Waushara County Lakes Study
Round Lake

Final Report
to Waushara County and
Wisconsin Department of Natural Resources

N. Turyk, R. Haney and D. Rupp

Center for Watershed Science and Education
College of Natural Resources
University of Wisconsin-Stevens Point
Authors listed are from the UW-Stevens Point unless otherwise noted.

**Aquatic Plants**
Jen McNelly

**Sediment Core**
Samantha Kaplan
Paul Garrison (Wisconsin Department of Natural Resources)

**Shoreland Assessments**
Ed Hernandez and Waushara County Land Conservation Department Staff
Dan McFarlane

**Water Quality and Watersheds**
Nancy Turyk, Paul McGinley, Danielle Rupp and Ryan Haney
Ed Hernandez and Waushara County Land Conservation Department Staff

**UW-Stevens Point Students**
Melis Arik, Nicki Feiten, Sarah Hull, Chase Kasmerchak, Justin Nachtigal, Matt Pamperin, Scott Pero, Megan Radske, Anthony Recht, Cory Stoughtenger, Hayley Templar, Garret Thiltgen

**Editor:** Jeri McGinley

---

**ACKNOWLEDGMENTS**

We are grateful to many people for supporting this project by providing insight, enthusiasm, and funding. We would like to recognize our project partners:

Waushara County Watershed Lakes Council

Waushara County Staff and Citizens

Wisconsin Department of Natural Resources Professionals, Mark Sessing and Ted Johnson

Wisconsin Department of Natural Resources Lake Protection Grant Program

Dr. Samantha Kaplan and Dr. Paul McGinley

UW-Stevens Point Water and Environmental Analysis Lab
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRIMARY AUTHORS</td>
<td>3</td>
</tr>
<tr>
<td>ACKNOWLEDGMENTS</td>
<td>3</td>
</tr>
<tr>
<td>TABLE OF CONTENTS</td>
<td>5</td>
</tr>
<tr>
<td>LIST OF FIGURES</td>
<td>6</td>
</tr>
<tr>
<td>LIST OF TABLES</td>
<td>6</td>
</tr>
<tr>
<td>ROUND LAKE STUDY RESULTS</td>
<td>7</td>
</tr>
<tr>
<td>WAUSHARA COUNTY LAKES STUDY BACKGROUND</td>
<td>7</td>
</tr>
<tr>
<td>ABOUT ROUND LAKE</td>
<td>7</td>
</tr>
<tr>
<td>WHERE IS THE WATER COMING FROM? - WATERSHEDS AND LAND USE</td>
<td>9</td>
</tr>
<tr>
<td>ROUND LAKE SURFACE WATERSHED</td>
<td>10</td>
</tr>
<tr>
<td>ROUND LAKE GROUNDWATER WATERSHED</td>
<td>11</td>
</tr>
<tr>
<td>WATER QUALITY</td>
<td>12</td>
</tr>
<tr>
<td>AQUATIC PLANTS</td>
<td>18</td>
</tr>
<tr>
<td>SHORELANDS</td>
<td>21</td>
</tr>
<tr>
<td>CONCLUSIONS &amp; RECOMMENDATIONS</td>
<td>23</td>
</tr>
<tr>
<td>REFERENCES</td>
<td>26</td>
</tr>
<tr>
<td>GLOSSARY OF TERMS</td>
<td>27</td>
</tr>
</tbody>
</table>
LIST OF FIGURES

FIGURE 1. CONTOUR MAP OF THE ROUND LAKE LAKEBED.........................................................8
FIGURE 2. LAND USES IN THE ROUND LAKE SURFACE WATERSHED........................................10
FIGURE 3. GROUNDWATER FLOW DIRECTION NEAR ROUND LAKE............................................11
FIGURE 4. CARTOON SHOWING INFLOW AND OUTFLOW OF WATER IN A SEEPAGE LAKE. ...................................8
FIGURE 5. TEMPERATURE PROFILES IN ROUND LAKE, 2010-2012..............................................12
FIGURE 6. DISSOLVED OXYGEN PROFILES IN ROUND LAKE, 2010-2012.......................................14
FIGURE 7. AVERAGE MONTHLY WATER CLARITY IN ROUND LAKE, 2010-2012 AND HISTORIC. ........................................................................................................................................15
FIGURE 8. ESTIMATED PHOSPHORUS LOADS FROM LAND USES IN THE ROUND LAKE WATERSHED. ........................................................................................................................................17
FIGURE 9. NUMBER OF AQUATIC PLANT SPECIES OBSERVED AT EACH SAMPLE SITE IN ROUND LAKE, 2012 ....................................................................................................................................20
FIGURE 10. OVERALL SHORELAND HEALTH AROUND ROUND LAKE, 2011 ..................................22

LIST OF TABLES

TABLE 1. MINERALS AND PHYSICAL MEASUREMENTS IN ROUND LAKE, 2010-2012........12
TABLE 2. ROUND LAKE AVERAGE WATER CHEMISTRY, 2010-2012........................................13
TABLE 3 SEASONAL SUMMARY OF NUTRIENT CONCENTRATIONS IN ROUND LAKE, 2010-2012 ........................................................................................................................................16
TABLE 4. MODELING DATA USED TO ESTIMATE PHOSPHORUS INPUTS FROM LAND USES IN THE ROUND LAKE WATERSHED (LOW AND MOST LIKELY COEFFICIENTS USED TO CALCULATE RANGE IN POUNDS) ..................................................................................................................17
TABLE 5. LIST OF AQUATIC PLANTS IDENTIFIED IN THE 2012 AQUATIC PLANT SURVEY OF ROUND LAKE ........................................................................................................................18
ROUND LAKE STUDY RESULTS

