boaters to utilize this practice. Posters and pamphlets are available from the WDNR and UWEX that provide information and illustrations of milfoil, zebra mussel, and other nonnative aquatic species; discuss the importance of removing plant fragments from boats; and, remind boaters of their duty in this regard.

Recreational Use Management

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

Currently, watercraft are restricted to slow-no-wake speeds within 100 feet of lake shorelines. These areas typically coincide with water depths of less than five feet in depth. Demarcation of Eurasian water milfoil control areas and similar environmentally valuable or sensitive areas of the Lake is recommended. It is also recommended that the Town of Eagle continue to enforce the recreational boating ordinance appended hereto as Appendix B.

Public Informational and Educational Programming

Educational and informational brochures and pamphlets of interest to homeowners and supportive of the recreational use and shoreland zoning regulations are available from UWEX, WDNR, and the Waukesha County Department of Parks and Land Use. These cover topics such as beneficial lawn care practices and household chemical use guidelines. These brochures could be provided to homeowners through local media, direct

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

distribution, or targeted school or public library displays. Many of these ideas can be integrated into ongoing, larger-scale municipal activities such as anti-littering campaigns, recycling drives, and similar pro-environment activities.

In addition to public informational programming, or informal educational programming, discussed above, there are a number of school-based educational opportunities that the community can utilize at the middle school level and at the high school level. Such programming as Project WET (Water Education Training) are available from and supported by UWEX and provide youth the opportunity to experience “hands on” the aquatic environment and become better informed about current and future lake issues and concerns. Therefore, activities of this type, such as Project WET, which could be arranged through agreements involving local lake organizations, municipalities, and school districts, are considered a viable option.

Finally, reporting of water quality sampling results to the public and participation of the Eagle Spring Lake Management District (ESLMD) in the UWEX CLMN Monitoring Program should be continued. The information gained at first hand by the public during participation in this program increases the credibility of the proposed changes in the nature and intensity of use to which the Lake is subjected.

SUMMARY

This chapter has described options that could be employed in managing the types of problems recorded as occurring in Eagle Spring Lake and which could, singly or in combination, assist in achieving and maintaining the water quality and water use objectives set forth in Chapter VI of the lake tributary area inventory. Selected characteristics of these measures are summarized in Table 26.

An evaluation of the potential management measures for improving the Eagle Spring Lake water quality was carried out on the basis of the effectiveness, cost, and technical feasibility of the measures. Those alternative measures not considered further at this time include: phosphorus precipitation and inactivation, nutrient load reduction through sediment management, dredging, chemical eradication of roughfish, biological control of aquatic plants, lake bottom covering, development of time and/or space zoning schemes for managing surface use, and development of alternative institutions. The remaining measures are considered viable options to be considered further for incorporation in the recommended plan described in Chapter VIII.

Table 26

SELECTED CHARACTERISTICS OF ALTERNATIVE LAKE MANAGEMENT MEASURES FOR EAGLE SPRING LAKE

Plan Element	Subelement	Alternative Management Measure	Considered Viable for Inclusion in Recommended Lake Management Plan
Land Use	Zoning	Implement regional land use and county development plans within tributary area	Yes
		Maintain existing density in lakeshore areas; consider application of conservation development principles for new development	Yes
	Stormwater management	Develop and implement consistent stormwater management ordinances in all riparian communities; periodically review stormwater ordinances	Yes
	Protecting environmentally sensitive lands	Implement regional natural areas and critical species habitat protection and management plan recommendations within the tributary area; protect wetlands, woodlands, shorelands, and other environmental corridor lands and natural features according to the Mukwonago River watershed protection plan	Yes
Pollution Abatement	General nonpoint source pollution abatement	Implement regional water quality management plan and county land and water resource management plan recommendations within tributary area	Yes
	Rural nonpoint source controls	Develop farm conservation plans that encourage conservation tillage, contour farming, contour strip cropping, crop rotation, grassed waterways, and pasture and streambank management in agricultural areas of the tributary area	Yes
	Urban nonpoint source controls	Promote urban housekeeping practices, public educational programming, and grassed swales	Yes
		Consider development of shoreland protection ordinances	Yes
	Developing area nonpoint source controls	Enforce construction site erosion control ordinances; review ordinances for consistency with NR 152	Yes
		Use conservation subdivision designs and develop integrated stormwater management systems	Yes
	Public sanitary sewerage system management	Conduct periodic review of sewer service area needs within sewered areas of the tributary area	Yes
	Onsite sewage disposal system management	Implement onsite sewage disposal system management, including inspection and maintenance	Yes
Water Quality	Water quality monitoring	Continue participation in the UWEX Citizen Lake Monitoring Network program	Yes
	Water quality improvement	Monitor internal phosphorus loading and consider periodic alum treatment to achieve phosphorus inactivation in lake sediments	No
		Promote nutrient load reduction in the lake basin through sediment management	No
		Modify outlet control operations	No
		Drawdown	No
		Water level stabilization	No
		Dredging	No[a]

Table 26 (continued)

Plan Element	Subelement	Alternative Management Measure	Considered Viable for Inclusion in Recommended Lake Management Plan
Aquatic Biota	Fisheries management	Protect fish habitat	Yes
		Maintain shoreline and littoral zone fish habitat by maintaining existing shoreline structures and repair as necessary using vegetative means insofar as practicable; reconstruction may require WDNR Chapter 30 permits	Yes
		Encourage shoreline restoration projects and creation of buffer strips, and promote consistency in application of landscaping practices in sensitive shoreline areas, through informational programming and demonstration sites	Yes
		Investigate application of water level variations (increases and decreases) timed to promote wetland inundation to support spawning of northern pike	Yes
		Continue stocking of selected game fish species and monitor roughfish populations	Yes
		Consider chemical eradication of rough fish populations	No
		Enforce size and catch limit regulations	Yes
	Aquatic plant management	Conduct periodic aquatic plant reconnaissance surveys and update aquatic plant management plan every three to five years	Yes
		Limited use of aquatic herbicides for control of nuisance plants such as Eurasian water milfoil and purple loosestrife	Yes[a]
		Consider mechanically harvesting aquatic macrophytes to provide navigational channels and fish lanes, control nuisance plants and to promote growth of native plants	Yes[b]
		Manually harvest aquatic plants from around docks and piers where feasible	Yes
		Employ biological controls using inocula of Eurasian water milfoil weevils	No
		Consider using biological controls for management of purple loosestrife on an as-needed basis	Yes
		Use sediment covers to shade out aquatic plant growth around piers and docks	No
		Collect floating plant fragments from shoreland areas to minimize rooting of Eurasian water milfoil	Yes
Water Use	Recreational use management	Enforce boating regulations to maximize public safety; improve signage	Yes
		Develop time and/or space zoning schemes to limit surface use conflicts	No
		Maintain recreational boating access from the public access site pursuant to Chapter NR 7 guidelines	Yes
		Maintain navigational access, especially from public recreational boating access site(s) to main basin of Lake	Yes
		Support community participation in Clean Boats, Clean Waters Program	Yes

Table 26 (continued)

Plan Element	Subelement	Alternative Management Measure	Considered Viable for Inclusion in Recommended Lake Management Plan
Water Quantity	Hydrological management	Consider Eagle Spring Lake as one of a cascade of impoundments on the Mukwonago River and operate the Dam in concert with the dams at Lake Beulah and Lower Phantom Lake	Yes
Ancillary Management Measures	Public informational and educational programming	Conduct public informational programming and educational programming on aquatic plants, options for their management, and other topics of relevance to lake residents utilizing seminars and distribution of informational materials	Yes
		Support participation of schools in Project WET, Adopt-A-Lake, etc.	Yes
		Encourage methods of preventing unwanted intrusions of invasive biota at public recreational boat access	Yes

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

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

Source: SEWRPC.

Chapter VIII

RECOMMENDED MANAGEMENT PLAN FOR EAGLE SPRING LAKE

INTRODUCTION

This chapter presents a recommended and refined lake management plan for Eagle Spring Lake. The plan builds upon the experiences and lessons learned during the period of implementation of the initial comprehensive lake management plan for Eagle Spring Lake, summarized in Table 27;[1] upon data and analyses set forth in various Staff Memoranda compiled by the Southeastern Wisconsin Regional Planning Commission (SEWRPC) staff, reproduced herein as Appendix D; and, upon the updated and refined inventories of land use and land and water management practices, pollution sources in the area tributary to Eagle Spring Lake, the physical and biological quality of the waters of the Lake, recreational use and population forecasts, and an evaluation of alternative lake management measures, set forth in Chapters II through VII of this document. The elements of the recommended plan were selected from among the alternatives described in Chapter VII, and evaluated on the basis of those feasible alternatives, set forth in Table 26, that may be expected to best meet the foregoing lake management objectives. While analyses of water quality and biological conditions indicate that the water quality of Eagle Spring Lake is generally good, and there are few impediments to water-based recreation, access by recreational watercraft is limited in some portions of the Lake by water depths and growths of aquatic macrophytes. Consequently, based upon a review of the inventory findings and consideration of planned developments within the area tributary to the Lake, as set forth in the adopted Waukesha County development plan,[2] measures will be required to continue to protect and maintain the high quality of the Lake for future lake users. Therefore, this plan sets forth recommendations for: land use management, including protection of the environmentally sensitive lands, in the area tributary to Eagle Spring Lake; pollution abatement; water quality monitoring and improvement; aquatic plant and fisheries management; recreational water use management; and, informational programming. The recommended plan sets forth means for: 1) providing water quality conditions suitable for full-body contact recreational use and the maintenance of healthy communities of warmwater fish and other aquatic life, pursuant to Chapters NR 102 and NR 104 of the *Wisconsin Administrative Code*; 2) reducing the severity of existing or

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[1]*SEWRPC Community Assistance Planning Report No. 226,* A Lake Management Plan for Eagle Spring Lake, Waukesha County, Wisconsin, *October 1997.*

[2]*SEWRPC Community Assistance Planning Report No. 209,* A Development Plan for Waukesha County, Wisconsin, *August 1996; see also SEWRPC Planning Report No. 48,* A Regional Land Use Plan for Southeastern Wisconsin: 2035, *June 2006.*

Table 27

IMPLEMENTATION STATUS OF INITIAL COMPREHENSIVE LAKE MANAGEMENT PLAN ELEMENTS FOR EAGLE SPRING LAKE: 1997-2010

Plan Element	Subelement	Management Measures	Implementation Status: 2010
Land Use and Zoning	Land use development planning	Observe guidelines set forth in the regional land use plan, including protection of environmental corridors	Ongoing: Refined through Waukesha County development plan, and supported by the *Town of Eagle Comprehensive Plan* and *Town of Eagle Land Use Plan* prepared by the Waukesha County Department of Parks and Land Use, November 2009
	Zoning modifications	Modify [Waukesha County] zoning ordinances to minimize open space losses and encourage cluster development	Ongoing: Supported by Waukesha County Zoning Code; Waukesha County Shoreland and Floodland Protection Ordinance as amended; and, Waukesha County Shoreland and Floodland Subdivision Control Ordinance
		Maintain current [Walworth County] zoning ordinances which minimize open space losses	Ongoing: Supported by *Walworth County 2010 Land and Water Resource Management Plan*, and *A Multi-Jurisdictional Comprehensive Plan for Walworth County: 2035*
	Density management	Maintain historic medium- and low-density residential uses	Ongoing: Supported by the *Town of Eagle Comprehensive Plan* and *Town of Eagle Land Use Plan* prepared by the Waukesha County Department of Parks and Land Use, November 2009
	Protection of primary environmental corridors	Preserve environmental corridor areas as recommended in regional land use plan and in Walworth and Waukesha County park and open space plans	Ongoing: Refined through the regional natural areas and critical species habitat protection and management plan, and the Mukwonago River watershed protection plan
Watershed Land Management	Urban nonpoint source controls	Good urban housekeeping practices	Ongoing: Supported by the *Waukesha County Land and Water Resource Management Plan 2006-2010*
		Develop stormwater management system plan	Pending
	Construction site erosion control	Continue enforcement of existing ordinances	Ongoing: Supported by Waukesha County Zoning Code
	Rural nonpoint source controls	Implement good soil conservation and nutrient management practices by preparation of detailed farm plans	Ongoing: Supported by the *Waukesha County Land and Water Resource Management Plan 2006-2010*
	Onsite sewage disposal system management	Develop informational and educational program to promote sound maintenance practices and periodic inspections	Ongoing: Supported by the Eagle Spring Lake Management District website: http://www.eaglespringlake.us/
		Ultimately construct public sanitary sewer	Pending: Forecast land development scenarios set forth in the planned *Sanitary Sewer Service Area for the Village of Mukwonago, Waukesha County, Wisconsin* have not materialized; Eagle Spring Lake Management District has recommended that this not proceed as recommended

Table 27 (continued)

Plan Element	Subelement	Management Measures	Implementation Status: 2010
Water Quality Management	Water quality monitoring	Continue participation in WDNR Self-Help Monitoring Program	Ongoing: now the University of Wisconsin-Extension Citizen Lake Monitoring Network
Lake Level Management	Outlet structure control	Maintain lake level between elevation 820.53 and 820.83 NGVD-29	Completed: New operating permit issued October 8, 2009 Completed: Repairs approved by WDNR on February 17, 2010
Aquatic Plant Management	Chemical treatment	Limited to use of 2,4-D to control of Eurasian water milfoil growth around docks, and purple loosestrife in wetlands and on shorelines	Ongoing
	Major channel harvesting	Harvest aquatic plants as required; avoid disturbance of lake bottom	Ongoing
	Minor channel harvesting	Harvest fishing lanes	Ongoing
	Eurasian water milfoil	Control dense, nuisance areas of Eurasian water milfoil as necessary, using appropriate methods and techniques pursuant to Wisconsin Department of Natural Resources guidelines	Ongoing
Boating Access	Small area dredging	Dredge boat access lanes where necessary	Completed: May 2006
Fisheries management	Fish survey	Implement a fishery survey by the Wisconsin Department of Natural Resources and a citizen-based creel survey conducted by Eagle Spring Lake Management District with assistance from Department of Natural Resources	Completed: Wisconsin Department of Natural Resources fisheries survey was conducted during 2008
	Refine fishery management plan	Utilize survey findings to refine fishery management strategy	Completed: Wisconsin Department of Natural Resources fisheries management plan was updated during 2008
	Refine fish stocking	Stock fish as required based on refined plan	Ongoing: Northern pike stocked periodically by the Wisconsin Department of Natural Resources
	Modification of fishing regulation limits	Adjust size and number restrictions for anglers based upon analysis of surveys	Completed: Wisconsin Department of Natural Resources have established mandatory slot size regulations excluding 14- to 18-inch largemouth bass from the harvest
Habitat Protection and Lake Use Management	Implementation of ordinances	Implementation of “slow-no-wake” restrictions; site for propeller cleaning facility with signage	Completed in part: Town of Eagle Ordinance No. 09-02 repealed and recreated Ordinance 93-02, An Ordinance to Provide for Safety and Welfare on and around Eagle Spring Lake and Ordinance 97-04, An Ordinance Regarding the Operation of Motor Vehicles Pending: Propeller cleaning station was not used by boaters; appropriate signage was installed
	Restrict harvesting	Restrict harvesting to areas shown on Map 24	Ongoing
Shoreland Protection	Maintain structures	Maintain existing structures	Ongoing as necessary
	Vegetative buffer strips	Install and maintain erosion control structures	Ongoing as necessary
Informational and Educational Program	Public informational and educational programming	Continue and refine public awareness and informational programming	Ongoing

Source: SEWRPC.

potential infestations of nonnative species which constrain or preclude desired water uses, pursuant to Chapter NR 40 of the *Wisconsin Administrative Code*; 3) improving opportunities for water-based recreational activities, pursuant to Chapter NR 1 of the *Wisconsin Administrative Code*; and, 4) protecting environmentally sensitive areas, pursuant to Chapters NR 107 and NR 109 of the *Wisconsin Administrative Code*. These measures complement and refine the watershedwide land use controls and management measures recommended in the adopted regional water quality management plan as refined,[3] the Mukwonago River watershed protection plan,[4] and the Waukesha County land and water resource management plan.[5]

PAST AND PRESENT MANAGEMENT MEASURES

The initial comprehensive lake management plan for Eagle Spring Lake set forth a comprehensive program of lake management measures recommended for application in Eagle Spring Lake and its tributary area.[6] These measures included both tributary area-based actions and in-lake actions, and included measures applicable to both Eagle Spring Lake and the upstream Lulu Lake. These recommended plan elements are summarized in Table 28. Since the publication of the initial comprehensive lake management plan, the Eagle Spring Lake Management District (ESLMD), in partnership with the Wisconsin Department of Natural Resources (WDNR), The Nature Conservancy (TNC), and local units of government, has executed an active program of land and water resources management that has implemented many of the recommendations. Although many of the actions cited in Table 27 are indicated as ongoing, this program of lake management forms the foundation upon which the recommendations set forth in this Chapter are based.

Tributary Area Management Actions

The initial comprehensive lake management plan for Eagle Spring Lake set forth two major areas for recommended actions with respect to land management in the tributary area, including action related to the refinement of planning and zoning systems applicable to the watershed, and the implementation of best practices on both rural agricultural lands and urban lands, the management of construction site erosion, and the protection of high-value wildlife habitat. Rural nonpoint source pollution control measures recommended included the development of detailed farm plans with the assistance of the County land conservation departments in the drainage area, as well as implementation of nutrient management plans. Recommended urban management practices included implementation of stormwater management practices in the watershed, including grassed swales, wet detention basins, and urban good housekeeping practices. Implementation of the construction site best management practices set forth in the Wisconsin Construction Site Best Management Practices Handbook also was recommended. Finally, the plan recommended protection of the high-value wildlife habitat located adjacent to Eagle Spring Lake.

As shown in Table 27, the activities associated with land use planning and zoning in the watershed remain ongoing, with significant development pressures occurring or expected to occur in portions of the drainage area. While significant innovation has occurred in the area of land use planning, with the preparation and adoption of

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[3]*SEWRPC Planning Report No. 30,* A Regional Water Quality Management Plan for Southeastern Wisconsin: 2000, *Volume Three*, Recommended Plan, *June 1979 as refined in SEWRPC Memorandum Report No. 93*, A Regional Water Quality Management Plan for Southeastern Wisconsin: An Update and Status Report, *March 1995.*

[4]*SEWRPC Community Assistance Planning Report No. 309,* Mukwonago River Watershed Protection Plan, *June 2010.*

[5]*Waukesha County,* Land and Water Resource Management Plan: 1999-2002, *December 1998.*

[6]*SEWRPC Community Assistance Planning Report No. 226,* op. cit.

Table 28

RECOMMENDED MANAGEMENT PLAN ELEMENTS FOR EAGLE SPRING LAKE

Plan Element	Subelement	Management Measures	Management Responsibility[a]
Land Use	Zoning	Observe guidelines set forth in the regional land use plan and Waukesha County development plan	Waukesha County, Village of Eagle, and Town of Eagle
		Enforce adequate setbacks and promote environmentally friendly landscaping practices in shoreland areas	Waukesha County, Village of Eagle and WDNR
		Maintain historic lake front residential dwelling densities to extent practicable	Town of Eagle
	Stormwater management	Develop and implement consistent stormwater management ordinances in all riparian communities; periodic review of stormwater ordinances	Town of Eagle
		Restrict pollutant loading from stormwater discharges to the Lake through implementation of stormwater management practices	Waukesha County, Village of Eagle, Town of Eagle, and WDNR
		Install construction site erosion control measures as required by local ordinance; enforce construction site erosion control and stormwater ordinance provisions	Private landowners, Waukesha County, Village of Eagle, Town of Eagle, WDNR, and WDATCP
	Protection of environmentally sensitive lands	Establish adequate protection of wetlands and shorelands, and other environmental corridor lands and isolated natural features, and consider public or private acquisition of features of local or greater significance, as set forth in the regional natural areas and critical species habitat protection and management plan	Walworth County, Waukesha County, Village of Eagle, Village of East Troy, Town of Eagle, Town of Troy, TNC, and WDNR
Pollution Abatement	General nonpoint source pollution abatement	Implement regional water quality management plan and county land and water resource management plan recommendations within tributary area	Walworth County, Waukesha County, Village of Eagle, Village of East Troy, Town of Eagle, and Town of Troy
	Rural nonpoint source controls	Promote sound rural land management practices to reduce soil loss and contaminant loadings through preparation of farm conservation plans in accordance with the county land and water resource management plans	USDA, WDATCP, Walworth County, and Waukesha County
	Urban nonpoint source controls	Promote sound urban housekeeping and yard care practices through informational programming	Walworth County, Waukesha County, Village of Eagle, Village of East Troy, Town of Eagle, and Town of Troy
		Consider development of lawn care management and shoreland protection ordinances	Town of Eagle, and Village of Eagle
	Developing area nonpoint source controls	Enforce construction site erosion control and stormwater management ordinances; review ordinances for concurrency with NR 152	Walworth County, Waukesha County, Village of Eagle, Village of East Troy, Town of Eagle, and Town of Troy
		Use conservation subdivision designs and develop integrated stormwater management systems where appropriate densities exist	Walworth County, Waukesha County, Village of Eagle, Village of East Troy, Town of Eagle, and Town of Troy
Point Source Pollution Control	Sewerage system management	Refine regional water quality management plan to remove the Lake tributary area from the planned sewer service area	SEWRPC, and WDNR
		Implement onsite sewage disposal system management, including inspection and maintenance, in those portions of the watershed not served by public sanitary sewerage systems	Walworth County, Waukesha County, ESLMD, and private landowners

Table 28 (continued)

Plan Element	Subelement	Management Measures	Management Responsibility[a]
Water Quality and Water Quantity	Water quality monitoring	Continue participation in UWEX CLMN monitoring program	ESLMD, and UWEX
	Hydrology	Maintain outlet structure and monitor water levels; continue to operate water control structures in accordance with permit	WDNR and ESLMD
	Cascade of dams	Consider operating the dams at Eagle Spring Lake, Lake Beulah, and Lower Phantom Lake as a cascade of dams	WDNR, ESLMD, LBLMD, and Village of Mukwonago
Aquatic Biota	Fisheries management	Protect fish habitat	Town of Eagle, WDNR, ESLMD, TNC, and individuals
		Conduct periodic fish surveys to determine management and stocking needs; continue stocking; conduct periodic creel census; enforce size and catch limit regulations	WDNR
		Maintain existing shoreline structures and repair as necessary using vegetative means insofar as practicable; reconstruction may require WDNR Chapter 30 permits	Waukesha County, Town of Eagle, WDNR, and private landowners
		Encourage shoreline restoration projects and creation of buffer strips, and promote consistency in application of landscaping practices in sensitive shoreland areas, through informational programming and demonstration sites	Waukesha County, Town of Eagle, WDNR, TNC, private landowners, and UWEX
	Aquatic plant management	Conduct periodic reconnaissance surveys of aquatic plant communities and update aquatic plant management plan every three to five years	WDNR, and ESLMD
		Manually harvest around piers and docks as necessary[b]	Private landowners
		Mechanically harvest boating access lanes and fish cruising lanes as may become necessary	WDNR, and ESLMD
		Limited use of aquatic herbicides for control of nuisance aquatic plant growth where necessary; specifically target Eurasian water milfoil[c]	WDNR, and ESLMD
		Limited use of aquatic herbicides for control of invasive plant growth where necessary; specifically purple loosestrife infestations[c]	WDNR, Town of Eagle, ESLMD, and private landowners
		Use purple loosestrife beetles to control purple loosestrife infestations as appropriate	Town of Eagle, ESLMD, WDNR, and private landowners
		Collect floating plant fragments from shoreland areas to minimize rooting of Eurasian water milfoil and deposition of organic materials in Lake	Private landowners, and ESLMD
Water Use	Recreational use management	Maintain recreational boating access from the public access sites pursuant to Chapter NR 7 guidelines	WDNR
		Maintain navigational access, especially from public recreational boating access site(s) to main basin of Lake; maintain adequate depths for navigation as required, subject to WDNR permits	WDNR and ESLMD
		Continue to enforce and periodically review, recreational boating (summer) and vehicular use (winter) ordinances	Town of Eagle, and WDNR

Table 28 (continued)

Plan Element	Subelement	Management Measures	Management Responsibility[a]
Ancillary Measures	Public informational and educational programming	Continue public awareness and informational programming	Walworth County, Waukesha County, Village of Eagle, Village of East Troy, Town of Eagle, Town of Troy, ESLMD, UWEX, WDNR, and TNC
		Encourage inclusion of lake studies in environmental curricula (e.g., Project WET, Adopt-A-Lake)	Kettle Moraine School District, UWEX, and WDNR

[a] *Recommended lake management responsibility includes Walworth and Waukesha Counties, the Villages of Eagle and East Troy, and the Towns of Eagle and Troy, with support from the Eagle Spring Lake Management District (ESLMD), the Wisconsin Department of Natural Resources (WDNR), Wisconsin Department of Agriculture, Trade and Consumer Protection (WDATCP), the University of Wisconsin Extension (UWEX), and the Citizen Lake Monitoring Network (CLMN) administered by UWEX. Additional support is recommended to be provided through The Nature Conservancy (TNC), Lake Beulah Lake Management District (LBLMD), the Phantom Lakes Lake Management District (PLMD), the Kettle Moraine School District, and private landowners.*

[b] *Manual harvesting beyond a 30 linear foot width of shoreline harvesting is subject to WDNR permitting pursuant to Chapter NR 109 of the* Wisconsin Administrative Code*. Use of mechanical harvesting is subject to WDNR permitting pursuant to Chapter NR 109 of the* Wisconsin Administrative Code*.*

[c] *Use of aquatic herbicides requires a WDNR permit pursuant to Chapter NR 107 of the* Wisconsin Administrative Code*.*

Source: SEWRPC.

the so-called "smart growth" plans at the local government and county levels, much of the zoning review remains to be decided on a case-by-case basis. Most of these cases occur in the areas immediately tributary to Eagle Spring Lake, as much of the drainage area is in protective ownership and is managed by the WDNR or TNC as part of the Kettle Moraine State Forest. This ownership is consistent with the regional natural areas and critical species habitat protection and management plan,[7] and the recently published Mukwonago River Watershed protection plan.[8] These actions, some of which have occurred since the publication of the initial comprehensive lake management plan, serve to minimize the risk to Eagle Spring Lake of future water quality degradation. Indeed, as shown in Chapter IV, these actions have contributed to the reduction in contaminant loading to the Lake and the maintenance of good water quality in the Lake.

