Loveless Lake Planning Grant Report
Polk County, Wisconsin

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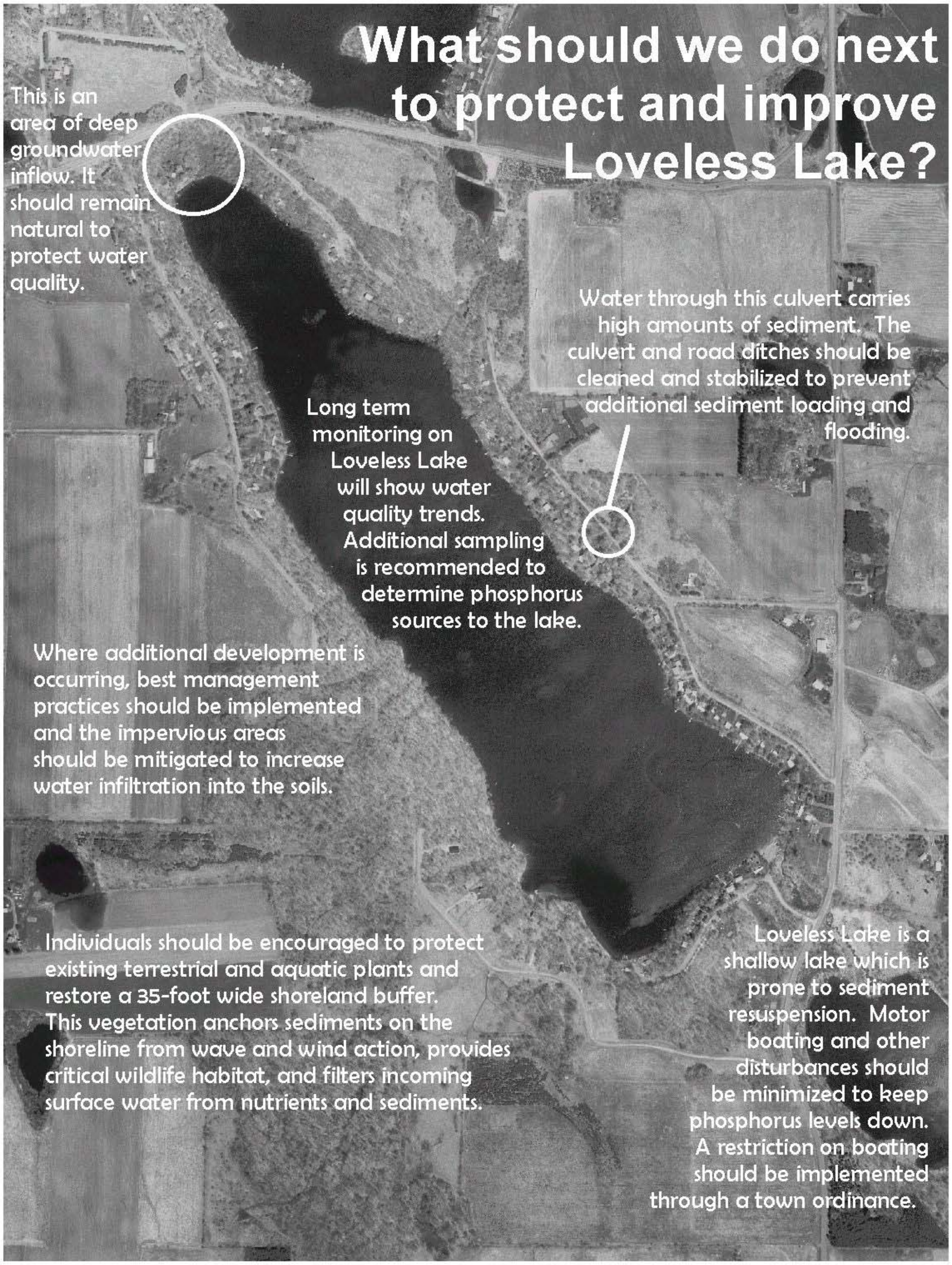
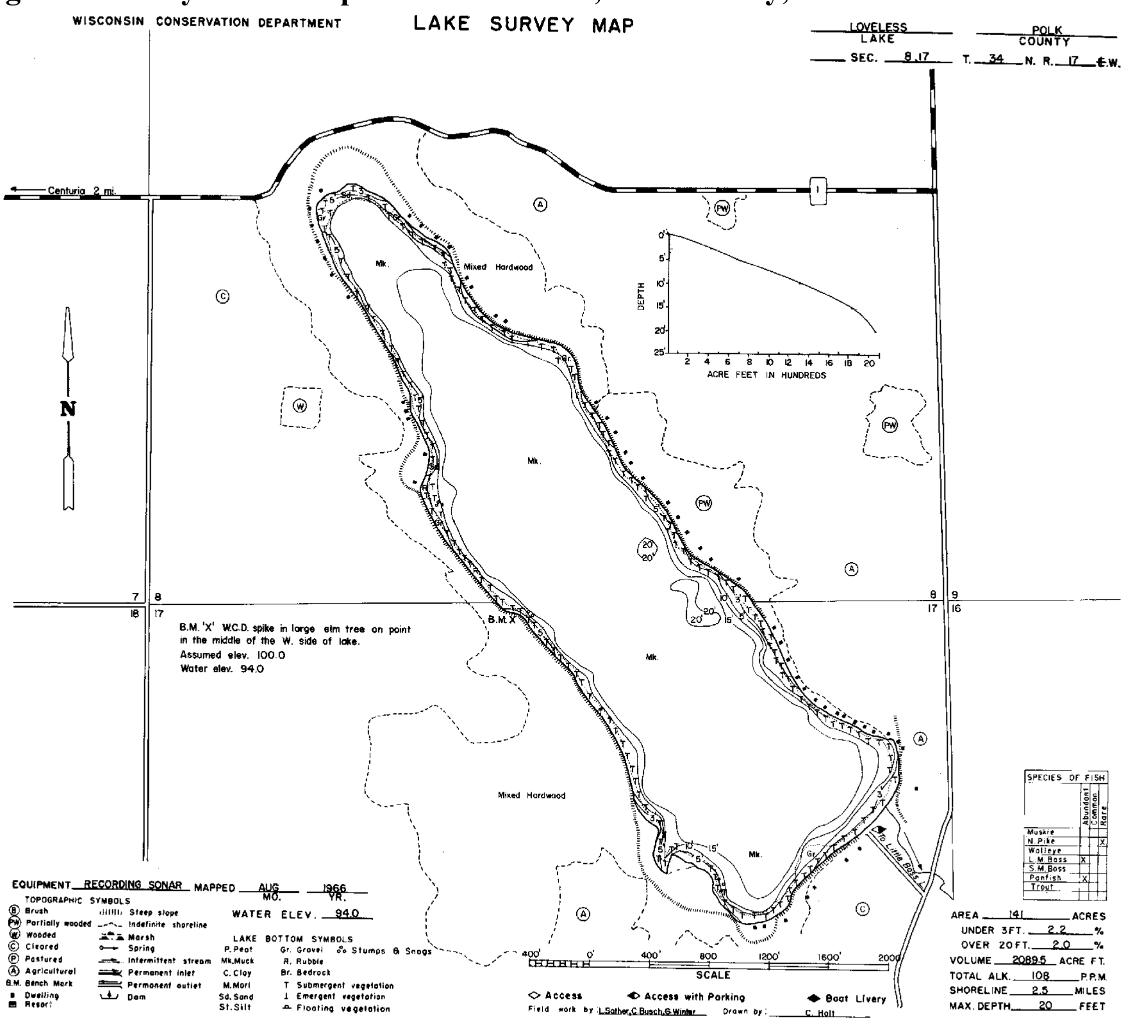

What should we do next to protect and improve Loveless Lake?
This is an area of deep groundwater inflow. It should remain natural to protect water quality.
Water through this culvert carries high amounts of sediment. The culvert and road ditches should be cleaned and stabilized to prevent additional sediment loading and flooding.
Long term monitoring on Loveless Lake will show water quality trends. Additional sampling is recommended to determine phosphorus sources to the lake.
Where additional development is occurring, best management practices should be implemented and the impervious areas should be mitigated to increase water infiltration into the soils.
Individuals should be encouraged to protect existing terrestrial and aquatic plants and restore a 35-foot wide shoreland buffer. This vegetation anchors sediments on the shoreline from wave and wind action, provides critical wildlife habitat, and filters incoming surface water from nutrients and sediments.
Loveless Lake is a shallow lake which is prone to sediment resuspension. Motor boating and other disturbances should be minimized to keep phosphorus levels down. A restriction on boating should be implemented through a town ordinance.

Introduction

This report is a summary of the water quality in Loveless Lake. Data was collected in 2002 by Polk County Land and Water Resources Department (LWRD) staff and lake volunteers. This report characterizes the current status of the lake, models the phosphorus loading to the lake, and summarizes Loveless Lake residents' perceptions. The Center for Watershed Science and Education at the University of Wisconsin – Stevens Point compiled the water chemistry information, and management recommendations were put together by the Polk County LWRD.

Physical setting

Figure 1. Bathymetric Map of Loveless Lake, Polk County, Wisconsin



Loveless Lake is a 141-acre groundwater drainage lake located in central Polk County, Wisconsin. Groundwater drainage lakes receive much of their water inflow from groundwater. Loveless Lake is also fed by precipitation and surface runoff from the watershed. Water leaves this lake through a surface water outlet and by groundwater discharge. It is disputed whether Long Lake, which is situated to the northwest of Loveless, contributes water to Loveless (and, therefore, affects water quality.) Long Lake does have a culvert which leaves the southern end and runs under County Road I. (Long Lake and Loveless Lake are separated by County Road I.) The water flow in the culvert is minimal and first enters a wetland area where the water remains. Given a significant event, water would then follow the topography and flow over land east of Loveless towards Little Bass Lake. The fate of groundwater from Long Lake is uncertain. However, the groundwater seeping through the northern banks of Loveless Lake has a low temperature and appears to come from deep groundwater.

