

2014

Waushara County Lakes Study Spring Lake

Final Report
to Waushara County and
Wisconsin Department of Natural Resources

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SPRING 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 Spring Lake between fall 2010 and fall 2012.

ABOUT SPRING 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. Spring Lake is located in the township of Marion, south of the town of Spring Lake, and south of Highway 21, with two public boat launches located on its southern and eastern sides. Spring Lake is a 50-acre groundwater drainage lake with surface runoff and groundwater contributing most of its water. The maximum depth in Spring Lake is 37 feet; the lakebed has slopes ranging from gradual to steep, with an average lake depth of 22 feet (Figure 1). Spring Lake has a water residence time of 17 months. The residence time helps determine the potential effects of nutrients entering the lake and the length of time pollutants may stay in the lake. Its bottom sediments are mostly muck with a small amount of sand found in the southwestern corner of the lake.

The water quality in Spring 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 Spring 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 Spring Lake is called a surface watershed. Groundwater also feeds Spring 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 and 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 to vegetation on the landscape, and may be a source of pollutants. Impervious (hard) surfaces such as roads, rooftops, and compacted soil prevent rainfall from soaking into the ground, which may result in more runoff that carries pollutants to the lake. Wastewater, animal waste, and fertilizers used on lawns, gardens and crops can contribute nutrients that can encourage the growth of algae and aquatic plants in our lakes.

A variety of land management practices can be put into place to help reduce impacts to our lakes. Some practices are designed to reduce runoff. These include protecting/restoring wetlands, installing rain gardens, swales and 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.

SPRING LAKE SURFACE WATERSHED

The surface watershed for Spring Lake is approximately 1,988 acres (Figure 2). The dominant types of land use in the watershed are agriculture (50%) and forests (27%). The land closest to the lake often has the greatest impact on water quality and habitat; Spring Lake's shoreland is surrounded primarily by development, wetlands and forests.

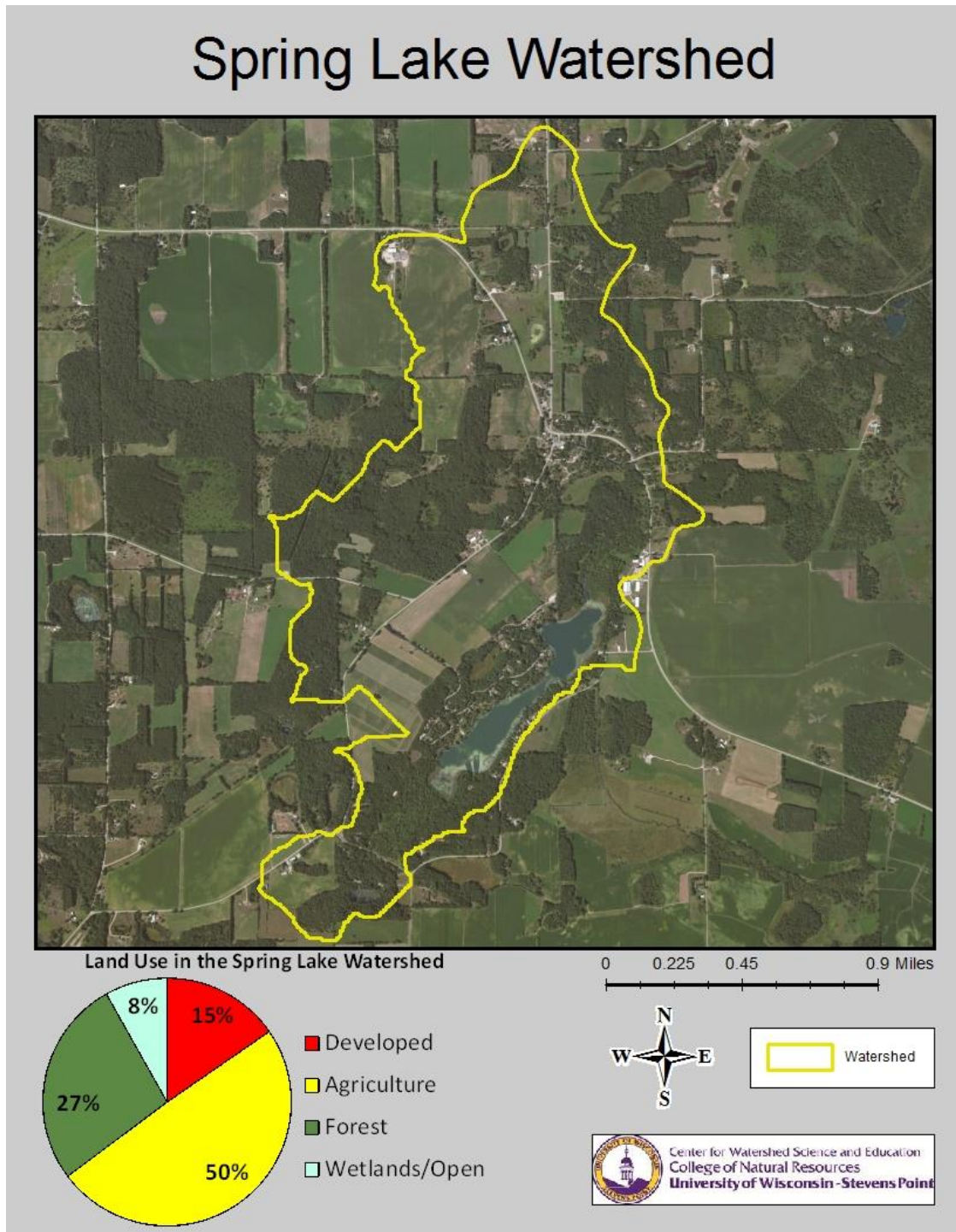


FIGURE 2. LAND USE IN THE SPRING LAKE WATERSHED.