Proactive actions by the ESLMD with respect to the inspection and maintenance of onsite wastewater disposal systems, and informational programming with respect to the use of yard care products and other agrochemicals and shoreland management also have minimized the risk to the Lake of contamination from these urban sources. Such programming is ongoing, and is supported by recent Legislative initiatives such as the 2009 *Wisconsin Act* 9 which has restricted the use of phosphorus-based fertilizers in urban areas. As with the rural land management practices and actions, these activities remain ongoing.

As noted, the ESLMD has established strong working relationships with the TNC, Friends of the Mukwonago River, and other groups active in the watershed. In addition, informal meetings between Commissioners from the various public inland lake protection and rehabilitation districts within the Mukwonago River watershed continue to strengthen the watershed-based approach recommended in the aforereferenced Mukwonago River Watershed protection plan.

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

[8] *SEWRPC Community Assistance Planning Report No. 309,* op. cit.

In-Lake Management Actions

The initial comprehensive lake management plan for Eagle Spring Lake included a number of in-lake management measures applicable to the Lake, as summarized in Table 27. While many of these measures also remain ongoing in terms of their execution, actions recommended with respect to the Wambold and Kroll dams and the lake water surface elevation have been resolved during the period of plan implementation. Similarly, recommendations relating to the lake fishery and to aquatic plant management have been implemented. The ESLMD continues to pursue an aggressive aquatic plant management program aimed at minimizing the occurrence of Eurasian water milfoil in the Lake through a combination of mechanical harvesting and aquatic herbicide application. These actions have contributed to the recreational enjoyment of the Lake community and its visitors as well as to the stability of the Lake ecosystem, which remains in an aquatic plant dominated state. Fisheries management actions undertaken by the WDNR also have reduced the imbalance in the lake fish populations.

Additional actions recommended in the initial comprehensive lake management plan included actions to protect in-lake habitat and shorelands. Implementation of the aquatic plant management recommendations by the ESLMD, as noted above, has formed a practical; contribution to preserving the diverse habitat and integrity of the aquatic ecosystems in both Eagle Spring Lake and Lulu Lake, although the recommended propeller cleaning station on the channel between Eagle Spring Lake and Lulu Lake proved less than successful. Nevertheless, implementation of the community awareness and educational programming set forth in the initial comprehensive lake management plan has heighten awareness of the need to manage nonnative species in the Lakes. Actions such as Clean Boats, Clean Waters have given practical effect to the recommended awareness building program, and involvement of local schools in river monitoring under the auspices of the Waukesha County Stream Watch program has provided hands-on training for youth.

Continuing water quality sampling and aquatic plant management—particularly focused on nonnative species—continues to form an important element of the ESLMD activities.

RECOMMENDED MANAGEMENT MEASURES

Tributary Area Management Measures

Land Use Control and Management

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

The recommended land use plan for the area tributary to Eagle Spring Lake under buildout conditions is described in Chapter II. The framework for the plan is the regional land use plan as prepared and adopted by the Southeastern Wisconsin Regional Planning Commission (SEWRPC), and refined through the Waukesha County and Walworth County land and water conservation plans,[9] the Waukesha County development plan,[10] and

[9]*Walworth County,* Walworth County 2010 Land and Water Resource Management Plan, *April 2010; Waukesha County,* Waukesha County Land and Water Resource Management Plan 2006-2010*, January 2006.*

[10]*SEWRPC Community Assistance Planning Report No. 209,* A Development Plan for Waukesha County, Wisconsin, *August 1996.*

community-level “smart growth plans.”[11] The recommended land use and county development plans envision that urban land use development within the area tributary to Eagle Spring Lake will occur primarily at low densities and only in areas which are covered by soils suitable for the intended use; which are not subject to special hazards such as flooding; and, which are not environmentally sensitive, that is, not encompassed within the SEWRPC-delineated environmental corridors described in Chapter V.

Development in the Shoreland Zone

A major land use issue which has the potential to affect Eagle Spring Lake is the redevelopment of existing lakefront properties, replacing lower-density uses with higher-density, multi-family dwellings with potential for increased roof areas, parking areas, and other areas of impervious surfaces. Replacement of a pervious land surface with an impervious surface will increase the rate of stormwater runoff to the Lake, increase pollutant loadings to the Lake, and reduce groundwater recharge. While these effects can be moderated to some extent through structural stormwater management measures, there is likely to be an adverse impact on the Lake from significant redevelopment in the area tributary to the Lake involving conversion to higher-density land uses. For this reason, maintenance of the historic low- and medium-density residential character of the shoreline of Eagle Spring Lake to the maximum extent practical is recommended. Where higher density development maybe envisioned, provision for onsite stormwater management facilities, pursuant to the requirements of Chapter NR 151 of the *Wisconsin Administrative Code*, is strongly recommended, including provision for the maintenance of such infrastructure. Review of existing shoreland protection ordinances to ensure conformance with the requirements of Chapters NR 151 and NR 153, of the *Wisconsin Administrative Code*, also is recommended.

Development in the Tributary Area

Another land use issue which has the potential to affect the Lake is the potential development for urban uses of the agricultural and other open space lands in the tributary area. As previously noted, much of the land within the watershed tributary to the Mukwonago River upstream of Eagle Spring Lake is currently in conservation ownership, either as part of the Kettle Moraine State Forest or under private conservation ownership through TNC. However, the potential still remains for large-lot residential development. Should such development occur in areas of the tributary area to the Lake in which such development was not envisioned in the adopted regional land use and county development plans, much of the open space areas remaining in the tributary area could be replaced over time with large-lot urban development. This has the potential to significantly increase the pollutant loadings to the Lake, as well as to increase the pressures for recreational use of the Lake. Under the full buildout condition envisioned in the Waukesha County development plan, a significant portion of the undeveloped lands outside of the environmental corridors and other environmentally sensitive areas, could potentially be developed for low-density urban uses. Consequently, adherence to the stormwater management and onsite sewage disposal requirements set forth in the *Wisconsin Administrative Code* remains an ongoing concern.

The existing zoning in the tributary area basin permits development generally on large suburban-density lots over much of the remaining open lands other than the environmental corridors. Control of shoreland redevelopment, and the related intensification of use, is not specifically addressed in the existing zoning codes. It is recommended that the impact of future land use development on Eagle Spring Lake be minimized through review and modification of the applicable zoning ordinance regulations and zoning district maps to address the concerns noted. Changes in zoning ordinances are recommended to minimize the areal extent of development by providing specific provisions and incentives for the clustering of residential development on smaller lots within conservation subdivisions, thus preserving significant portions of the open space within each property or group of properties considered for development, and minimizing the “footprint” of the developed area relative to the open space on and around a development site. Within the lands tributary to Eagle Spring Lake in and adjacent to the

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[11]*See Waukesha County Department of Parks and Planning,* Town of Eagle Comprehensive Plan, *November 2009.*

Village of Eagle, these recommendations have been incorporated into the comprehensive land use plan for the Town of Eagle,[12] and/or reflected in the prevailing Town and County Codes of Ordinances.[13]

It is further recommended that development within the area tributary to the Lake, including setback and landscaping provisions, be carefully reviewed by the relevant governmental agencies and entities. Such review would address specific shoreland zoning requirements, and could consider the stormwater and urban nonpoint source pollution abatement practices proposed to be included in shoreland development activities. Provision for shoreland buffers, use of appropriate and environmentally friendly landscaping practices, and inclusion of stormwater management measures that provide water quality benefits are practices to be encouraged.

Stormwater Management

It is recommended that Waukesha County and the Town of Eagle take an active role in promoting urban nonpoint source pollution abatement. Actions to promote urban nonpoint source pollution abatement would include the conduct of specific stormwater management planning within specific portions of the tributary area located within each municipality where further urban development or redevelopment is anticipated. Such a planning program should include a review of the stormwater management ordinances, to ensure that the ordinance provisions reflect state-of-the-art runoff and water quality management requirements, and to ensure that there is harmony between the ordinances governing urban density development in each of the municipalities draining to Eagle Spring Lake. Adoption by all riparian municipalities of common stormwater management ordinance provisions is strongly recommended.

Management of Environmentally Sensitive Lands

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

Nevertheless, some wetland and woodland areas have been identified for acquisition in the adopted regional natural areas and critical species habitat protection and management plan, as summarized in Chapter V.[14] Implementation of the recommendations of the adopted park and open space plan for Waukesha County[15] and related land use plans as noted above would complement the protection and preservation of these environmentally sensitive lands.

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[12]*See Waukesha County Department of Parks and Planning,* Town of Eagle Comprehensive Plan, op. cit.*; page 10-2 specifically notes that "The Town of Eagle has a long standing agreement with the Village of Eagle regarding library and fire protection services. The Village of Eagle Advisory Committee has recommended that the Village abide by the density requirements and zoning regulations in areas of the Town adjacent to the Village, so that development can occur at the same overall density within either community."*

[13]*See, for example, Chapters 14, "Parks and Land Use," and 15, "Public Works,"* Waukesha County Code of Ordinances, http://www.waukeshacounty.gov/page.aspx?SetupMetaId=11982&id=11986.

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

[15]*SEWRPC Community Assistance Planning Report No. 137,* A Park and Open Space Plan for Waukesha County, *December 1989.*

Nonpoint Source Pollution Control

The recommended tributary area land management measures are specifically aimed at reducing the water quality impacts on Eagle Spring Lake of nonpoint sources of pollution within the tributary area. These measures are set forth in the aforereferenced regional water quality management plan and the Waukesha County land and water resource management plan. As indicated in the lake and tributary area inventory, the only significant sources of phosphorus loading to the Lake that are subject to potential controls are rural and urban nonpoint sources, and onsite sewage disposal systems in the tributary area. All of the lakeshore areas of Eagle Spring Lake currently are served by onsite sewage disposal systems, which are inspected on a regular basis. Nevertheless, the lakeshore area remains subject to the recommendation that the urban enclave surrounding Eagle Spring Lake be ultimately connected to the Village of Mukwonago wastewater treatment facility, as set forth in the recommended sewer service area plan.[16] As of 2010, land use changes within the areas served by this treatment plant have removed some of the intermediate service areas from consideration for service, making the proposed connection of the Eagle Spring Lake community unlikely. Based upon consideration of these changes in land ownership and land use, as well as of the water quality of the Lake, such connection is no longer recommended.

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

Rural Nonpoint Source Pollution Controls

The implementation of nonpoint source pollution controls in rural areas requires the cooperative efforts of, among others, the Town of Eagle, Waukesha County, and private landowners. Technical assistance can be provided by the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS); the Wisconsin Department of Agriculture, Trade and Consumer Protection; and the Waukesha County Department of Parks and Land Use. State and Federal soil erosion control and water quality management programs, individually or in combination, can be used to achieve pollutant reduction goals. Such programs include the USDA Environmental Quality Incentive Program (EQIP), the WDNR runoff management and lake protection programs, and various local land acquisition initiatives.

Highly localized, detailed, and site-specific measures are required to effectively reduce soil loss and contaminant runoff in rural areas. These measures are best defined and implemented at the local level through the preparation of detailed farm conservation plans. Practices which are considered most applicable within the area tributary to Eagle Spring Lake include conservation tillage, integrated nutrient and pesticide management, and pasture management. In addition, it is recommended consideration be given to cropping patterns and crop rotation cycles, with attention to the specific topography, hydrology, and soil characteristics for each farm. A reduction of about 25 percent in the nonpoint source loading from rural lands could provide up to about a 15 percent reduction in total phosphorus loading to Eagle Spring Lake. Implementation of the recommendations and work planning activities set forth in the Walworth and Waukesha County land and water resource management plans would constitute a major step toward implementation of these lake management recommendations.

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[16]*Pursuant to the recommendations set forth in SEWRPC Community Assistance Planning Report No. 191,* Sanitary Sewer Service Area for the Village of Mukwonago, Waukesha County, Wisconsin, *November 1990, as amended.*

The cost of the needed measures will vary depending upon the details of the recommended farm conservation plans. These costs may be expected to be incurred to a large extent for purposes of agricultural land erosion control in any case. Cost-share funding may be available to encourage installation of appropriate land management measures through the cost share programs promulgated in Chapters NR 153 and NR 154 of the *Wisconsin Administrative Code*.

Urban Nonpoint Source Pollution Controls

The development of urban nonpoint source pollution abatement measures should be focused on the Eagle Spring Lake area, primarily in the Town of Eagle. The most viable measures to control urban nonpoint sources of pollution appear to be good urban land management and good urban housekeeping practices. Such practices consist of fertilizer and pesticide use management, litter and pet waste controls, and management of leaf litter and yard waste. The promotion of these measures requires an ongoing public informational program. It is recommended that the Town of Eagle, in cooperation with the ESLMD, take the lead in sponsoring such programming for the Eagle Spring Lake community through regular public informational meetings and mailings. The agency should also ensure that relevant literature, available through the University of Wisconsin-Extension (UWEX) and the WDNR, is made available at these meetings and at the local Public Library and government offices. These measures may be expected to provide about a 25 percent reduction in urban nonpoint source pollution runoff and up to about a 5 percent reduction in total phosphorus loadings to the Lake.

Developing Areas and Construction Site Erosion Control

It is recommended that, primarily, Waukesha County and the Town of Eagle continue efforts to control soil erosion attendant to construction activities in accordance with existing ordinances. As noted in Chapter III, Waukesha County has adopted construction erosion control ordinances. Enforcement of the ordinances is generally considered effective. The provisions of these ordinances apply to all development except single- and two-family residential construction. The single- and two-family construction erosion control is to be carried out as part of the building permit process.

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

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

Onsite and Public Sewage Disposal System Management

The lakeshore areas and areas tributary to Eagle Spring Lake are served by onsite sewage disposal systems. Onsite sewage disposal systems have been estimated to contribute a mass of phosphorus to the Lake that could approach 10 percent of the total phosphorus load, although, given the good agreement between forecast and observed total phosphorus concentration in Eagle Spring Lake, this load is likely to be significantly less. Current County ordinance provisions requiring the regular inspection and maintenance of onsite sewage disposal systems. These requirements have been reinforced by the requirements of the ESLMD, which apply to all households surrounding the Lake. These inspections and associated maintenance actions should be enforced to minimize potential phosphorus loadings from this source. It also is recommended that Waukesha County, in cooperation with the Town of Eagle and ESLMD, continue to provide the public informational and educational programs to encourage affected property owners to have existing onsite systems inspected and any needed remedial measures undertaken, as appropriate. Homeowners should be advised of the rules and regulations governing, and the limitations of onsite sewage disposal systems, on a regular basis and should be encouraged to undertake preventive maintenance programs, especially of those older systems not yet subject to the inspection requirements of the County ordinance.

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

In-Lake Management Measures

The recommended in-lake management measures for Eagle Spring Lake are summarized in Table 28 and are graphically summarized on Map 24. The major recommendations include: water quality monitoring; fisheries management and habitat protection; nonpoint-source pollution abatement; shoreland protection; aquatic plant management; recreational use management, and informational and educational programming.

Surface Water Quality Management

Continued water quality monitoring of Eagle Spring Lake is recommended. Lake sampling protocol conducted under the ongoing Citizen Lake Monitoring Network (CLMN) is recommended with various water quality parameters being measured several times a year at a central station in the deepest portion of the main lake basin.

Fisheries Management

Continued implementation of the WDNR fisheries management measures being undertaken on Eagle Spring Lake—including monitoring of the carp population, promotion of the largemouth bass and northern pike communities, and maintenance of the 14-inch through 18-inch slot limit governing the harvest of largemouth or smallmouth bass with a bag limit of only one fish over 18 inches—is recommended. Periodic baseline fishery surveys should continue to be conducted with the following objectives:

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

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

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

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

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

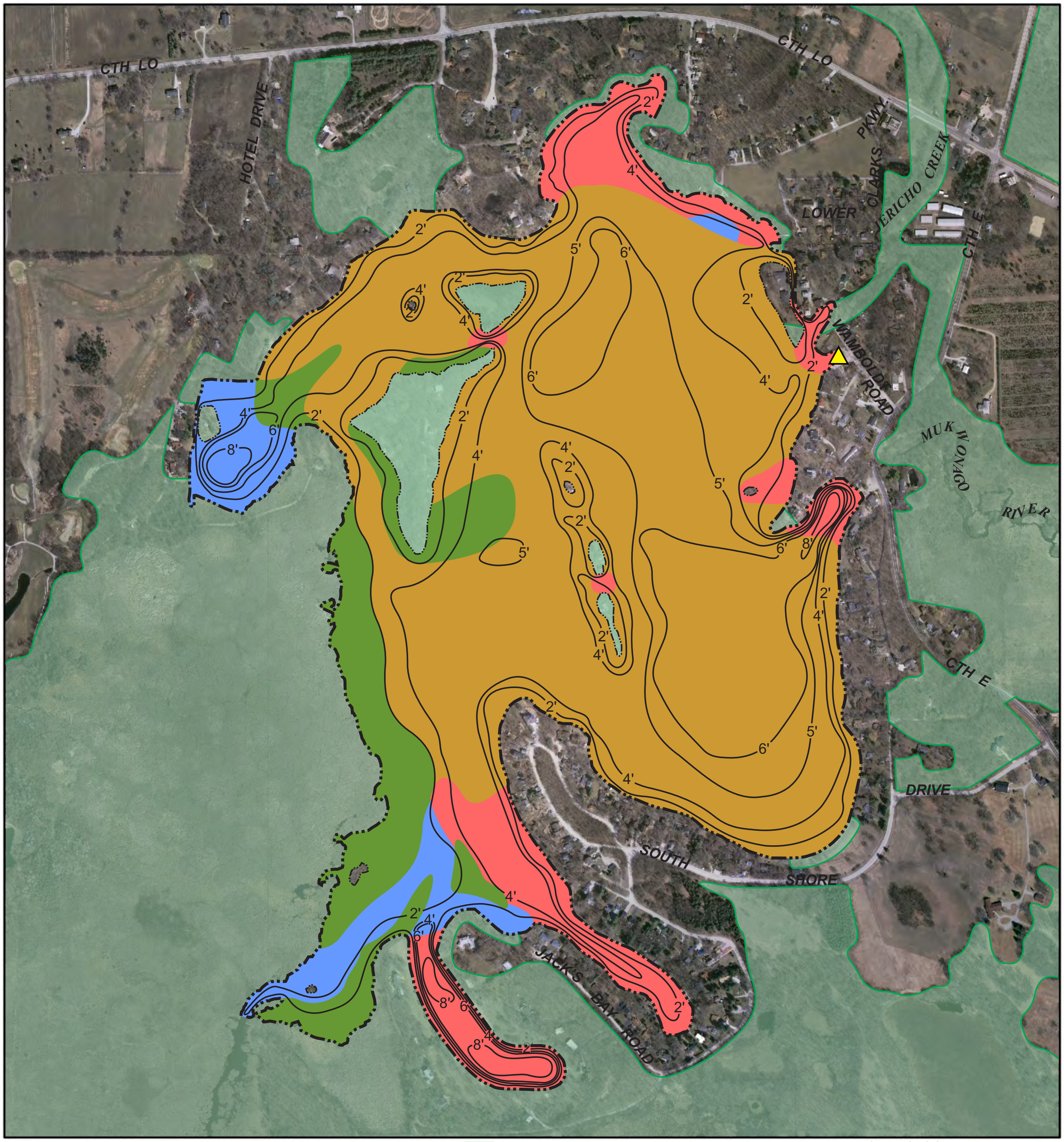
These actions could provide a sound basis for the ESLMD and the WDNR to continue the stocking program and to revise, as may be found necessary, the current fishing regulations regarding the size and number of fish to be taken seasonally. Should rough fish population increases be shown to warrant intervention, reintroduction of the “carp-out fisheree” event or further commercial harvesting should be considered.

Habitat Protection

The habitat protection measures recommended for Eagle Spring Lake are designed to provide for habitat protection by avoiding disturbances in fish breeding areas during spring and autumn, managing aquatic plants and maintaining stands of native aquatic plants. In particular, this recommendation extends to, and includes, any WDNR-delineated Chapter NR 107 sensitive areas that may be located in a lake. At the time of writing, there were no State designated environmentally sensitive areas designated in Eagle Spring Lake. Nevertheless, it is recommended that environmentally valuable lands, such as shoreland wetlands and riparian corridors, be preserved, as recommended in the Mukwonago River Watershed protection plan.

Map 24

RECOMMENDED LAKE MANAGEMENT PLAN FOR EAGLE SPRING LAKE



— 4' — WATER DEPTH CONTOUR IN FEET

PUBLIC ACCESS SITE

MANAGEMENT ZONES

FISHING: Harvest narrow channels-approximately 15 feet wide perpendicular to shore about every 100 to 200 feet-use of chemicals for algae and aquatic plant control not recommended in these areas

BOATING: Harvest channels approximately 50 feet wide parallel to the shoreline of the main basin of the lake-limited use of chemicals for algae and aquatic plant control recommended in these areas

HABITAT: Ecologically valuable areas-no aquatic plant management activities-use of chemicals for algae and aquatic plant control not recommended in these areas

ACCESS: Harvest narrow channels-approximately 15 feet wide around the perimeter of the southern bay areas and the inlet area to provide boating access from these areas to the main basin of the lake- limited use of chemicals for algae and aquatic plant control recommended in these areas

ECOLOGICALLY VALUABLE AREAS TO BE PROTECTED

LAND USE MANAGEMENT
- Encourage maintenance of open space uses
- Preserve environmental corridors

WATERSHED MANAGEMENT
- Promote good housekeeping practices in urban areas
- Conduct onsite sewage disposal system management program
- Prepare farm plans for agricultural lands

MONITORING PROGRAM
- Conduct fish survey
- Conduct water quality monitoring

FISH MANAGEMENT
- Review and refine stocking program as required

SHORELINE PROTECTION
- Maintain and repair existing structures

EURASIAN WATER MILFOIL MANAGEMENT PROGRAM
- Control nuisance eurasian water milfoil conditions as necessary

DATE OF PHOTOGRAPHY: APRIL 2005

GRAPHIC SCALE

0 250 900 FEET

PUBLIC INFORMATION AND EDUCATION
- Continue public awareness program

Source: SEWRPC.

Shoreland Protection

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

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

Aquatic Plant Management

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

Alternative Methods for Aquatic Plant Control

Various aquatic plant management techniques, chemical, mechanical, biological and physical, are potentially applicable on Eagle Spring Lake. A number of these methods have been employed with varying success on Eagle Spring Lake in the past, although mechanical control measures, supplemented by Eurasian water milfoil-targeted herbicide treatments, have been the major methods utilized throughout the Lake over the years.

CHEMICAL CONTROLS

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

Selective use of chemical control may be a suitable technique for the control of infestations of Eurasian water milfoil and other nuisance species, especially in areas where other means are not practicable. Chemical applications in early spring and late fall have been found to be effective in controlling such infestations of milfoil and facilitating the resurgence of growth of native plant species in lakes in Southeastern Wisconsin.[17] Chemical applications should be conducted in accordance with current administrative rules, under the authority of a State permit, and by a licensed applicator working under the supervision of WDNR staff. Records accurately delineating treated areas and the type and amount of herbicide used in each area, should be carefully documented and used as a reference in applying for permits in the following year. In addition, the use of the herbicide 2,4-D has been shown to be effective in the control of hybrid water milfoil (*Myriophyllum spicatum* x *sibiricum*) populations present in the Lake at a rate of 150 pounds per acre of granular 2,4-D.[18]

MECHANICAL CONTROLS

Mechanical harvesting of aquatic plants has been used as a means of controlling plant growth on Eagle Spring Lake in the past. The most significant impact of mechanical harvesting is the removal of the organic plant biomass, decreasing nutrient inputs to the Lake. Potential negative impacts of mechanical harvesting, as outlined by the U.S. Environmental Protection Agency,[19] include: the removal of small fish, limited depths of operation, propagation of plant fragments, and time needed to treat specific areas of a waterbody. However, mechanical harvesting does offer temporary relief from nuisance aquatic plant growths, especially when conducted in accordance with a management plan designed to optimize benefits and minimize adverse impacts.