Topographic maps were used to identify the areas of high relief around Loveless Lake which form the boundaries of the 450-acre surface watershed (Figure 2) while groundwater contour maps where used to identify the boundaries of the approximately 850-acre watershed (Figure 3). Loveless Lake has a maximum depth of approximately 20 feet and an outflow on the southeastern end of the lake, which flows into Little Bass Lake.

The size of the watershed and the fate of precipitation within the watershed influence the amount of water which enters the lake. Large watersheds collect the water flowing over and through them which end up in the lakes. The average annual precipitation in Polk County is 31 inches (http://www.crh.noaa.gov/mkx/climate/wipcpn.gif), and approximately one fourth (8 inches) is discharged to lakes and streams via groundwater and surface water (WDNR, Wisconsin Lake Modeling Suite, 2002). The movement of this water from the land to the lake contributes to the water quality in lakes. Nutrients, organic material, and contaminants are transported with the water to the lake where they influence the chemical characteristics of the lake water. For this reason, understanding the land use within the watershed is important to this study.

Figure 2. Loveless Lake Surface Watershed Boundary, Polk County, Wisconsin

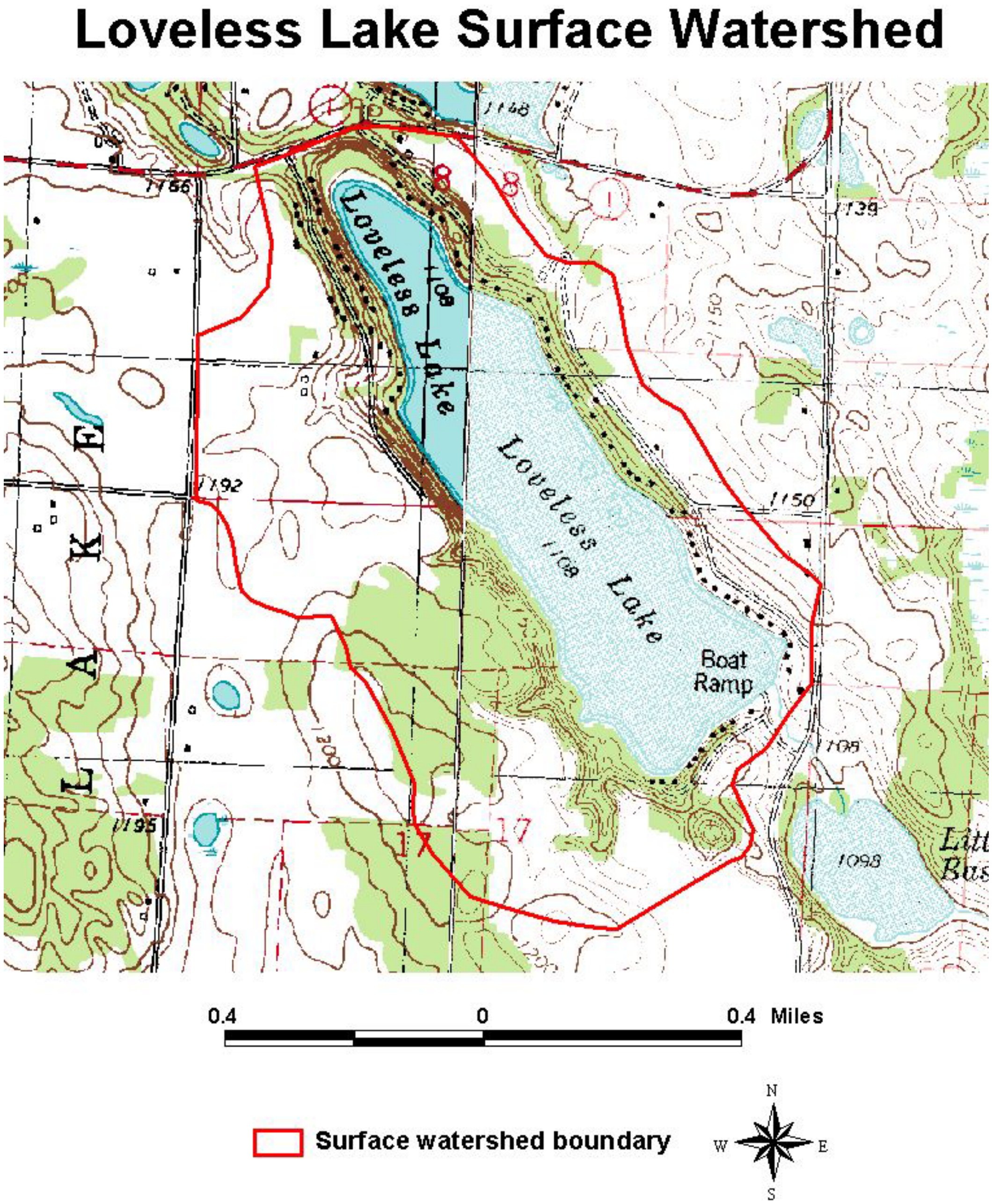
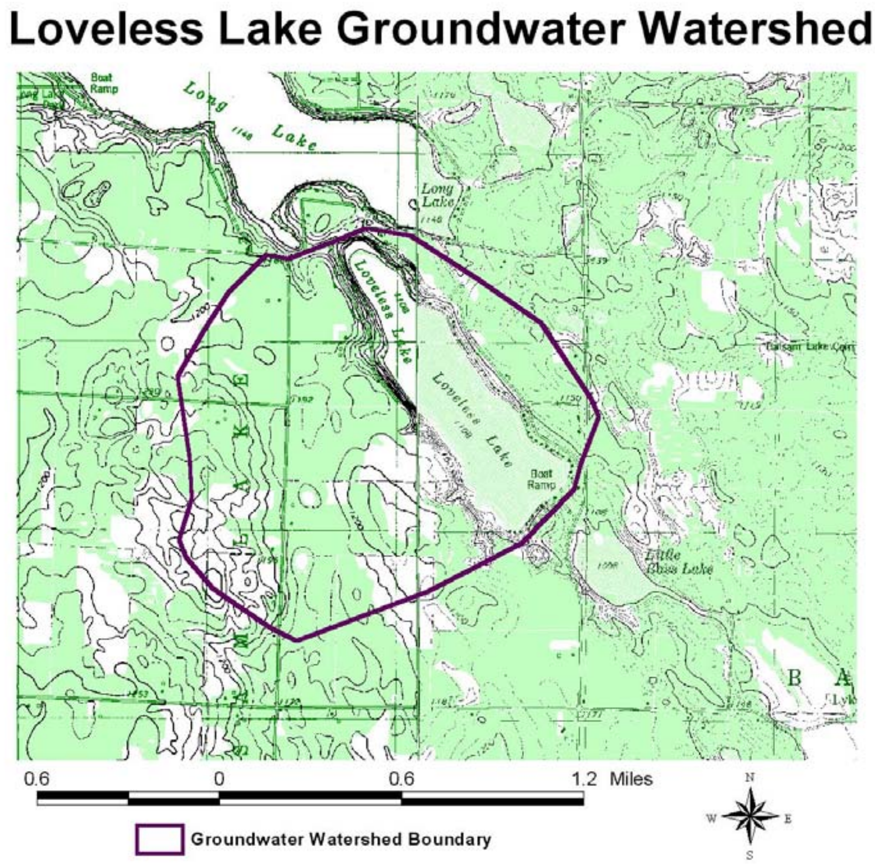