WAUSHARA COUNTY LAKES STUDY BACKGROUND

Lakes and rivers contribute to the way of life in Waushara County. Local residents and visitors alike enjoy fishing, swimming, boating, wildlife viewing, and the peaceful nature of the lakes. Healthy lakes add value to our communities. They provide places to relax and recreate, and they can stimulate tourism. Like other infrastructure in our communities, lakes require attention and good management practices to remain healthy in our developing watersheds.

Thirty-three lakes in Waushara County were selected for this study. The study focused on learning about the lakes’ water quality, aquatic plant communities, shoreland habitats, watersheds and histories in order to help people make informed lake management decisions. This report summarizes data collected for Round Lake between 2010 and 2012.

ABOUT ROUND LAKE

To understand a lake and its potential for water quality, fish and wildlife, and recreational opportunities, we need to understand its physical characteristics and setting within the surrounding landscape. The lake is located in the township of Springwater, east of Wild Rose, and south of County Highway A, with one public boat launch located on its southern side. Round Lake is a 74-acre seepage lake with surface runoff and groundwater contributing most of its water. The maximum depth in Round Lake is 19 feet; the lakebed has a gradual slope (Figure 1). Its bottom sediments are mostly muck with small amounts of sand found periodically along the perimeter of the lake.
FIGURE 1. CONTOUR MAP OF THE ROUND LAKE LAKEBED.
The water quality in Round Lake is a reflection of the land that drains to it. The water quality, the amount of algae, aquatic plants, the fishery and other animals in the lake are all affected by natural and manmade characteristics. Natural characteristics that affect a lake include the amount of land that drains to the lake, the hilliness of the landscape, types of soil, extent of wetlands, and the type of lake. Within the lake’s watershed, alterations to the landscape, the types of land use, and the land management practices are examples of how people may affect the lake.

It is important to understand where Round Lake’s water originates in order to understand the lake’s health. During snowmelt or a rainstorm, water moves across the surface of the landscape (runoff) towards lower elevations such as lakes, streams, and wetlands. The land area that contributes runoff to Round Lake is called a surface watershed. Groundwater also feeds Round Lake; its land area may be slightly different than the surface watershed. The surface watershed is shown in Figure 2.

The capacity of the landscape to shed or hold water and contribute or filter particles determines the amount of erosion that may occur, the amount of groundwater feeding a lake, and ultimately, the lake’s water quality and quantity. Essentially, landscapes with a greater capacity to hold water during rain events and snowmelt help to slow the delivery of the water to the lake. Minimizing excess runoff is desirable because it allows more water to recharge the groundwater which feeds the lake year round - even during dry periods or when the lake is covered with ice.

Land use and land management practices within a lake’s watershed can affect both its water quantity and quality. While forests and grasslands allow a fair amount of precipitation to soak into the ground, resulting in more groundwater and better water quality, other types of land uses may result in increased runoff, less groundwater recharge, and may be sources of pollutants that can impact the lake and its inhabitants. Areas of land with exposed soil can produce soil erosion. Soil entering the lake can make the water cloudy and cover fish spawning beds. Soil also contains nutrients that increase the growth of algae and aquatic plants. Development on the land often results in changes to natural drainage patterns, alterations in vegetation on the landscape, and may be a source of pollutants. Impervious (hard) surfaces such as roads, rooftops, and compacted soils prevent rainfall from soaking into the ground, which may result in more runoff carrying pollutants to the lake. Wastewater, animal waste, and fertilizers used on lawns, gardens, and crops can contribute nutrients that can enhance the growth of algae and aquatic plants in our lakes.

A variety of land management practices can be put in place to help reduce impacts to our lakes. Some practices are designed to reduce runoff. These include protecting/restoring wetlands, installing rain gardens, swales, rain barrels, and routing drainage from pavement and roofs away from the lake. Some practices are used to help reduce nutrients from moving across the landscape towards the lake. Examples include manure management practices, eliminating/reducing the use of fertilizers, increasing the distance between the lake and a septic drainfield, protecting/restoring native vegetation in the shoreland, and using erosion control practices. Waushara County staff and other professionals can work with landowners to determine which practices are best suited to a particular property.
The surface watershed for Round Lake is approximately 296 acres (Figure 2). The dominant land uses in the watershed are forests (51%) and development (49%). The lands closest to the lake often have the greatest impact on water quality and habitat. Land uses near Round Lake’s shoreland include development, forests, and wetlands.

**Figure 2. Land uses in the Round Lake surface watershed.**
The more the lake’s water interacts with groundwater, the more influence the geology has on the lake. The length of time water remains below ground affects the temperature and chemistry of the groundwater. Groundwater temperature is near constant year round; during the summer, groundwater feeding Round Lake will help keep the lake water cooler.