In addition to controlling nuisance aquatic plant growth conditions, harvesting has been shown to promote better balance within the in-lake fishery by providing access for larger game fish, such as the largemouth bass, to smaller prey fishes and organisms which can utilize the dense plant beds. Narrow channels harvested to provide navigational access also provide "cruising lanes" for predator fish to migrate into the macrophyte beds to feed on smaller fish. Consideration of use of harvesting should future needs arise to control nuisance levels of aquatic macrophytes or invasive species such as Eurasian water milfoil is recommended.

MANUAL CONTROLS

Manual methods of aquatic plant control, such as raking or hand-pulling, while environmentally sound, are difficult to employ on a large-scale. Although very effective for small-scale application, for example, in and around docks and piers, manual techniques are generally not practical for large-scale plant control methods. Manual means are recommended on Eagle Spring Lake to control nearshore plant growths, especially around piers and docks.

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[17]*It should be noted that, at the time of writing, late fall herbicide treatments are considered to be experimental in Wisconsin and will not typically be permitted by the WDNR at this time, pending further research into the use of such treatments. It also is noted that many plants become dormant during late fall and winter, die back, and do not meet the nuisance standards established pursuant to Chapter NR 107 of the* Wisconsin Administrative Code *as the basis for the application of aquatic herbicides. Consequently late fall applications of herbicides are not recommended.*

[18]*Angela L. Ortenblad, Allison M. Zappa, Abby R. Kroken, and Robert C. Anderson, "Effectiveness of Granular 2,4-D Treatment on Hybrid Watermilfoil (*Myriophyllum sibiricum *x* spicatum*) in Eagle Spring Lake, Wisconsin," Wisconsin Lutheran College Biology Department Technical Bulletin 008, March 2006; see also, Allison M. Zappa and Robert C. Anderson, "Follow up Study on the Effectiveness of Granular 2,4-D Treatment on Hybrid Watermilfoil (*Myriophyllum sibiricum *x* spicatum*) in Eagle Spring Lake, Wisconsin," Wisconsin Lutheran College Biology Department Technical Bulletin 010, April 2007.*

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

SHORELINE CLEANUP CREW

Decomposing, floating vegetation can build up along the shorelines, and, together with terrestrial leaf litter, can limit the use of shoreline areas. Not only is this material unsightly and potentially foul smelling, but it also contributes to the creation of the organic and mucky substrates favored by invasive plant species such as Eurasian water milfoil. Shoreline cleanup is a laborious job that can require substantial amounts of labor and time. To alleviate this problem, the ESLMD, in cooperation with shoreline property owners, could institute a comprehensive program of shoreline cleanup to act in conjunction with harvesting operations to collect aquatic plant fragments and minimize the likelihood of such fragments taking root in new areas of the Lake.

INFORMATIONAL AND EDUCATIONAL PROGRAMMING

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

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

The Eagle Spring Lake community has consistently supported informational and educational programming within their community, have encouraged environmentally sound behaviors within the Lake, and have contributed to shoreland restoration efforts and lake monitoring as well. Thus, ongoing informational and educational programming is recommended.

Recommended Aquatic Plant Management Measures

It is recommended that continued aquatic macrophyte surveys be conducted at about five-year intervals, depending upon the observed degree of change in the aquatic plant communities. In addition, information on the aquatic plant control program should be recorded and should include descriptions of: major areas of nuisance plant growth; areas chemically treated and/or harvested; and in areas where harvesting is conducted, species harvested and amounts of plant material removed from the lake, and species and approximate numbers of fish caught in the harvest. It is further recommended that a daily harvester log, containing this information, be maintained. This information, in conjunction with the conduct of the recommended aquatic macrophyte surveys, will allow evaluation of the effectiveness of the aquatic plant control program over time and allow adjustments to be made in the program to maximize its benefit.

To enhance the use of Eagle Spring Lake while maintaining the quality and diversity of the biological communities, the following recommendations are made:

1. Reconnaissance surveys of the aquatic plant communities in Eagle Spring Lake are recommended to be conducted periodically and the approved aquatic plant management plan should be updated every three to five years.

2. Early spring treatments using targeted herbicide applications offer the opportunity to limit the spread of milfoil, especially Eurasian water milfoil and hybrid milfoil, to other portions of the Lake; consequently, the use of targeted spring herbicide treatments, with priority being given to the portion

of the Mukwonago River flowing in to Eagle Spring Lake from Lulu Lake, is recommended. Additionally, riparian landowners should be encouraged to collect aquatic plant fragments from around their piers and docks and remove these from the Lake at regular intervals. Placement and maintenance of signage at the Eagle Spring Lake end of the channel between Eagle Spring and Lulu Lakes, advising boat operators to remove and properly dispose of aquatic plants from their propellers, also is recommended.

3. Additional use of chemical herbicides is recommended to be limited to controlling nuisance growths of nonnative aquatic plant species in shallow water around docks and piers where harvesting is unable to reach. Maintenance of shoreland areas around docks and piers remains the responsibility of individual property owners. It is recommended that chemical applications, if required, be made by licensed applicators in early spring subject to State permitting requirements to maximize their effectiveness on nonnative plant species, while minimizing impacts on native plant species and acting as a preventative measure to reduce the development of nuisance conditions. Such use should be evaluated annually and the herbicide applied only on an as needed basis. Only herbicides that selectively control milfoil, such as 2,4-D and fluridone, should be used. Algicides, such as Cutrine Plus, are not recommended because there are few significant, recurring filamentous algal or planktonic algal problems in the Eagle Spring Lake and valuable macroscopic algae, such as *Chara* and *Nitella* are killed by this product.

4. Continued mechanical harvesting is recommended as the need arises. As indicated in Chapter V, this will, in the long-term, help to maintain good water quality conditions by removing plant materials which are currently contributing to an accumulation of decomposing vegetation and associated nutrient recycling. In areas where harvesting occurs, it is recommended that shared-access channels be harvested to minimize the potential detrimental effects on the fish and invertebrate communities. Directing boat traffic through these common channels would help to delay the regrowth of vegetation in these areas. Additionally, surface harvesting is recommended, cutting to a depth to remove the surface canopy of nonnative aquatic plants, such as the Eurasian water milfoil. This should provide a competitive advantage to the low-growing native plants present in the Lake. By not disturbing the low-growing species which generally grow within one to two feet of the lake bottom and in relatively low densities, leaving the root stocks and stems of all cut plants in place, the resuspension of sediments in Eagle Spring Lake will be minimized, and some degree of cover will continue to be provided for panfish populations which support the bass population in the Lake. Further, cutting should not be broad-based, but focused on boating channels and selected navigation areas, and on controlling stands of Eurasian water milfoil and other nonnative aquatic plants where they exist.

5. The control of rooted vegetation between adjacent piers is recommended to be left to the riparian owners concerned, as it is time consuming and costly for a mechanical harvester to maneuver between piers and boats and such maneuvering may entail liability for damage to boats and piers. The ESLMD may wish to obtain informational brochures regarding shoreline maintenance, such as information on hand-held specialty rakes made for this specific purpose, to inform residents of the control options available.

6. The collection of aquatic plant fragments and other debris along shoreline areas is recommended.

7. It is recommended that ecologically valuable areas be excluded from aquatic plant management activities, especially during fish spawning seasons. Any aquatic plant management limitations that may be set forth within a future WDNR Chapter NR 107 sensitive area determination are incorporated herein by reference.

8. It also is recommended that, during the recommended aquatic plant surveys, attention be given to any nonnative organisms that maybe recorded from the Lake in order to facilitate the early detection and control of future-designated nonnative species that may occur. Such control could be effected with

the assistance of funds provided under the Chapter NR 198, aquatic invasive species control grant program, and should be undertaken as soon as possible once the presence of a nonnative, invasive species is observed and confirmed, reducing the risk of spread from waters where they are present and restoring native aquatic communities. Control of currently designated invasive species, designated pursuant to Chapter NR 109 of the *Wisconsin Administrative Code*, using appropriate control measures, is recommended throughout the Lake.

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

The recommended aquatic plant control areas are shown on Map 24. The control measures in each area are designed to optimize desired recreational opportunities and to protect the aquatic resources.

The recommended aquatic plant management plan represents a continuation of the current aquatic plant management program conducted by the ESLMD.

OTHER LAKE MANAGEMENT MEASURES

Hydrological Management

Professor Milan Straskraba introduced the concept of reservoir cascades to explain the effects of upstream impoundments on downstream impoundments.[20] The interactions of the impoundments within these cascade systems have been briefly described by Professors Straskraba and Jose Tundisi as follows:[21]

> "From a water quality standpoint, reservoir cascades are specific because any effect on an individual reservoir will be transferred to those below it. In a reservoir cascade, the water quality of the top reservoir is usually similar to the water quality of a solitary reservoir. The water quality of the second and lower reservoirs [is] usually all modified. The extent to which a reservoir modifies the water quality of another reservoir below it depends on whether the higher reservoir is a deep, stratified reservoir (profound effects) or a shallow reservoir (less effects). The intensity of these influences depends upon the connecting stream order, trophic levels in the reservoir and the distance between reservoirs. Reservoirs that are located on higher order streams and have greater retention times have greater effects on the outflowing river. The distance between one reservoir and another is also relevant; at a distance of several hundred kilometers from the reservoir, the river resumes a natural state and water quality effect from the upper reservoir are no longer observed. This effect is most important where reservoirs are closely situated."

In the case of the Mukwonago River, the proximity of the Lulu Lake and Eagle Spring Lake is such that, despite the absence of an impounding structure on Lulu Lake, the surface water elevations of the two Lakes are both controlled by the Wambold dam impounding Eagle Spring Lake, as shown in Figure 5 in Chapter II of this report. Nevertheless, the creation of the deltaic area at the point of entry of the Mukwonago River into Lulu Lake would

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[20]*M. Straskraba, "Limnological Particularities of Multiple Reservoirs Series,"* Archiv fur Hydrobiologie, Supplement: Advances in Limnology*, Volume 33, pages 677–678, 1990.*

[21]*M. Straskraba and J.G. Tundisi*, Guidelines of Lake Management, *Volume 9*, Reservoir Water Quality Management, *International Lake Environment Committee Foundation, Kusatsu, Japan, 1999. ISBN: 4-906356-26-5.*

suggest that the combined Lulu-Eagle Spring Lake system does indeed modify the water quality of the Mukwonago River between the point of entry to the two lakes and its point of discharge from the Wambold dam, which was substantiated in a recent report.[22]

The relationship between Eagle Spring Lake and Lower Phantom Lake, about 6.5 miles downstream, provides a more classical case of the reservoir cascade, although this relationship is somewhat obscured by the entry of Jericho Creek and outflows from Lake Beulah and the numerous springs discharging to the Mukwonago River upstream of Lower Phantom Lake. In this case, the impacts of Eagle Spring Lake, at an elevation of approximately 820 feet above National Geodetic Vertical Datum of 1929 (NGVD29), on the water quality of Lower Phantom Lake,[23] at an elevation of about 780 feet above NGVD29, are also moderated by the fact that both waterbodies are shallow lakes, each with a mean depth of four feet, and each having relatively low residence times. Lake Beulah also contributes to this cascade with discharge from the Lake Beulah dam entering the Mukwonago River approximately 2.5 miles upstream of Lower Phantom Lake. Lake Beulah has a surface elevation of 808 feet above NGVD29 and is about 1.4 miles upstream from the confluence with the Mukwonago River.

This cascade effect has led to the overall reduction in total phosphorus from upstream to downstream as shown in the Mukwonago River Watershed protection plan.[24] The data indicate that nutrients are generally assimilated by algae and other aquatic plants as water travels from upstream to downstream. In contrast to the limited water quality impacts between the reservoirs, the retention time effects of the Wambold dam on Lower Phantom Lake were clearly demonstrated during the June 2008 flood, which the U.S. Geological Survey estimated to have an annual flood probability of occurrence at the Mukwonago River stream gauge ranging from 0.5 percent to 1 percent.[25] The ESLMD, as owner and operator of the Wambold dam, made the decision to minimize the release of water from that impoundment in order to reduce flooding pressures on the Lower Phantom Lake dam, which was in danger of being over-topped. By effectively operating these reservoirs as a cascade system, the potential loss of the Lower Phantom Lake dam was prevented. Consequently, it is recommended that these impoundments be considered as a cascade and operated in conjunction with each other to minimize potential downstream risk.

Recreational Use Management

With respect to boating ordinances applicable to Eagle Spring Lake, it is recommended that current levels of enforcement be maintained. In addition, recreational boating access users should be made aware of the presence of the exotic invasive species Eurasian water milfoil within Eagle Spring Lake. Appropriate signage should be placed at the public recreational boating sites, and supplemental materials on the control of invasive species should be made available to the public. These materials also could be provided to riparian householders by means of mail drops or distribution of informational materials at public buildings, such as municipal buildings and the public library, and to nonriparian users by means of informational materials provided at the entrance to the public recreational boating access site. In addition, it is recommended that disposal bins be made available at the public recreational boating access sites for disposal of plant materials and other refuse removed from watercraft using the public recreational boating access sites. Continuation of the Clean Boats, Clean Waters program is recommended in this regard as a means of disseminating information to users of the public recreational boating access site.

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[22]*Hey and Associates, Inc.,* Eagle Spring Lake Water Quality Summary and Management Report, Eagle Spring Lake, Eagle, Wisconsin, *January 2005.*

[23]*See the data presented in University of Wisconsin-Milwaukee, "Status of Stream Habitat, Aquatic Biotic Integrity & Longear Sunfish Populations in the Mukwonago River Watershed," December 2003.*

[24]*SEWRPC Community Assistance Planning Report No. 309,* op. cit.

[25]*U.S. Geological Survey Scientific Investigations Report 2008–5235, "Flood of June 2008 in Southern Wisconsin," 2008.*

Public Informational and Educational Programs

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

Given the extent of public interest in Eagle Spring Lake, it is recommended that the ESLMD consider offering regular informational programs on the Lake and issues related thereto. Such programming can provide a mechanism to raise awareness of the Lake issues, and provide a focal point from which to distribute the informational materials referred to above. Specifically, the support of youth education by the ESLMD through the local school districts is recommended, including adoption of lake-related educational programs such as Project WET. The cost for conducting this informational and educational program is estimated to be $1,200 per year.

PLAN IMPLEMENTATION AND COSTS

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

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

The suggested lead agency or agencies for initiating program-related activities, by plan element, are set forth in Table 28. Table 29 provides an estimate of the costs of these elements, where they can be readily determined, linked to possible funding sources where such are available. In general, it is recommended that the ESLMD continue to provide a coordinating role for community-based lake management actions, in cooperation with the appropriate local government units.

Table 29

ESTIMATED COSTS OF RECOMMENDED LAKE MANAGEMENT MEASURES FOR EAGLE SPRING LAKE

Plan Element	Management Measure	Estimated Cost: 2000-2020[a] Capital	Estimated Cost: 2000-2020[a] Annual Operation and Maintenance	Potential Funding Sources[b]
Land Use	Observe regional and county land use plan guidelines	- -	- -	Walworth County, and Waukesha County
	Density management in the shoreland zone; enforce adequate setbacks and promote environmentally friendly landscaping practices in shoreland areas	- -	- -	Walworth County, Waukesha County, Village of Eagle, Village of East Troy, Town of Eagle, and Town of Troy
	Develop and implement consistent stormwater management ordinances in all riparian communities; periodic review of stormwater ordinances	- -	- -	Walworth County, Waukesha County, Village of Eagle, Village of East Troy, Town of Eagle, and Town of Troy
	Protection of environmentally sensitive lands and environmental corridors	- -	- -	WDNR Lake Protection Grant and Stewardship Grant Programs, Walworth County, Waukesha County, Village of Eagle, Village of East Troy, Town of Eagle, Town of Troy, ESLMD, and TNC
Pollution Abatement	Implement regional and county land and water resource management plans	- -[c]	- -[c]	Walworth County, Waukesha County, USDA EQUIP, and WDNR/ WDATCP Runoff Management Program
	Rural nonpoint source controls	- -[c]	- -[c]	Walworth County, Waukesha County, and WDNR/WDATCP Runoff Management Program
	Urban nonpoint source controls	- -[c]	- -[c]	Walworth County, Waukesha County, and WDNR/WDATCP Runoff Management Program
	Construction site erosion controls and stormwater management ordinances	- -[c]	\$250-\$500 per acre[c]	Municipalities, Walworth County, Waukesha County, private firms, and individuals
	Stormwater management systems developed where appropriate densities exist; use conservation subdivision designs	- -	- -	Walworth County, Waukesha County, Village of Eagle, Village of East Troy, Town of Eagle, and Town of Troy
	Onsite sewage system management	- -[c]	\$100-\$200[c]	Walworth County, Waukesha County, Village of Eagle, Village of East Troy, Town of Eagle, Town of Troy, and ESLMD
Water Quality	Continue participation in UWEX CLMN monitoring program	- -	\$200[d]	ESLMD, and UWEX
Hydrology	Maintain outlet structure and monitor water levels	- -	\$1,000	WDNR, and ESLMD
	Operate the dams as a cascade of reservoirs	- -	- -	ESLMD, Walworth County, Village of Mukwonago, and WDNR
Aquatic Biota	Protect fish habitat	- -	- -	Walworth County, Waukesha County, Village of Eagle, Village of East Troy, Town of Eagle, Town of Troy, and private landowners

Table 29 (continued)

Plan Element	Management Measure	Estimated Cost: 2000-2020[a] Capital	Estimated Cost: 2000-2020[a] Annual Operation and Maintenance	Potential Funding Sources[b]
Aquatic Biota (continued)	Maintain shoreline and littoral zone fish habitat	- -	- -	Walworth County, Waukesha County, Village of Eagle, Village of East Troy, Town of Eagle, Town of Troy, ESLMD, and private landowners
	Conduct periodic fish surveys and continue stocking of selected gamefish	- -	- -	WDNR, and ESLMD
	Enforce size and catch limit regulations	- -	- -	WDNR
	Encourage shoreline restoration projects through informational programming and demonstration sites	- -	- -	Walworth County, Waukesha County, Village of Eagle, Village of East Troy, Town of Eagle, Town of Troy, ESLMD, UWEX, and private landowners
	Conduct periodic reconnaissance surveys of aquatic plant communities; continue to monitor invasive species	- -	$1,500[e]	WDNR Lake Management Planning Grant Program, and ESLMD
	Update aquatic plant management plan every three to five years	- -	$1,500[e]	WDNR Lake Management Planning Grant Program, and ESLMD
	Use (limited) aquatic herbicides for control of nuisance plants, such as Eurasian water milfoil	- -	$1,000 per acre[f]	Town of Eagle, ESLMD, TNC, WDNR, and individuals
	Consider mechanically harvesting aquatic macrophytes to provide navigational channels and fish lanes, control nuisance plants and to promote growth of native plants, if future conditions warrant this type of management	- -	$1,650[g]	WDNR Lake Management Planning Grant and Recreational Boating Facilities Grant Programs, and ESLMD
	Manually harvest aquatic plants from around docks and piers, where feasible	$100	$100	ESLMD, and individuals
	Collect floating plant fragments from shoreland areas to minimize rooting of Eurasian water milfoil	- -	- -	ESLMD, and individuals
Water Use	Enforce regulations governing the operation of watercraft; improve signage and materials at public recreational access site to aid in the identification and control of exotic species	$500	$100	WDNR; ESLMD to support ongoing participation in Clean Boats, Clean Waters awareness program
	Maintain recreational boating access from the public access sites pursuant to Chapter NR 7 guidelines	- -	- -	WDNR
	Maintain navigational access, especially from public recreational boating access site(s) to main basin of Lake; maintain adequate depths for navigation as required, subject to WDNR permits	- -	- -	WDNR

Table 29 (continued)

Plan Element	Management Measure	Estimated Cost: 2000-2020[a] Capital	Annual Operation and Maintenance	Potential Funding Sources[b]
Ancillary Management Measures	Public informational and educational programming; seminars, programs, Project WET, Adopt-A-Lake	- -	$1,200	ESLMD, UWEX/WDNR/WAL Lakes partnership, and school districts
	Provide and conduct programming on aquatic plants and various management measures	- -	- -	WDNR Lake Management Planning Grant Program, and ESLMD
Total	- -	$600+	$13,900+	- -

[a]*All costs expressed in January 2010 dollars.*

[b]*Unless otherwise specified, USDA is the U.S. Department of Agriculture; USGS is the U.S. Geological Survey; WDNR is the Wisconsin Department of Natural Resources; WDATCP is the Wisconsin Department of Agriculture, Trade and Consumer Protection; UWEX is the University of Wisconsin-Extension; WAL is the Wisconsin Association of Lakes; ESLMD is the Eagle Spring Lake Management District; TNC is The Nature Conservancy; and CLMN is the Citizen Lake Monitoring Network.*

[c]*Costs vary with the amount of land under development during any given year.*

[d]*Monitoring conducted under the auspices of the CLMN Monitoring Program involves no cost, but does entail a time commitment from the volunteer.*

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

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

[g]*Based on actual year 2010 harvesting expenses reported to the WDNR by the ESLMD.*

Source: SEWRPC.

APPENDICES

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Appendix A

ILLUSTRATIONS OF COMMON AQUATIC PLANTS FOUND IN EAGLE SPRING LAKE

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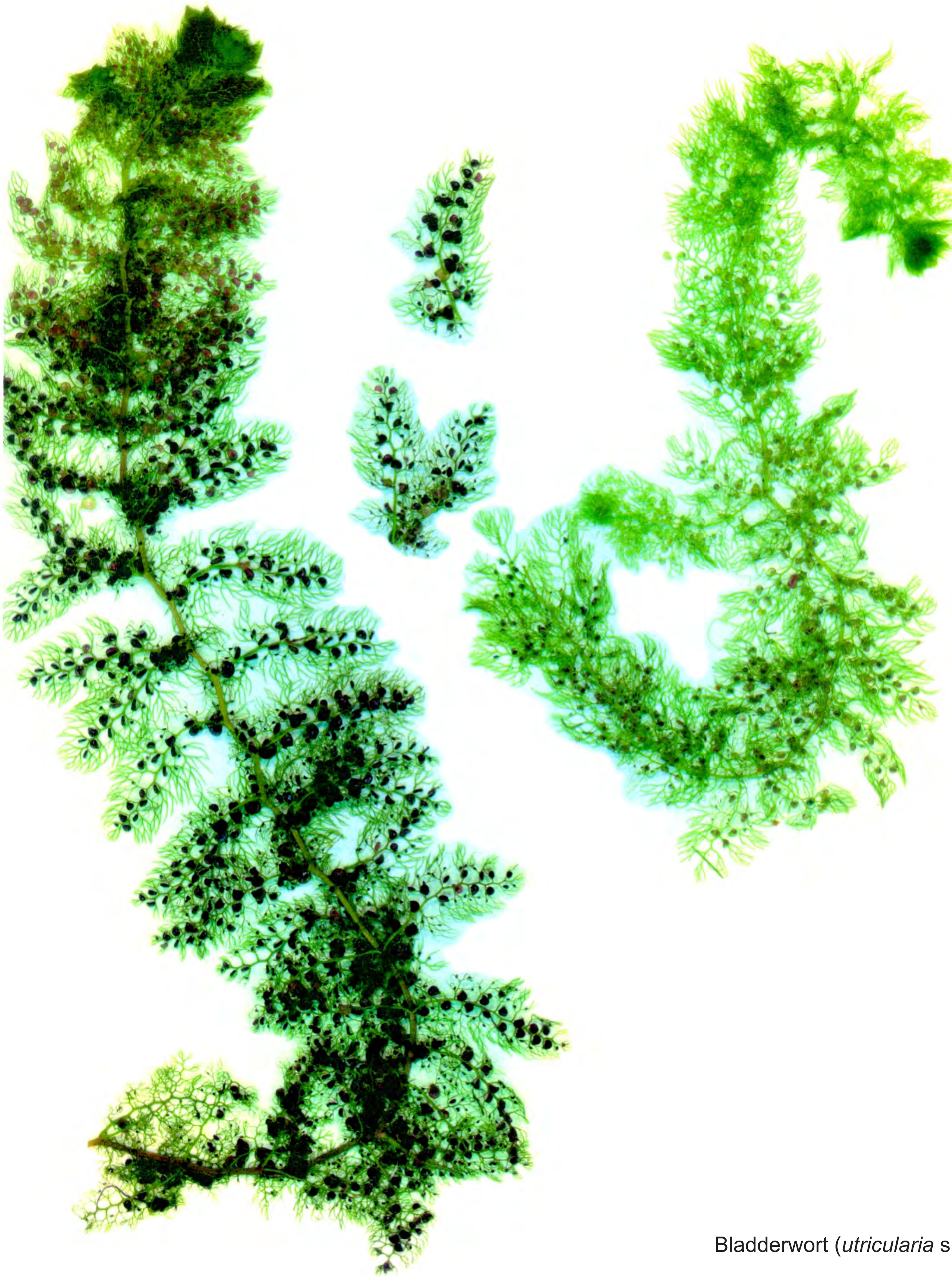


Bladderwort (*utricularia* sp.)