Figure 3. Groundwater Watershed of Loveless Lake, Polk County, Wisconsin



Land Use

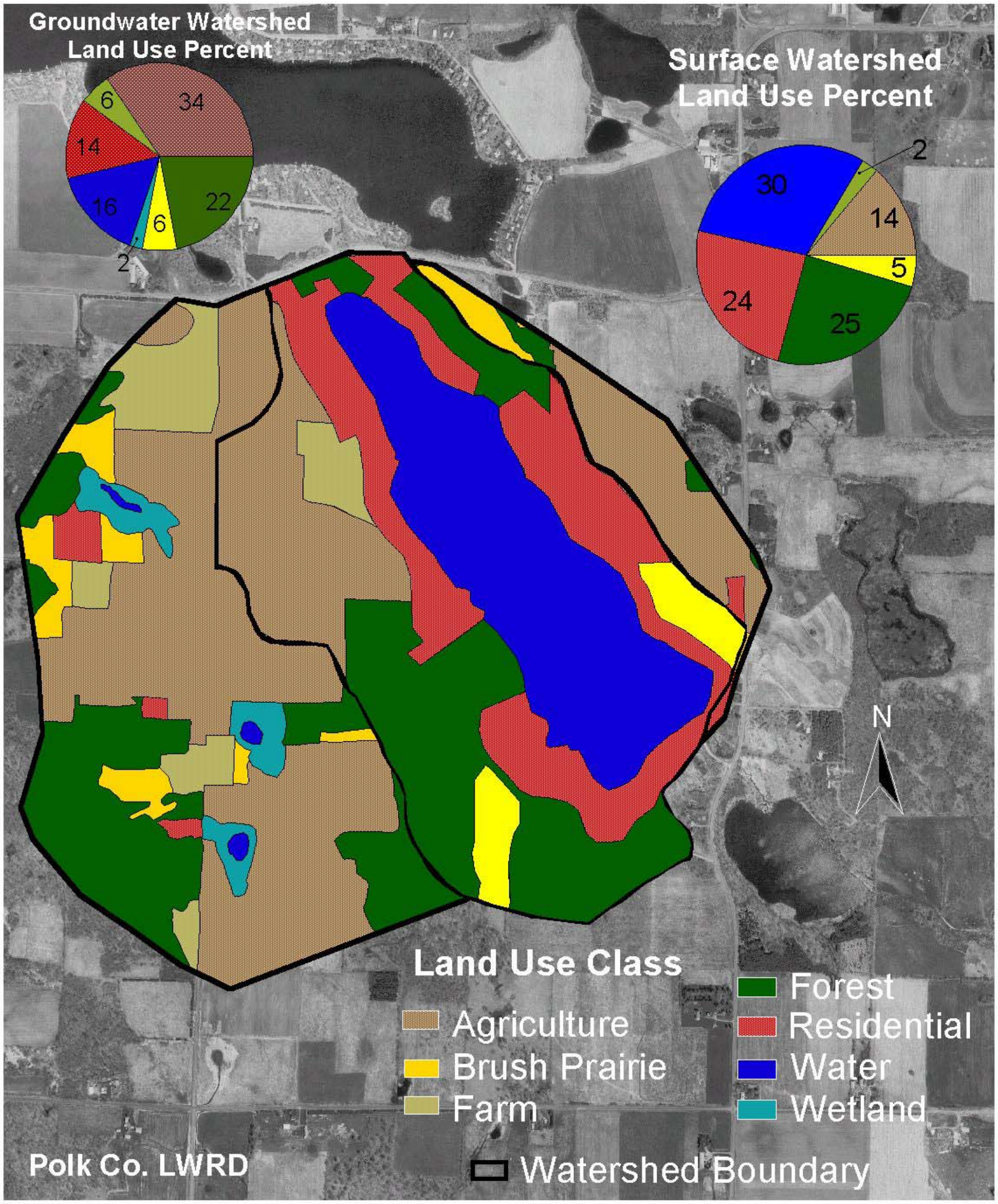
The presence of human activity in a watershed can affect the movement of water and nutrients and the hydrology or storage in a watershed. Excess available nutrients can be transported to lakes and rivers via groundwater, runoff, and sedimentation. Land use practices within the surface and groundwater watershed of Loveless Lake most likely plays an important role in the water quality of Loveless Lake. Estimates of land use types in the watershed were based on aerial photographs taken by Polk County in 2001 and geo-referenced. Land use types where digitized and summarized.

The 450–acre surface watershed of Loveless Lake includes 136 acres (30%) of lake surface and 314 acres of land area. Forest land comprises 25% of the surface watershed, and residential covers 24%. Residential uses can contribute nutrients and other pollutants from sources such as road runoff, septic systems, lawn and garden fertilizers, and animal wastes. Techniques to minimize residential impact to surface water quality include applying buffer strips along the land-water interface to reduce water flow and filter surface runoff, increasing the distance between lakes and septic systems, limiting the use of lawn and garden fertilizers, and not storing organic debris (e.g., lawn clippings or leaves) near the water or concentrated flow areas. Keeping soil vegetated rather than having exposed, bare soil will prevent erosion, which will also help water quality.

Agriculture covers approximately 14% of the land area in the surface watershed, while brush prairie covers nearly 5% and farmsteads cover approximately 2%. Agriculture and farmsteads can contribute nutrients and other pollutants to the surface and groundwater when sources such as fertilizers, pesticides, and animal wastes come into contact with infiltrating rainwater or surface drainage within the watershed and are transported to the lake. Reducing the transport of nutrients to the lake from agricultural practices includes the implementation of best management practices to reduce the availability and transport of nutrients.

Because Loveless Lake is mainly groundwater fed, land use within the groundwater watershed is also important to the water quality. Figure 4 displays the land use within the surface and groundwater watersheds. Agriculture (34%) is the predominant land cover in the groundwater watershed. Forested land is the next predominant land use, covering 22%. Open water covers approximately 16% of the groundwater watershed, residential lots cover 14%, and wetlands make up about 2% of the groundwater watershed. Although groundwater does not transport nutrients in solid forms to the lake, dissolved nutrients and pesticides in the groundwater can be transported to the lake over time. Increased concentrations of nutrients in groundwater can result from animal and human waste and fertilizers.

Figure 4. General Land Uses within the Loveless Lake Surface and Groundwater Watersheds



Water Chemistry

Groundwater, precipitation, and surface runoff (overland flow) enter Loveless Lake. This study focused on the water chemistry of lake water, groundwater seeps, and concentrated surface runoff from culverts discharging to the lake.

The different forms of nitrogen and phosphorus are examined because many water quality problems are related to increasing the nutrient levels of the water. Increased biologic productivity results from high nutrient concentrations and can contribute to nuisance algal blooms, reductions in water clarity, and ultimately oxygen depletion as the organic material is decomposed. These changes in water quality can occur slowly (or rapidly) over many years and lead to a buildup of organic matter and nutrients in the lake sediments. Reversing trends in water quality can, therefore, be a slow process because the lake sediment can act as a reservoir of nutrients, replenishing the lake water for many years.

Mid-lake Water Quality Data

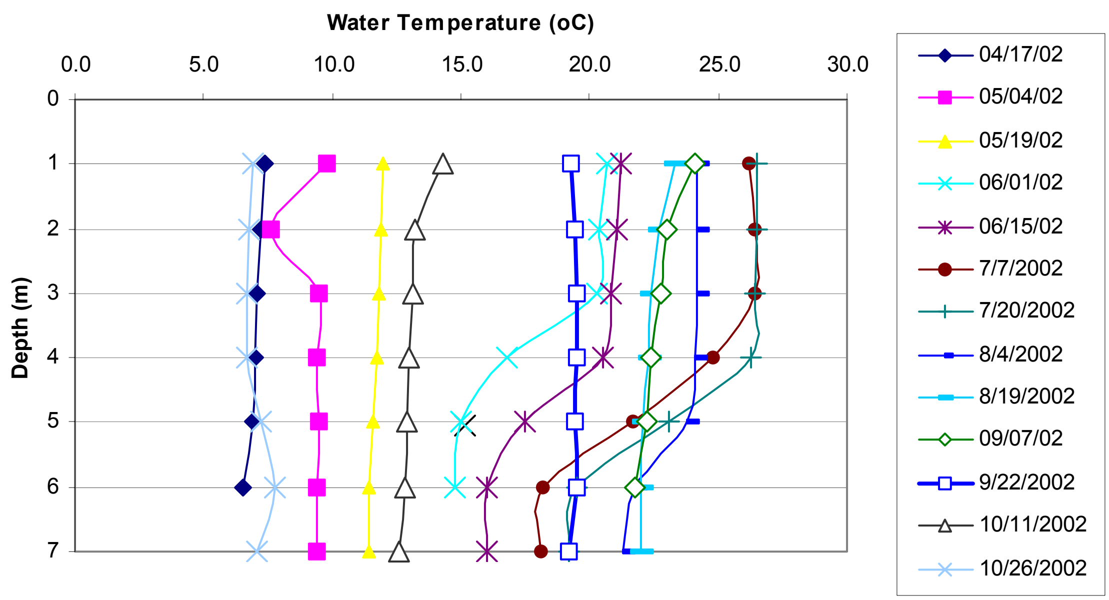
All mid-lake water quality data from the summer of 2002 are presented in Appendices A – C. Profiles and water samples were collected in the deep hole of the lake. Lake profiles were taken bimonthly by volunteers on the lake. Mid-lake water chemistry samples were collected by LWRD staff during the spring and fall turnover events. The following is a description of results for each major group of water quality characteristics.

Temperature, Dissolved Oxygen, and Specific Conductance

Temperature, dissolved oxygen, and specific conductance profiles were collected from the deep hole of Loveless Lake once in April and twice each month from May through October 2002. Differences in temperature tell us about the continuity and mixing of the lake. Dissolved oxygen is increased by photosynthesis of plants and decreased by respiration (decomposition) of organic material in the water column. Knowing the dissolved oxygen concentrations tells us if the water is conducive to wildlife and indicates when photosynthesis and decomposition are occurring. Specific conductance gives an indication of the ions dissolved in the water. Dissolved ions come from biological activity in the water, the geology of the nearby bedrock, or impacts directly from the lake surface and land runoff.

Loveless Lake is typical of a shallow, northern temperate lake; temperatures warm during the summer and a slight stratification may develop between the surface and bottom waters. But for the majority of the year, the water column remains mixed. Shallow lakes are prone to being mixed because wind action across the surface of the lake (termed ‘fetch’) is able to turn the water over. This results in a near uniform water composition throughout the water column. Differences in temperature and water chemistry will still be observed at the very bottom of the lake where the sun does not warm the bottom water as readily and the sediment-water interface dominates the water chemistry. Mixing of shallow lakes can be exacerbated by removal of aquatic vegetation and motorboat activity. Figure 5 illustrates the temperature profiles in Loveless Lake throughout 2002, which gradually warms until the end of July and then slowly begins to cool. Slight temperature stratification was present in June and July, indicated by the curved lines.