SPRING LAKE GROUNDWATER 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 Spring 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 Spring Lake on its western side.

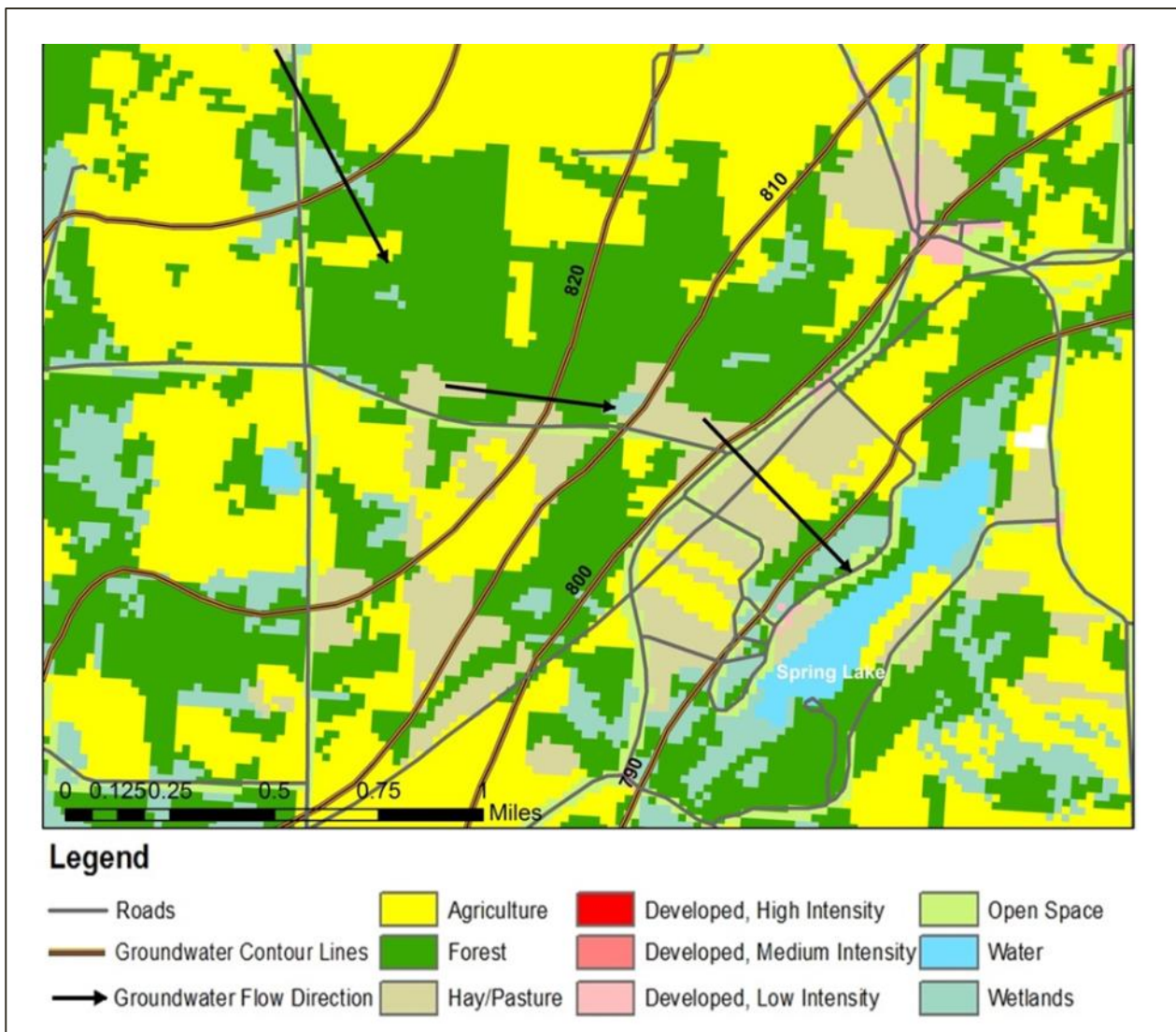
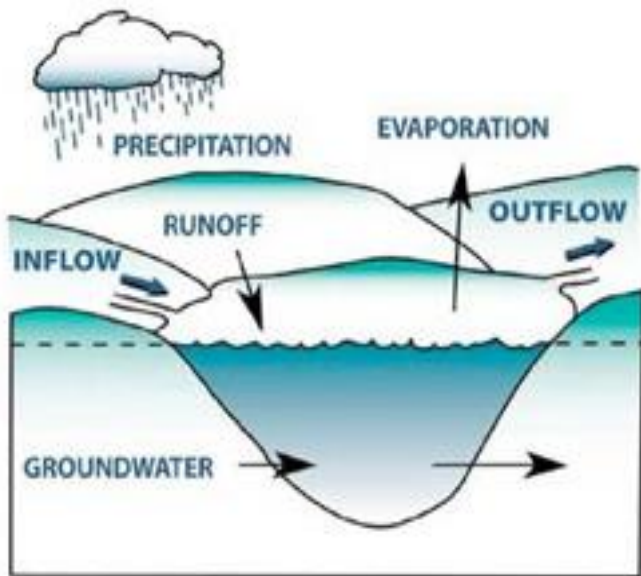


FIGURE 3. GROUNDWATER FLOW DIRECTION NEAR SPRING LAKE.