Groundwater flows below ground from higher to lower elevations, discharging into wetlands, streams, and lakes. The groundwater feeding the lakes in Waushara County originates nearby. The black arrows in Figure 3 indicate the general direction of groundwater flow. Much of the groundwater enters Round Lake from the west.

**Figure 3. Groundwater Flow Direction Near Round Lake.**
Lake water quality is a result of many factors including the underlying geology, the climate, and land management practices. Assessing lake water quality allows us to evaluate current lake health and changes from the past. We can then identify what is needed to achieve a more desirable state or preserve an existing state for aesthetics, recreation, wildlife and the fishery. During this study, water quality in Round Lake was assessed by measuring different characteristics including temperature, dissolved oxygen, water clarity, water chemistry, and algae.

The source of a lake’s water supply is important in determining its water quality and choosing management practices to preserve or influence that quality. Round Lake is classified as a seepage lake, or a lake that receives its water primarily through groundwater, and, to a lesser extent, direct runoff and precipitation (Figure 4). Seepage lakes generally have longer retention time (length of time water remains in the lake), which affects contact time with nutrients that feed the growth of algae and aquatic plants. Seepage lakes are also more vulnerable to contamination moving towards the lake in the groundwater. Examples for Round Lake may include septic systems, agriculture, and road salt.

The geologic composition that lies beneath a lake has the ability to influence the temperature, pH, minerals, and other properties in a lake. Seepage lakes have higher concentrations of minerals, which are picked up by groundwater moving through soil and rock. Some substances are filtered out as groundwater moves through the soil, but other materials dissolve into the groundwater (Shaw et al., 2000). Minerals such as calcium and magnesium around Round Lake dissolve, making the water hard. The average hardness for Round Lake during the 2010-2012 sampling period was 64 mg/L, which is considered moderately hard (Table 1). Hard water provides the calcium necessary for building bones and shells for animals in the lake. The average alkalinity was 64 mg/L; higher alkalinity in inland lakes can support higher species productivity. Hardness and alkalinity also play roles in the type of aquatic plants that are found in a lake (Wetzel, 2001).

Table 1. Minerals and physical measurements in Round Lake, 2010-2012.

<table>
<thead>
<tr>
<th>Round Lake</th>
<th>Alkalinity (mg/L)</th>
<th>Calcium (mg/L)</th>
<th>Magnesium (mg/L)</th>
<th>Hardness (mg/L as CaCO₃)</th>
<th>Color SU</th>
<th>Turbidity (NTU)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Value</td>
<td>64</td>
<td>13.1</td>
<td>7.2</td>
<td>64</td>
<td>13.7</td>
<td>1.8</td>
</tr>
</tbody>
</table>
Chloride concentrations, and to lesser degrees sodium and potassium concentrations, are commonly used as indicators of how a lake is being impacted by human activity. The presence of these compounds where they do not naturally occur indicates sources of water contaminants.

Potassium, chloride and sodium concentrations in Round Lake were all low (Table 2); however, atrazine, an herbicide commonly used on corn, was present in the samples that were analyzed from Round Lake (0.10 ug/L DACT). The presence of this chemical suggests that agricultural activities in the surrounding area are impacting water quality. Some toxicity studies have indicated that reproductive system abnormalities can occur in frogs at these levels (Hayes et al., 2003; Hayes et al., 2001).

**Table 2. Round Lake average water chemistry, 2010-2012.**

<table>
<thead>
<tr>
<th>Round Lake</th>
<th>Average Value (mg/L)</th>
<th>Reference Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low</td>
<td>Medium</td>
</tr>
<tr>
<td>Potassium</td>
<td>0.3</td>
<td></td>
</tr>
<tr>
<td>Chloride</td>
<td>1.2</td>
<td></td>
</tr>
<tr>
<td>Sodium</td>
<td>1.7</td>
<td></td>
</tr>
</tbody>
</table>

Dissolved oxygen is an important measure in aquatic ecosystems because a majority of organisms in the water depend on oxygen to survive. Oxygen is dissolved into the water from contact with the air, which is increased by wind and wave action. Algae and aquatic plants also produce oxygen when sunlight enters the water, but the decomposition of dead plants and algae reduces oxygen in the lake. Some forms of iron and other metals carried by groundwater can also consume oxygen when the groundwater discharges to the lake.

In a lake, the water temperature changes throughout the year and may vary with depth. During winter and summer when lakes stratify (layer), the amount of dissolved oxygen is often lower towards the bottom of the lake. Dissolved oxygen concentrations below 5 mg/L can stress some species of cold water fish and over time can reduce the amount of available habitat for sensitive species of cold water fish and other aquatic organisms.

Water temperature was measured in Round Lake from surface to bottom at the time of sample collection (Figure 5). Throughout most of the year, the temperature in Round Lake remained fairly uniform from the lake’s surface down to 16 feet. For a short period in June 2011 and July 2011, the lake was weakly stratified, but mixed again later in the summer. In some lakes, episodes of mixing and stratification throughout the summer can lead to enhanced algae blooms, as nutrient-rich water towards the lake bottom is introduced into warmer conditions near the lake’s surface.
Following a similar pattern to temperature, dissolved oxygen in Round Lake experiences episodes of mixing and stratification (Figure 6). During the summer when the lake is stratified, dissolved oxygen concentrations drop sharply at approximately 12 feet in depth. In the winter, dissolved oxygen concentrations dropped within the upper 4 feet of water; however, concentrations did not fall to critical levels.
Water clarity is a measure of the depth that light can penetrate into the water. It is an aesthetic measure and is also related to the depth that rooted aquatic plants can grow. Water clarity is affected by water color, turbidity (suspended sediment), and algae, so it is normal for water clarity to change throughout the year and from year-to-year.