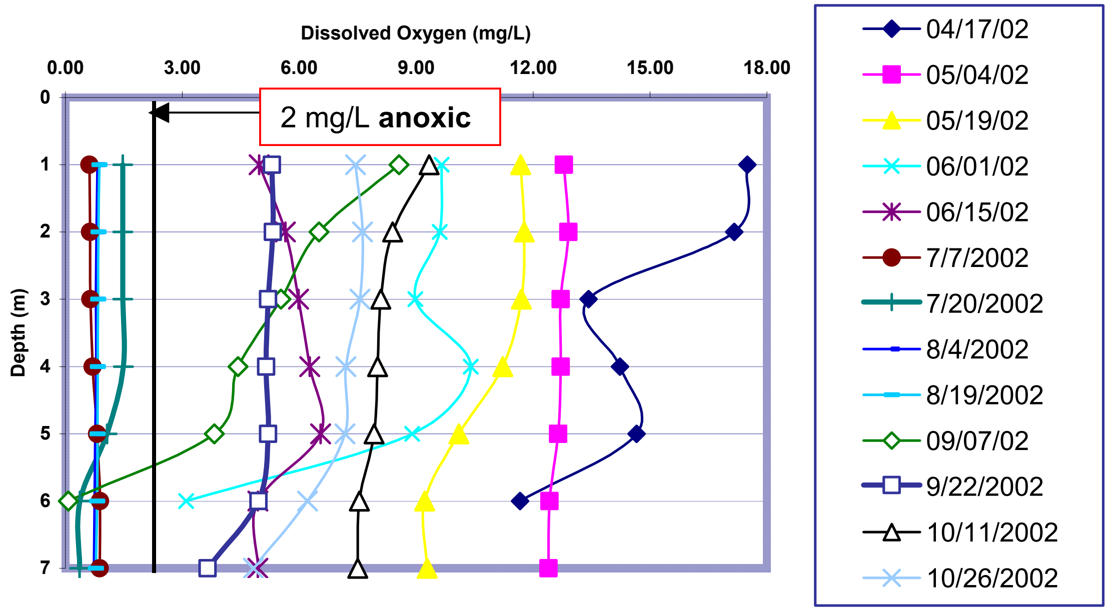
Figure 5. 2002 Temperature Profiles in Loveless Lake, Polk County, Wisconsin



Dissolved oxygen in Loveless Lake was also quite uniform throughout the water column. (See Figure 6.) Dissolved oxygen (DO) concentrations in Loveless Lake topped out at 17.5 mg/L at spring turnover. The DO steadily decreased throughout the summer months, dropping below 1 mg/L in July and August in the <u>entire</u> lake profile. DO concentrations below 2 mg/L are considered to be anoxic when not enough oxygen is present to support other larger organisms. Typical lakes will see a dissolved oxygen reduction in the hypolimnion (bottom waters) during the summer, but Loveless Lake exhibits a reduction within the entire water column. The reduced exposure from the atmosphere, the increase in temperature, and the decomposition of plant and animal tissue and organic matter in the bottom sediments frequently use up most of the available dissolved oxygen in the hypolimnion.

The area where the profiles were taken is located near a variety of historical and current loading events and sources including: shoreline slumping, ditch runoff and roadside erosion, and septic and animal waste in conjunction with large runoff events (see Appendix A). These historic additions of nutrients not only serve to drive the internal loading cycle, but add to the increased densities of Curly-leaf pondweed (CLP). As these higher density beds of CLP die off they add to the anoxia problem, which increases internal releases on top of the phosphorous released from decaying CLP tissues. The area where the profile was taken is also nestled in an area with low boat traffic and low wind or wave action. Therefore, this area receives little mixing with the atmosphere, and the dissolved oxygen in the area becomes depleted by biological demand. Other areas of the lake that are better mixed may not be completely depleted in oxygen.

Figure 6. 2002 Dissolved Oxygen Profiles in Loveless Lake, Polk County, Wisconsin



Another general water quality parameter that was measured is conductivity (as well as specific conductance – conductivity normalized at 25 °C). This is a measure of the ability of a solution to conduct electrical flow. Conductivity increases with increasing ion content, so the more dissolved material in the water (calcium, magnesium, sodium, potassium, bicarbonate, sulfate, and chloride), the greater its conductivity of electrical flow (Wetzel, 2001). High values of conductivity are indicators of possible pollution, such as road salt and failing septic systems. Conductivity in Loveless Lake ranged from 127 *u*S to 282 *u*S with an average of 181 *u*S and suggests a water of intermediate mineralization. Most of these dissolved substances are naturally occurring, which dissolve as water passes through the watershed.

Secchi Depth and Chlorophyll *a*

Lake volunteers have been collecting “self-help” data since 1994 through the DNR lake monitoring program. This past data includes Secchi depth, total phosphorus, and chlorophyll *a* concentrations, all of which can be found in Appendix D. Secchi depth is a measure of water clarity, and can be affected by small particulates such as algae and suspended sediment in the water as well as water color (dissolved particles in the water). Water clarity can often be directly related to chlorophyll *a*, a measure of algae growth. Because the level of algal growth in the lake is usually related to the concentration of nutrients, particularly phosphorus, chlorophyll *a* can also be an indicator of phosphorus levels (Shaw et. al. 1996). The relationship between chlorophyll *a* and Secchi depth can be complicated by the presence of suspended particles, particularly in shallow lakes where wind mixing of bottom sediments might also reduce the water clarity.

The water clarity is measured with a Secchi disk, which is an 8-inch disk with alternating black and white quadrants. It is lowered over the side of a boat at the deep hole until it can no longer be seen, then raised until it is just visible. This depth (or the average of the two) is termed the Secchi depth. During the summer of 2002, Secchi depth was measured more frequently than in past years, taken twice a month with the temperature and dissolved oxygen profiles. The Secchi depth ranged from 21 feet in May to 3.5 feet in August with an average of 11 feet. Secchi depth reached its minimum during the summer of 2002 from July through the end of August. Secchi depth tends to be deeper in the late fall, winter, and early spring when there is little biological activity and little runoff from the surrounding land (therefore, water clarity is better during these times.) Figure 7 shows Secchi depth during the summer of 2002. The data collected for this grant indicate that the water clarity in Loveless Lake ranges from very poor to very good throughout the year, with most of the year having good water clarity. The self-help data collected since 1994 gives an average Secchi depth of 9 feet, which indicates water clarity of fair to good (Table 1). Water clarity in 2002 was the best in May when the Secchi depth reached the bottom of the lake. This period of relatively clear water was followed by a decline in water clarity over the growing season. This reduction in clarity suggests internal sources of phosphorus, such as release from the sediments, release from the vegetation, or wind-induced mixing of sediments, can contribute to the algal production during the summer. The precipitation/lake stage information also shows considerable inflow to the lake during several storms in August. Although water quality sampling was not performed during those storms, the storm runoff data suggest an influx of nutrients into the lake during those events.

Figure 7. Secchi Depth in Loveless Lake During the Summer of 2002

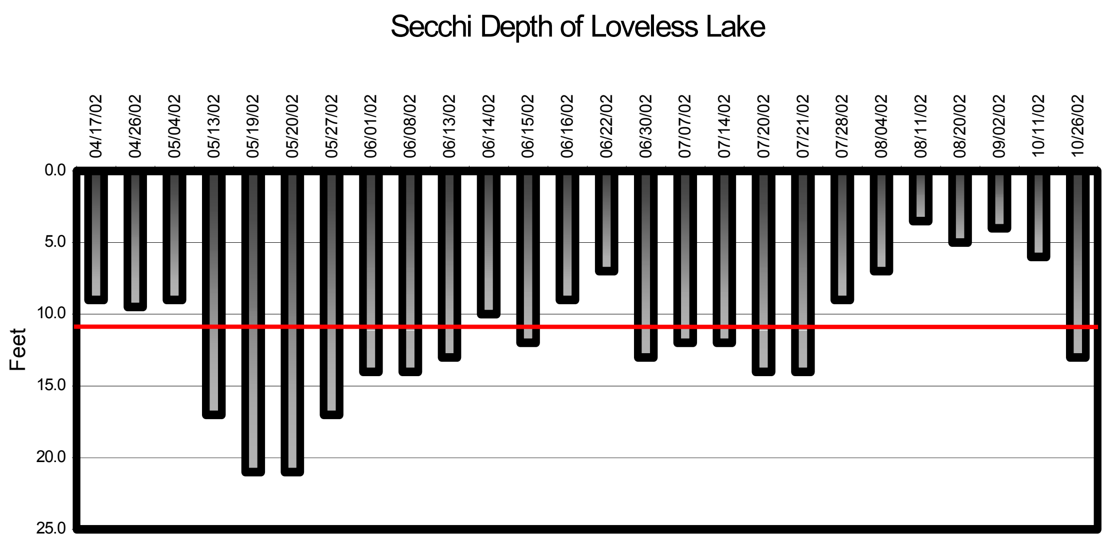


Table 1. Water Clarity Index Based on Secchi Depth Measurements

Water Clarity	Secchi depth (ft)
Very Poor	3
Poor	5
Fair	7
Good	10
Very Good	20
Excellent	32

*Adapted from Shaw et al., 2000.

Chlorophyll *a* was not collected through this grant during 2002. The average chlorophyll *a* in Loveless Lake collected through the Self Help program since 1994 was 15.52 ug/L. This is an indication of a eutrophic lake.

Phosphorus

In more than 80% of Wisconsin's lakes, phosphorus is considered the limiting nutrient in that its concentration will determine the amount of plant and algae growth (Shaw et. al. 2000). Phosphorus is present in a variety of forms, but typically evaluated as either soluble reactive phosphorus (also termed orthophosphate or PO_4^{3-}) or total phosphorus (TP). Soluble reactive phosphorus (SRP) is dissolved phosphorus in the water column that is immediately available to plants and algae. For this reason, SRP is usually present in low concentrations (about 5% of TP, Wetzel, 2001) and recycled quickly. Total phosphorus (TP) is a measure of the dissolved phosphorus *plus* organic and inorganic particulate phosphorus suspended in the water. TP is often used as a measure of lake phosphorus because it is more representative of the total quantity of phosphorus. Aquatic plants rely on phosphorus in the water column for growth; however, they can also obtain phosphorus from the sediment. Phosphorus concentrations are generally much higher in the sediment and that likely serves as a principle nutrient source for many rooting plants.