Bushy Pondweed (*najas flexilis*)

Cattail (*typha latifolia*)

Coontail (*ceratophyllum demersum*)

Curly-Leaf Pondweed (*potamogeton crispus*)
Exotic Species (nonnative)

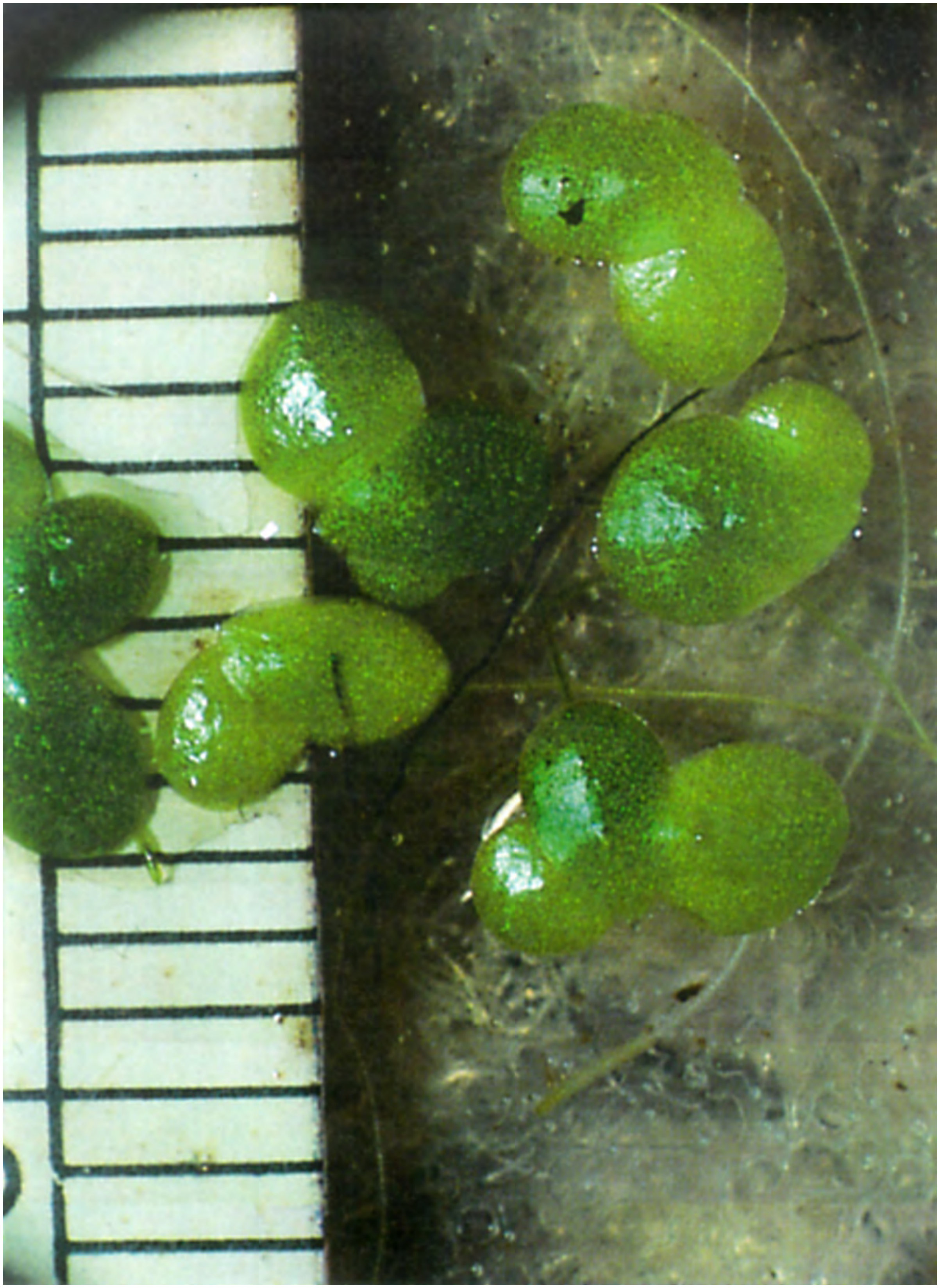
Eurasian Water Milfoil (*myriophyllum spicatum*)
Exotic Species (nonnative)

Flat-Stem Pondweed (*potamogeton zosteriformis*)

Floating-Leaf Pondweed (*potamogeton natans*)

Illinois Pondweed (*potamogeton illinoensis*)

Leafy Pondweed (*potamofeton foliosus*)



Lesser Duckweed (*lemna minor*)

NOTE: Plant species in photograph are not shown proportionate to actual size

Source: Steve D. Eggers and Donald M. Reed, Wetland Plants and Plant Communities of Minnesota & Wisconsin*,*
2nd Edition, 1997

Muskgrass (*chara vulgaris*)

Native Water Milfoil (*myriophyllum* sp.)

Needle Spike Rush (*ecleocharis acicularis*)

Sago Pondweed (*potamogeton pectinatus*)

Small Bur Reed (*sparganium minimum*)

Spiny Naiad (*najas marina*)

Variable Pondweed (*potamogeton gramineus*)

Water Stargrass (*zosterella dubia*)

Waterweed (*elodea canadensis*)

White Water Lily (*nymphaea odorata*)

White Water Crowfoot (*ranunculus longirostris*)

Eel-Grass / Wild Celery (*valisneria americana*)

Yellow Water Lily (*nuphar variegatum*)

Appendix B

TOWN OF EAGLE
RECREATIONAL BOATING ORDINANCE

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STATE OF WISCONSIN - TOWN OF EAGLE - WAUKESHA COUNTY

ORDINANCE NO. 09-02
AN ORDINANCE TO REPEAL AND RECREATE ORDINANCE 93-02
AN ORDINANCE TO PROVIDE FOR SAFETY AND WELFARE
ON AND AROUND EAGLE SPRING LAKE AND ORDINANCE 97-04
AN ORDINANCE REGARDING THE OPERATION OF MOTOR VEHICLES

WHEREAS, Eagle Spring Lake is heavily used by the residents of the Town of Eagle and visitors to the lake; and

WHEREAS, Eagle Spring Lake provides a home and habitat to natural wildlife,

NOW, THEREFORE, the Town Board of the Town of Eagle repeals and recreates Chapter 12 of the Code of Ordinances containing regulations and procedures for enforcement effective on, in and around Eagle Spring Lake:

12.01 STATUTORY PROVISIONS INCORPORATED

State boating laws as found in Secs. 30.50 to 30.71, and 30.99 Statutes, as amended from time to time, are adopted by reference.

12.02 ADDITIONAL REGULATIONS

1. No person shall swim more than 100 feet from shore without being accompanied by an escort boat.
2. No person shall water ski or surf board from 7:30 p.m. or sunset, whichever is sooner, until 8:30 a.m., the following day.
3. No person shall tow more than three persons at one time whether on skis or surf board and not more than three persons at one time shall be towed behind one boat.
4. No person shall operate a motorboat or watercraft in excess of slow-no-wake between 7:30 p.m. or sunset, whichever is earlier, and sunrise the following day or 8:30 a.m., whichever is later. "Slow-no-wake" means - that speed at which a boat moves as slowly as possible while still maintaining steerage control.
5. All piers and rafts shall be marked by red reflectors of not less than 3 inches in diameter placed not more than 3 feet from the outer limits of any pier.
6. No person shall tow or be towed behind a motorboat unless the person being towed is wearing a life jacket approved by U.S.C.G.
7. Interference with markers prohibited. No person shall, without authority, remove, damage, destroy, moor, or attach any watercraft to any buoy, beacon or marker placed in or on Eagle Spring Lake by the authority of the State of Wisconsin, or the Town of Eagle.
8. No person shall throw or deposit any metal cans, glass bottles, wood, paper or other litter or debris in or on Eagle Spring Lake or the surrounding shoreline.
9. No person shall operate a motor vehicle, defined as every motorized device weighing in excess of 1,000 lbs., upon icebound Eagle Spring Lake, except for the exclusive purpose of shoreline or lake property maintenance or repair.
10. No person shall drive a car recklessly or imprudently on the ice.
11. No person shall operate a motor boat or personal water craft in a clockwise direction around the lake during skiing hours.
12. No person shall obstruct the channel or channel access during skiing hours. The channel is the area between Powers Island and Tuohy's Resort.

13. No person shall operate a motor boat or water craft of any kind with a speed exceeding that which is reasonable and prudent with regard to the conditions. In addition, a maximum speed limit of 50mph has been established for Saturdays, Sundays, and Holidays.

<u>12.03 RISK AND LIABILITY</u>

All traffic on the ice bound waters of the lake shall be at the risk of the traveler as set forth in §30.81(3) Statutes. Nothing in this chapter shall be construed as rendering the enacting authority liable for any accident to those engaged in permitted traffic while this chapter is in effect.

<u>12.04 SPECIFIC AREAS DESIGNATED</u>

The areas shown on the attached map incorporated by reference marked by buoys are designated as areas reserved for that activity at that speed and none other:

Slow-no-wake boating: S   Swimming: W
Navigation: N   In: I   Out: O

<u>12.05 BUOY PLACEMENT</u>

The Lake Management District shall be responsible for placing, maintaining and removing authorized buoys. The buoys shall consist of those shown on the attached map incorporated by reference as follows:

Slow-no-wake boating: S   *Informational:*
Swimming: W   In: I
Navigation: N   Out: O

Hazard Warning Buoys:
Stump: T
Shallow: H

<u>12.06 PENALTIES</u>

A. STATE BOATING AND WATER SAFETY LAWS.

Wisconsin boating penalties as found in s. 30.80, Wis. Stats., and deposits as established in the Uniform Deposit and Bail Schedule are hereby adopted by reference with all references to fines are amended to forfeitures and all references to imprisonment are deleted.

B. LOCAL BOATING LAWS. GENERAL PROVISIONS.

Any person violating the provisions of this ordinance which is not an adopted state statute shall be subject to a forfeiture of not less than *$25.00* nor more than $50.00 for the first offense within a year and not less than *$50* nor more than $100 for any subsequent violations within the year. Each motor vehicle violation shall carry a forfeiture of a minimum of *$50* to a maximum of $1,000 plus assessments and costs as allowed by law. Failure to pay the forfeiture shall subject the violator to up to ninety (90) days in the county jail. The violator shall pay, in addition to the forfeiture, court costs, jail assessment and penalty assessments imposed by law. Each day a violation continues shall constitute a separate offense.

C. DEPOSITS REQUIRED.

1. For all offenses listed in the Uniform Wisconsin Deposit and Bail Schedule for Conservation, Boating, Snowmobile and ATV Violations, the arresting officer shall require the alleged offender to deposit the amount set forth in the schedule ***SCHEDULED DEPOSIT.***

a. NON-SCHEDULED DEPOSIT.

If a deposit schedule has not been established for a specific violation, the arresting officer shall require the alleged offender to deposit the maximum forfeiture permitted by this ordinance plus the penalty assessment, jail assessment fee and court costs, as amended from time to time.

2. If you have been issued a Citation by a Town of Eagle Lake Patrol Officer, you have these choices to handle this Citation:

A. **PAY** the fine amount on the Citation. You may mail your payment to the Joint Municipal court System or pay the fine at the Joint Municipal Court System before the Court Date.

B. **APPEAR** in court on the Court Date if you wish a Trial.
MUST APPEAR in Court if the Citation is marked “Must Appear”. If you do not appear in Court an Arrest Warrant or Driver’s License Suspension may be ordered by the Judge.

The back of the pink Citation also explains your choices.

Fines may be paid at: Fines may be mailed to:

Joint Municipal Court System	Joint Municipal Court System
North Prairie Village Hall	PO Box 98 130
North Harrison Street	North Prairie, WI 53153-0098
North Prairie, WI 53153-0098	

Wednesdays 5 pm – 8 pm
Make checks payable to: **Joint Municipal Court System**.

Questions regarding Court please call Clerk of Courts (262) 392-2265, Wednesdays 5:00 pm – 8:00 pm.

<u>12.07 ENFORCEMENT</u>

A. ENFORCEMENT PROCEDURE

§§66.14.114, 66.115, 66.119 and 66.12, Wis. Stats. as amended from time to time are adopted and by reference made a part of this Ordinance as if fully set forth herein. Any act required to be performed or prohibited by any statute incorporated by reference is required or prohibited by Ordinance. The Town of Eagle elects to use the citation method of enforcement.

B. ISSUANCE OF CITATIONS

All sections of this Ordinance shall be enforced by the Lake Patrol Officer or the Town Board's appointed representatives.

12.08 OTHER REMEDIES

Neither this ordinance nor the issuance of a citation shall preclude the Town Board or any Authorized officer from other proceedings.

Enacted this 2nd day of March, 2009, on motion of Supervisor Davis, Seconded by Supervisor Malek.

Approved:

____

Town of Eagle Robert Kwiatkowski, Town Chairman

Attest:

____

Lynn M. Pepper, Clerk

Ayes 4 Nays 0 Absent 1

STATE OF WISCONSIN TOWN OF EAGLE WAUKESHA COUNTY

ORDINANCE NO. 10-01

AN ORDINANCE TO REPEAL AND RECREATE SECTION 12.01 OF ORDINANCE NO. 93-02, "AN ORDINANCE TO PROVIDE FOR SAFETY AND WELFARE ON AND AROUND EAGLE SPRING LAKE"' TO PROVIDE AN EXEMPTION TO THE SLOW NO WAKE PROVISIONS IN WIS. STAT. § 30.66(3)(a)

WHEREAS, the Town of Eagle has established regulations for the public safety and welfare on and around Eagle Spring Lake under Ordinance No. 93-02; and

WHEREAS, Section 12.01 of Ordinance 93-02 adopts State boating laws as found in Sections 30.50 to 30.71 and 30.99 of the Wisconsin Statutes as amended from time to time; and

WHEREAS, 2009 Wisconsin Act 31 provides for various amendments to Sections 30.66 and 30.69 of the Wisconsin Statutes including, but not limited to, the creation of Section 30.66(3)(ag)(1), which establishes a general prohibition on the operation of a motorboat, other than a personal watercraft, at a speed in excess of slow no-wake within 100 feet of the shoreline of any lake; and

WHEREAS, 2009 Wisconsin Act 31 also creates Wis. Stats. § 30.66(3)(ag)(2), which permits the Town to provide an exemption to the provisions of Wis. Stat. § 30.66 (3)(ag)(1) or, in the alternative, to substitute a lesser number of feet; and

WHEREAS, by letter dated July 25, 2009, the Eagle Spring Lake Management District has recommended that the Town Board adopt an ordinance pursuant to Wis. Stat. § 30.66 (3)(ag)(2) to exempt Eagle Spring Lake from the aforementioned slow no-wake provisions of Wis. Stat. § 30.66 (3)(ag)(1); and

WHEREAS, the Town Board, having considered the foregoing recommendation by the Eagle Spring Lake Management District and the potential impact of the proposed exemption on the public health, safety, and welfare, including the public's interest in preserving the state's natural resources, and the Town Board having determined that it is in the interest of the public health, safety, and welfare to establish an exemption to the provisions of Wis. Stat. § 30.66 (3)(ag)(1); and

WHEREAS, pursuant to Wis. Stat. § 30.77(1)(d), the Town Board submitted the text of this Ordinance to the Wisconsin Department of Natural Resources for an advisory review on August 25, 2009 and at least sixty (60) days prior to any final action by the Town Board and the Town Board having received and duly considered the advisory report of the Wisconsin Department of Natural Resources pertaining to this Ordinance;

NOW, THEREFORE, the Town Board of the Town of Eagle, Waukesha County, Wisconsin, DO ORDAIN AS FOLLOWS:

SECTION 1: Section 12.01, "Statutory Provisions Incorporated", of Ordinance No. 93-02 of the Town of Eagle, entitled "An Ordinance to Provide for Safety and Welfare on and Around Eagle Spring Lake" is hereby repealed and recreated to read as follows:

12.01 STATUTORY PROVISIONS INCORPORATED

(1) State boating laws as found in Secs. 30.50 to 30.71, and 30.99 Statutes, as amended from time to time, are adopted by reference.

(2) Pursuant to the provisions of Section 30.66(3)(ag)(2) of the Wisconsin Statutes, Eagle Spring Lake shall be exempt from the provisions in Section 30.66(3)(ag)(1) of the Wisconsin Statutes that prohibit operation of a motorboat, other than a personal watercraft, at a speed in excess of slow no-wake within 100 feet of the shoreline.

SECTION 2: SEVERABILITY

The several sections of this ordinance are declared to be severable. If any section or portion thereof shall be declared by a court of competent jurisdiction to be invalid, unlawful or unenforceable, such decision shall apply only to the specific section or portion thereof directly specified in the decision, and shall not affect the validity of any other provisions, sections or portions thereof of the ordinance. The remainder of the ordinance shall remain in full force and effect. Any other ordinances whose terms are in conflict with the provisions of this ordinance are hereby repealed as to those terms that conflict.

SECTION 3: EFFECTIVE DATE

This ordinance shall take effect on March 1, 2010, following its posting or publication as provided by law.

Dated this 1st day of March, 2010.

TOWN OF EAGLE

Attest:

Lynn M. Pepper, Town Clerk

Approved:

Robert Kwiatkowski, Town Chairman

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Appendix C

NONPOINT SOURCE POLLUTION CONTROL MEASURES

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

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

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

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

Table C-1

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

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

Table C-1 (continued)

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

Table C-1 (continued)

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

Table C-1 (continued)

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

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

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

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

Source: SEWRPC.

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

Table C-2

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

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

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

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

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

Source: SEWRPC.

Appendix D

SEWRPC STAFF MEMORANDA RELATING TO THE IMPLEMENTATION OF RECOMMENDED LAKE MANAGEMENT MEASURES SET FORTH IN SEWRPC COMMUNITY ASSISTANCE PLANNING REPORT NO. 226, *A LAKE MANAGEMENT PLAN FOR EAGLE SPRING LAKE, WAUKESHA COUNTY, WISCONSIN*

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Appendix D-1

SEWRPC STAFF MEMORANDUM

RESULTS OF THE COMMUNITY QUESTIONNAIRE SURVEY: 2000
NOVEMBER 7, 2000

INTRODUCTION

Pursuant to your June 30, 1998, letter request submitted jointly with that of the Phantom Lakes Management District, and the letter agreement between the Eagle Spring Lake Management District and the Southeastern Wisconsin Regional Planning Commission dated June 1, 1999, the Commission staff prepared and distributed a questionnaire survey designed to identify existing and potential future water quality and use issues and concerns relating to Eagle Spring Lake. The survey instrument was distributed to the electors of the Eagle Spring Lake Management District during the summer of 1999. Responses were received through September 30, 2000. The Commission staff is pleased to submit to you herewith the results of the analysis of the responses received to the Phantom-Eagle Spring Lakes Recreational Water Use and Water Quality Survey.

BACKGROUND

Eagle Spring Lake is a 311-acre drainage lake, located in the Town of Eagle in Waukesha County. Local concern over the state of the Lake prompted the formation of a Town Sanitary District that was later converted to a Chapter 33, *Wisconsin Statutes*, public inland lake protection and rehabilitation district in 1990. Subsequently, the Eagle Spring Lake Management District has enrolled in the Wisconsin Department of Natural Resources (WDNR) Self-Help Monitoring Program, with lake residents carrying out the monitoring prescribed under that program. In addition, water quality monitoring, pursuant to the Trophic State Index monitoring protocol established by the WDNR, was carried out on the Lake by the U.S. Geological Survey from 1991 through 1996.

Eagle Spring Lake is one of four major lakes situated along the Mukwonago River. These lakes include, from west to east, Lulu Lake, an 84-acre drainage lake in the Walworth County portion of the drainage basin; Eagle Spring Lake, a 311-acre drainage lake in the Waukesha County portion of the drainage basin; Lower Phantom Lake, a 433-acre drainage lake in the Waukesha County portion of the drainage basin; and Upper Phantom Lake, a 107-acre drained lake located adjacent to Lower Phantom Lake and connected thereto by an unnamed tributary stream, also in the Waukesha County portion of the drainage basin. Of these lakes, the Southeastern Wisconsin Regional Planning Commission has prepared a lake management plan for Eagle Spring Lake, elements of which also included consideration of the transportation of nuisance aquatic plant species between Eagle Spring Lake and upstream Lulu Lake, and an aquatic plant management plan for Upper and Lower Phantom Lakes.

The Mukwonago River is a major tributary stream to the Fox River, entering the Fox River main stem in the northern portion of the Middle Fox River Basin. The River flows in a generally easterly direction, from its point of origin within the Town of Troy, Walworth County, to its confluence with the Fox River in the Town of Vernon, Waukesha County. Significant portions of the Mukwonago River have been designated as Exceptional Resource Waters pursuant to Chapter NR 102 of the *Wisconsin Administrative Code*.

Portions of these lake management actions have been funded, in part, through the Chapter NR 190 Lake Management Planning Grant Program.

QUESTIONNAIRE SURVEY TECHNIQUE

The current questionnaire survey was constructed as a mail drop questionnaire survey of the electors of the Eagle Spring Lake Management District and undertaken during the summer of the year 1999. The questionnaire was compiled in a manner consistent with the lake user survey protocol prepared by the University of Wisconsin-Extension for the Wisconsin Lakes Partnership. A copy of the Phantom-Eagle Spring Lakes Recreational Water Use and Water Quality Survey instrument is appended hereto as Exhibit A. Funding for the survey was provided, in part, through a Chapter NR 190 Lake Management Planning Grant awarded to the Eagle Spring Lake and Phantom Lakes Management Districts.

The overall purpose of the survey was to discover the degree of satisfaction of the respondents with respect to lake water quality, recreational opportunities, and ordinance enforcement, as well as to identify their knowledge of lake management activities undertaken by the Districts. More specifically, the survey was designed to facilitate determination of the types of actions necessary to achieve or maintain desired water quality and lake use conditions conducive to such uses, as the initial step in the process of refining and updating the management program conducted by the Districts within the Mukwonago River basin.

The Commission staff prepared and distributed the Phantom-Eagle Spring Lakes Recreational Water Use and Water Quality Survey to electors of the Eagle Spring Lake Management District during the summer of 1999. Upon return, these surveys were carefully tabulated and evaluated by Commission staff. This letter report includes a summary of the responses to survey instruments received through September 30, 2000. A total of 84 surveys, or 33 percent of the 255 questionnaires dispatched to electors within the Eagle Spring Lake Management District, were received by that date. Overall, a total of 190 surveys, or 28 percent of the 678 questionnaires dispatched to electors of both Lake Management Districts, were returned. A summary of the responses is appended hereto as Exhibit B.

RESPONDENT PROFILE

A majority of respondents were year-round residents of Eagle Spring Lake. A majority of respondents had resided on Eagle Spring Lake for more than 10 years, and used the Lake for recreation with their family and friends. The Phantom Lakes electors followed this general profile. as well.

LAKE USE

A majority of respondents (64 percent) felt Eagle Spring Lake to be moderately used, although 26 percent felt the Lake was heavily- or over-used on weekends. Collectively, respondents from both Districts rated power boating, walking/jogging, swimming/diving/scuba, bird watching, and picnicking/barbecuing as the activities most favored. Boating and swimming are considered active recreational pursuits, while walking, picnicking and bird watching are considered more passive activities. Respondents from both Districts rated the operation of personal watercraft—jet skiing—as the least important activity; the perceived overabundance of jetskis was of significant concern to 27 percent of Eagle Spring Lake respondents and 46 percent of Upper Phantom Lake respondents.

The importance of power boating to Eagle Spring Lake respondents is notable, with 28 percent of respondents spending an average of 40 days per year engaged in this activity. Of those responding, 29 owned ski boats with an average horsepower ranging from 35 hp to 260 hp. Respondents also owned 57 motor boats, with average horsepower of 70 hp. In addition, 23 percent of respondents spent an average of 19 days per year engaged in rowing/canoeing and the operation of nonpowered watercraft.

With respect to other activities reported, a plurality of respondents (36 percent) spent an average of 32 days per year engaged in swimming/diving/scuba diving activities, and an average of 38 days per year fishing (59 percent of respondents) and 13 days per year ice fishing (40 percent of respondents), respectively. Walking/jogging was a popular year round activity, with 27 percent of respondents engaging in this activity for an average of 120 days per year.

ISSUES AND CONCERNS IDENTIFIED

The most significant concerns expressed and issues identified by the respondents to the Eagle Spring Lake survey were the following:

- General water quality—identified as a concern by 92 percent of respondents,
- Sedimentation and loss of Lake depth—identified by 63 percent of respondents, and
- The decline of the fishery—identified by 37 percent of respondents.

These issues and concerns are described in more detail below.