During the study, water clarity in Round Lake was considered good. Water clarity ranged from 8 feet to 18.5 feet over the two-year monitoring period (Figure 7). Monthly averages were poorer than historic monthly averages in the spring and early summer. Average water clarity was better than the historic monthly averages for the balance of the growing season. The historic data ranged from 2001-2009. The color (staining) was relatively low (Table 1), so the variability in water clarity throughout the year is primarily due to fluctuating algae and re-suspended sediment.

![Round Lake Secchi Depth](image)

**Figure 7. Water Clarity in Round Lake, 2010-2012 and historic.**

Chlorophyll $a$ is a measurement of the green pigment found in all plants, including algae. It is used as an estimate of algal biomass; typically, the higher the chlorophyll $a$ number, the higher the amount of suspended algae in the water. Concentrations of chlorophyll $a$ greater than 10 ug/L may be perceived as a mild algae bloom, while concentrations greater than 20 ug/L may be perceived as a nuisance bloom. Chlorophyll $a$ concentrations in Round Lake varied slightly throughout the monitoring season, ranging from 0.5 ug/L in August 2012 to 5 ug/L in June 2011. The average measurement for the monitoring period was 2.6 ug/L, which is considered low.

Nutrients (phosphorus and nitrogen) are used by algae and aquatic plants for growth. Phosphorus is present naturally throughout the watershed in soil, plants, animals and wetlands. Common sources from human activities include soil erosion, animal waste, fertilizers and septic systems.

It is most common for phosphorus to move from the land to the water through surface runoff, but it can also travel to the lake in groundwater. Once in a lake, a portion of the phosphorus becomes part of the aquatic system in the form of plant and animal tissue, and sediment. The phosphorus continues to cycle within the lake for many years.
During the study, total phosphorus concentrations in Round Lake ranged from a high of 40 ug/L on February 22, 2011 to a low of 8 ug/L on August 6, 2012 (Table 3). The summer median phosphorus concentrations were 13 ug/L and 12 ug/L in 2011 and 2012, respectively. These are below both Wisconsin’s phosphorus water quality standard of 40 ug/L and the proposed flag value of 15 ug/L for shallow seepage lakes such as Round Lake.

Table 3. Seasonal summary of nutrient concentrations in Round Lake, 2010-2012.

<table>
<thead>
<tr>
<th>Round Lake</th>
<th>Inorganic Nitrogen (mg/L)</th>
<th>SRP (ug/L)</th>
<th>Total P (ug/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Min Avg Max</td>
<td>Min Avg Max</td>
<td>Min Avg Max</td>
</tr>
<tr>
<td>Fall</td>
<td>0.01 0.81 1.60</td>
<td>4 4 4</td>
<td>14 15 16</td>
</tr>
<tr>
<td>Spring</td>
<td>0.05 0.05 0.05</td>
<td>8 14 17</td>
<td>24 24 24</td>
</tr>
<tr>
<td>Summer</td>
<td>0.05 0.08 0.10</td>
<td>3 6 9</td>
<td>8 14 17</td>
</tr>
<tr>
<td>Winter</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Estimates of phosphorus from the landscape can help to understand the phosphorus sources to Round Lake. Land use in the surface watershed was evaluated and used to populate the Wisconsin Lakes Modeling Suite (WILMS) model. In general, each type of land use contributes different amounts of phosphorus in runoff and through groundwater. The types of land management practices that are used and the distance from the lake also affect the contributions to the lake from a parcel of land. While forests and development comprise the greatest areas of the watershed, modeling results indicated that developed land had the greatest percentage of phosphorus contribution from the watershed to Round Lake (Figure 8). The phosphorus contributions by land use category, called phosphorus export coefficients, are shown in Table 4. The phosphorus export coefficients have been obtained from studies throughout Wisconsin (Panuska and Lillie, 1995).
Figure 8. Estimated phosphorus loads from land uses in the Round Lake watershed.

Table 4. Modeling data used to estimate phosphorus inputs from land uses in the Round Lake watershed (low and most likely coefficients used to calculate range in pounds).

<table>
<thead>
<tr>
<th>Round Lake Land Use</th>
<th>Phosphorus Export Coefficient (lbs/acre-yr)</th>
<th>Land Use Area Within the Watershed</th>
<th>Estimated Phosphorus Load</th>
<th>Pounds</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>0.1</td>
<td>74 25</td>
<td>7-20</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>Developed</td>
<td>0.27</td>
<td>108 37</td>
<td>29-57</td>
<td>71</td>
<td></td>
</tr>
<tr>
<td>Barren/Herbaceous/Wetland</td>
<td>0.09</td>
<td>0 0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Forest</td>
<td>0.04</td>
<td>114 38</td>
<td>5-9</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Cultivated Agriculture</td>
<td>0.45</td>
<td>0 0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

*Values are not exact due to rounding and conversion.
AQUATIC PLANTS

Aquatic plants are the forested landscape within a lake. They provide food and habitat for a wide range of species including fish, waterfowl, turtles, amphibians, as well as invertebrates and other aquatic animals. They improve water quality by releasing oxygen into the water and utilizing nutrients that would otherwise be used by algae. A healthy lake typically has a variety of aquatic plant species which creates diversity that makes the aquatic plant community more resilient and can help to prevent the establishment of non-native aquatic species.