According to Shaw et al., (2000), local sources of phosphorus can be largely enhanced by human activities. These activities include soil erosion, non-Wisconsin purchased detergents, septic systems, runoff from lawns, gardens, and agricultural fields and/or barnyards, construction site runoff, and development. Dishwasher detergents contain phosphorus, whereas laundry detergents purchased in Wisconsin do not. Regional sources of phosphorus may include shoreline slumping, ditch runoff and roadside erosion, and septic and animal waste.

This phosphorus enters the lake through groundwater inflow and surface runoff. Lake systems are sensitive to relatively low concentrations of phosphorus, and overturn concentrations of SRP above 10 ug/L and TP above 20 *u*g/L are often used to indicate a likelihood of nuisance algae blooms (Shaw et al., 2000).

Loveless Lake had soluble reactive phosphorus concentrations of 10 *u*g/L in the spring and 43 *u*g/L in the fall. The total phosphorus concentration was 24 *u*g/L in the spring and 53 *u*g/L in the fall. The total phosphorus concentration in the spring suggests there is enough phosphorus to fuel algae blooms. As reflected by the Secchi depth measurements, the productivity of the lake is increased during the growing season due to warmer temperatures, increased hours of daylight, and probably continuous contributions of nutrients either through runoff or internal recycling from the sediments.

Trophic Status Index

Trophic status is another interpretation of water quality. Lakes can be categorized into three categories based on trophic state – oligotrophic, mesotrophic, and eutrophic (Shaw et al., 2000). The category is meant to serve as an overall interpretation of the lake's productivity level. Oligotrophic lakes are generally clear, deep, and free of aquatic vegetation or large algae blooms. They are low in nutrients and do not support large fish populations, but can support a fishery of large game fish. Oligotrophic lakes are often limited by phosphorus and contain nitrogen in excess of growth demand (Wetzel, 2001). Eutrophic lakes are high in nutrients and support a large biomass (all plants and animals living in the lake). They are usually more productive with a greater aquatic plant biomass, subject to frequent algae blooms, or a combination of both. Eutrophic lakes often support large fish populations, but are also susceptible to oxygen depletion. Small, shallow, eutrophic lakes are especially vulnerable to winter kill, which can reduce the number and variety of fish. Mesotrophic lakes lie between the oligotrophic and eutrophic stages.

Trophic status is commonly measured by Secchi depth (water clarity), total phosphorus, and chlorophyll *a* concentrations (measure of algae). Although many factors influence these relationships, the link between Secchi depth, phosphorus, and chlorophyll *a* is the basis of comparison for the Trophic State Index (TSI) (Lillie and Mason, 1983). Three equations for the TSI were examined for Loveless Lake. The calculations were based on self-help data, as summer samples were not collected. These equations are:

TSI (P) = 14.42 * Ln [TP] + 4.15 (where TP is in ug/L)

TSI (C) = 30.6 + 9.81 Ln [Chlor-a] (where the chlorophyll a is in ug/L)

TSI (S) = 60 - 14.41 * Ln [Secchi] (where the Secchi depth is in meters)

TSI (Average) = [TSI (P) + TSI (C) + TSI (S)] / 3

The results from the calculations are presented below in Table 2.

Table 2. TSI Values for Loveless Lake Since 1994

Year	TSI (P)	TSI (C)	TSI (S)	TSI (Average)
1994	58	64	46	56
1995	49	51	42	47
1996	49	52	44	48
1997	62	49	44	52
1998	61	65	48	58
1999	61	61	47	56
2000	62	56	47	55
2001	57	53	47	52
2002			43	

Based on Table 2, it appears that the TSI for phosphorus and chlorophyll *a* are generally higher than that for water clarity. This suggests that while Loveless Lake has relatively high phosphorus and chlorophyll *a* concentrations (the TSI is in the eutrophic status), it can have water clarity which is better than would be expected (TSI in the upper mesotrophic status). This may reflect the influence aquatic plants can have, which may improve water clarity by competing with algae for nutrients, can reduce wave mixing of sediments, and may enhance the settling of phosphorus from the water column.

Alkalinity, Calcium, and Total Hardness

According to Shaw et al. (2000) a lake's hardness and alkalinity are affected by the type of minerals in the soils and bedrock in the watershed and by how much the lake water comes into contact with these minerals. If a lake receives most of its water from groundwater that flows through an aquifer containing calcite ($CaCO_3$, a.k.a. limestone) and dolomite ($CaMgCO_3$), hardness and alkalinity will be high. Total hardness measures calcium, magnesium, sodium, and sulfur. Alkalinity measures the amount of carbonate. A level of hardness greater than 120 mg/L is considered hardwater. Hardness and alkalinity greater than 150 mg/L as $CaCO_3$ can cause marl ($CaCO_3$) to precipitate out of the water. This bi-product is harmless and can actually result in more fish production than soft water lakes (Shaw et al., 2000). It can also act as a balancing mechanism; phosphorus may co-precipitate with marl, thereby controlling algae blooms.

Total hardness in Loveless Lake during spring and fall turnover was 92 mg/L as $CaCO_3$ for both samples. This falls into the moderately hard water category (Table 3). The calcium hardness was also measured at spring turnover and fall turnover. The calcium concentrations during 2002 were 62 mg/L and 44 mg/L as $CaCO_3$ in the spring and fall, respectively, with an average of 53 mg/L $CaCO_3$. This means that calcium makes up about 58% of the total hardness in Loveless Lake.

Table 3. Categorization of Hardness by mg/L as ($CaCO_3$)

Level of Hardness	Total Hardness (mg/L as $CaCO_3$)
Soft	0 – 60 mg/L
Moderately Hard	**61 – 120 mg/L**
Hard	121 – 180 mg/L
Very Hard	> 180 mg/L

*Adapted from Shaw et al., 2000.

Alkalinity is related to hardness in that the source of calcium and magnesium (i.e. hardness) and much of the alkalinity is from dissolution of the same rocks and minerals. Alkalinity, also called acid neutralizing capacity, is the ability of a lake to resist changes in pH. The alkalinity of Loveless Lake is relatively high, meaning that it resists changes in pH relatively well. The average alkalinity during spring and fall turnover in 2002 was 86 mg/L. Since the alkalinity is greater than 25 mg/L (Table 4), Loveless Lake is not sensitive to acid rain.

Table 4. Sensitivity of Lakes to Acid Rain Based on Alkalinity Concentrations

Sensitivity to Acid Rain	Alkalinity (mg/L $CaCO_3$)
High	0 – 2 mg/L
Moderate	2 – 10 mg/L
Low	10 – 25 mg/L
Not Sensitive	**> 25 mg/L**

*Adapted from Shaw et al., 2000.

Nitrogen

Nitrogen is another important nutrient in lakes for plant and algae growth. Nitrogen concentrations above 10 mg/L could pose a threat to human health, especially in the form of nitrate because of its role in methemoglobinemia (Blue Baby Syndrome). In Wisconsin, nitrogen does not occur naturally in most soil minerals, but is a major component of organic matter (Shaw et al., 2000). According to Shaw et al. (2000), nitrogen compounds often exceed 0.5 mg/L in rainfall, and therefore precipitation may be the primary nitrogen source for pristine seepage and some drainage lakes. Other sources of nitrogen within the watershed include fertilizer and animal wastes on agricultural lands. The amount of nitrogen in lake water usually can be related to local land use such as septic systems or lawn and garden fertilizer used on lakeshore property.

Nitrate and ammonium are two forms of nitrogen that are readily available to plants and can rapidly move with groundwater and surface water. The forms of nitrogen that were analyzed for Loveless Lake are NH_4^+ (ammonium), $NO_2^- + NO_3^-$ - N (nitrite + nitrate), and Total Kjeldahl Nitrogen (TKN), which is organic nitrogen plus ammonium. Both forms of inorganic nitrogen (NO_3+NO_2 and NH_4^+) are used by aquatic plants and algae and are very soluble, which means they are readily leached to groundwater. These forms can be transformed to organic nitrogen, and from organic nitrogen back to inorganic forms through the nitrogen cycle.

Loveless Lake water was analyzed during spring and fall turnover. The nitrate + nitrite-nitrogen concentration was 0.54 mg/L in the spring and 0.24 mg/L in the fall. Ammonium concentrations were 0.05 mg/L in the spring and 0.11 mg/L in the fall. The TKN concentrations were 0.4 mg/L in the spring and 0.8 mg/L in the fall. Total nitrogen was 0.94 mg/L in the spring and 1.04 mg/L in the fall. These values are in the mid-range for Wisconsin lakes.

Nitrogen to Phosphorus Ratio

A plant's need for nutrients usually does not occur at the same rate. That is to say that a plant may need a large amount of phosphorus or nitrogen, but only a small amount of manganese or zinc. In the same way, the ratio of nitrogen to phosphorus is not usually one to one. Typically, plants and algae need about 10-15 times the amount of nitrogen as they do phosphorus. By comparing the total nitrogen content of the water to the total phosphorus concentration, a lake manager can see if the lake is nitrogen or phosphorus limited. Loveless Lake has a TN:TP ratio of 26:1. This means there is 26 more times the amount of nitrogen, and the lake is phosphorus limited. Because the lake is phosphorus limited, this means that any addition of phosphorus will help algae or plants grow and could spur a bloom. Lake managers and Loveless Lake residents, therefore, need to control the phosphorus input to the lake to maintain a healthy ecosystem. Best management practices should be implemented within the watershed to limit phosphorus loading.