WATER QUALITY

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 Spring 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. Spring Lake is a groundwater drainage lake, which receives its water primarily via groundwater, with lesser inputs from surface runoff and direct precipitation (Figure 4). Water exits Spring Lake via a small outlet stream. Groundwater drainage lakes often have higher concentrations of minerals such as calcium and magnesium, which travel with groundwater moving through soil and rock. Groundwater drainage lakes can be vulnerable to contamination moving towards the lake in the groundwater.



The geologic composition that lies beneath a lake has the ability to influence its temperature, pH, minerals, and other properties (Shaw et al., 2000). As groundwater travels, some substances are filtered out, but other materials in the soil dissolve into the groundwater. Minerals such as calcium and magnesium in the soil around Spring Lake are dissolved in the water, making the water hard. The average hardness for Spring Lake during the 2010-2012 sampling period was 229 mg/L, which is considered hard (Table 1). Hard water provides the calcium necessary for building bones and shells for animals in the lake. The average alkalinity was 211 mg/L; higher alkalinity in inland lakes can support higher species productivity. Hardness and alkalinity also play a role in the type of aquatic plants that are found in a lake (Wetzel, 2001).

FIGURE 4. CARTOON SHOWING INFLOW AND OUTFLOW OF WATER IN A GROUNDWATER DRAINAGE LAKE.

TABLE 1. MINERALS AND PHYSICAL MEASUREMENTS IN SPRING LAKE, 2010-2012.

| Spring Lake | Alkalinity (mg/L) | Calcium (mg/L) | Magnesium (mg/L) | Hardness (mg/L as CaCO ₃) | Color (SU) | Turbidity (NTU) |
|---------------|-------------------|----------------|------------------|---------------------------------------|------------|-----------------|
| Average Value | 211 | 41.8 | 24.1 | 229 | 18.6 | 2.03 |

Chloride concentrations, and to lesser degrees sodium and potassium concentrations, are commonly used as indicators of how strongly a lake is being impacted by human activity. The presence of these compounds where they do not naturally occur indicates the movement of pollutants from the landscape to the lake.

Spring Lake had elevated potassium, chloride, and sodium concentrations on average during the monitoring period (Table 2), indicating that human activities were impacting the lake water. Chloride and sodium sources can include animal waste, septic systems, fertilizers, and road-salt. Sources of potassium include fertilizers, animal waste, and septic systems. Atrazine, an herbicide commonly used in corn production, averaged 0.12 ug/L DACT in the samples that were analyzed from Spring Lake. The presence of this chemical suggested that agricultural activities in the surrounding area were impacting water quality. Some toxicity studies have indicated that reproductive system abnormalities can occur in frogs at these levels (Hayes et al., 2003 and Hayes et al., 2001).

TABLE 2. SPRING LAKE AVERAGE WATER CHEMISTRY, 2010-2012.

| Spring Lake | Average Value | | | Reference Value | | |
|------------------|---------------|--------|------|-----------------|----------|------|
| | Low | Medium | High | Low | Medium | High |
| Potassium (mg/L) | | | 1.63 | <.75 | 0.75-1.5 | >1.5 |
| Chloride (mg/L) | | | 12.5 | <3 | 3.0-10.0 | >10 |
| Sodium (mg/L) | | | 4.7 | <2 | 2.0-4.0 | >4 |

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.

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 cold water species of fish and other aquatic organisms.

Water temperature and dissolved oxygen were measured in Spring Lake from top to bottom at the time of each sample collection. Throughout much of the year, temperatures in Spring Lake were warmer near the top and cooler near the bottom. This is typical for Wisconsin lakes, but layering results in the inability of oxygen and nutrients to mix throughout the lake. Profiles taken during the fall turnover showed uniform temperatures from top to bottom (Figure 5).

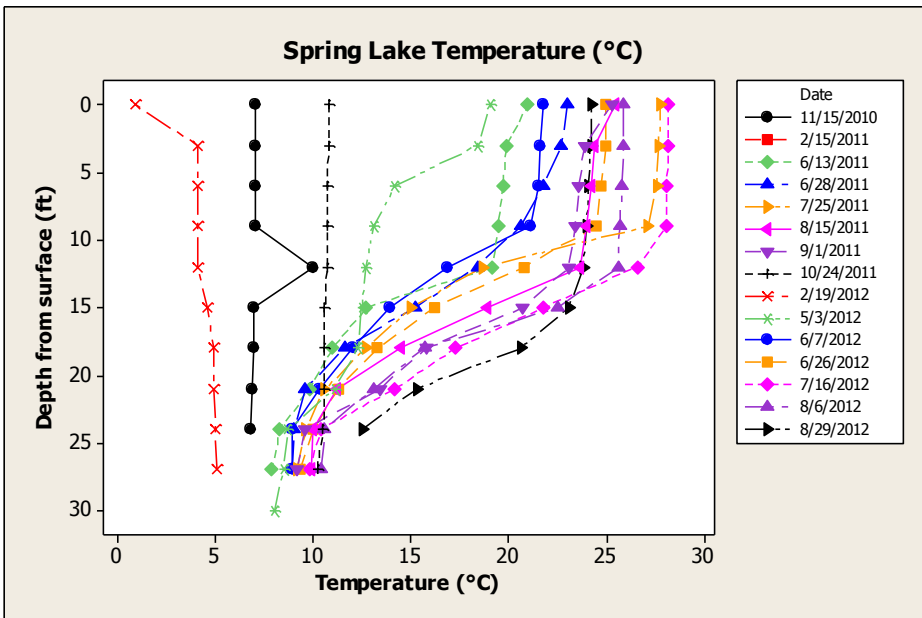


FIGURE 5. TEMPERATURE PROFILES IN SPRING LAKE, 2010-2012.