During the 2012 aquatic plant survey in Round Lake, ninety-three percent (188 of 203) of the sites sampled had vegetative growth. Of the sampled sites within Round Lake, the average depth was 13 feet and the maximum depth was 21 feet. Twenty-three species of aquatic plants were found in Round Lake, which is above-average when compared with other lakes in the Waushara County Lakes Study (Table 5). The greatest plant diversity was found in the southwestern shallows of the lake (Figure 9).

Table 5. List of aquatic plants identified in the 2012 aquatic plant survey of Round Lake.

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Scientific Name</th>
<th>Coefficient of Conservatism Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emergent Species</td>
<td></td>
<td></td>
</tr>
<tr>
<td>northern blue-flag</td>
<td>Iris versicolor</td>
<td></td>
</tr>
<tr>
<td>common arrowhead</td>
<td>Sagittaria latifolia</td>
<td>3</td>
</tr>
<tr>
<td>softstem bulrush</td>
<td>Schoenoplectus tabernaemontani</td>
<td>4</td>
</tr>
<tr>
<td>broad-leaved cattail</td>
<td>Typha latifolia</td>
<td>1</td>
</tr>
<tr>
<td>Floating Leaf Species</td>
<td></td>
<td></td>
</tr>
<tr>
<td>white water lily</td>
<td>Nymphaea odorata</td>
<td>6</td>
</tr>
<tr>
<td>water smartweed</td>
<td>Polygonum amphibium</td>
<td>5</td>
</tr>
<tr>
<td>Submergent Species</td>
<td></td>
<td></td>
</tr>
<tr>
<td>coontail</td>
<td>Ceratophyllum demersum</td>
<td>3</td>
</tr>
<tr>
<td>muskgrass</td>
<td>Chara spp.</td>
<td>7</td>
</tr>
<tr>
<td>needle spikerush</td>
<td>Eleocharis acicularis</td>
<td>5</td>
</tr>
<tr>
<td>common waterweed</td>
<td>Elodea canadensis</td>
<td>3</td>
</tr>
<tr>
<td>water star-grass</td>
<td>Heteranthera dubia</td>
<td>6</td>
</tr>
<tr>
<td>northern water-milfoil</td>
<td>Myriophyllum sibiricum</td>
<td>6</td>
</tr>
<tr>
<td>Eurasian water-milfoil</td>
<td>Myriophyllum spicatum</td>
<td>0</td>
</tr>
<tr>
<td>slender naiad</td>
<td>Najas flexilis</td>
<td>6</td>
</tr>
<tr>
<td>southern naiad</td>
<td>Najas guadalupensis</td>
<td>8</td>
</tr>
<tr>
<td>large-leaf pondweed</td>
<td>Potamogeton amplifolius</td>
<td>7</td>
</tr>
<tr>
<td>Fries’ pondweed</td>
<td>Potamogeton friesii</td>
<td>8</td>
</tr>
<tr>
<td>variable pondweed</td>
<td>Potamogeton gramineus</td>
<td>7</td>
</tr>
<tr>
<td>Illinois pondweed</td>
<td>Potamogeton illinoensis</td>
<td>6</td>
</tr>
<tr>
<td>white-stem pondweed</td>
<td>Potamogeton praelongus</td>
<td>8</td>
</tr>
<tr>
<td>flat-stem pondweed</td>
<td>Potamogeton zosteriformis</td>
<td>6</td>
</tr>
<tr>
<td>white water crowfoot</td>
<td>Ranunculus aquatilis</td>
<td>8</td>
</tr>
<tr>
<td>wild celery</td>
<td>Vallisneria americana</td>
<td>6</td>
</tr>
<tr>
<td>aquatic moss</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The dominant plant species in the survey was flat-stem pondweed (*Potamogeton zosteriformis*), followed by white-stem pondweed (*Potamogeton praelongus*) and muskgrass (*Chara* spp.). Flat-stem pondweed provides food to waterfowl, and invertebrates and fish make use of the plant for cover and habitat. White-stem pondweed provides grazing opportunities to waterfowl, muskrat, beaver and deer. It also provides valuable habitat to muskellunge. Muskgrass is a favorite food source for a wide variety of waterfowl, and muskgrass beds offer cover and food to fish, especially young trout, largemouth bass, and smallmouth bass (Borman et al., 2001).

The Floristic Quality Index (FQI) evaluates the closeness of a plant community to undisturbed conditions. Each plant is assigned a coefficient of conservatism value (C-value) that reflects its sensitivity to disturbance. C-values range from 0 to 10. The higher the number, the more intolerant the plant is of disturbance. A C-value of zero is assigned to exotic and most nonvascular species. These numbers are used to calculate the FQI. The FQI for Round Lake was 26.2, which was slightly higher than the average FQI of 23.2 for all lakes in the Waushara County Lakes Study. No species of special concern in Wisconsin were found in Round Lake.