Inflow Water Quality Data

The following section describes the water chemistry study completed on inflowing water to Loveless Lake (versus lake water.) The two types of inflow studied include surface water and groundwater. Surface runoff enters Loveless Lake at several locations and carries with it nutrients and sediment from properties around the lake. The most conspicuous of surface runoff are areas where substantial quantities of flow concentrate during a storm. These include culverts under the roads near the lake and roadside ditches. Runoff event samples were collected once during May and June of 2002 from the culverts to evaluate their impact on the lake water quality. Flow in these culverts normally occurs only during rainfall events. Figure 7 displays the locations of the culvert sample sites. All Inflow data is presented in Appendices E and F.

All surface runoff and groundwater samples were analyzed for ammonium-(N), nitrate + nitrite-(N), total Kjeldahl nitrogen (TKN), soluble reactive phosphorus (SRP), and total phosphorus (TP). In addition, surface runoff event samples collected from the culverts were also analyzed for total suspended solids (TSS) and chloride. The analyses were conducted at the Water and Environmental Analysis Lab (WEAL) at the University of Wisconsin-Stevens Point.

Total suspended solids (TSS) are a measure of solids in the water that can be trapped by a filter. TSS are important for several reasons. Measures of TSS include algae, sediment (soil), and decaying plant and animal matter which are in the lake. High concentrations of suspended solids can cause many problems for aquatic life. For example, high TSS can block light from submerged vegetation. As the amount of light passing through the water is reduced, photosynthesis slows down, thereby reducing the oxygen concentrations in the water column released by aquatic vegetation. When suspended solids settle to the bottom of a water body, they can smother the eggs of fish and aquatic insects, suffocating newly hatched insect larvae. TSS can also fill in the spaces between gravel substrate making the area less desirable for egg deposition for some fish species and alter bottom-dwelling biological communities. TSS transport to a lake may also include nutrients such as nitrogen and phosphorus, which can increase biological and aquatic plant growth, reduce water clarity, contribute to oxygen depletion through decomposition, and increase sedimentation.

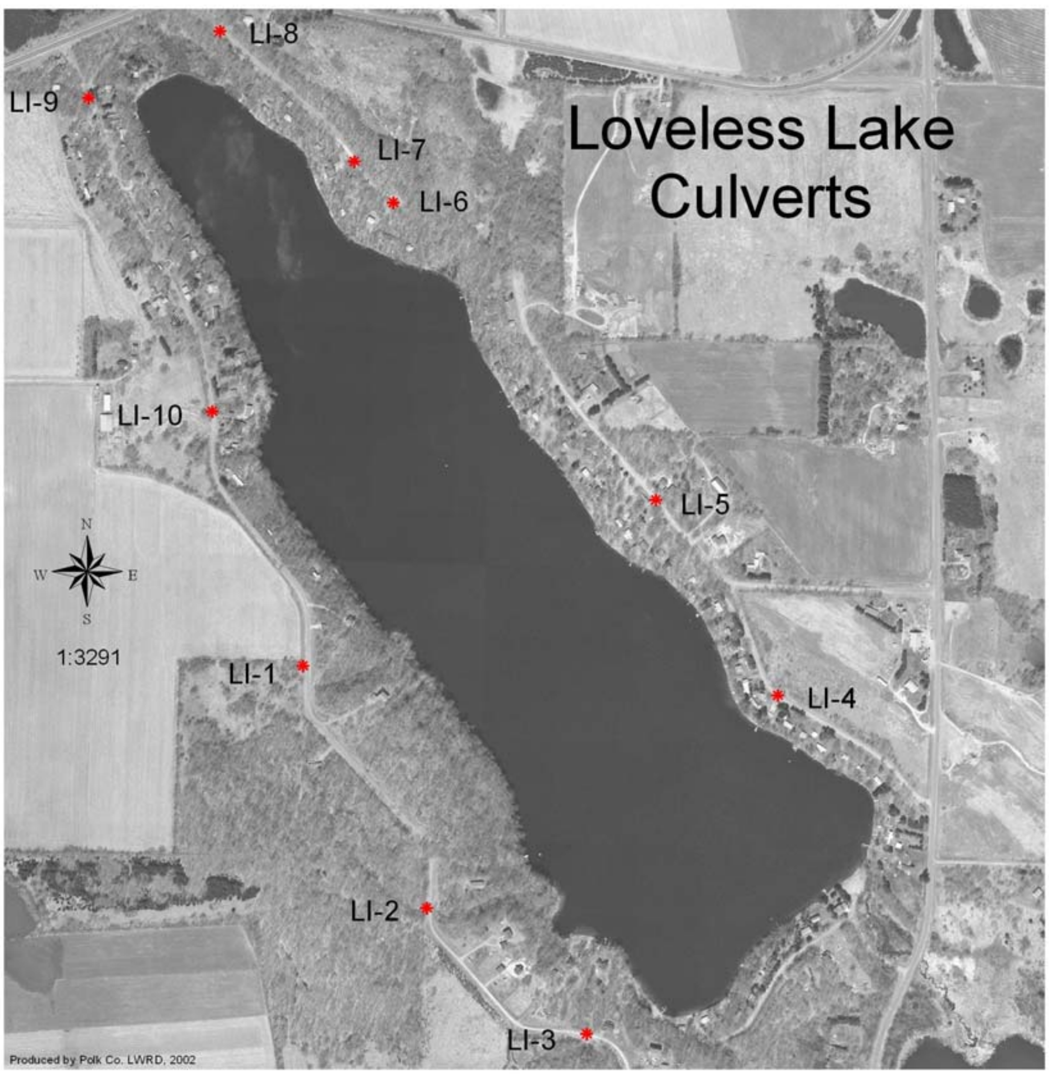
Surface water samples were also analyzed for chloride. Chloride analysis provides a general indication of the impact of land use on water quality. While chloride levels are normally low in Wisconsin waters, de-icing chemicals, septic effluent, fertilizers, and manure can increase chloride concentrations.

Surface runoff samples were collected from culverts 1, 2, 3 and 7 in May and from culverts 1, 2 and 5 in June. Figure 8 shows the culvert locations. Nitrate + nitrite-(N) concentrations in culverts 2, 3, 5, and 7 were 0.22, 0.19, 0.19 and 0.29 mg/L respectively (see Table 5). Ammonium-(N) and nitrate + nitrite-(N) concentrations were low in all culverts, ranging from <0.01 to 0.09 mg/L and <0.02 to 0.29 mg/L, respectively. Culverts 2 and 5 had elevated TSS concentrations of 112 and 912 mg/L. Culvert 5 had the greatest concentrations of TKN (measure of organic nitrogen and ammonium), total phosphorus, and TSS of all the sites in 2002. The concentrations of total phosphorus in the event samples ranged from 0.043 to 2.060 mg/L with an average of 0.48 mg/L, which is considerably above the current in-lake concentrations. Although the impact of this runoff on the lake also depends on the flow of water entering during those events, this demonstrates how surface runoff into the lake can be a mechanism for transporting nutrients into the water.

Table 5. Inflow Sampling Data for Loveless Lake, Polk County, Wisconsin

Collection Date	Type	Location	Total Kjeldahl Nitrogen (mg/L)	Dissolved Orthophosphate (mg/L)	Total Phosphorus (mg/L)	Total Suspended Solids (mg/L)
05/08/02	Culvert	LI-1	0.62	0.028	0.043	5
05/08/02	Culvert	LI-2	0.68	0.032	0.095	13
05/08/02	Culvert	LI-3	0.71	0.053	0.079	8
05/07/02	Culvert	LI-7	1.88	0.472	0.601	2
06/21/02	Culvert	LI-1	0.98	0.056	0.161	22
06/21/02	Culvert	LI-2	1.69	0.097	0.300	112
06/21/02	Culvert	LI-5	6.36	0.944	2.060	912

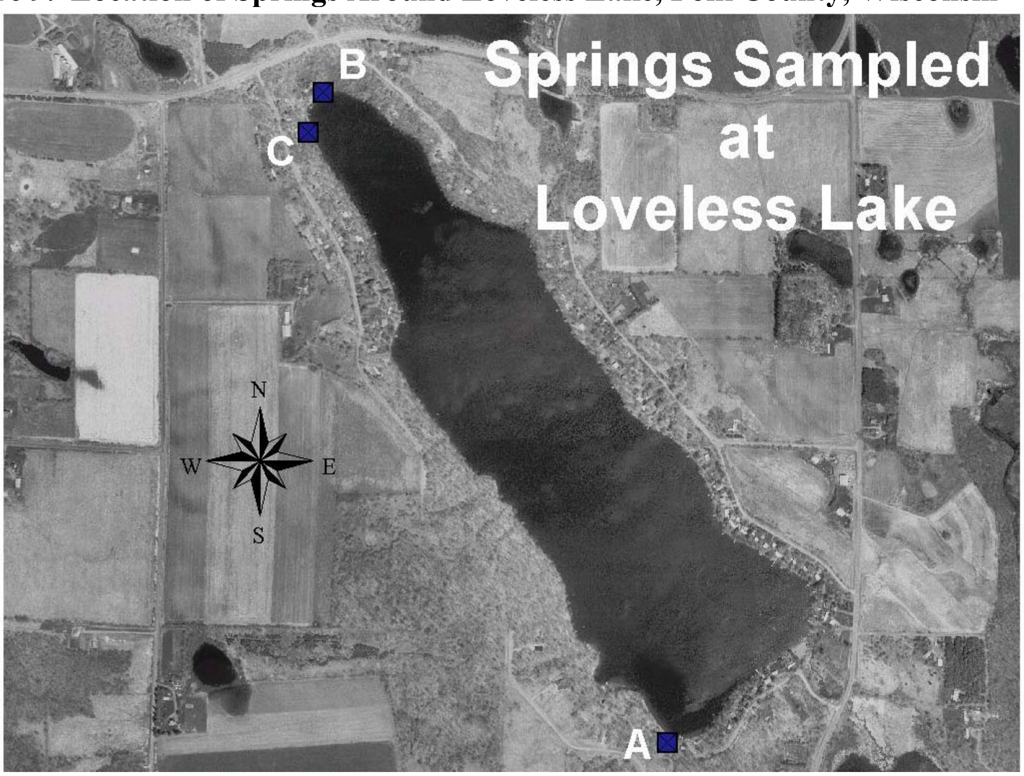
Figure 8. Location of Loveless Lake Culverts



Groundwater enters Loveless Lake through the soil substrate. Groundwater sampling in this study focused on the springs identified around the lake by a lake resident. Three samples were collected from the springs one time in September (see Figure 9). The springs are areas where groundwater discharges (seeps) out of the ground throughout the year. Groundwater is also likely entering the lake along the shoreline, just beneath the lake surface. Water samples from the springs were collected using a small well (mini-piezometer), inserted approximately six inches into the ground. Once the water was flowing through the well, a sample was collected.