Measurements of dissolved oxygen in Spring Lake followed a similar pattern to temperature. There were similar concentrations of dissolved oxygen from top to bottom during the fall and spring (Figure 6). Similar to temperature, dissolved oxygen concentrations were higher at the surface and lower towards the bottom during other times of the year. During the winter when ice prevents water contact with the atmosphere, dissolved oxygen concentrations declined with depth. The winter samples demonstrated that dissolved oxygen concentrations can become very low in Spring Lake.

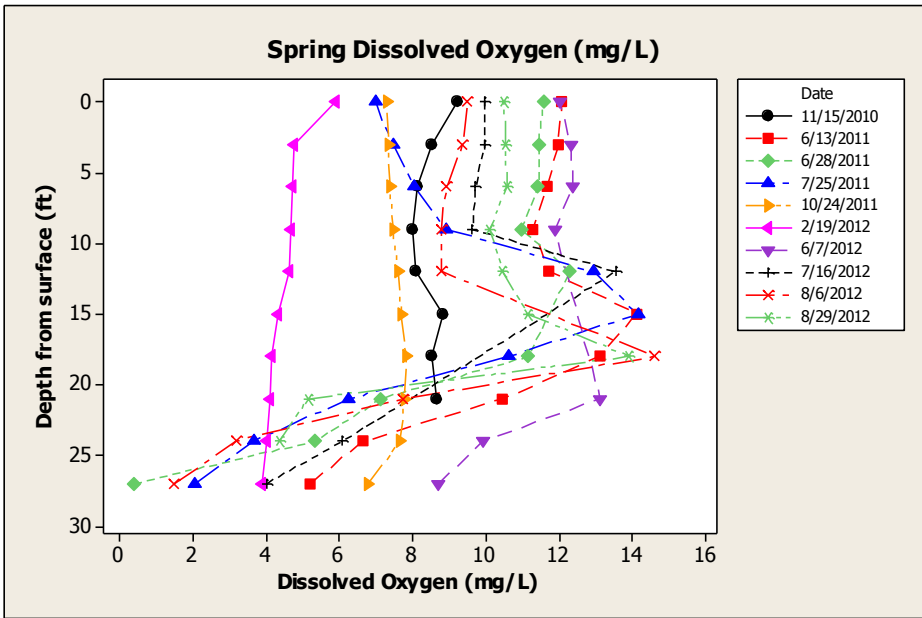


FIGURE 6. DISSOLVED OXYGEN PROFILES IN SPRING LAKE, 2010-2012.

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. In Spring Lake, color and turbidity were relatively low (Table 1), indicating that the variability in transparency throughout the year is primarily due to fluctuating algae concentrations and re-suspended sediment following storms and/or heavy boating activity.

In Spring Lake, water clarity ranged from 6.5 feet to 15.5 feet (Figure 7). It is typical to have variability in a lake, often based on seasonal conditions. When compared with historic data, the average water clarity measured during the study was slightly better in May, June, July, August, and October, and worse in September. Water clarity in Spring Lake is typically poorer in August and September. This corresponds with the period when algae growth is greatest.

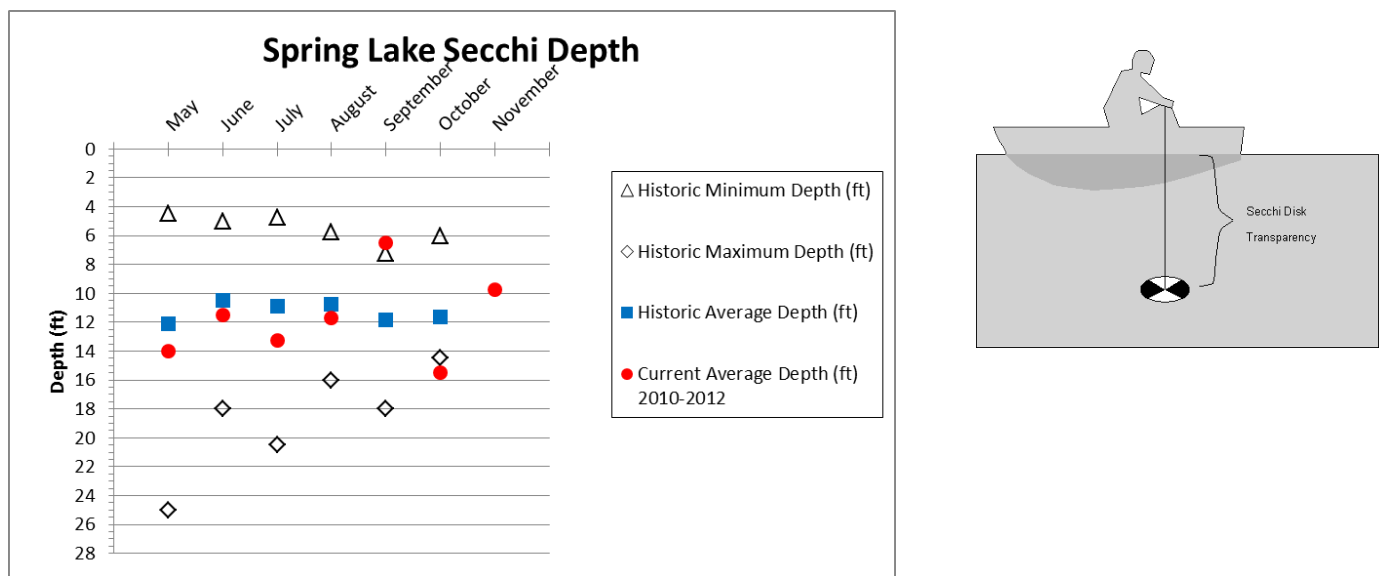


FIGURE 7. WATER CLARITY IN SPRING LAKE, 2010-2012 AND HISTORIC.