The C-values in Round Lake ranged from 0 to 8, with an average C-value of 6.2 (Table 5). Round Lake was home to four species of aquatic plants with C-values of eight or greater, which are considered high quality species: southern naiad (*Najas guadalupensis*), Fries’ pondweed (*Potamogeton friesii*), white-stem pondweed (*Potamogeton praelongus*), and white water crowfoot (*Ranunculus aquatilis*).

The Simpson Diversity Index (SDI) quantifies biodiversity based on a formula that uses the number of species surveyed and the number of individuals per site. The SDI uses a decimal scale from zero to one. Values closer to one represent higher amounts of biodiversity. Round Lake had an SDI of 0.91. This represents above average biodiversity when compared to the lakes in the Waushara County Lakes Study.

During the full aquatic plant survey in 2012, Eurasian watermilfoil (EWM), a non-native species, was identified in Round Lake for the first time. It was found predominantly in the southern portion of the lake. Some of the EWM population was found in dense patches, and EWM was often mixed with northern watermilfoil. Efforts should be made to prevent the Eurasian watermilfoil from spreading.

Overall, the aquatic plant community in Round Lake can be characterized as having above-average diversity when compared to all of the other lakes in the Waushara County Lakes Study, with aquatic species that are common to central Wisconsin lakes. The identification of Eurasian watermilfoil within the lake is cause for concern. The habitat, food source, and water quality offered by the plant community within Round Lake should be the focal points of future lake management strategies.
Figure 9. Number of aquatic plant species observed at each sample site in Round Lake, 2012.
Shoreland vegetation is critical to a healthy lake ecosystem. It provides habitat for many aquatic and terrestrial animals including birds, frogs, turtles, and many small and large mammals. It also helps to improve the quality of the runoff that is flowing across the landscape towards the lake. Healthy shoreland vegetation includes a mix of tall grasses/flowers, shrubs and trees which extend at least 35 feet landward from the water’s edge.

To better understand the health of the Waushara County lakes, shorelands were evaluated by professionals from the Center for Land Use Education and Waushara County as a part of the Waushara County Lakes Study. The survey inventoried the type and extent of shoreland vegetation. Areas with erosion, rip-rap, barren ground, sea walls, structures and docks were also inventoried.

A scoring system was developed for the collected data to provide a more holistic assessment. Areas that are healthy will need strategies to keep them healthy, and areas with potential problem areas and where management and conservation may be warranted may need a different set of strategies for improvement. The scoring system is based on the presence/absence and abundance of shoreline features, as well as their proximity to the water’s edge. Values were tallied for each shoreline category and then summed to produce an overall score. Larger scores denote a healthier shoreline with good land management practices. These are areas where protection and/or conservation should be targeted. On the other hand, lower scores signify an ecologically unhealthy shoreline. These are areas where management and/or mitigation practices may be desirable for improving water quality.

The summary of scores for shorelands around Round Lake is displayed in Figure 10. The shorelands were color-coded to show their overall health based on natural and physical characteristics. Blue shorelands identify healthy shorelands with sufficient vegetation and few human disturbances. Red shorelands indicate locations where changes in management or mitigation may be warranted. Much of Round Lake’s shorelands are in good shape, but large segments of shoreland have challenges that should be addressed. For a more complete understanding of the ranking, an interactive map showing results of the shoreland surveys can be found on Waushara County’s website at http://gis.co.waushara.wi.us/ShorelineViewer/.
Figure 10. Overall shoreland health around Round Lake, 2011.
ROUND LAKE CONCLUSIONS & RECOMMENDATIONS

In general, Round Lake had good water quality, but indications of inputs to the lake from activities on the landscape were observed. Atrazine was present in samples collected from the lake, indicating that land use practices in the watershed are influencing the water quality in Round Lake. Although sources of phosphorus from agriculture and developed land exist in the Round Lake watershed, the moderately hard water (from calcium in the groundwater) in Round Lake has helped to minimize the effects of the additional nutrients.

- The hard water in Round Lake provides the calcium necessary for building bones and shells for animals in the lake and the higher alkalinity can support higher species productivity. Hardness and alkalinity also play roles in the types of aquatic plants that are found in the lake.
- When compared with historic data, the average water clarity during the study was poorer in May and June and better throughout the remainder of the growing season.
- Atrazine, an herbicide commonly used on corn cropland, was found in low concentrations in Round Lake. Some toxicity studies have indicated that reproductive system abnormalities can occur in frogs at these levels. The presence of this chemical suggests that agricultural activities in the surrounding watershed are impacting Round Lake.
- Routine monitoring of water quality can help to track changes in Round Lake. A monitoring plan should be designed and carried out.

In general, each type of land use contributes different amounts of phosphorus and nitrogen in runoff and through groundwater. The types of land management practices that are used and their distances from the lake affect the contributions to the lake from a parcel of land.