General Water Quality

A majority of respondents to the Eagle Spring Lake questionnaire survey (92 percent) were concerned with the general water quality of the Lake. A majority of respondents (86 percent) felt the Lake had deteriorated during their period of residence at the Lake.

In analyzing the reason for this perception, respondents were asked to indicate the basis for their perceptions. Based upon both water clarity and water testing, and algae and aquatic plants, a majority of Eagle Spring Lake respondents (56 percent and 86 percent, respectively) perceived the water quality to be poor. Conversely, 72 percent of Eagle Spring respondents felt the water quality was good based upon aesthetic and wildlife conditions. An overwhelming majority of respondents (96 percent) felt the Lake had excessive algal and aquatic plant growth, specifically identifying Eurasian water milfoil as a factor in this problem. A number of respondents attributed the abundance of this plant to “excessive nutrients and sediment, coupled with too many motor boats and poor management with the mechanical harvesters” and septic system failures.

In describing their perception of “good” water quality, respondents generally agreed that good water quality could be described as “a healthy balance of aquatic plants (possibly including milfoil, but not to the current extent), better clarity, more diverse and abundant wildlife, and less boat noise and pollution.”

Respondents were asked how they would like to see the excessive algae and aquatic plants controlled. A majority of respondents preferred dredging of nutrient-rich sediments (72 percent), septic pumping to be required by the District (70 percent), and restricted fertilizer use within the watershed (53 percent) as the primary means of reducing nutrient loads to the Lake. Mechanical harvesting remained the preferred method of aquatic plant management within the Lake, with 61 percent of respondents favoring this measure over other aquatic plant management techniques such as chemical or biological control measures and development controls within 500 feet of the lakeshore.

Sedimentation and Loss of Lake Depth

Another concern of Eagle Spring Lake respondents (63 percent) was sedimentation and the perceived loss of Lake depth. This concern is shared to some degree with the respondents to the Lower Phantom Lake questionnaire survey (32 percent of respondents). Both Lakes are fairly shallow, having a maximum depth of about 12 feet. In both Lakes, 72 percent of respondents indicated support for dredging as a means of algal and aquatic plant control as well as of increasing Lake depth.

Perceived Decline of the Fishery

Some respondents (37 percent) to the Eagle Spring Lake survey also indicated concern over a perceived decline in the Lake fishery. Their concern was embodied in the opinion of the majority of respondents (89 percent) who rated the fishing quality fair to poor. A majority of respondents (59 percent) spent an average of 38 days per year fishing during open water periods, while a plurality of respondents (40 percent of respondents) spent an average of 13 days per year ice fishing. All of the anglers reported catching panfish, although respondents were split as to whether these fishes had increased or decreased in this system. Likewise, all of the anglers agreed that walleyed pike had decreased in abundance in the Lake. Largemouth bass and northern pike were other popular angling species (caught by 82 and 36 percent of anglers reporting, respectively) that were perceived to have declined in abundance. In contrast, the anglers reported carp to have increased in abundance over the last five years.

OTHER ISSUES AND CONCERNS

Regulations and Law Enforcement Issues and Concerns

Respondents were generally satisfied with respect to the enforcement of boating, and fish and game regulations on the Lakes (58 percent of respondents), land use zoning regulations in the watershed (52 percent of respondents), and sanitation regulations related to waste disposal and sewage in the watershed (55 percent of respondents). About 20 percent of respondents had no opinion with respect to these issues. Of those respondents indicating dissatisfaction with the level of regulation, more (about 30 percent of respondents) expressed concern with respect to land use and sanitation regulations in the watershed than with law enforcement on the Lakes (about 10 percent of respondents were dissatisfied).

Lake Management District Issues and Concerns

A majority of respondents (54 percent) reported that they attended the annual meeting of the Eagle Spring Lake Management District on a regular basis. The majority of respondents (69 percent) agreed that the Eagle Spring Lake Management District was generally doing a good job in lake management. Many empathized with the difficulties faced by the Board of Commissioners; one elector noted that, "as difficult as it is to balance the issues, public sentiment, DNR regulations, etc.–they do an excellent job!" Notwithstanding, some electors felt left out, with little control over the decisions made with respect to managing the Lake, noting that the Board of Commissioners appeared to be "close-minded" or pursuing "personal agendas" with respect to certain lake management issues.

Many respondents expressed concern over the chemical herbicides that were put into Eagle Spring Lake. Some respondents commented that the District should place greater efforts on informational and educational programming.

FISCAL RESPONSIBILITY FOR LAKE AND RIVER IMPROVEMENTS

The majority of respondents to the Eagle Spring Lake survey (78 percent) indicated a willingness to contribute more money for lake or river-related improvements. This is in contrast to the position of the Phantom Lakes survey respondents, only 49 percent of whom were willing to pay more. Many Eagle Spring Lake respondents indicated their willingness to fund lake management measures related to dredging (64 percent), better aquatic plant management (33 percent), and onsite sewage disposal system improvements (19 percent). About 10 percent of respondents indicated their willingness to fund fish stocking. Numerous respondents (65 percent of those commenting) indicated a desire for a greater monetary contribution for the implementation of lake management measures from the State.

With respect to potential for financial assistance from the State, funds for lake management activities are available primarily through the Chapter NR 190, Lake Management Planning Grant Program, and the Chapter NR 191, Lake Protection Grant Program. The Eagle Spring Lake Management District has applied to the Chapter NR 190, Lake Management Planning Grant Program, for financial support of lake management activities in recent years. Some additional funding may be available through the Chapter NR 7, Recreational Boating Facilities Grant Program, for the acquisition of aquatic plant harvesters and related equipment.

* * *

#31674 V1 - EAGLE SPRING LAKE SURVEY LTR
PCE/JAT/pk

Eagle Spring Lake Management District
P.O. Box 196
Eagle, Wisconsin 53119

EAGLE SPRING LAKE MANAGEMENT DISTRICT

PHANTOM LAKES MANAGEMENT DISTRICT

LAKE USE AND WATER QUALITY SURVEY

Dear Friends and Neighbors,

The Mukwonago River, linking a chain of lakes that includes Eagle Spring and Phantom Lakes, has been designated by the State of Wisconsin as an Outstanding Resource Water. Besides the Wisconsin Department of Natural Resources, Waukesha County and the municipalities along this portion of the River, the Eagle Spring Lake Management District and Phantom Lakes Management District have specific responsibilities for protecting and enhancing the water quality of the River and Lakes. We are conducting this survey to determine your opinions regarding the state of the river, lakes and surrounding development.

Please take a few minutes to provide us with your opinions and responses to the following questions and return you thoughts to us in the prepaid envelope provided. Your responses will be kept in strict confidence. Thanks for your participation. Your response will help us to develop an appropriate strategy for protecting these valuable water resources.

Sincerely,

Ed Mack, Chairman
Board of Commissioners
Eagle Spring Lake Management District

Dennis Ward, Chairman
Board of Commissioners
Phantom Lakes Management District

JAT/pk
#9775 V1 - EAGLE-PHANTOM SURVEY

Enclosure

EAGLE SPRING-PHANTOM LAKES
RECREATIONAL WATER USE AND WATER QUALITY SURVEY

1. Please tell us about your use of the River and its Lakes (circle one):

   A. Are you a:
      1. year-round resident
      2. part-time resident, summer
      3. part-time resident, weekends

   B. Do you live on:
      1. Eagle Spring Lake
      2. Lower Phantom Lake
      3. Upper Phantom Lake
      4. Mukwonago River
      5. None of the above

   C. How many years have you lived in this area?
      1. Less than one year
      2. One year to five years
      3. Six years to 10 years
      4. More than 10 years

2. How do you use Eagle Spring and/or Phantom Lakes and/or the Mukwonago River?

   A. <u>Fishing</u> (If you do not fish skip to B)

   Days fished per year ________

   Which species of fish did you catch last year? (circle all that apply)

a. Northern Pike	e. Panfish
b. Walleyed Pike	f. Carp
c. Largemouth Bass	g. Bullhead
d. Smallmouth Bass	h. Other (please specify) ___________________________

   Which waterbodies did you fish? (circle all that apply)

a. Eagle Spring Lake	d. Mukwonago River
b. Lower Phantom Lake	e. Upper Phantom Lake
c. Lulu Lake	

   Which of the following fish do you think increased in SIZE of fish caught (write I), decreased in SIZE of fish caught (write D), or remained the same (write S), within the last five years?

____ a. Northern Pike	____ g. Panfish
____ b. Walleyed Pike	____ i. Carp
____ c. Largemouth Bass	____ j. Bullhead
____ d. Smallmouth Bass	____ k. Other (please specify) ______________________

Which of the following fish do you think increased in NUMBER of fish caught (write I), decreased in NUMBER of fish caught (write D), or remained the same (write S), within the last five years?

____ a. Northern Pike ____ g. Panfish
____ b. Walleyed Pike ____ i. Carp
____ c. Largemouth Bass ____ j. Bullhead
____ d. Smallmouth Bass ____ k. Other (please specify) ______________________

How do you rate the fishing quality?

____ a. excellent
____ b. good
____ c. fair
____ d. poor

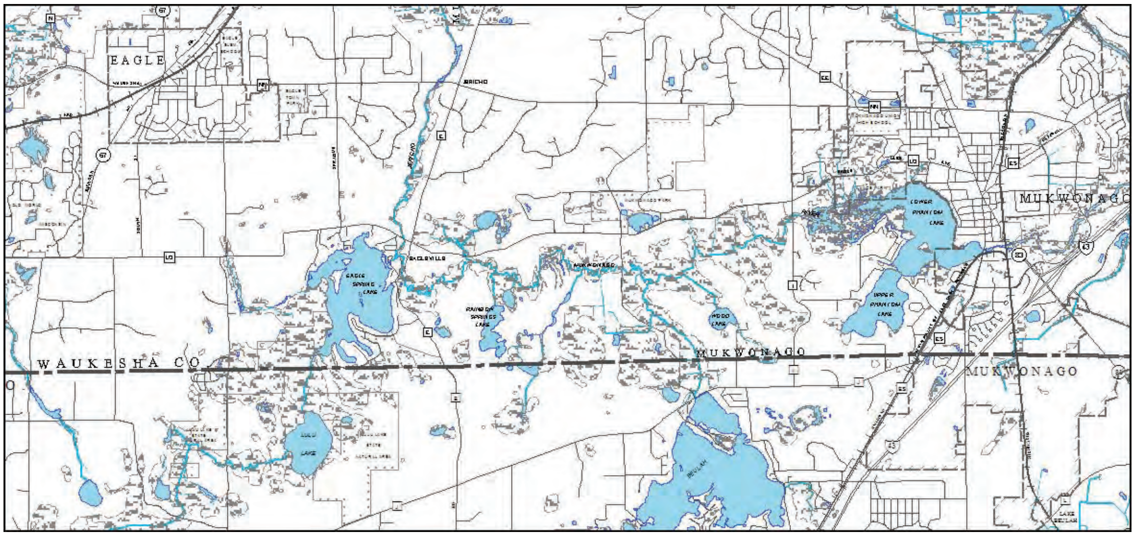
How many days did you ice fish over the past year? ________ days

B. Recreation

The following list contains a number of popular water based activities. If you engage in any of these activities, please indicate the approximate number of days per year you spend on the activity in the space provided. In the last column indicate the relative importance of that activity to you by ranking the activities from 1 through 5, with 1 being least important and 5 being most important.

	Year Round (number of days)	Spring/Summer Only (number of days)	Fall/Winter Only (number of days)	Relative Importance (1-5)
Power Boating	______	______	______	______
Type of Boat:	*Ski Boat*	*Motor Boat*	*Fishing Boat*	*Other Boats*
Horse Power:	______	______	______	______
Number Owned:	______	______	______	______
Jet Skiing	______	______	______	______
Snowmobiling	______	______	______	______
Sailing/Boardsailing	______	______	______	______
Rowing/Canoeing	______	______	______	______
Waterskiing	______	______	______	______
Cross-Country Skiing	______	______	______	______
Swimming/Diving/ SCUBA-Diving	______	______	______	______
Bird Watching	______	______	______	______
Picnicking/Barbecuing	______	______	______	______
Walking/Jogging	______	______	______	______
Other (specify ______________)	______	______	______	______

Which parts of the river, lake or lakeshore do you usually use? Please place an "x" on the areas that you use regularly.



When you use the Mukwonago River and chain of lakes, do you usually do so... (circle one):

a. on your own
b. with family
c. with friends
d. in a group

Do you consider these water resources that you use to be... (circle one):

a. lightly used
b. moderately used
c. heavily used
d. over used

Why? ____

____

____

3. Please tell us how you feel about the following issues which can affect your use of the Mukwonago River and its Lakes.

A. <u>Regulations and law enforcement issues:</u>

How would you rate your general level of satisfaction with law enforcement on the lakes and river (e.g., boating, fish and game regulations)? (circle one)

a. Well satisfied
b. Satisfied
c. No strong feeling
d. Not satisfied
e. Very dissatisfied

How do you rate your general level of satisfaction with land use zoning regulations in the lake watershed? (circle one)

a. Well satisfied
b. Satisfied
c. No strong feeling
d. Not satisfied
e. Very dissatisfied

How do you rate your general level of satisfaction with sanitation regulations in the lake watershed? (circle one)

a. Well satisfied
b. Satisfied
c. No strong feeling
d. Not satisfied
e. Very dissatisfied

B. Water quality issues:

Do you consider the Lakes and River to have good water quality

— Based upon water clarity and water tests? (circle one)

a. Yes   b. No

Why? ____________________

— Based upon algae and aquatic plants? (circle one)

a. Yes   b. No

Why? ____________________

— Based upon aesthetics and wildlife conditions? (circle one)

a. Yes   b. No

Why? ____________________

How would you describe good water quality?

____

____

In your opinion, how has the quality of the lake changed since you first moved to or visited the area? (circle one)

a. Improved
b. Stayed the same
c. Deteriorated
d. Don't know

C. Aquatic Plant Management Issues:

Do you feel that the lakes have excessive algae and aquatic plant growth? (circle one)

a. Yes   b. No   c. Don't know

Why? ____________________

If you answered no or don't know to this question C1, skip to Part D, Other Issues.
If you answered yes to question C1, please answer the following question.

How would you like to see the excessive algae and aquatic plants controlled?

1...........2...........3...........4...........5
Least Preferred................Most Preferred

a.	Mechanical harvesting of weeds	1	2	3	4	5
b.	Use algae/aquatic plant chemicals	1	2	3	4	5
c.	Biological control of weeds by weevil	1	2	3	4	5
d.	Restrict use of fertilizer for all properties:					
	– Within 500 feet of lakeshore	1	2	3	4	5
	– Within 1,000 feet of lakeshore	1	2	3	4	5
	– Within the watershed	1	2	3	4	5
e.	Place additional development controls on these areas:					
	– Along the shoreline	1	2	3	4	5
	– Within 500 feet of the lakeshore	1	2	3	4	5
	– Within 1,000 feet of the lakeshore	1	2	3	4	5
	– Within the watershed	1	2	3	4	5
f.	Dredging	1	2	3	4	5
g.	Septic pumping required by District	1	2	3	4	5
h.	Other ________________________	1	2	3	4	5
i.	Other ________________________	1	2	3	4	5

D. <u>Other Issues:</u>

What are your top FIVE concerns about the Mukwonago River and chain of lakes (place a number “1” next to the issue that is most important to you, a number “2” next to the second most important issue, and so on)?

____ General water quality
____ Number of boats
____ Speed of boats
____ Size of boats
____ Number of water skiers
____ Number of jet skiers
____ Use of lake and access sites by nonresidents
____ Decline in fishery resources
____ Excessive noise
____ Unpleasant odors
____ Farm runoff
____ Urban stormwater runoff
____ Development around the lake
____ Shoreline erosion
____ Wetland preservation
____ Water levels that fluctuate too much
____ Sedimentation/shallow areas
____ Other (please specify) ________________________

What do you think could be done about your concerns to improve the situation?

____

____

Would you be prepared to pay more than you currently do for any improvements to the lake or river environment or facilities that you may have indicated above? (circle one)

a. Yes b. No

If NO, who should pay? ____

How should the funds be raised? ______________________________________

If YES, which additional improvements would you be willing to pay for?

____

____

E. <u>Lake Management District Issues</u>:

If you live within either the Eagle Spring Lake Management District or the Phantom Lakes Management District, please answer the following questions:

Do you think the Lake Management Districts are generally doing a good job in lake management? Please comment.

____

____

Lake management districts are required to hold an annual meeting between Memorial Day and Labor Day to approve the annual budget, elect commissioners, and conduct any other business brought before the districts.

I regularly attend the annual meetings(circle one)

a. Yes b. No

If NO, please indicate if you do not attend because (check all that apply):

____ I have to work
____ The meetings are held at an inconvenient time
____ I am out of town during this period
____ I would prefer the meetings to be held on another day

If you have checked any of the boxes above, please tell us what time, date, or other accommodation (such as absentee balloting) we can make to better meet your scheduling needs:

____

Are there any other issues that you would like to draw to our attention at this time?

____

____

____

____

THANK YOU FOR YOUR COOPERATION

SOUTHEASTERN WISCONSIN REGIONAL PLANNING COMMISSION

916 N. EAST AVENUE
P.O. BOX 1607
WAUKESHA, WISCONSIN 53187-1607

Exhibit B

PUBLIC OPINION OF LAKE USE AND WATER QUALITY OF THE MUKWONAGO RIVER AND CHAIN OF LAKES

I. METHODOLOGY

A. Questionnaire survey using a mail-back survey method during summer 1999.

B. Analysis based upon 190 responses out of 678 possible. This correlates to a 28 percent return of questionnaire surveys by the Eagle Spring Lake and Phantom Lakes electors.

II. RESPONDENT PROFILE

Eagle Spring Lake

Collectively 255 questionnaire surveys were mailed to Eagle Spring Lake electors, with 84 responses received. This correlates to a 33 percent return.

A. Majority of respondents (70 percent) were year-round residents; 19 percent were summer residents; and 11 percent were weekend residents.

B. Majority of respondents (73 percent) had resided on Eagle Spring Lake for more than 10 years.

Lower Phantom Lake

Collectively 423 questionnaire surveys were mailed to Phantom Lakes electors, with 106 responses received. This correlates to a 25 percent return.

A. Majority of respondents (95 percent) were year-round residents; 2 percent were summer residents; and 3 percent were weekend residents.

B. Majority of respondents (61 percent) had resided on Lower Phantom Lake for more than 10 years.

Upper Phantom Lake

A. Majority of respondents (96 percent) were year-round residents; 4 percent were summer residents; and there were no weekend residents reported.

B. Majority of respondents (69 percent) had resided on Upper Phantom Lake for more than 10 years.

Nonriparian

A. Majority of respondents (62 percent) had resided near the aforementioned bodies of water as year-round residents; there were no seasonal residents reported; and 10 percent were weekend residents.

B. Majority of respondents (62 percent) had resided near the aforementioned bodies of water for more than 10 years.

III. LAKE USE

Collectively, the majority of respondents (52 percent) used these waterbodies with family; 23 percent of respondents used the waterbodies with friends; 19 percent of respondents reported using the waterbodies alone; and 6 percent used the waterbodies with a group.

A. Categories of Use

Collectively the most popular activities included: power boating, walking/jogging, swimming/diving/scuba, bird watching, and picnicking/barbecuing. The least popular activity was jet skiing.

<u>Eagle Spring Lake</u>

1. Power boating was the most important use, rated as 5.0 on a five-point scale, where 5.0 is the most important use, followed by rowing/canoeing, swimming/diving/scuba and walking/jogging—all of which had an average rating of 4.0; and water skiing, bird watching, and picnicking/barbecuing—all of which had an average rating of 3.0. Tubing, hunting, ice hockey, ice skating, and sight-seeing were also mentioned.

2. Jet skiing and cross-country skiing were the least important uses, rated as 2.0 on a five-point scale, where 1.0 is the least important use.

<u>Lower Phantom Lake</u>

1. Walking/jogging was the most important use, rated as 5.0 on a five-point scale, where 5.0 is the most important use, followed by power boating, swimming, rowing/canoeing, bird watching, and picnicking/barbecuing—all of which had an average rating of 4.0; snowmobiling, sailing/board sailing, water skiing, and cross-country skiing—all of which had an average rating of 3.0. Fishing, hunting, paddle boating, photography, and biking were also mentioned.

2. Jet skiing was the least important use, rated as 2.0 on a five-point scale, where 1.0 is the least important use.

<u>Upper Phantom Lake</u>

1. Power boating, rowing/canoeing, waterskiing, swimming/diving/scuba, bird watching, picnicking/barbecuing, and walking/jogging were the most important uses, rated as 4.0 on a five-point scale, where 5.0 is the most important use, followed by sailing/board sailing, rated as 3.0. Duck hunting, ice skating, bicycling and water volleyball were also mentioned.

2. Snowmobiling and cross-country skiing, rated at 2.0 on a five-point scale, where 1.0 is the least important use, and jet skiing, rated as 1.0, were the least important uses.

<u>Nonriparian</u>

1. Waterskiing, swimming/diving/scuba, and picnicking/barbecuing were the most important uses, rated as 5.0 on a five-point scale, where 5.0 is the most important use, followed by power boating, rowing/canoeing, and bird watching, rated as 4.0.

2. Jet skiing was the least personally most important use, rated as 1.0 on a five-point scale, where 1.0 was the least important use.

B. Intensity of Use

Collectively 48 percent of Phantom-Eagle Spring Lakes Recreational Water Use and Water Quality Survey respondents felt the Lakes of the Mukwonago River watershed to be moderately-used.

Eagle Spring Lake

1. Majority of respondents (64 percent) felt Eagle Spring Lake to be moderately-used. Fewer respondents felt Eagle Spring Lake to be lightly-used (10 percent), heavily-used (18 percent), or over-used (8 percent).

Lower Phantom Lake

1. Majority of respondents (85 percent) felt Lower Phantom Lake was moderately-to heavily-used. Fewer respondents felt Lower Phantom Lake to be over-used (9 percent) or lightly-used (6 percent).

Upper Phantom Lake

1. Plurality of respondents (48 percent) considered Upper Phantom Lake to be moderately-used. Fewer respondents felt Upper Phantom Lake to be heavily-used (32 percent) or over-used (20 percent).

Nonriparian

1. Plurality of respondents (45 percent) felt these water resources to be over-used. Fewer respondents felt these water resources to be moderately-used (36 percent).

C. Frequency of Use

Overall, respondents of this questionnaire/survey live fairly active lifestyles. Some of the most frequented Lake activities of the respondents include: bird watching, walking/jogging, picnicking/barbecuing, power boating, and swimming/scuba/snorkeling. A majority of respondents (57 percent) fish the Lakes.

Eagle Spring Lake

1. On an annual basis, bird watching was the most frequently engaged-in activity (averaging 180 days per year), including more than 23 percent of the respondents. Walking/jogging (averaging 120 days per year) also included just over 23 percent of the respondents. Picnicking/barbecuing (averaging 72 days per year) included just over 23 percent of the respondents, while power boating (averaging 40 days per year) included 28 percent of the respondents.

2. During spring and summer, power boating was the most frequently engaged-in activity (averaging 118 days), followed by bird watching (averaging 74 days), walking/jogging (averaging 70 days), and rowing/canoeing and swimming/diving/scuba (both averaging 36 days).

3. During autumn and winter, bird watching was the most frequently engaged-in activity (averaging 170 days), followed by walking/jogging (averaging 60 days), and swimming/diving/scuba (averaging 18 days).

4. Majority of respondents (59 percent) spent 38 days per year fishing during open water periods, and 40 percent of respondents spent 13 days ice-fishing.

Lower Phantom Lake

1. On an annual basis, bird watching was the most frequently engaged-in activity (averaging 258 days per year) including 24 percent of respondents. Walking/jogging was the second most frequently engaged-in activity (averaging 233 days per year) involving 20 percent of respondents. Picnicking/barbecuing was a favorite activity of respondents (averaging 109 days per year), but only involving 14 percent of respondents. Power boating, jet-skiing, and swimming/diving/scuba were also popular activities of respondents (averaging about 60 days per year, respectively). Power boating involved only seven percent of respondents, while jet skiing involved only one percent of respondents. Swimming/diving/scuba involved 14 percent of respondents.

2. During spring and summer, bird watching was the most frequently engaged-in activity (averaging 71 days), followed by walking/jogging (55 days), power boating (50 days), jet skiing (35 days), waterskiing (32 days), picnicking/barbecuing (30 days), swimming/diving/scuba (18 days), rowing/canoeing (12 days), and sailing/boardsailing (1 day).

3. During autumn and winter, bird watching (averaging 106 days) was the most frequently engaged-in activity, followed by walking/jogging (75 days), cross-country skiing (23 days), power boating (22 days), snowmobiling (18 days), picnicking/barbecuing (10 days), jet skiing and waterskiing (both 5 days), rowing/canoeing (4 days), and swimming/diving/scuba (3 days).

4. On average, 57 percent of the respondents spent 46 days per year fishing during open water periods and 42 percent of the respondents spent 16 days ice fishing.