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. Additional 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 forms of plant tissue, animal tissue, and sediment. The phosphorus continues to cycle within the lake for many years.

Total phosphorus concentrations in samples collected from Spring Lake ranged from a high of 22 ug/L in February and November 2011 to a low of 3 ug/L in July 2011 (Table 3). The summer median total phosphorus was 14 ug/L and 10.5 ug/L in 2011 and 2012, respectively. This is below Wisconsin’s phosphorus standard of 30 ug/L for deep drainage lakes. During the study, inorganic nitrogen concentrations were high enough in the spring to enhance algal blooms throughout the summer (Shaw et al., 2000).

Chlorophyll *a* is a measurement of algae in the water. Chlorophyll *a* concentrations in Spring Lake varied little throughout the monitoring season, ranging from a high of 3 ug/L to a low of 0.5 ug/L. The average during the monitoring period was 1.7 ug/L.

TABLE 3. SEASONAL SUMMARY OF NUTRIENT CONCENTRATIONS IN SPRING LAKE, 2010-2012.

| Spring Lake | Inorganic Nitrogen (mg/L) | | | Organic Nitrogen (mg/L) | | | Total Nitrogen (mg/L) | | | Soluble Reactive Phosphorus (ug/L) | | | Total Phosphorus (ug/L) | | |
|-------------|---------------------------|------|------|-------------------------|------|------|-----------------------|------|------|------------------------------------|-----|-----|-------------------------|-----|-----|
| | Min | Avg | Max | Min | Avg | Max | Min | Avg | Max | Min | Avg | Max | Min | Avg | Max |
| Fall | 1.40 | 2.75 | 4.10 | 0.47 | 0.58 | 0.68 | 2.48 | 3.56 | 4.64 | 4 | 6 | 8 | 14 | 18 | 22 |
| Spring | 1.80 | 1.97 | 2.13 | 0.50 | 0.50 | 0.50 | 2.72 | 2.72 | 2.72 | 1 | 3 | 5 | 11 | 13 | 14 |
| Summer | | | | | | | | | | | | | 3 | 12 | 19 |
| Winter | 2.06 | 2.38 | 2.69 | 0.39 | 0.41 | 0.42 | 2.69 | 3.03 | 3.36 | 1 | 11 | 20 | 13 | 18 | 22 |

Estimates of phosphorus from the landscape can help to understand the phosphorus sources to Spring 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 or inflowing stream also affect the contributions to the lake from a parcel of land. Based on modeling results, agriculture had the greatest percentages of phosphorus contributions from the watershed to Spring 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).

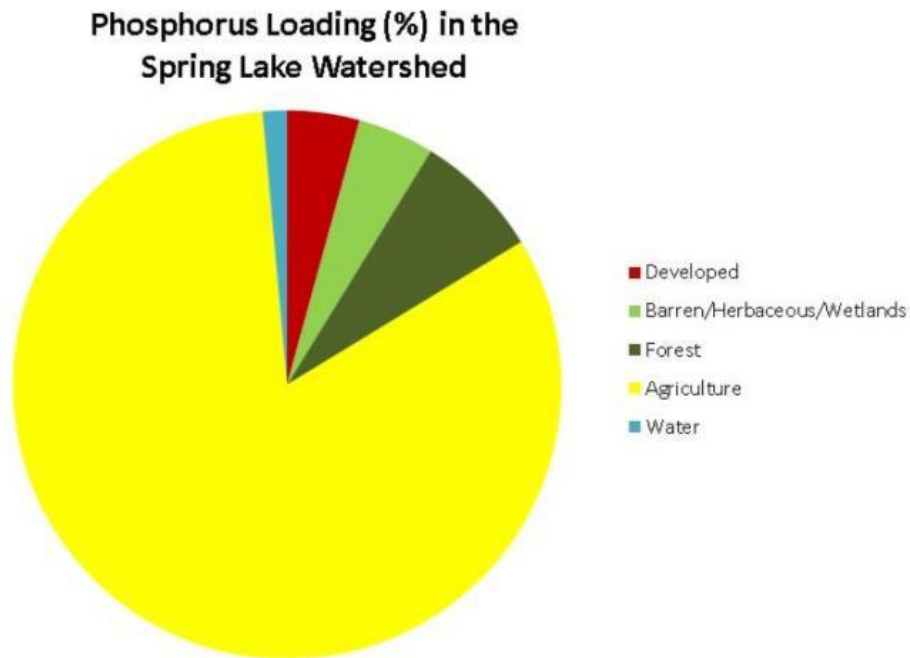


FIGURE 8. ESTIMATED PHOSPHORUS LOADS FROM LAND USES IN THE SPRING LAKE WATERSHED.