Spring A is located on the southwest shore about 10 feet from Loveless Lake. This spring had elevated ammonium-(N) (3.89 mg/L) and TKN (69.98 mg/L) and low nitrate + nitrite-(N) (0.1 mg/L). This spring also had relatively high concentrations of soluble reactive phosphorus (SRP) (2.14 mg/L) and total phosphorus (9.08 mg/L). The high ammonium concentration suggests organic matter decomposition was occurring at the site. The relatively high levels of nutrients found also reflect this breakdown. In addition, suspended sediment was found in this sample, indicating that sediment may have also been collected, and the results of the total nutrients may not be entirely representative of groundwater alone.

Figure 9. Location of Springs Around Loveless Lake, Polk County, Wisconsin



Spring B is located on the northern shore of Loveless Lake approximately 50 feet from the lake. This spring had low concentrations of both nitrogen and phosphorus (<.60 and 0.22 mg/L, respectively). The sample for this site did not have sediment in the water sample.

Spring C is located on the northern shore of Loveless Lake, west of spring B, approximately 4 feet from the lake. Spring C had relatively low concentrations of ammonium-N and nitrate + nitrite-N, while having a very high concentration of TKN. Due to the great difference between these concentrations, the TKN concentration may be excessively high due to organic sediment in the sample. This spring also had a relatively high concentration of total phosphorus (9.76 mg/L).

Although the groundwater investigation did not provide enough information to link land use with groundwater quality, it did demonstrate that the discharge of groundwater into organic-rich soils and/or disturbed soils and the subsequent transport of these materials to the lake by water flow could increase the nutrients in the lake. The high concentrations of nitrogen and phosphorus in the groundwater could originate from natural or human-related sources.

To further determine background nutrient levels in the groundwater and the impact of land use on the groundwater quality, re-sampling of the springs is recommended. The reconnaissance should also include other groundwater sampling points (such as water supply or monitoring wells) in order for conclusions to be drawn on the quality of the groundwater and its impact on Loveless Lake.

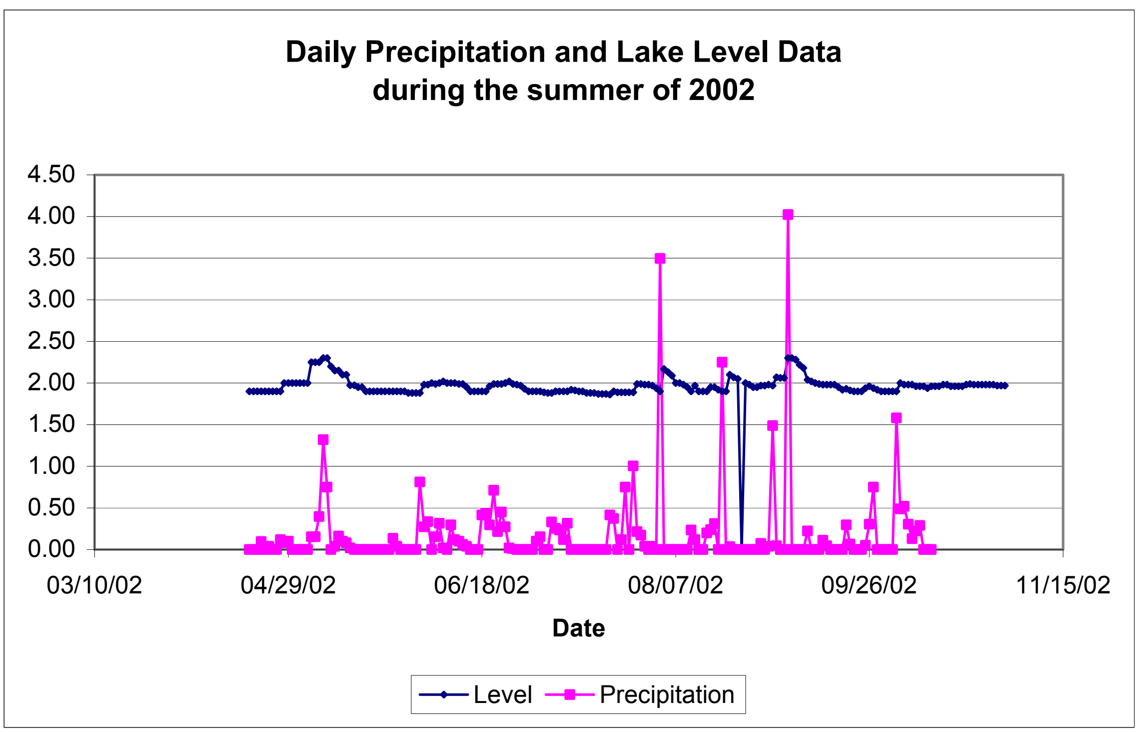
Precipitation and Lake Level Data

Precipitation is the third source of water to Loveless Lake. Although the water chemistry of the precipitation was not analyzed, lake residents measured the amount of precipitation and lake levels daily during the summer of 2002. Monitoring the precipitation and lake level can tell us if there is a correlation to elevated nutrient levels and water flow. The data are displayed in Appendix C.

During the summer of 2002, Loveless Lake received approximately 30 inches of rainfall. The net change in the level of Loveless Lake between April and September of 2002 was a decrease of 0.02 inches. Figure 6 graphs the daily precipitation and lake level for the summer of 2002.

Overall, the water level in the lake did not change substantially during the season, and thirty inches of precipitation is consistent with an average year. Water entered the lake during the season from direct precipitation or surface and groundwater flow and generally left the lake through the outlet or groundwater discharge. The lake level and precipitation data show how the lake responds to precipitation events (Figure 10). Increases in lake water level immediately after a storm suggest there are considerable quantities of water which enter the lake immediately after a storm. While some of that may be enhanced groundwater flow from the infiltration of precipitation, it probably also represents discharge of surface runoff through areas of concentrated flow (such as the culvert drainage areas). This runoff can be a significant contributor of nutrients and sediments to the lake. While lake shore buffers and grass-lined waterways can help filter the pollutants, efforts to reduce the amount of water which directly runs into the lake will slow the transfer of nutrients from the watershed to the lake. Identification of areas that likely contribute runoff to the lake during storms and implementation of management practices upland from these drainage areas may reduce the transfer of sediments and nutrients to the lake.

Figure 10. Daily Precipitation and Lake Level Data during Summer 2002



Lake Sediment

Sediment samples were collected along a transect in Loveless Lake during October of 2002 using a Petite Ponar. Figure 11 displays the location of the dredge sample sites. Samples were collected from the lake bottom and analyzed for percent total phosphorus, percent total nitrogen, and percent dry matter. Results can be found in Table 6.

Nutrients that are in the sediment can contribute to algal and plant growth in the lake. Water that is in contact with the sediment transfers nutrients from the sediment to the water column. The decay of aquatic plants and animals, which have accumulated nutrients from the sediment, can also transfer the nutrients to the water column. This transfer occurs during wind mixing and overturn mixing, providing the food for algae and other plants. The transfer of nutrients can also occur from mixing caused by motorboats or other disturbance of the lake sediments. This is termed internal loading and occurs 20-30 times more often by resuspension than from undisturbed sediments (Scheffer, 1998).

Percent total phosphorus in the sediment samples ranged from 0.06 to 0.14 percent. Total nitrogen ranged from 0.9 to 1.3 percent. The average total phosphorus and nitrogen concentrations are very typical of Wisconsin lakes and are able to sustain rooted vascular plants.

Figure 11. Dredge Sample Sites in Loveless Lake, Polk County, Wisconsin

Percent dry matter of sediment samples tells us in relative terms the amount of organic matter (dead plants) in the samples versus the amount of minerals (such as rock, sand, clay, and silt material). A higher value for percent dry matter means there is more mineral in the sample. The samples taken along the outer edge of Loveless Lake (samples LOV-3 and LOV-11) have more minerals and follow a gradual trend of less minerals as you reach the center of the lake. At the center of the lake (sample LOV-6), which is approximately where the deep hole is located, the organic matter content of the sample seems to be higher in the sediment sample. As dead plant material and detritus float in the lake, they tend to settle to the bottom and get washed to the lowest point by wave action. This is a typical pattern in most lakes.