Upper Phantom Lake

1. On an annual basis, bird watching was the most frequently engaged-in activity (averaging 269 days per year) performed by 50 percent of the respondents. Walking/jogging and picnicking/barbecuing were also important activities of respondents (averaging 176 days and 90 days per year respectively) representing 42 percent of respondents for both activities. Rowing/canoeing and power boating were other favorite activities of respondents (averaging 79 and 71 days per year, respectively) performed by 27 percent of respondents for both activities.

2. During spring and summer, walking/jogging was the most frequently engaged-in activity (averaging 90 days), followed by swimming/diving/scuba (averaging 58 days), and power boating (averaging 49 days).

3. During autumn and winter, walking/jogging was the most frequently engaged-in activity (averaging 150 days), followed by cross-country skiing (averaging 21 days), and power boating and picnic/barbecuing (both averaging 18 days).

4. On average, 65 percent of respondents spend approximately 40 days per year fishing during open water periods, and 23 percent of respondents spend approximately 9 days ice-fishing per year.

Nonriparian

1. On an annual basis, bird watching was the frequently most engaged-in activity (averaging 365 days per year) including 40 percent of respondents. Walking/jogging (averaging 88 days per year) included 60 percent of respondents. Swimming/diving/scuba (averaging 25 days per year) included 40 percent of respondents.

2. During spring and summer, swimming/diving /scuba was the most frequently engaged in activity (averaging 23 days), followed by sailing/board sailing (averaging 15 days), and rowing/canoeing and water-skiing (both averaging 12 days).

3. During autumn and winter, swimming/diving/scuba was the most frequently engaged in activity (averaging 20 days), followed by snowmobiling (averaging 8 days).

4. On average, 47 percent of respondents spent 12 days per year fishing during open water periods, and 13 percent of respondents spent 6 days ice fishing.

D. Levels of Satisfaction

Collectively, 53 percent of respondents rated the fishing quality of these Lakes as good. A majority of the respondents caught panfish (97 percent), largemouth bass (68 percent), and northern pike (57 percent). Overall, anglers perceived that the walleyed pike and largemouth bass populations had decreased in these systems.

Eagle Spring Lake

1. Majority of respondents (89 percent) rated the fishing quality fair to poor, only 11 percent rated the fishing quality good. Panfish (caught by 100 percent of anglers), largemouth bass (caught by 82 percent), and northern pike (caught by 36 percent) were the most common angling species. Northern pike, walleyed pike, and largemouth bass were perceived to have declined in abundance over the last five years. Carp were perceived to be increasing. Bullhead species were generally thought to have remained about the same over the last five years. Anglers were split as to whether smallmouth bass and panfish decreased or remained the same during this period.

Lower Phantom Lake

1. Majority of respondents (47 percent) rated the fishing quality good, 33 percent rated the fishing quality fair, and 11 percent rated the fishing quality poor. Panfish (caught by 100 percent of anglers), largemouth bass (65 percent), northern pike (62 percent) were the most common angling species. Carp and bullhead were generally thought to have remained at the same abundance over the last five years. Northern pike seem to be increasing in this system. Walleyed pike, largemouth bass and panfish were perceived to have declined in abundance over the last several years. No conclusion regarding smallmouth bass was evident.

Upper Phantom Lake

1. Majority of respondents (89 percent) rated the fishing quality good, only 11 percent rated the fishing quality poor. Panfish (caught by 88 percent of anglers), largemouth bass (67 percent), and northern pike (59 percent) were the most frequently caught angling species. Panfish catches were perceived to have declined over the last five years. Anglers were split as to whether northern pike and largemouth bass increased or

decreased in abundance over the last five years, but the majority of anglers indicated carp to be increasing and bullheads remaining about the same.

Nonriparian

1. Majority of respondents (63 percent) rated the fishing quality good, while 37 percent felt it was fair. Panfish (caught by 100 percent of anglers), northern pike (71 percent), largemouth bass (57 percent), and smallmouth bass (29 percent) were the most common angling species. Northern pike, smallmouth bass, and carp were perceived to have increased in abundance over the last five years. Largemouth bass were perceived to have decreased in abundance during this period. Anglers were split as to whether panfish increased or decreased over the last five years.

E. Concerns

Collectively, the greatest concern among respondents (63 percent) was the general water quality of the Lakes. Other, related concerns included lake access and use by nonresidents, shoreline erosion, wetland preservation, decline of the fishery, development around the Lakes, and the numbers and speed of boats and watercraft.

Eagle Spring Lake

1. Majority of respondents (92 percent) were concerned with the general water quality of Eagle Spring Lake. Sedimentation and loss of lake depth also was a concern of respondents (63 percent). Other concerns were the decline of the fishery (37 percent), use and access by nonresidents (33 percent), shoreline erosion (32 percent), and the number of jet skis (27 percent). Wetland preservation, development around the Lake, the numbers and speed of boats, farm runoff, and excessive noise were also mentioned as issues.

Lower Phantom Lake

1. Majority of respondents (51 percent) were concerned with the general water quality of Lower Phantom Lake. Use of and access to the Lake by nonresidents (46 percent), shoreline erosion (34 percent), sedimentation and loss of Lake depth (32 percent), speeds of boats (31 percent), development around the lake (27 percent), and decline of the fishery (24 percent) were also issues of concern.

Upper Phantom Lake

1. Majority of respondents (65 percent) were concerned with general water quality, development around the lake (62 percent), and use of and access to the Lake by nonresidents (54 percent). The abundance of jet skis (46 percent), wetland preservation (35 percent), and numbers of boats (35 percent) were also issues of concern.

Nonriparian

1. Plurality of respondents (46 percent) were concerned with general water quality, sizes of boats, use of and access to the Lakes by nonresidents, decline of the fishery, urban stormwater runoff, and wetland preservation. The number of jet skis was another major concern (38 percent of respondents).

F. Management

Eagle Spring Lake

1. Majority of respondents (69 percent) felt the Eagle Spring Lake Management District was doing a good job.

2. Majority of respondents (78 percent) were willing to contribute more money for lake-related improvements.

3. Many respondents (65 percent of those commenting) indicated a desire for a greater monetary contribution from the State.

4. Majority of respondents preferred dredging (72 percent) and District-managed septic pumping (70 percent) as management options to reduce nutrient loading to the Lake and control aquatic plant growth.

5. Some respondents (31 percent of those commenting) felt that Eagle Spring Lake required better aquatic plant management.

6. Lake management measures that respondents indicated a willingness to pay for included dredging (64 percent), aquatic plant management (33 percent), District-managed septic pumping (19 percent), and shoreline stabilization and fish stocking (both at 8 percent).

Lower Phantom and Upper Phantom Lakes

1. Majority of respondents (52 percent) felt the Phantom Lake Management District was doing a good job, 28 percent felt they were not doing a good job, and 20 percent expressed no opinion.

2. Residents were almost equally divided as to whether they were willing to contribute more money for lake-related improvements (49 percent were willing, while 51 percent were not willing, to pay more).

3. Many respondents (33 percent of those commenting) indicated a desire for a greater monetary contribution from the State.

4. Many respondents (75 percent) commented that additional funds should be raised through Lake user fees–specifically, a boat launch fee.

5. Majority of respondents (62 percent) preferred onsite sewage disposal system pumping for nutrient and aquatic plant control. On Lower Phantom Lake, a majority of respondents (72 percent) also indicated dredging as a preferred management option.

6. Lake management measures that respondents indicated a willingness to pay for included aquatic plant management (18 percent); in addition, respondents from Lower Phantom Lake indicated a willingness to pay for dredging (21 percent), District-managed septic pumping (18 percent), and shoreline stabilization (12 percent).

Nonriparian

1. Majority of respondents (67 percent) felt the Phantom Lakes and Eagle Spring Lake Management Districts were doing a good job.

2. Majority of respondents (81 percent) were not willing to contribute more money for lake-related improvements.

3. Many respondents (44 percent) felt lake users should contribute money for lake-related improvements; an equal number of respondents (44 percent) felt local, state, or federal funds also should be allocated for lake-related improvements.

4. Majority of respondents (88 percent) preferred septic pumping for nutrient and aquatic plant control. Respondents were split as to whether dredging was necessary.

5. Lake management measures that respondents indicated a willingness to pay for included mandatory public sewerage and better stormwater management measures to keep runoff from the lakes.

IV. COMPILATION OF ALL WATERBODIES CONSIDERED

A. Use of Lakes and River

1. Three percent of respondents reported using all of the waterbodies considered in this survey. Three percent also reported using the Mukwonago River. Lulu Lake was utilized by 31 percent of the respondents. Upper and Lower Phantom Lakes were utilized by 36 and 40 percent of respondents, respectively. Eagle Spring Lake was utilized by 39 percent of the respondents.

B. Regulations and Law Enforcement Issues

1. Majority of respondents (62 percent) indicated satisfaction with law enforcement on the Lakes and River, 14 percent indicated no opinion, and 24 percent indicated dissatisfaction.

2. Plurality of respondents (43 percent) indicated satisfaction with land use zoning regulations in the Lake watershed, 27 percent indicated no opinion, and 30 percent indicated dissatisfaction.

3. Plurality of respondents (45 percent) indicated satisfaction with sanitation regulations in the Lake watershed, 16 percent indicated no opinion, and 39 percent indicated dissatisfaction.

C. Water Quality Issues

1. Based upon water clarity and water testing, the majority of the respondents (57 percent) considered the Lakes and River as having good water quality; 38 percent of the respondents did not consider the Lakes and River as having good water quality (a

majority of these respondents (68 percent) were electors of the Eagle Spring Lake Management District).

2. Based upon algal and aquatic plant growth, the majority of respondents (67 percent) did not consider the Lakes and River as having good water quality (the majority of these respondents (64 percent) were electors of the Eagle Spring Lake Management District).

3. Based on aesthetic and wildlife conditions, the majority of respondents (72 percent) considered the Lakes and River as having good water quality.

4. Majority of respondents (58 percent) perceived the quality of the Lakes and River had deteriorated since they first moved to or visited the area (the majority of these respondents (68 percent) were electors of the Eagle Spring Lake Management District), 30 percent perceived the water quality to have stayed the same, and 10 percent perceived the water quality to have improved.

5. Majority of respondents (79 percent) felt that the Lakes and River had excessive algal and aquatic plant growth; 42 percent of Upper Phantom Lake residents did not feel this to be a problem, while 96 percent of Eagle Spring Lake respondents and 73 percent of Lower Phantom Lake respondents perceived algal and aquatic plant growth as excessive.

A. Algae and Aquatic Plant Control Preferences

1. Majority of respondents (68 percent) preferred mechanical harvesting. Fewer respondents preferred aquatic herbicides or biological controls (about 45 percent reported these to be the least preferred methods).

2. Majority of respondents (56 percent) preferred restricting fertilizer use within 500 feet of the shoreline, while 49 percent and 48 percent preferred restricting fertilizer use within 1,000 feet of the shoreline, or throughout the Mukwonago River watershed, respectively.

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SEWRPC STAFF MEMORANDUM

SUMMARY NOTES ON WATER LEVEL ISSUES RELATING TO EAGLE SPRING LAKE – WAMBOLD DAM, WAUKESHA COUNTY, WISCONSIN

BACKGROUND

As noted in the May 7, 2001, letter from Mr. Thomas A. Day, Chairman of the Eagle Spring Lake Management District, the Regional Planning Commission staff originally considered the increase in lake level in the context of the comprehensive lake management planning program completed by the Regional Planning Commission at the request of the Eagle Spring Lake Management District. This report, SEWRPC Community Assistance Planning Report No. 226, *A Lake Management Plan for Eagle Spring Lake, Waukesha County, Wisconsin,* was published in October 1997.

The discussion of water level management measures was included within that plan at the request of the Lake Management District Commissioners and Wisconsin Department of Natural Resources-South East Region staff. The plan noted that the minimum and maximum operating levels of between 817.3 feet and 817.6 feet above the National Geodetic Vertical Datum of 1929 (NGVD-29)—reported *in litt.* dated June 16, 1995 by Ms. Liesa Nesta of the WDNR staff and referenced Dam File #67.4—should be corrected by 2.65 feet as a result of a refinement in the elevation of the benchmark against which these levels were assessed. Based upon the data provided by Ms. Nesta, the actual operating levels reported to have been established by the Wisconsin Public Service Commission in their 1954 ruling, should be 819.9 feet and 820.2 feet above NGVD-29.

[NOTE: These elevations are now being reevaluated by KWB.]

REFINEMENT OF THE BENCHMARK ELEVATION AND LOCAL DATUM

The 2.65 feet adjustment was derived from survey data maintained by the Regional Planning Commission. These data showed that the elevation of Bench Mark No. FX N-12-C was adjusted from 818.581 feet above NGVD-29 to 821.226 feet, or by about 2.65 feet. These data are maintained in the Commission's Record of Vertical Control Stations for the Fox River Watershed Planning Program, and related to the bench mark located on the Northwest wingwall of the dam at the northern outlet to Eagle Spring Lake, originally placed by the Wisconsin Railroad Commission. A previous refinement—set forth *in litt.* dated December 16, 1985, by Dr. Kurt W. Bauer, Executive Director of SEWRPC and referenced CA-709-03—had suggested that this adjustment should be from 818.581 feet to 821.44 feet above NGVD-29, or about 2.9 feet. However, this was subsequently further refined, and an adjustment of 2.65 feet is currently noted in the Regional Planning Commission's record for Benchmark No. FX N-12-C.

Commission staff also reviewed the Wisconsin Public Service Commission findings of fact and order set forth in their docket 2-WP-997, dated October 14, 1954, amending the operating level of Eagle Spring Lake. In that order, the Commission staff note that the operating levels were established at 98.80 feet and 99.10 feet with respect to a Public Service Commission datum. This datum is based upon Public Service Commission Benchmark No. 291-A, described as a brass cap located on the left upstream wingwall of the dam, having a nominal elevation of 100.0 feet. Based upon the known elevation of this benchmark of 821.226 feet above NGVD-29, as set forth in the Regional Planning Commission's data base, the equivalent operating levels of Eagle Spring Lake would be between 820.0 feet and 820.3 feet above NGVD-29.

These investigations created the need to reconcile the approximately 0.1 feet difference in the reported operating levels set forth in the adopted lake management plan for Eagle Spring Lake and the lake level elevation estimated based upon the known elevation of the Public Service Commission benchmark. Ms. Nesta, in the attachment to her aforereferenced letter of June 16, 1995, noted a further correction to the benchmark, numbered 291-F, subsequent to the installation of the local gauge and consequent to the inspection of the dam structure carried out by WDNR staff on April 30, 1987. At that time, the surface elevation of the lake, reported to be 818.04 feet above NGVD-29 was refined as 817.98 feet above NGVD-29, or by about 0.06 feet. This is consistent with the February 1966 note set forth in the Lake Studies—Control Structures report on the dam. This report noted the elevation of the datum referenced 291-D, and described as a square cut on the right upstream wingwall on the western gates of the Wambold Dam, as 100.06 feet, Public Service Commission datum. This would suggest that the lake level elevations established by the Public Service Commission in their order referenced 2-WP-997 and dated October 14, 1954, possibly should be adjusted by 0.06 feet, or by about 0.1 feet. Such an adjustment would negate any difference between operating levels reported in the adopted lake management plan and established by the Public Service Commission. However, the referenced benchmark referred to in the report is not the brass cap referenced in the Public Service Commission order of 1954, and this adjustment may be suspect—requiring the recommended lake levels to be adjusted by about 0.1 feet.

RECOMMENDED MODIFICATION OF THE LAKE SURFACE ELEVATION

With respect to the modification of the mandated operating levels of Eagle Spring Lake, the Regional Planning Commission staff reviewed their recommendations, set forth in the adopted lake management plan. That plan recommended that the operating levels of the Lake be increased by about 0.6 feet to between 820.53 feet and 820.83 feet above NGVD-29. The recommendations reflected the current operating regime of the Wambold Dam impounding Eagle Spring Lake that has been maintained since about April 10, 1958, as documented by Ms. Nesta in an attachment to her aforereferenced letter of June 16, 1995.

Subsequently, pursuant to the August 3, 1998, order of the Wisconsin Department of Natural Resources, the Eagle Spring Lake Management District is required to return the lake elevations to within the maximum and minimum permitted by the Wisconsin Public Service Commission, and undertake certain specific investigations to ensure the safety of Wambold Dam. To date, the District has completed the structural investigation—set forth in the letter report dated April 3, 2000—and dam failure analysis—set forth in the report dated January 2001—both prepared by Graef, Anhalt, Schloemer & Associates, Inc. Based upon the findings set forth in these documents, the Wambold Dam, and associated structures and earthworks, has been reported to be structurally sound. As a consequence, the Regional Planning Commission staff understand that the District Commissioners intend to pursue the recommendations, set forth in the adopted lake management plan for Eagle Spring Lake, to formally increase the operating levels of Eagle Spring Lake to between 820.53 feet and 820.83 feet above NGVD-29.

PROCESS FOR AMENDING OPERATING LEVELS OF DAMS

The process for increasing the operating level is set forth in Section 31.13 of the *Wisconsin Statutes*. This requires that the owner of an existing dam wishing to raise or enlarge same must apply to the Wisconsin Department of Natural Resources for an amendment of the current permit—the 1954 order of the Wisconsin Public Service Commission. In this regard, the Regional Planning Commission staff have established from Mr. Konstantin Margovsky, WDNR Dam Safety Engineer, that a formal increase in the lake level of Eagle Spring Lake would constitute an enlargement of the existing impoundment. To this end, notes relevant to the information required to be presented to the Wisconsin Department of Natural Resources in an application for enlargement by the owner of the dam, pursuant to the requirements of Sections 31.05 and 31.13, *Wisconsin Statutes*, are set forth in Table 1 appended hereto.

CURRENT STATUS OF THE PROPOSED ALTERATION IN LAKE LEVEL ELEVATION

Section 31.06, *Wisconsin Statutes*, requires that the Wisconsin Department of Natural Resources, upon receipt of an application, convene a hearing. This hearing would consider, *inter alia*, whether the applicant has satisfied the ownership and maintenance requirements set forth in Sections 31.05(3) and 31.14(2) or (3). It would appear, from the aforereferenced letter of Ms. Nesta dated June 16, 1995, that the WDNR would stipulate the requirement set forth in Section 31.05(3) that the applicant own or hold an enforceable option to acquire 65 percent of the lands to be flowed. This stipulation would appear to be consistent with the exemption from this requirement of entities having the power of eminent domain, which power a public inland lake protection and rehabilitation district constituted pursuant to Chapter 33, *Wisconsin Statutes*, is presumed to enjoy. In addition, Ms Nesta notes that, given the “long history of higher levels, the legal concept of prescriptive rights will apply, and the Management District will not be required to obtain flowage easements from surrounding property owners to keep the level higher.”

To this end, it would appear that the letter from Mr. James G. Wilhelm, then Chairman of the Eagle Spring Lake Management District, dated July 13, 1995, was intended to be a response to Ms. Nesta. It also would appear that the letter was intended to be an application to the WDNR pursuant to the requirements of Section 31.13, *Wisconsin Statutes*. Mr. Wilhelm’s letter requested and applied for an increase in lake operating level to a [corrected] elevation of between 820.53 feet and 820.83 feet above mean sea level. This range of elevations is consistent with the recommendations set forth in the adopted lake management plan. Mr. Wilhelm’s letter further requested the WDNR convene the required hearing on the increase in lake surface elevation at the District’s 1995 annual meeting. It would appear that this hearing was never convened.

ADDITIONAL RELEVANT CONCERNS

In the adopted lake management plan for Eagle Spring Lake, the Regional Planning Commission staff noted that “any significant” decrease in lake surface elevation may be expected to increase aquatic plant growth “in the already limited areas of the Lake that are now in open water...adversely impact[ing] the lake fishery by reducing spawning opportunities” and further limiting recreational use and boating opportunities in the Lake. Subsequently, the Regional Planning Commission staff, in a staff memorandum transmitted to the Eagle Spring Lake Management District Board of Commissioners *in litt.* dated February 18, 1999, further considered the consequences of lake level modification in their discussion of dredging alternatives, noting that “drawdown followed by sediment removal using conventional drag-line or clamshells dredging techniques was discounted” due to potentially serious “impact[s] not only on the recreational use of the Lake by riparians and visitors to Eagle Spring Lake, but also on the aquatic flora and fauna of the Lake, including fish populations.” These concerns remain.

In addition, however, conversations between Dr. Jeffrey A. Thornton of the Commission staff, and Mr. Todd Shoemaker, a graduate student at the University of Wisconsin-Madison, would suggest additional concerns with respect to the impact of lake surface elevation changes at Eagle Spring Lake. These concerns relate to the impact of water levels on the ecology and hydrology of the upstream Chapter NR 102 Outstanding Resources Water, Lulu Lake. These concerns were subsequently discussed with Mr. Day, Chairman of the Eagle Spring Lake Management District, and appear to relate to the concern of The Nature Conservancy regarding the potential for higher water levels to encourage encroachment of cattails and purple loosestrife in the vicinity of the two waterbodies. Commission staff considered these concerns based upon the likely hydrological impacts of altering the water surface elevation at Eagle Spring Lake, and the likely ecological impacts on aquatic and wetland plant growth in the two Lakes.

Potential Hydrologic Impacts

With respect to the hydrology of the system, the adopted lake management plan notes the hydrologic connection between Lulu Lake and Eagle Spring Lake. The plan reports that there is a navigable channel linking the two waterbodies. In addition, the wetland and environmental corridor maps contained within the adopted lake management plan clearly show extensive wetland systems bordering this channel. Both of these connections are likely to be hydrologically pervious, or of such character as to allow the free movement of water from Lulu Lake to Eagle Spring Lake. The implication of this is that a decrease in water level within the downstream waterbody could potentially be reflected in a concomitant decrease in the water level in the upstream lake. The reported water surface elevations of the two lakes differ by about one foot on the applicable U.S. Geological Survey 7.5 minute series topographic map for the East Troy quadrangle—the elevations being 821 feet and 822 feet above sea level, North American datum, respectively.

Potential Ecological Impacts

Assuming that these systems are hydrologically linked, it may be assumed that a reduction in lake surface elevation in Eagle Spring Lake of about 0.6 feet as required to bring the Wambold Dam into conformity with its operating permit would result in about a 0.6 feet decrease in water level in Lulu Lake. While the precise impact of such a drawdown on the lake ecosystems would require further investigation, the potential impact can be assessed based upon the following data reported by the WDNR in their lake use reports for Eagle Spring Lake—Wisconsin Department of Natural Resources Lake Use Report No. FX-19, dated 1969—and Lulu Lake—Wisconsin Department of Natural Resources Lake Use Report No. FX-39, dated 1969. The former indicates that about 22 percent of Eagle Spring Lake is less than three feet in depth, while the latter indicates that about 10 percent of Lulu lake is less than three feet in depth. Although this would suggest that Lulu Lake has a less extensive littoral, or nearshore, zone than Eagle Spring, the presence of significant areas of nearshore shallows could result in additional encroachment of rooted aquatic plants within the basins of both lakes. While much of Lulu Lake has somewhat steeply sloping banks that rapidly drop off to depths of greater than 10 feet, the southeastern portions of the Lake have less steeply sloped shores of up to 300 feet or more in width, to the five foot depth contour. In contrast, much of the western shoreline of Eagle Spring Lake, and portions of the northern and southeastern shorelines, of between 500 feet and 1,500 feet in width, are less than four feet in depth.

Cattails, *Typha latifolia* and *Typha augustifolia* and their hybrids, are limited by water depth, with the latter, narrow leaf cattail having the ability to grow in deeper water of up to about two to three feet in depth. The former, broad leaf cattail generally outcompetes the narrow leafed variety in water of up to one foot in depth, and can extend shoreward to elevations of up to two to three feet above the high water mark. While cattails do have positive ecological—in that they support insects, provide food for muskrats and beaver, attract marsh birds, waterfowl and songbirds, and provide spawning habitat for sunfish and shelter for juvenile fishes—they can outcompete other, often more desirable species of shoreland plants, creating dense monospecific stands. Such stands often limit access to lakes, and, in the case of already constricted areas like the channel linking Eagle Spring and Lulu Lakes, can impede boating traffic. In addition, citizen complaints can arise during periods of the year when the plants are flowering and seeding. Complaints include an increase in allergy-like symptoms and nuisance complaints related to the airborne distribution of the seeds that lodge in curtains and home furnishings, etc.

Purple loosestrife, *Lythrum salicaria*, displays many of the same invasive characteristics of cattails, but, unlike the cattails, are nonnative species having no natural predators. Purple loosestrife can outcompete even cattails and, similarly, forms dense, monospecific stands with little ecologic value. The plant can encroach rapidly into newly exposed areas of lake bed, and, as a consequence of the volume of seed distributed by the plants, can remain at viable populations levels for several years even after the adult plants are cut or pulled. While the plants have not been recorded in the Lulu Lake area—at the time of the wetland surveys conducted during the regional natural areas and critical species habitat protection and management planning program—inclusive of the wetlands forming the western shore of Eagle Spring Lake, both Lakes are well within the range of these plants and there is a real likelihood of the plants entering these systems.