TABLE 4. MODELING DATA USED TO ESTIMATE PHOSPHORUS INPUTS FROM LAND USES IN THE SPRING LAKE WATERSHED (LOW AND MOST LIKELY COEFFICIENTS USED TO CALCULATE RANGE IN POUNDS).

| Spring Lake Watershed Land Use | Phosphorus Export Coefficient (lbs/acre-yr) | Land Use Area Within the Watershed | | Estimated Phosphorus Load | |
|-----------------------------------|--|--|-----------|------------------------------|-----------|
| | | Acres | Percent | Pounds | Percent |
| Water | 0.1 | 52 | 3 | 4-13 | 1 |
| Developed | 0.04 | 298 | 15 | 13-26 | 4 |
| Barren/Herbaceous/Wetland | 0.09 | 158 | 8 | 14-42 | 5 |
| Forest | 0.04 | 524 | 26 | 23-42 | 8 |
| Cultivated Agriculture | 0.45 | 957 | 48 | 256-683 | 82 |

Although a fair amount of phosphorus comes off of the landscape, the hard water in Spring Lake has helped to buffer nutrient impacts from the watershed as evidenced by lower measures of algae. The hard water has limited buffering capacity, so measures should be taken to reduce near shore and watershed-scale impacts to the lake. Atrazine and inorganic nitrogen are traveling in the groundwater that flows into the lake. The likely source is agriculture. Septic systems and lawn/garden fertilizer may also be contributing some of the inorganic nitrogen.

AQUATIC PLANTS

(Based on contributions from Golden Sands Resource Conservation & Development Council, Inc., 2014)

Aquatic plants play important roles in a lake's ecosystem. They provide habitat for the fishery and other aquatic organisms, stabilize the sediment, reduce erosion, buffer temperature changes and waves, and infuse oxygen into the water. Aquatic plants near shore provide food, shelter and nesting material for shoreland mammals, shorebirds and waterfowl. It is not unusual for otters, beavers, muskrats and deer to be seen along a shoreline in their search for food or nesting material. The aquatic plants that attract the animals to these areas contribute to the beauty of the shoreland and lake.

The rapid and dominant growth of aquatic invasive plants, such as Eurasian watermilfoil (EWM), can reduce the recreational value of a lake. Aquatic invasive plants may also outcompete and cause a decline in native vegetation, which degrades habitat diversity and can alter the aquatic ecosystem.

An aquatic plant survey was conducted by Golden Sands Resource Conservation & Development Council, Inc. on Spring Lake in August 2013. Twenty-five species of aquatic plants were found in Spring Lake (Table 5). This number of species was above-average compared with other lakes in Waushara County. The number of species that were identified at each sampling site are shown in Figure 9. Eighty-nine percent (115 of 129) of the sites visited had vegetative growth. The greatest depth at which aquatic plant growth was found was 19 feet.

The dominant plant species found in Spring Lake was muskgrass (*Chara* spp.), followed by coontail (*Ceratophyllum demersum*). Muskgrass and coontail are favorite waterfowl foods and also offer cover for fish. A number of invertebrate and fish species use the bushy stems and stiff whorls of the leaves of the coontail as habitat, especially in the winter when other aquatic plants have died back (Borman et al., 2001).

The Floristic Quality Index (FQI) evaluates how close a plant community is to undisturbed conditions. Each plant is assigned a coefficient of conservatism value (C-value) that reflects its sensitivity to disturbance, and these numbers are used to calculate the FQI. C-values range from 0 to 10. The lower the number, the more tolerant the plant is of disturbance. Having more plants with low C-values than high C-values is an indicator of disturbance, as the lower C-value plants better tolerate stresses caused by disturbance. A C-value of 0 is assigned to exotic species. C-values for each species of aquatic plant found in Spring Lake are displayed in Table 5. The FQI for Spring Lake was 27.8, which is slightly above-average for all lakes in the Waushara County Lakes Study.

In Spring Lake, C-values ranged from 0 to 9. Five of the twenty-five species found in Spring Lake had a C-value of 8, indicating good health in the aquatic plant community. The species with the highest frequency of occurrence within vegetated areas was *Chara* spp., with a C-value of 7. Three invasive plant species were observed: EWM, curly-leaf pondweed (CLP), and narrow-leaf cattail. All have C-values of 0.

TABLE 5. LIST OF AQUATIC PLANT SPECIES IDENTIFIED IN SPRING LAKE, 2013.

| Common name | Scientific name | Sampled | Visuals | C-value |
|--------------------------|-----------------------------------|---------|---------|---------|
| coontail | <i>Ceratophyllum demersum</i> | x | x | 3 |
| muskgrass | <i>Chara</i> spp. | x | x | 7 |
| common waterweed | <i>Elodea canadensis</i> | x | x | 3 |
| water stargrass | <i>Heteranthera dubia</i> | x | x | 6 |
| northern watermilfoil | <i>Myriophyllum sibiricum</i> | | x | 6 |
| Eurasian watermilfoil | <i>Myriophyllum spicatum</i> | | x | 0 |
| whorled watermilfoil | <i>Myriophyllum verticillatum</i> | x | x | 8 |
| slender naiad | <i>Najas flexilis</i> | x | | 6 |
| southern naiad | <i>Najas guadalupensis</i> | x | x | 8 |
| stoneworts | <i>Nitella</i> spp. | x | | 7 |
| bullhead pond lily | <i>Nuphar variegata</i> | x | x | 6 |
| white water lily | <i>Nymphaea odorata</i> | x | x | 6 |
| curly-leaf pondweed | <i>Potamogeton crispus</i> | x | | 0 |
| Fries' pondweed | <i>Potamogeton friesii</i> | x | x | 8 |
| variable pondweed | <i>Potamogeton gramineus</i> | x | x | 7 |
| Illinois pondweed | <i>Potamogeton illinoensis</i> | x | x | 6 |
| floating-leaf pondweed | <i>Potamogeton natans</i> | | x | 5 |
| flat stem pondweed | <i>Potamogeton zosteriformis</i> | x | x | 6 |
| hard-stem bulrush | <i>Schoenoplectus acutus</i> | x | x | 6 |
| sago pondweed | <i>Stuckenia pectinata</i> | x | x | 3 |
| narrow-leaf cattail | <i>Typha angustifolia</i> | | x | 0 |
| creeping bladderwort | <i>Utricularia gibba</i> | x | | 9 |
| common bladderwort | <i>Utricularia macrorhiza</i> | x | x | 7 |
| small purple bladderwort | <i>Utricularia resupinata</i> | x | | 9 |
| filamentous algae | | x | | - |