- Identifying and taking steps to improve water quality in Round Lake will depend upon understanding the sources of nutrients to the lake and identifying those that are manageable. Although forest and development are the dominant land uses in the watershed, modeling results indicate that developed land is estimated to have the greatest percentage of phosphorus contributions from the watershed to Round Lake.
- Over-application of chemicals and nutrients should be avoided. Landowners in the watershed should be made aware of their connection to Round Lake and should work to reduce their impacts through the implementation of water quality-based best management practices.
- Shoreland health is critical to a healthy lake’s ecosystem. Round Lake’s shoreland was assessed for the extent of vegetation and disturbances. Shoreland vegetation provides habitat for many aquatic and terrestrial animals including birds, frogs, turtles, and many small and large mammals. It also helps to improve the quality of the runoff that is flowing across the landscape towards the lake. Healthy shoreland vegetation includes a mix of tall grasses/flowers, shrubs and trees which extend at least 35 feet landward from the water’s edge. Alone, each manmade feature may not pose a problem for a lake, but on developed lakes, the collective impact of manmade disturbances can be a problem for lake habitat and water quality.
  - Much of Round Lake’s shorelands are in good shape, but large segments of shoreland have challenges that should be addressed.
  - Most of Round Lake’s eastern shoreland ranked as poor.
  - Structures such as seawalls, rip-rap (rocked shoreline), and artificial beach often result in habitat loss.
Erosion can contribute sediment to the lake, which can alter spawning habitat and carry nutrients into the lake. Round Lake had a lot of erosion when compared with other lakes in the Waushara County Lakes Study.

Unmanaged runoff from rooftops of structures located near shore can also contribute more sediment to the lake.

Docks and artificial beaches can result in altered in-lake habitat. Denuded lakebeds provide opportunities for invasive species to become established and reduce habitat that is important to fish and other lake inhabitants.

- The Waushara County Land Conservation Department and Natural Resources Conservation Service (NRCS) have professional staff available to assist landowners interested in learning how they can improve water quality through changes in land management practices.

Aquatic plants are the forested landscape within a lake. They provide food and habitat for a wide range of species including fish, waterfowl, turtles, amphibians, as well as invertebrates and other aquatic animals. They improve water quality by releasing oxygen into the water and utilizing nutrients that would otherwise be used by algae. A healthy lake typically has a variety of aquatic plant species which creates diversity that makes the aquatic plant community more resilient and can help to prevent the establishment of non-native aquatic species.

- The diversity of an aquatic plant community is defined by the type and number of species present throughout the lake. Twenty-three species of aquatic plants were found in Round Lake, which is above-average when compared with other lakes in the Waushara County Lakes Study.

- Round Lake had above average aquatic plant biodiversity compared to the lakes in the Waushara County Lakes Study, based on the calculated species diversity index of 0.91.

- Round Lake was home to four species of aquatic plants with C-values of eight or greater, which are considered high quality species: southern naiad, Fries’ pondweed, white-stem pondweed, and white water crowfoot.

- A 2013 aquatic invasive species (AIS) reconnaissance survey of Round Lake by Golden Sands Resource Conservation & Development Council, Inc. revealed the presence of two invasive species of plants in Round Lake.
  - Eurasian watermilfoil (EWM) is an invasive species, was present in Round Lake. EWM can create dense beds that can damage boat motors, make areas non-navigable, stunt or alter the fishery, create problems with dissolved oxygen, and prevent activities like fishing and swimming. This plant can produce a viable seed; however, its primary mode of reproduction and spread is fragmentation. A one-inch fragment is enough to start a new plant, making EWM very successful at reproducing.
  - Curly leaf pondweed (CLP) was found Round Lake. CLP dies off in late June, releasing phosphorus into the water. The timing of die-off can be problematic by influencing algae blooms. CLP also starts growing under the ice in early spring before other plants, giving it a competitive advantage over native plant species.

- Since populations of EWM and CLP are present, an aquatic plant management (APM) plan should be developed. The APM should identify recommended measures to manage these plants in Round Lake.

- The amount of disturbed lake bed from raking or pulling of plants should be minimized, since these open spaces are simply “open real estate” for aquatic invasive plants to establish.

- Boats and trailers that have visited other lakes can be a primary vector for the transport of aquatic invasive species (AIS). Volunteer boat inspectors at the boat landing, trained through the Clean
Boats Clean Waters (CBCW) program, can help prevent new AIS introductions. Disturbed conditions often encourage the colonization of AIS.

- Monitoring for AIS should be conducted routinely throughout the lake by either trained citizen volunteers or paid personnel.
REFERENCES


GLOSSARY OF TERMS

Algae: One-celled (phytoplankton) or multicellular plants either suspended in water (plankton) or attached to rocks and other substrates (periphyton). Their abundance, as measured by the amount of chlorophyll a (green pigment) in an open water sample, is commonly used to classify the trophic status of a lake. Numerous species occur. Algae are an essential part of the lake ecosystem and provide the food base for most lake organisms, including fish. Phytoplankton populations vary widely from day to day, as life cycles are short.

Atrazine: A commonly used herbicide. Transports to lakes and rivers by groundwater or runoff. Has been shown to have toxic effects on amphibians.

Blue-Green Algae: Algae that are often associated with problem blooms in lakes. Some produce chemicals toxic to other organisms, including humans. They often form floating scum as they die. Many can fix nitrogen (N2) from the air to provide their own nutrient.

Calcium (Ca++): The most abundant cation found in Wisconsin lakes. Its abundance is related to the presence of calcium-bearing minerals in the lake watershed. Reported as milligrams per liter (mg/l) as calcium carbonate (CaCO3), or milligrams per liter as calcium ion (Ca++).