The established wetland and aquatic plant flora in the Lulu Lake and Eagle Spring Lake system has developed as a result of the maintenance of water levels within the range indicated as being approximately 0.6 feet higher than those indicated in the Public Service Commission order. These higher levels have been maintained in Eagle Spring Lake for a period in excess of 40 years. This would suggest that those portions of the Lakes inundated by these higher water levels will have assumed a lacustrine character, while their fringing wetlands will have developed as a result of these higher water levels. Many of the native plant communities that inhabit the wetland fringe areas surrounding the lakes appear to be intact, based upon surveys conducted by the Regional Planning Commission during the planning program that led to the preparation of the regional natural areas and critical species habitat protection and management plan. Similarly, within the current littoral zone, the existing flora and character of these areas is that of a lake. Altering the water levels at this point could disrupt the ecological balance within these areas that has developed over the previous four decades. While there is evidence that wetland and aquatic vegetation can remain dormant in the lake sediments for many years, and that, over time, a new ecological balance would be likely to redevelop should the water levels be reduced, recent experience within the Southeastern Wisconsin Region, especially with the drawdown at Big Muskego Lake—a waterbody with many of the same attributes as Eagle Spring Lake—would suggest there is a significant risk of undesirable biological invasions occurring that could degrade the flora, and the wildlife and fish habitat of both Lake systems. This should be of paramount concern given the outstanding ecological quality of the Lulu Lake and Mukwonago River systems, established under existing hydrologic conditions.

CONCLUSION

Given the obvious concerns related to hydrologic and ecological impacts, and the documented maintenance of water levels in Eagle Spring Lake that have consistently and without apparent distress to the Wambold Dam and its appurtenances exceeded the established operating levels as ordered in the order of the Public Service Commission, referenced 2-WP-997 and dated October 14, 1954, the Commission staff confirm their recommendation, set forth in the adopted lake management plan for Eagle Spring Lake, that the lake levels be formally increased to reflect the actual operating regime of the dam. It is recommended that the levels be increased to a minimum operating level of 820.53 feet and a maximum operating level of 820.83 feet above NGVD-29, as set forth in the adopted lake management plan. Further, based upon a review of the relevant procedures and processes to accomplish this formal increase in surface elevation, the Commission staff concur with the recommendations set forth by Ms. Liesa Nesta of the Wisconsin Department of Natural Resources, that the District has apparently satisfied the requirements of Chapter 31, *Wisconsin Statutes*, with the exception that the WDNR must convene a hearing on the proposed enlargement of the waters impounded by the Wambold Dam. The Commission staff endorse the actions of the District Board of Commissioners in seeking an early resolution to this issue.

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Table 1

NOTES ON THE PROPOSED APPLICATION BY THE EAGLE SPRING LAKE MANAGEMENT DISTRICT TO ENLARGE THE EXISTING WAMBOLD DAM IMPOUNDING EAGLE SPRING LAKE

Chapter 31 Requirement	Notes
§31.05(1): name of the navigable water and specific description of the site	Mukwonago River, immediately upstream of its confluence with Jericho Creek, in the Town of Eagle, Waukesha County, Wisconsin, generally located within the northwest quarter of U.S. Public Land Survey Section 36, Township 5 North, Range 17 East
§31.05(6): name of the town in which the dam is located and nearest existing dam site	Town of Eagle; the nearest existing dam is the Phantom Lakes Dam located approximately five and one-half miles downstream on the Mukwonago River, below its confluence with Jericho Creek, in the Village of Mukwonago
§31.05(7): ownership or flowage rights [A Map also must be provided]	C. H. Jeffery and L. Wambold, subsequently transferred to the Wambold Estate and Ceylon LeVeille, subsequently transferred to the Eagle Spring Sanitary District—currently the Eagle Spring Lake Management District, a governmental body established pursuant to Chapter 33, Wisconsin Statutes
§31.13(1)(a): year in which the dam was completed	First constructed about 1836, subsequently reconstructed
§31.13(1)(b): legislative permission	The dam has been subject to operating order issued by the Railroad Commission of Wisconsin, numbered WP-240 and dated February 8, 1924, subsequently repealed and replaced by an operating order issued by the Public Service Commission of Wisconsin, numbered 2-WP-997 and dated October 14, 1954, which order currently prevails
§31.13(1)(c): description of the dam and the maximum height or head of water to be maintained	An earthen dike with a concrete outlet section having stop-log gates and a steel lift gate, having an existing operating level of between 98.80 feet and 99.10 feet, Public Service Commission datum; the proposed increase in pool elevation is approximately 0.56 feet, or between 99.36 and 99.66 feet, Public Service Commission datum—no structural changes in the dam or of operation are considered necessary as these levels are consistent with the elevations at which the lake has been maintained since April 1958
§31.13(1)(d): purpose for which the dam has been used, is used, and is proposed to be used	For milling purposes or to protect the rights of riparian owners below the dam, which ceased as of 1954; the lake is currently used and proposed to be used for recreational purposes
§31.13(1)(e): approximate amount of hydraulic power	none: as of 1954, the owner of the mill and mill rights, Ceylon LeVeille, did not operate the mill with water power and petitioned the Commission to abandon whatever obligation to operate the dam, which was subsequently transferred to the Eagle Spring Lake Management District
§31.05(8) and 31.13(1)(f): additional information	Eagle Spring Lake is immediately downstream of Lulu Lake, a designated Chapter NR 102, Outstanding Resource Water of the State, and hydrologically connected thereto by a navigable channel and extensive wetland complex; alteration of the level of Eagle Spring Lake is likely to affect the level of upstream Lulu Lake given the small difference in surface elevation indicated between these waterbodies—elevations reported as 822 feet above mean sea level for Lulu Lake and as 821 feet above mean sea level for Eagle Spring Lake, North American datum of 1927 on the U.S. Geological Survey 7.5 minute series topographic map for the East Troy quadrangle
§31.14(2): proof of ability to maintain dam	The dam is owned and operated by the Eagle Spring Lake Management District, a duly constituted governmental body established pursuant to Chapter 33, *Wisconsin Statutes*, initially constituted as a town sanitary district under Chapter 60, *Wisconsin Statutes*, and subsequently converted to a public inland lake protection and rehabilitation district

SUMMARY POINTS

- Letter from Eagle Spring Lake Management District requesting SEWRPC assistance in resolving lake level concerns
- Initial recommendations regarding lake levels, and correction to NGVD-29 elevations, set forth in CAPR 226, *A Lake Management Plan for Eagle Spring Lake, Waukesha County, Wisconsin*, October 1997
- Lake surface elevations reported therein abstracted from a letter by Ms Liesa Nesta, WDNR-SER, dated June 16, 1995 and referenced Dam File #67.4
- 2.65 feet adjustment calculated from SEWRPC Record of Vertical Control Stations for the Fox River Watershed Planning Program: 818.581 feet refined to 821.226 feet NVGD-29
- Earlier 2.9 feet adjustment cannot be documented except *in litt.*, per SEWRPC file CA-709-03
- PSC Order in docket 2-WP-997 dated October 14, 1954 set operating levels of Wambold Dam according to a local datum of 100.0 feet, as 98.80 and 99.10 feet, using a benchmark numbered 291-A
- Calculating the lake levels from the known elevation of the local datum (821.226 feet NGVD-29), results in a 0.06 feet difference between the elevations calculated using the WDNR information and PSC information
- This value possibly could be accounted for if the elevation of the PSC datum is 100.06 feet, as indicated on a February 1966 Lake Studies—Control Structures worksheet; however, the reference station appears to be different to the PSC benchmark (square cut versus a brass cap), and is numbered 291-F
- Ms. Nesta documented the elevations of the lake surface of Eagle Spring Lake, suggesting that the lake levels have consistently exceeded the ordered levels by about 0.6 feet since 1958
- Since a dam inspection conducted during 1998, the Eagle Spring Lake Management District has completed a dam break analysis and structural integrity survey; however, they have not actioned the order to return the Lake to its PSC-ordered operating levels, and intend to petition for the formal establishment of the higher levels
- The process for amending the PSC order is set forth in Section 31.13, *Wisconsin Statutes*, and it appears from correspondence between the District and WDNR-SER that the request has been lodged by the District in a letter response to Ms. Nesta from Mr. James G. Wilhelm, then District Chairman; however, this process does not appear to have been consummated by the required public hearing
- Public concerns related to water levels in Eagle Spring Lake include recreational and ecological impacts, particularly on the fisheries and aquatic plants; The Nature Conservancy also indicated concern about encroachment of cattails as a consequence of high water
- Hydrologic impacts of reducing water levels may affect not only Eagle Spring Lake but also Lulu Lake, given the similarity of their levels—821 feet above NGVD-29 and 822 feet above NGVD-29, respectively—and the presence of an extensive system of wetlands between the waterbodies
- Ecological impacts include the encroachment of cattails and the opportunity for purple loosestrife infestations on the lakeward fringe of the lake shorelands of both lakes; extensive shallows exist along the southeastern fringe of Lulu Lake and the western and northern shores of Eagle Spring Lake

- Recent experience with the drawdown at Big Muskego Lake—a waterbody with many of the same attributes as Eagle Spring Lake—would suggest there is a significant risk of undesirable biological invasions occurring that could degrade the flora, and the wildlife and fish habitat of both Lake systems

- This risk is noteworthy given that Lulu Lake and portions of the downstream Mukwonago River are state-designated Chapter NR 102 Outstanding Resource Waters

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SEWRPC Staff Memorandum

NOTES ON THE FEASIBILITY OF DREDGING OF EAGLE SPRING LAKE, WAUKESHA COUNTY, WISCONSIN, COMPILED FROM FACILITATED DISCUSSIONS CONVENED BY THE EAGLE SPRING LAKE MANAGEMENT DISTRICT

February 17, 1999

BACKGROUND

Dredging is one of several lake management measures that fall under the general heading of water level management. Other water level management measures related to the deepening of a waterbody include dam construction or modification, while drawdown and placement of fill are measures related to decreasing the depth of a waterbody. Measures which involve the removal or placement of materials on a lake bed are regulated under Chapter 30 of the Wisconsin Statutes and require the issuance of permits by both State and Federal authorities; namely, the Wisconsin Department of Natural Resources and the U.S. Army Corps of Engineers, respectively, under Section 404 of the Federal Clean Water Act of 1977 as amended.

Dredging as a lake management measure can be employed for the purposes of enhancing navigation, habitat, and species composition. The advantages of dredging as a management measure are that it restores or creates depth, removes contaminants, and is quickly effective. However, these benefits have associated disadvantages. In the short-term, these disadvantages include increased turbidity, potential oxygen depletion, contaminant resuspension, alteration of water temperature as a result of insolation, destruction of benthic habitat, generation of odors and associated aesthetic degradation, and noise. While these disadvantages are generally confined to the period during which the dredging operation is in progress, longer-term disadvantages include risk of nuisance species invasion and a variable longevity of project effectiveness which is affected by the control of sediment sources.

Dredging can be a potentially applicable lake management measure when lake management goals are to increase lake depth and promote navigability, increase hydraulic capacity to reduce or control flooding, remove contaminated sediment and minimize toxic substance mobilization, remove contaminated sediment and minimize nutrient release, decrease sediment oxygen demand and prevent fish kills, discourage aquatic plant growth, and/or counter the effects of lake aging. Dredging is generally considered a potentially applicable lake management measure in situations where the control of external sediment sources has been effected or determined to be ineffective; and where the primary use of the waterbody is for navigation or conveyance of water; and where there is an high potential for the release of contaminants and/or nutrients that will adversely impact the aquatic environment and impair the structure or function of the ecosystem, or where the public health, welfare, or safety is threatened as a result of depth or sediment contaminant related concerns. Dredging may be considered as a potentially applicable lake management measure, under certain circumstances, for situations where the control of external contaminant sources has been effected or determined to be ineffective; and where human recreational uses of a waterbody are impaired; or where the ecological balance of a waterbody can be restored by the removal of sediments, contaminants, and/or benthic organisms. Dredging is not generally considered to be an appropriate lake management measure in situations where the external sources of sediment and contaminants have not been controlled, where there is a risk of greater environmental damage occurring as a result, where the primary justification is aesthetic, or where an area has been determined to be an environmentally sensitive area pursuant to Section 144.26 of the Wisconsin Statutes.

Should dredging be identified as a feasible and recommended lake management measure, specific measures should be put into place to minimize the environmental disturbances associated with this activity.

Specifically, measures should be taken to protect lake water quality by containing sediments and suspended materials disturbed by the dredging operation and ensuring that the return flow of water from the spoils disposal site, or confined disposal facility (CDF), meets the conditions set forth in the Wisconsin Pollution Discharge Elimination System (WPDES) permit and does not contribute to the pollution of the waterbody. Measures should also be taken to minimize the remobilization of certain priority pollutants if they are present within the sediments. In addition, measures should be take to ensure that the CDF is adequately sized, that excess water is effectively managed, that the depth to which spoils are deposited facilitates rapid drying and reworking of the spoils into the soil profile, and that specific soil loss control measures, such as provision of tracking pads to limit movement of spoils offsite, are installed.

DREDGING AS A LAKE MANAGEMENT MEASURE IN EAGLE SPRING LAKE

A lake management plan has been completed for Eagle Spring Lake and is set forth in SEWRPC Community Assistance Planning Report No. 226, A Lake Management Plan for Eagle Spring Lake, Waukesha County, Wisconsin, published in October 1997. This plan sets forth recommended management measures for the protection and rehabilitation of Eagle Spring Lake, as summarized in the Table attached hereto as Exhibit A. The plan also documents the measures currently in place to control of external sources of sediment to Eagle Spring Lake, the recreational uses of Eagle Spring LakeXprimarily boating and fishing, and the environmental quality of Eagle Spring Lake. Eagle Spring Lake is situated between Lulu Lake and the Mukwonago River upstream of Lower Phantom Lake, both of which have been designated as Outstanding Resource Waters under Chapter NR 102 of the Wisconsin Administrative Code. In addition, the plan documents the extent of the soft flocculent sediments in the Lake basin, with about 85 percent of the lake bottom is covered by muck. With regard to sediment quality, ammonia-nitrogen and lead were determined to exceed the lowest effect level (LEL) established in the draft sediment quality screening criteria published by the Wisconsin Department of Natural Resources at specific sites within the Lake basin. The plan recommends limited, small-scale dredging for purposes of promoting public recreational boating access to the Lake, and sets forth specific goals regarding restoration and/or preservation of the aquatic plant flora of the Lake and its fishery. These findings and discussions during subsequent plan implementation meetings suggest that dredging should be considered as a potentially applicable lake management measure in Eagle Spring Lake.

Objectives of Dredging in Eagle Spring Lake

The Eagle Spring Lake Management District in their annual meeting held on August 8, 1998, gave due consideration to the recommendations set forth in the lake management plan and, by resolution of the electors of the district, instructed the Lake Management District Commissioners to further investigate the conditions under which dredging could be pursued as a lake management measure and the costs associated with the selective deepening of the Lake. Pursuant to this resolution, the Lake Management District convened a meeting with the Wisconsin Department of Natural Resources and Southeastern Wisconsin Regional Planning Commission staff on October 8, 1998, to discuss the potential assistance available in undertaking the relevant investigations. At that meeting, a program was agreed upon whereby the Lake Management District Commission, Wisconsin Department of Natural Resources staff, and interested lake residents would participate in a facilitated discussion of their mandate from the district electors, and that the Regional Planning Commission staff would act as facilitator. This facilitated discussion was convened at a meeting of the Eagle Spring Lake Management District Board of Commissioners held on November 5, 1998.

The Commissioners of the Eagle Spring Lake Management District, those electors of the District present, and Department of Natural Resources staff articulated the need for dredging based upon five principal uses of the waters of Eagle Spring Lake. A consensus was reached that the Lake should be a multiple purpose waterbody serving boating, swimming, fishing, and aesthetic purposes and contributing to the maintenance of property values in the Eagle Spring Lake community. It was further agreed that the latter two uses could be best served by achieving the first three uses identified. To this end, and citing data set forth in the lake management plan, the participants identified the characteristics of a boatable, swimmable and fishable lake:

! For the Lake to be considered boatable it would have to have adequate depth to permit the use of pontoon boats, ski-boats, and sailboats;

! For the Lake to be considered swimmable it would have to have adequate depth and clarity for diving, swimming outside of aquatic plant beds, and good water quality;

! For the Lake to be considered fishable it would have to have sufficient variation in depths to provide sand and gravel spawning areas, adequate and diverse (native) aquatic plant communities, deep water areas, shallow water areas, and marshlands.

Based upon these characteristics, the participants assigned water depths to each use. To be boatable with respect to ski-boats (and other high-speed watercraft), it was determined that the Lake should have between eight feet and 12 feet of depth in the boating areaXbased upon the estimated depth to which boat propellers create a disturbance of the Lake bottom which was approximated as five times the depth of the propeller shaft in the water. To be swimmable, the Lake should have at least six feet of depth for diving and about 12 feet of depth to create conditions that would limit the growth of aquatic plants. Thus, it was determined that the optimal depth to which portions of the lake should be dredged would be about 12 feet. It was also agreed that, in order to promote a diverse fishery, a variety of depths should be maintained within the Lake basin.

The meeting participants indicated specific areas of the Lake where deepening would be appropriate, based upon the use patterns reported in the lake management plan. To accommodate high-speed boating activities, the priority areas for sediment removal were identified as corridors within the main Lake basin of approximately 150 feet minimum width. This area is part of the recommended boating management zone identified in the lake management plan and shown on the map attached hereto in the aforereferenced Exhibit A. In addition, it was proposed to connect the boating management zone serving the northwestern embayment of the Lake with the main Lake basin by deepening a boating lane through the demarcated habitat area to the west of the islands in that area of the Lake. However, to protect the extensive wetland complex that forms a significant portion of the western shoreline of the Lake, it was agreed that the area demarcated as a fishing management zone along this shoreline in the lake management plan be protected. Finally, in addition to the areas set forth above, it was suggested that certain other sites, primarily in the embayments to the north and south of the main Lake basin be selectively deepened. These areas in the southern portion of the Lake had been demarcated as access management zones in the lake management plan and as a fishing management zone in the northern portion of the Lake. To this end, a conceptual dredging scheme was agreed by the participants, and is appended hereto as Exhibit B.

Potential Dredging Scheme for Eagle Spring Lake

Based upon the agreed conceptual dredging scheme determined at the meeting of November 5, 1998, an assessment of 16 potential dredging project areas was made as shown on the map attached hereto as Exhibit C. These areas were defined using data on the measured depths of soft sediment based upon a sediment survey conducted by the Eagle Spring Lake Management District in 1994. Sediment depths in the various project areas ranged from one to more than 12 feet of accumulated soft sediment. The estimated volume of sediment to be removed from within each of the 16 project areas is set forth in Table 1 below. The estimated volume was approximated by assuming a vertical cut across the project area to a depth that would result in an overlying water depth of 12 feet throughout the project area. It is recognized that the actual project, if implemented, would provide for sloped, rather than vertical walls within the dredged area. It should also be noted that no estimate of the volume of soft sediment to be removed by dredging could be made in some areas of the Lake due to the lack of data on the depth of sediment present in those areas. Such an estimate would be needed prior to the submission of a dredging plan to the Wisconsin Department of Natural Resources. Nevertheless, the estimated volume of material to be removed should the conceptual dredging project be fully executed is approximately 1,100,000 cubic yards of sediment.

Table 1

ESTIMATED VOLUME OF SEDIMENT TO BE REMOVED FROM EAGLE SPRING LAKE

Dredging Project Area	Approximate Areal Extent[a] (acres)	Sediment Depth (feet)	Sediment Volume (acre-feet)	Length of Cut[b] (feet)	Width of Cut[b] (feet)	Area of Cut[b] (square feet)	Sediment Volume (cubic feet)
1	25	6	150	1,375	875	1,203,125	7,218,750
2	20	8	160	937.5	562.5	527,344	4,220,000
3	10	6	60	1,187.5	500	593,750	3,562,500
4	12	8	96	1,500	500	750,000	6,000,000
5	4	8	32	500	250	125,000	1,000,000
6	3	6	18	690	187.5	129,375	776,250
7	6	6	36	1,125	250	281,250	1,687,500
8	6	8	48	1,000	125	125,000	1,000,000
9	5	8	40	375	375	140,625	1,125,000
10	2	2.5	5	375	125	46,875	117,250
11	4	12	48	562.5	375	105,500	1,266,000
12	3	1	3	1,000	125	125,000	125,000
13	2	- -[c]	- -	812.5	125	101,500	- -[c]
14	0.5	- -[c]	- -	375	125	46,875	- -[c]
15	1	- -[c]	- -	250	250	31,250	- -[c]
16	1	- -[c]	- -	250	187.5	46,875	- -[c]
Total	104.5	- -	696[d]	- -	- -	- -	28,098,250[e]

[a]*Based upon Exhibit B.*

[b]*Based upon Exhibit C.*

[c]*Depth of accumulated soft sediment is not known, not sediment sampling sites were located in these areas during the 1994 Eagle Spring Lake Management District survey.*

[d]*A sediment volume of 696 acre-feet equals approximately 1,123,000 cubic yards.*

[e]*A sediment volume of 28,098,250 cubic feet equals approximately 1,041,000 cubic yards.*

Dredging Method

While various means can be used to remove sediments from lakes, and especially from those lakes which have an water level control structure, such as Eagle Spring Lake, it was agreed among the participants in the discussion that the most acceptable means of removing accumulated soft sediments from Eagle Spring Lake would be by means of hydraulic dredging. This means of deepening the waterbody was determined to have the least impact not only on the recreational use of the Lake by riparians and visitors to Eagle Spring Lake, but also on the aquatic flora and fauna of the Lake, including fish populations. Hence, the use of drawdown followed by sediment removal using conventional drag-line or clamshell dredging techniques was discounted. The participants expressed interest in reviewing the experiences of the School Section Lake Management District in the conduct of their recent dredging project during which that District purchased and later resold an hydraulic dredger.

Cost of Dredging and Situation of the Confined Disposal Facility

During follow-up discussions with the Lake Management District Commissioners at their meeting held on December 15, 1998, it was concluded that the cost of conducting a dredging project and the siting of a disposal facility for the dredge spoils would be assumed to be similar to those costs and locations identified during the dredging project completed by the Eagle Spring Lake Management District during 1995. Those costs and locations are summarized in the aforenoted lake management plan for Eagle Spring Lake. Based upon the previous experience of the Eagle Spring Lake Management District, it can be estimated that the overall project costs for completing the dredging program as outlined above would approach $5,000,000. Based upon experiences elsewhere in the Southeast Wisconsin Region, such costs could range from $5,000,000 to as high as $15,000,000. However, such costs are subject to refinement. It should be noted that, as an initial step in the implementation of a dredging project, it will be necessary to secure the services of a consultant to prepare more detailed project plans and firmer cost estimates.