Invasive plant species are present in Spring 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 in the winter, and limit activities such as 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. CLP has a unique life cycle. It typically dies off in June, releasing phosphorus into the water from its decaying tissue. This can become problematic by enhancing algal blooms. It also starts growing under the ice before other plants, giving it a competitive advantage over native aquatic species. Narrow-leaf cattail also harms shoreline and wetland habitat by displacing native plants.

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 (Figure 9). The SDI uses a decimal scale from 0 to 1. Values closer to one represent higher amounts of biodiversity. The SDI of Spring Lake for the 2013 survey was 0.82. This represents an average biodiversity when compared to other lakes in the Waushara County Lakes Study.

Aquatic plants play another critical role in the lake’s ecosystem by using nutrients that would otherwise be available to algae. Any management activities should be planned to minimize the disturbance of native species in the water and on shore in order to maintain the balance between aquatic plants and algae. In addition, care should be taken to minimize raking the lake bed and pulling plants, since disturbing these valuable open spaces may allow invasive plants such as EWM to establish.

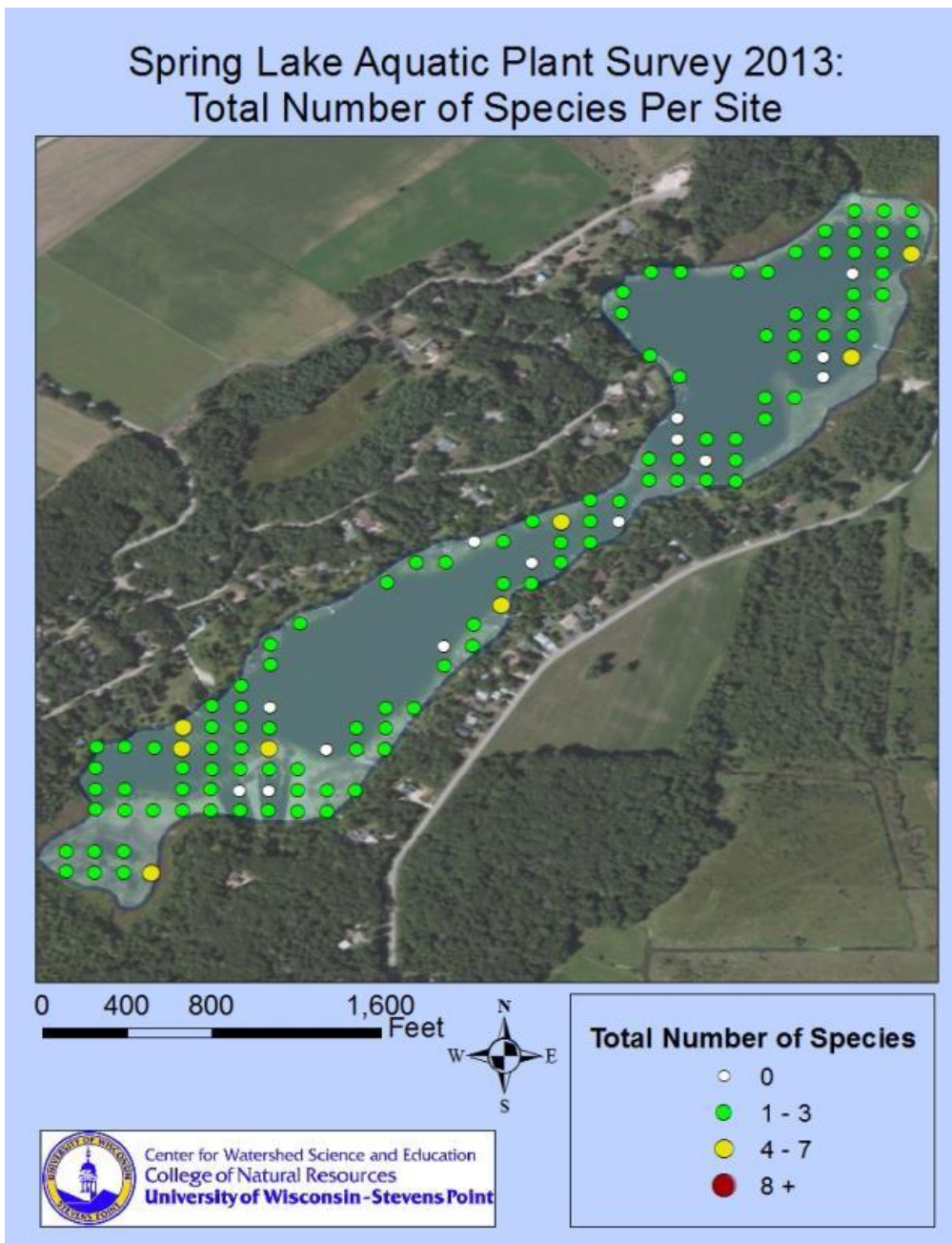


FIGURE 9. NUMBER OF AQUATIC PLANTS SPECIES OBSERVED AT EACH SAMPLE SITE IN SPRING LAKE, 2013.