Chloride (Cl-): The chloride ion (Cl-) in lake water is commonly considered an indicator of human activity. Agricultural chemicals, human and animal wastes, and road salt are the major sources of chloride in lake water.

Chlorophyll a: Green pigment present in all plant life and necessary for photosynthesis. The amount present in lake water depends on the amount of algae, and is therefore used as a common indicator of algae and water quality.

Clarity: See “Secchi disk.”

Color: Color affects light penetration and therefore the depth at which plants can grow. A yellow-brown natural color is associated with lakes or rivers receiving wetland drainage. Measured in color units that relate to a standard. The average color value for Wisconsin lakes is 39 units, with the color of state lakes ranging from zero to 320 units.

Concentration units: Express the amount of a chemical dissolved in water. The most common ways chemical data is expressed is in milligrams per liter (mg/l) and micrograms per liter (ug/l). One milligram per liter is equal to one part per million (ppm). To convert micrograms per liter (ug/l) to milligrams per liter (mg/l), divide by 1000 (e.g. 30 ug/l = 0.03 mg/l). To convert milligrams per liter (mg/l) to micrograms per liter (ug/l), multiply by 1000 (e.g. 0.5 mg/l = 500 ug/l).

Cyanobacteria: See “Blue-Green Algae.”

Dissolved oxygen: The amount of oxygen dissolved or carried in the water. Essential for a healthy aquatic ecosystem in Wisconsin lakes.

Drainage basin: The total land area that drains runoff towards a lake.

Drainage lakes: Lakes fed primarily by streams and with outlets into streams or rivers. They are more subject to surface runoff problems, but generally have shorter residence times than seepage lakes.

Emergent: A plant rooted in shallow water and having most of its vegetative growth above water.

Eutrophication: The process by which lakes and streams are enriched by nutrients, and the resulting increase in plant and algae. The extent to which this process has occurred is reflected in a lake's trophic classification: oligotrophic (nutrient poor), mesotrophic (moderately productive), and eutrophic (very productive and fertile).

Groundwater drainage lake: Often referred to as a spring-fed lake, it has large amounts of groundwater as its source and a surface outlet. Areas of high groundwater inflow may be visible as springs or sand boils. Groundwater drainage lakes often have intermediate retention times with water quality dependent on groundwater quality.
Hardness: The quantity of multivalent cations (cations with more than one +), primarily calcium (Ca++) and magnesium (Mg++) in the water expressed as milligrams per liter of CaCO3. Amount of hardness relates to the presence of soluble minerals, especially limestone or dolomite, in the lake watershed.

Intermittent: Coming and going at intervals, not continuous.

Macrophytes: See “Rooted aquatic plants.”

Marl: White to gray accumulation on lake bottoms caused by precipitation of calcium carbonate (CaCO3) in hard water lakes. Marl may contain many snail and clam shells. While it gradually fills in lakes, marl also precipitates phosphorus, resulting in low algae populations and good water clarity. In the past, marl was recovered and used to lime agricultural fields.

Mesotrophic: A lake with an intermediate level of productivity. Commonly clear water lakes and ponds with beds of submerged aquatic plants and mediums levels of nutrients. See also “eutrophication”.

Nitrate (NO3-): An inorganic form of nitrogen important for plant growth. Nitrate often contaminates groundwater when water originates from manure, fertilized fields, lawns or septic systems. In drinking water, high levels (over 10 mg/L) are dangerous to infants and expectant mothers. A concentration of nitrate-nitrogen (NO3-N) plus ammonium-nitrogen (NH4-N) of 0.3 mg/L in spring will support summer algae blooms if enough phosphorus is present.

Oligotrophic: Lakes with low productivity, the result of low nutrients. Often these lakes have very clear waters with lots of oxygen and little vegetative growth. See also “eutrophication”.

Overtun: Fall cooling and spring warming of surface water increases density, and gradually makes lake temperatures and density uniform from top to bottom. This allows wind and wave action to mix the entire lake. Mixing allows bottom waters to contact the atmosphere, raising the water's oxygen content. Common in many lakes in Wisconsin.

Phosphorus: Key nutrient influencing plant growth in more than 80% of Wisconsin lakes. Soluble reactive phosphorus is the amount of phosphorus in solution that is available to plants. Total phosphorus includes the amount of phosphorus in solution (reactive) and in particulate form.

Rooted aquatic plants (macrophytes): Refers to higher (multi-celled) plants growing in or near water. Macrophytes are beneficial to lakes because they produce oxygen and provide substrate for fish habitat and aquatic insects and provide food for many aquatic and terrestrial animals. Overabundance of such plants, especially problem species, is related to shallow water depth and high nutrient levels.

Secchi disk: An 8-inch diameter plate with alternating quadrants painted black and white that is used to measure water clarity (light penetration).

Sedimentation: Materials that are deposited after settling out of the water.

Stratification: The layering of water due to differences in density. As water warms during the summer, it remains near the surface while colder water remains near the bottom. Wind mixing determines the thickness of the warm surface water layer (epilimnion), which usually extends to a depth of about 20 feet. The narrow transition zone between the epilimnion and cold bottom water (hypolimnion) is called the metalimnion. Common in many deeper lakes in Wisconsin.

Watershed: See “Drainage basin.”