* * *

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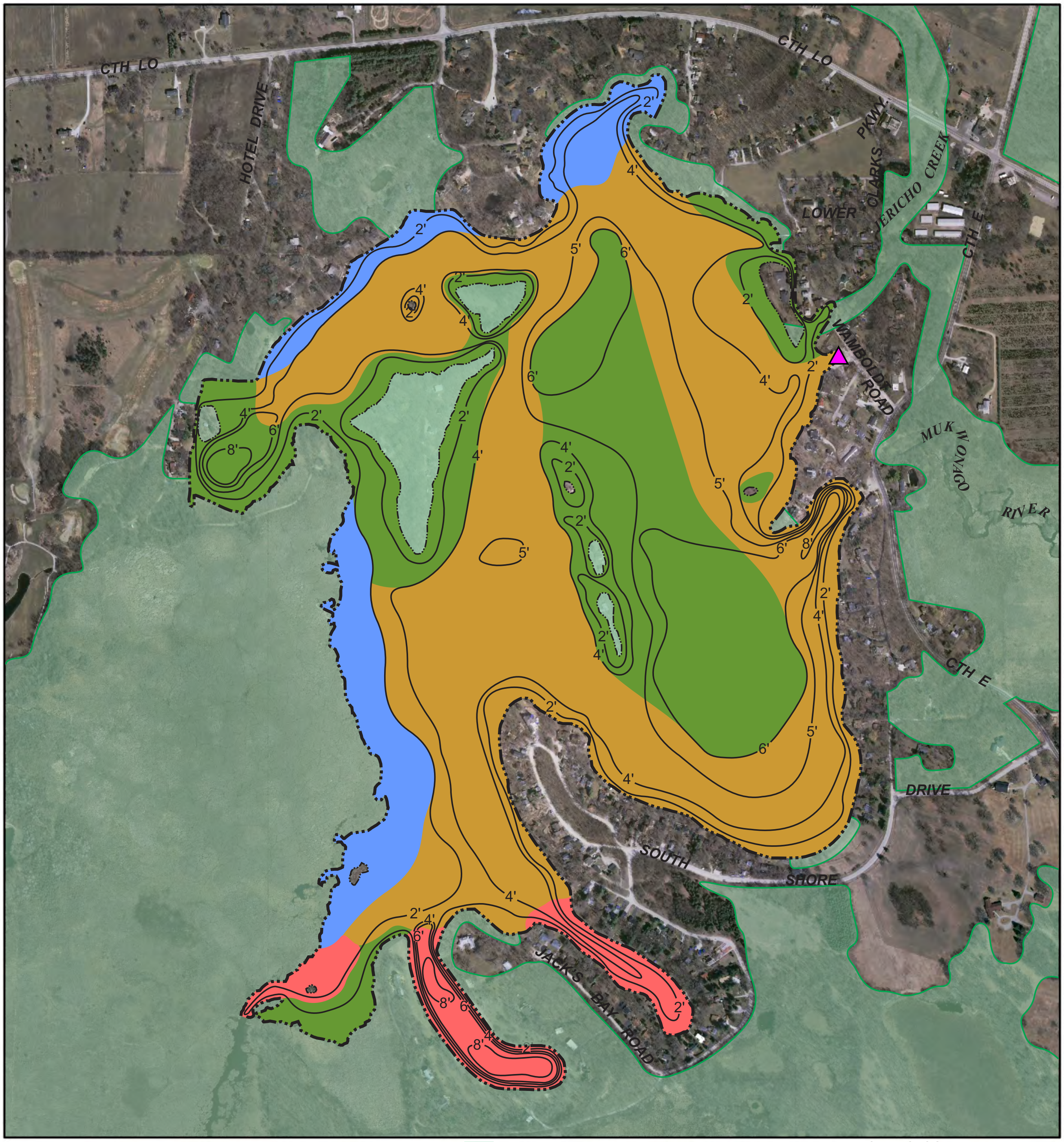
Exhibit A

RECOMMENDED LAKE MANAGEMENT PLAN FOR EAGLE SPRING LAKE



— 4' — WATER DEPTH CONTOUR IN FEET

PUBLIC ACCESS SITE

MANAGEMENT ZONES

FISHING: Harvest narrow channels-approximately 15 feet wide perpendicular to shore about every 100 to 200 feet-use of chemicals for algae and aquatic plant control not recommended in these areas

BOATING: Harvest channels approximately 50 feet wide parallel to the shoreline of the main basin of the lake-limited use of chemicals for algae and aquatic plant control recommended in these areas

HABITAT: Ecologically valuable areas-no aquatic plant management activities-use of chemicals for algae and aquatic plant control not recommended in these areas

ACCESS: Harvest narrow channels-approximately 15 feet wide around the perimeter of the southern bay areas and the inlet area to provide boating access from these areas to the main basin of the lake- limited use of chemicals for algae and aquatic plant control recommended in these areas

ECOLOGICALLY VALUABLE AREAS TO BE PROTECTED

LAND USE MANAGEMENT
- Encourage maintenance of open space uses
- Preserve environmental corridors

WATERSHED MANAGEMENT
- Promote good housekeeping practices in urban areas
- Conduct onsite sewage disposal system management program
- Prepare farm plans for agricultural lands

MONITORING PROGRAM
- Conduct fish survey
- Conduct water quality monitoring

FISH MANAGEMENT
- Review and refine stocking program as required

SHORELINE PROTECTION
- Maintain and repair existing structures

EURASIAN WATER MILFOIL MANAGEMENT PROGRAM
- Control nuisance eurasian water milfoil conditions as necessary

DATE OF PHOTOGRAPHY: APRIL 2005

GRAPHIC SCALE

0 250 900 FEET

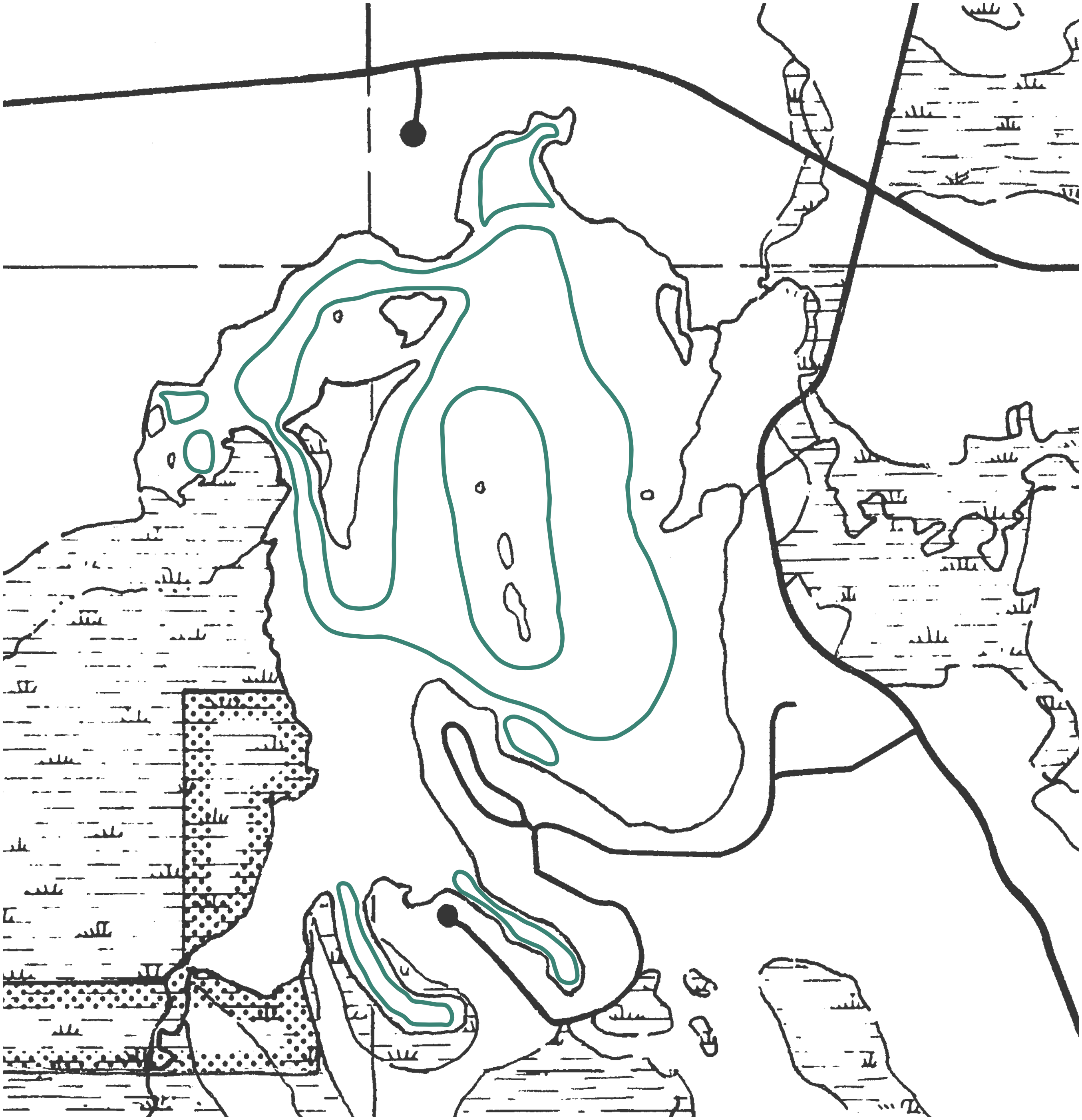
PUBLIC INFORMATION AND EDUCATION
- Continue public awareness program

Source: SEWRPC.

PRELIMINARY DRAFT

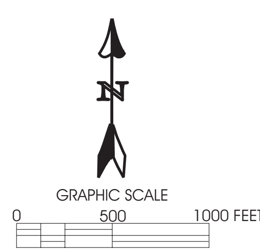
Exhibit B

CONCEPTUAL DREDGING SCHEME FOR EAGLE SPRING LAKE



LEGEND

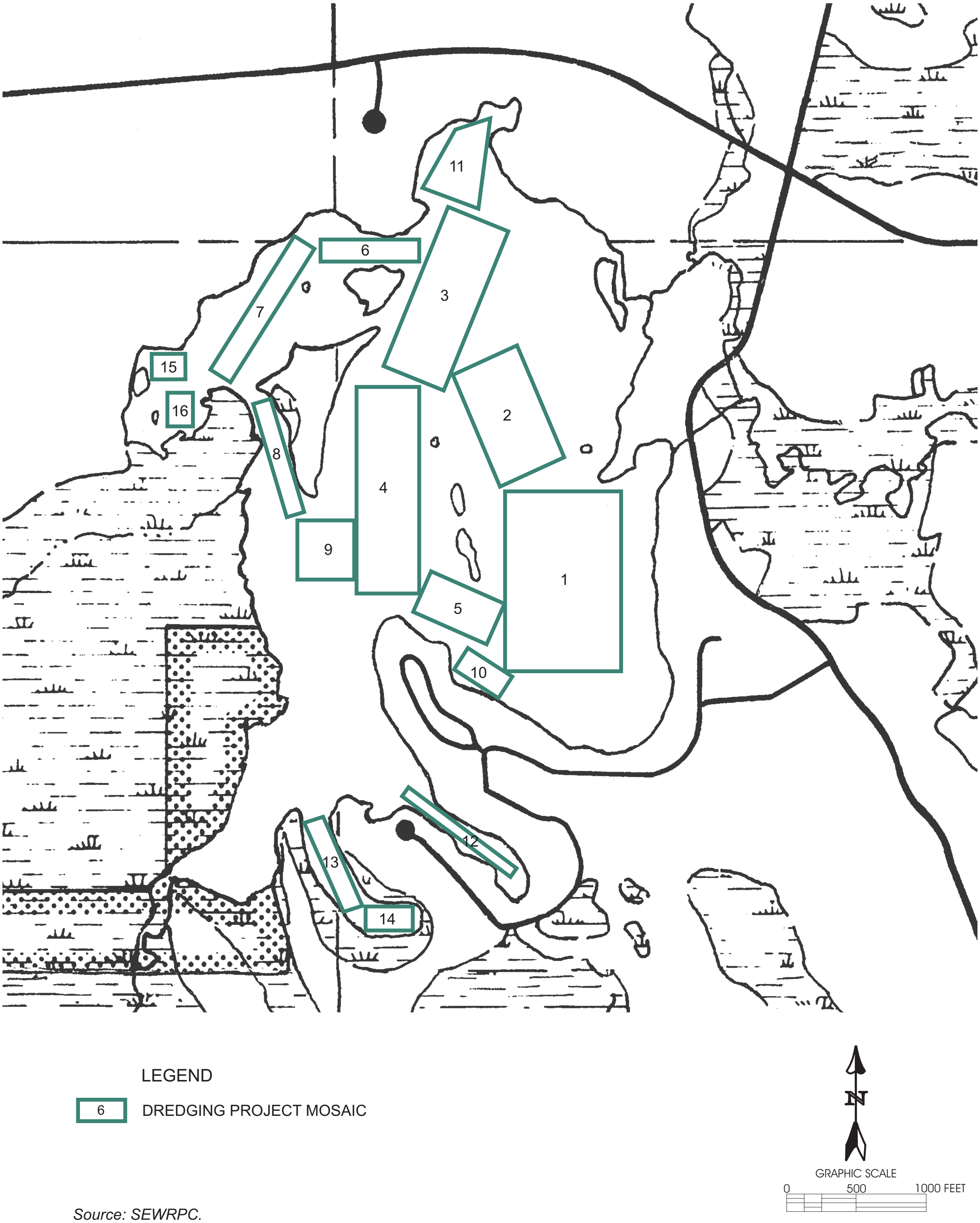
BOUNDARY OF PROPOSED DEEP WATER AREAS, MAXIMUM DEPTH 12 FEET



Source: SEWRPC.

Exhibit C

CONCEPTUAL DREDGING SCHEME FOR EAGLE SPRING LAKE



Source: SEWRPC.

SEWRPC Staff Memorandum

EAGLE SPRING LAKE, WAUKESHA COUNTY, WISCONSIN:
RECREATIONAL BOATING PLAN REVIEW
December 27, 2005

BACKGROUND

The Commission staff have provided assistance to the Eagle Spring Lake Management District, specifically in terms of the preparation of SEWRPC Community Assistance Planning Report No. 226, *A Lake Management Plan for Eagle Spring Lake, Waukesha County, Wisconsin*, which was published during October 1997, and subsequently in terms of participation on various task teams that were established by the Lake Management District to assist in implementing this management plan. To this end, we have assisted the Eagle Spring Lake Management District in the conduct of a dredging feasibility study and recreational user questionnaire survey, reported to the Lake Management District in a staff memorandum dated February 17, 1999 and a letter report dated November 7, 2000, respectively. A further SEWRPC staff memorandum dated May 16, 2001 addressed lake level concerns that were raised by the Lake Management District.

RECOMMENDED LAKE MANAGEMENT PLAN

The recommended lake management plan for Eagle Spring Lake, as set forth in SEWRPC Community Assistance Planning Report No. 226, suggested that recreational boating traffic be directed within an approximately ovoid pattern within the main basin of the Lake, as shown on Map 24 of the aforereferenced plan. This recommendation was predicated upon consideration of the aquatic plant communities, nature of and demand for recreational boating, and current recreational boating regulations applicable to various classes of watercraft. The latter regulations restrict operation of motorized watercraft to slow-no-wake speeds within 100 feet of piers and docks, and of personal watercraft (PWCs or “jetskis”®) to slow-no-wake speeds within 200 feet of the shoreline, which effectively limits operation of both classes of watercraft to slow-no-wake speeds within the western portions of the Lake delimited by the western shoreline of the Lake and the western edge of the nearshore island. Consequently, the plan alternatives included the suggestion that “jet skiing and water skiing should be restricted to the perimeter of the main basin of Eagle Spring Lake, and boating traffic through the Mukwonago River between Eagle Spring Lake and Lulu Lake could be restricted to slow-no-wake speeds, as part of zoning recreational use” (page 109).

This was further elaborated in terms of “the principle recreational use zoning actions required include the imposition of ‘Slow-No-Wake’ restrictions on those portions of the Lake bordering sensitive areas such as habitat zones, and where boating activities can be expected to come into conflict with other uses such as angling in the fishing zones” (page 126). Table 29 identified four management zones within the Lake, including recreational boating access and navigational lanes, angling areas, and habitat areas. The navigational lanes, identified as the buff-colored “Boating” area on Map 24 and as the “Boating Zone” in Table 29, were recommended to be “approximately 50 feet in width, parallel to the shoreline of the main lake basin to allow boating in the main lake basin area and avoid disturbance of the native flora in the central area of the Lake.” This was estimated to provide about 187 acres of boatable lake surface, or to encompass about 60 percent of the Lake surface.

These recommendations are similar to the proposed recreational boating traffic pattern indicated on the Exhibit appended as Map #2 to the December 14, 2005 letter from Mr. Thomas A. Day to Mr. Philip C.

Evenson, with the exception that the central track passing to the north of the smaller islands within the main lake basin shown on Map #2 is not recommended in the lake management plan. Indeed, this central track is in potential conflict with the plan that recommends that "disturbance of the native flora in the central area of the Lake" be avoided.

DREDGING

Subsequent to the publication of the lake management plan for Eagle Spring Lake, the Commission staff were requested by the District to further elaborate on alternatives to increase the boatable area of the Lake to enhance the boatable, swimmable, and fishable character of the waterbody. These objectives and the actions necessary to achieve an optimal lake depth to accommodate all three objectives were documented in the SEWRPC Staff Memorandum entitled, "Notes on the Feasibility of Dredging of Eagle Spring Lake, Waukesha County, Wisconsin, Compiled from Facilitated Discussions Convened by the Eagle Spring Lake Management District," and dated February 17, 1999. In this memorandum, approximate water depths to accommodate high speed boating—between eight and 12 feet of depth, swimming—between six and 12 feet of depth, and fishing—a variety of water depths—were determined and documented. In addition, to promote safe boating, boating lanes of approximately 150 feet minimum width were recommended. The locations of these boating lanes were consistent with the recommended boating management zone identified in SEWRPC Community Assistance Planning Report No. 226. Notwithstanding, navigational connections between the embayments to the north[west] and south of the main Lake basin and the main Lake basin were indicated. However, it also was recognized that a portion of this additional area was adjacent to the extensive wetland complex that forms the western shores of Eagle Spring Lake, and that some protection of this natural shoreline was required. As a result, portions of this area were indicated as fishing and habitat zones wherein high speed boating activities would be restricted to slow-no-wake speeds.

SURVEY OF LAKE MANAGEMENT DISTRICT ELECTORS

During the summer of 1999, the Commission staff, at the request of the Eagle Spring Lake Management District, conducted a questionnaire-based survey of property owners and electors of the District for the purpose of identifying issues of concern to said property owners and electors. Based on an approximately 30 percent return, three major issues emerged; namely, (1) general water quality, identified by over 90 percent of respondents; (2) sedimentation and loss of lake depth, identified by over 60 percent of respondents; and, (3) decline of the lake fishery, identified by over 30 percent of respondents. In relation to the first two of these issues of concern, three-quarters of respondents indicated that sediment removal was a preferred means of managing aquatic plant and algal growths as well as of increasing lake depth. About one-quarter of respondents owned and operated high speed watercraft on the Lake; watercraft operation occurred on an average of about 40 days per year, swimming on an average of about 30 days per year, and angling on an average of between 15 days—for ice fishing—and 40 days per year. About two-thirds of respondents from the Eagle Spring Lake community indicated a willingness to pay more for lake management activities, such as dredging, which would accomplish these objectives.

LAKE SURFACE ELEVATIONS

Ongoing concerns over Lake depth, related in part to the recreational uses and limitations identified in the aforereferenced lake management plan and in the questionnaire survey of lake management district electors, resulted in a further request to the Regional Planning Commission to address issues related to lake levels in Eagle Spring Lake. In the SEWRPC staff memorandum entitled, "Summary Notes on Water

Level Issues Relating to Eagle Spring Lake-Wambold Dam, Waukesha County, Wisconsin," dated May 16, 2001, the Commission staff reviewed and documented the ongoing concerns of the Wisconsin Department of Natural Resources and Eagle Spring Lake Management District regarding lake levels. These concerns included the discrepancy in the operating level of the impoundment as a result of changes of about 2.65 feet in the benchmarks utilized to gauge lake elevation, a recommended modification of the permitted operating levels of the impoundment, and the potential hydrological and ecological consequences of changes in lake level.

In terms of these issues, the Commission staff confirmed recommendations set forth in the aforereferenced lake management plan for Eagle Spring Lake that the lake levels stipulated in the operating permit for the dam be adjusted to account for the actual elevation of the benchmark identified in the permit—which, by itself, would increase the lake surface elevation by about 2.65 feet, and that the actual operating level of the impoundment be confirmed by amendment of the operating permit—Wisconsin Public Service Commission order number 2-WP-997 dated October 14, 1954—to reflect the actual and historic operating levels maintained within the impoundment that are approximately 0.6 feet higher than the permitted levels. These recommendations were consistent with the maintenance of hydrological conditions within the upstream Lulu Lake, an outstanding resource water of the State pursuant to Chapter NR 102 of the *Wisconsin Administrative Code*, and with the maintenance of a diverse shoreland wetland flora within and adjacent to the western shoreline of the Eagle Spring Lake basin. This diverse and linked wetland and aquatic ecosystem provides the natural resource base for wildlife, fish, waterfowl and bird communities utilizing the Lake and its environs and contributes to the aesthetic value of the resource to the human community.

SYNTHESIS

State regulations governing recreational boating access to public inland waters are set forth in Chapter NR 1 of the *Wisconsin Administrative Code*. These regulations define lake surface area requirements as a basis for establishing maximum and minimum recreational boating access standards. Eagle Spring Lake, with a surface area of about 311 acres, falls into the 100 acre to 499 acre category. The minimum access standards for lakes of this surface area range, set forth in Section NR 1.94(4)(d)1., are one parking space per 30 acres of lake "open water" surface area, with a maximum standard, set forth in Section NR 1.94(5)(b), of one parking space per 15 acres of lake surface area. "Open water acres" are defined in Section NR 1.91(2)(e) of the *Wisconsin Administrative Code* as "water body surface which appears as water predominantly devoid of emergent vegetation on recent aerial photographs representative of the navigation season," which determination is made by the Wisconsin Department of Natural Resources (WDNR). This determination is frequently, but not invariably, made on the basis of the lake surface area reported in WDNR Publication No. PUB-FH-800, *Wisconsin Lakes*, the latest edition of which is dated 2005. Using this surface area, and assuming that each parking space results in one watercraft being launched, Eagle Spring Lake would accommodate between 10 and 20 watercraft.

The recreational boating guidelines set forth in the adopted regional park and open space plan—SEWRPC Planning Report No. 27, *A Regional Park and Open Space Plan for Southeastern Wisconsin: 2000*, published in November 1977 and refined in subsequent regional land use plans, the most recent being SEWRPC Planning Report No. 45, *A Regional Land Use Plan for Southeastern Wisconsin: 2020*, published in December 1997—recommend an area of 40 acres per boat be considered to be a minimum area for safe waterskiing and fast boating activities. Using the same lake surface area as above, Eagle Spring Lake could accommodate about eight watercraft, based upon this somewhat more conservative areal allocation.

Implementation of the recreational boating traffic pattern recommended in the Eagle Spring Lake management plan would provide a boatable area of about 190 acres. This area would allow about five watercraft to be operated safely on Eagle Spring Lake based upon the SEWRPC guidelines, or between six and 12 watercraft to be operated on the Lake based upon the WDNR standards. At the time of drafting of the adopted lake management plan, observed usage of the Lake, during non-holiday or off-peak periods, suggested that “typical” usage by pleasure boaters, water-skiers, and PWC operators generally would exceed the SEWRPC guideline value, while all forms of recreational boating would approach or exceed the WDNR standards. This intensity of usage is consistent with the responses to the questionnaire survey from the electors of the Lake Management District summarized above. Consequently, maximizing the available boating area is not an unreasonable goal for the community.

Notwithstanding, in addition to ensuring adequate surface area for high speed boating activities, it is recommended that all boating activities be conducted in a safe manner. For this reason, operation of watercraft within and among the various islands present within the main basin of Eagle Spring Lake would be discouraged. The presence of the islands, particularly those in the northwestern portion of the Lake, obstructs views and creates a risk of collision between watercraft, especially those operating at high speed. It also increases the possibility of high speed and low speed watercraft conflicts in these confined waters. The confined waters also limit opportunities for corrective actions should such conflicts occur. Such a potentiality is not inconsistent with the intensity of usage of the Lake that meets or exceeds that envisioned in the State standards and Commission guidance.

With respect to other considerations relating to the passage of watercraft at speed through the channel created by the islands located within the northwestern quadrant of the Lake and the wetland fringe forming the lakeshore, the Commission staff note the speed restrictions applicable to motorized watercraft within 100 feet of a pier and to PWCs within 200 feet of the shoreline, summarized in WDNR Publication No. PUBL-LE-301, *Wisconsin Boating Regulations*, 2004 edition, and restate the concern identified in the adopted lake management plan with respect to width of the channel. The width of the channel is such that PWCs would be required to proceed at slow-no-wake speeds, while other motorized watercraft would proceed either at speed or at slow-no-wake speeds depending on the placement of piers within the waterway by riparian landowners. Such a situation serves to reemphasize the safety concerns noted above.

Finally, nonregulatory concerns identified by Commission staff relate to the effect of boat wakes on shorelands within Eagle Spring Lake. Shoreline erosion and loss of emergent aquatic and wetland plant communities have been reported from various areas of the Lake by the Eagle Spring Lake Management District Commissioners and electors. Such losses have been specifically identified in the northern portions of the Lake, where the areal extent of certain reed beds has been reported to have been greatly reduced. While recreational boating activities are unlikely to be solely responsible for such shoreland losses, recreational boating activities represent a controllable element in protecting these areas. Therefore, to the extent that recreational boating traffic can be directed away from these erosion-prone areas, shoreland and habitat losses can be moderated. Given that angling uses of Eagle Spring Lake were reported to occur at a similar frequency to boating uses during the questionnaire survey summarized above, protection of habitat should be a priority equal to that of provision of recreational boating area. Consequently, ecological concerns also would suggest limiting the extent of recreational boating to areas of the Lake less susceptible to disturbance. Maintenance of recreational boating access lanes, especially between the main lake basin and the embayments locally known as Jack’s Bay and Mary’s Bay as identified on Map #2, would be indicated to facilitate desired recreational boating activities.

RECOMMENDATION

The foregoing considerations suggest that the Eagle Spring Lake Management District Board of Commissioners reaffirm the recommendations set forth in SEWRPC Community Assistance Planning Report No. 226, *A Lake Management Plan for Eagle Spring Lake*, *Waukesha County*, *Wisconsin*, wherein high speed recreational boating activities were recommended to occur within the main lake basin. This recommendation is consistent with the alternative identified by the Board of Commissioners on Map #2 of the letter request, with the exception that the central track through the middle of the Lake is not recommended. This analysis is consistent with those provided by the Town of Eagle Lake Patrol officers in letters dated September 26, 2005, and October 3, 2005, copies of which were attached to your letter request. This recommendation would be applicable during the open water boating period.

* * *

JAT
#114540 V1 - EAGLE SPRING LAKE RECREATIONAL BOATING PLAN