SHORELANDS

Shoreland vegetation is critical to a healthy lake's 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 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 Spring 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. Large stretches of Spring Lake's shorelands are in good shape, but some portions have challenges that should be addressed. There were no stretches of Spring Lake shoreland that ranked as poor. 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/>.

Waushara County Shoreline Assessment *SPRING LAKE*

Map Date -- July, 2011
Aerial Date -- April, 2010



Summary
Shorelines are color-coded to show their overall health based on natural and physical characteristics. For example, shorelines shown in red indicate locations where management or mitigation may be warranted. Blue shorelines mark healthy riparian areas with natural vegetation and few human influences.

Calculating Shoreline Scores

- Scores are based on the presence/absence of:
- + Natural vegetation
 - + Human influences (docks, boathouses, etc)
 - + Erosion
 - + Structures



Map created by Dan McFarlane
Center for Land Use Education

FIGURE 10. OVERALL SHORELAND HEALTH AROUND SPRING LAKE, 2011.

CONCLUSIONS & RECOMMENDATIONS

In general, each type of land use contributes different amounts of phosphorus, nitrogen, and pollutants 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.

- Water quality measurements of potassium, chloride, sodium, inorganic nitrogen, and atrazine indicate that land use management practices in the watershed are influencing the water quality in Spring Lake.
- Of the lakes in the Waushara County Lake Study, Spring Lake had the highest nitrate ($\text{NO}_2 + \text{NO}_3\text{-N}$) concentrations. Sources of nitrate include fertilizers, septic systems, animal waste. The nitrate is likely moving to the lake in groundwater.
 - Water users around and upgradient of Spring Lake should have the water from their private wells tested to identify if they exceed the state and federal drinking water standard.
 - In a lake, nitrate can be readily used by plants and therefore can increase the growth of aquatic plants and some types of algae.
- Atrazine, an herbicide commonly used on corn, was detected in the samples that were analyzed from Spring Lake. Some toxicity studies have indicated that reproductive system abnormalities can occur in frogs at these levels. The presence of this chemical indicates that agricultural activities are influencing the water quality in Spring Lake.
- While phosphorus sources exist in the Spring Lake watershed, the hard water (from calcium in the groundwater) in Spring Lake has helped to minimize phosphorus impacts in the lake. The hard water has limited capacity to buffer phosphorus, so measures should be taken to reduce near shore and watershed-scale impacts to the lake.
- Over-application of chemicals and nutrients should be avoided. Landowners in the watershed should be made aware of their connection to the 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. Spring 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. Vegetation 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 extending at least 35 feet inland from the water's edge. Alone, each manmade disturbance may not pose a problem for a lake, but on developed lakes, the collective impact of these disturbances can be a problem for lake habitat and water quality.
 - Large stretches of shorelands around Spring Lake are considered healthy. Intermittent parts of the shoreland could be improved, but none of the shorelands were ranked as poor.
 - Strategies should be developed to ensure that healthy shorelands remain intact and efforts should be made to improve shorelands that have disturbance. Depending upon the source of disturbance, erosion should be controlled, vegetation should be restored, and/or excess runoff should be minimized.
 - Dissemination of relevant information to property owners is the first step towards maintaining healthy shorelands.
- 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.

Spring Lake is home to a good diversity of aquatic plants and has five species that indicate an overall healthy aquatic plant community. During the summer 2013 survey, most areas of the lake had medium densities of plants, which provided habitat for fish and other aquatic organisms and food for animals such as waterfowl, turtles, and fish. These densities should be low enough to accommodate recreational activities.

Three aquatic invasive plant species (AIS) exist in Spring Lake: Eurasian water milfoil (EWM), curly-leaf pondweed (CLP), and narrow-leaf cattail. Although these invasive species currently have low populations, all three species have the potential to overwhelm portions of the native plant community. Boats and trailers that have visited other lakes can be a primary vector for the transport of AIS. The lack of intensive high-speed recreational boating helps to preserve the integrity of Spring Lake by reducing disturbances to the lakebed that often encourage the colonization of AIS.

- CLP should be monitored annually in early June, and if the beds continue to expand, management should be considered.
- Since populations of EWM are present, an aquatic plant management (APM) plan should be developed. The plan should identify recommended measures to manage EWM in Spring Lake.
- Any plant management activities should be designed to minimize disturbance of the native species in the water and on shore, and to maintain the balance between aquatic plants and algae.
- Care should be taken to minimize the amount of disturbed lakebed from raking or pulling of plants, since these open spaces are “open real estate” for aquatic invasive plants to become established.
- Volunteer boat inspectors at the boat landing, trained through the Clean Boats, Clean Waters (CBCW) program, can help prevent new AIS introductions.
- Monitoring for AIS should be conducted routinely throughout the lake by either trained citizen volunteers or paid personnel.

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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 medium 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”.

Overturn: 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.”