Table 6. Dredge Sample Results

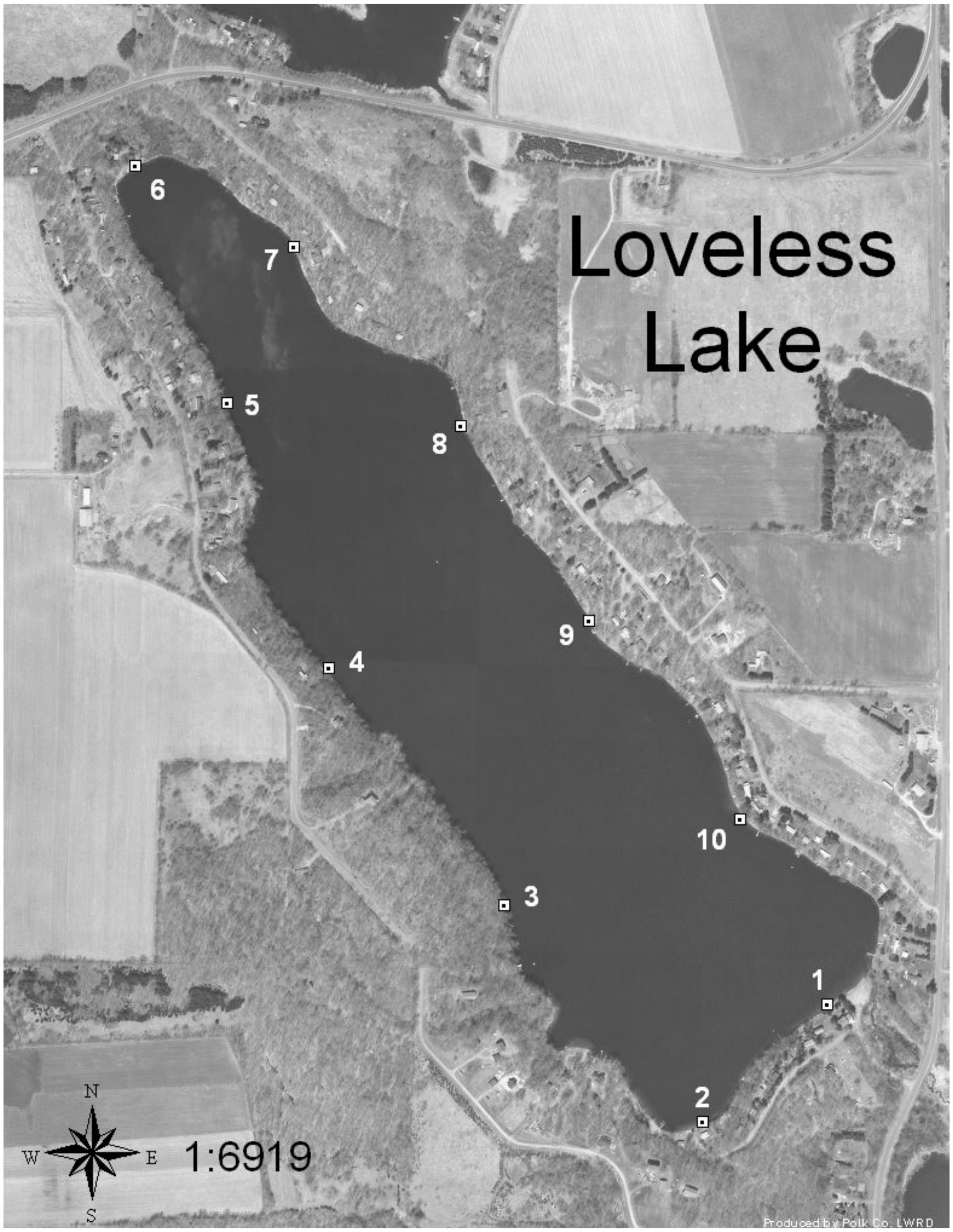
Sample Date	Location	Total Phosphorus %	Total Nitrogen %	Dry Matter %
10/15/2002	LOV-3	0.14	1.0	15.6
10/15/2002	LOV-4	0.08	1.3	12.3
10/15/2002	LOV-5	0.08	1.3	10.6
10/15/2002	LOV-6	0.08	1.3	9.1
10/15/2002	LOV-7	0.06	0.9	10.8
10/15/2002	LOV-8	0.08	1.2	10.9
10/15/2002	LOV-9	0.06	1.0	13.5
10/15/2002	LOV-10	0.08	1.0	11.0
10/15/2002	LOV-11	0.06	1.3	15.8

Aquatic Macrophytes

A survey of aquatic macrophytes was conducted during the summer of 2002 to determine the species of aquatic macrophytes present in Loveless Lake. Ten transects around the lake were sampled approximately every 1300 feet (see Figure 12) using the Jessen and Lounds method. This method uses a rake with a handle, making a figure eight in an area that is approximately 1 m^2. The rake is then inverted and brought to the surface for assessment. Species composition or dominance of a species at a site or certain water depth can be determined using this method. The results were then evaluated using three different indices or metrics, the Floristic Quality Assessment, Shannon-Wiener Diversity Index, and the Frequency of Occurrence for each species.

In each transect, the species were identified and approximate density (in percent) was recorded at each distance of 10, 25, 40, 55, 70, 85, and 100 feet from shore. All macrophyte data can be found in Appendix G. The 2002 aquatic plant survey revealed the presence of eleven species, listed in Table 7. Most of the plants identified are native to the region. However, curly leaf pondweed was also found, which is an exotic species that can aggressively compete with other native species. Under ideal conditions of shallow, nutrient-rich areas, curly leaf pondweed can establish itself if the site becomes disturbed. It quickly establishes monotypic flats and can present problems for the lake water quality and the native macrophyte community.

Figure 12. Aquatic Macrophyte Survey Transect Locations



The Frequency of Occurrence (FO) is defined as the number of sites along all transects in which the species occurred divided by the total number of sites in the lake with vegetation. FO is expressed as a percent. The FO for Loveless Lake determined *Potamogeton zosteriformis* (Flat-stem pondweed) to be the dominant species during this sampling event, occurring at 62.5% of the intervals. However, there were several species with a FO of more than twenty percent, these included: *Ceratophyllum* *demersum* (Coontail) at 44.6%, *Najas flexilis* (Slender naiad) at 30.4%, *and Vallisneria americana* (Wild celery) occurring at 48.2% of the sampling sites.

P. zosteriformis was by far the densest species in Loveless Lake. However, *C. demersum* and *V. americana* also had a high relative density compared to the other species sampled.

Table 7. Species of Aquatic Macrophytes Present in Loveless Lake, Polk County, Wisconsin

Scientific Name	Common Name
Ceratophyllum demersum	Coontail
Potamogeton crispus	Curly Leaf Pondweed
Elodea canadensis	Elodea/Common Waterweed
Cladophora	Filamentous Algae
Potamogeton zosteriformis	Flatstem Pondweed
Lemna trisulca	Forked Duckweed
Eriocaulon aquaticum	Pipewort
Potamogeton richardsonii	Richardson's Pondweed
Potamogeton pectinatus	Sago Pondweed
Najas minor	Slender Naiad
Vallisneria americana	Water Celery

The Shannon-Wiener Diversity Index was calculated for the lake. The Shannon-Wiener Index determines how difficult it would be to correctly predict the species of the next individual collected. This, in turn, tells us how diverse the plant community is. For example, a site with only one species present has an *H* value of 0. The higher the number, the more diverse a lake is. The Shannon-Wiener Index uses the equation:

$$H = -\sum_{i=1}^{s} (p_i)(\log_2 p_i)$$

where *H* = Shannon-Wiener Diversity, $\sum$ = sum of species, *s* = the number of species, p_i = the proportion of individuals of the total sample belonging to the *ith* species calculated as *ni/N* for each *ith* species with ni being the number in species *i* and *N* being the total number of individuals in the sample (Barbour, et al, 1987). Because the total number of individuals was not determined in this survey, the density of the species was substituted for the total number. It was thought that the density of the species would accurately represent the population of each individual species.

The Shannon-Wiener diversity index was calculated to be 2.01 for Loveless Lake. As the lake has much human impact, this is to be expected. Additional macrophyte monitoring would give a better understanding of the aquatic plant community, improve diversity indices, and increase our knowledge of invasive species coverage (*Potamogeton crispus*) in the lake.

The Wisconsin Floristic Quality Assessment (FQA) was used to determine the quality of the plant composition at each site in Loveless Lake. The FQA gives a somewhat subjective, but quantitative and uniform assessment of the natural flora. The FQA first uses an "average coefficient of conservatism" to then determine the "Floristic Quality Index" for a site. More information on the FQA can be found at http://www.botany.wisc.edu/wisflora/FloristicR.asp. Non-native plants are not assigned a coefficient of conservatism as they do not contribute to the quality of the site. The higher the floristic quality index (FQI) number at a site, the higher the floristic quality and biological integrity and indicates a lower level of disturbance at a site. The FQI numbers can be compared with other sites in the region or compared to the same site over time to determine the sites' natural quality. The index can also be used to identify natural areas, compare the quality of different sites or locations within a single lake, monitor long-term disturbance trends, and evaluate habitat restoration efforts.

Using the equation $I = \overline{C}\sqrt{N}$ (where *I* is the floristic quality, $\overline{C}$ is the average coefficient of conservation (obtainable from http://www.botany.wisc.edu/wisflora/FloristicR.asp) and $\sqrt{N}$ is the square root of the number of species), the floristic quality of Loveless Lake was determined to be 14.5. The average for this area of the state (North Central Hardwood Forest) is 17 to 24.4 with a median of 20.9. Loveless Lake is below the region average, indicating Loveless Lake has been disturbed and provides less than average habitat for wildlife. Disturbances to the lake can include water skiing and other boating activities, shoreline vegetation removal, and poor stormwater management. The presence of *P. crispus* also affects the Floristic Quality Index. The presence of curly leaf pondweed (*Potemogeton crispus)*, coontail (*Ceratophyllum demersum*), and common waterweed (*Elodea Canadensis*), which are generalist species and can tolerate a vast array of lake conditions, can make the Floristic Quality Index lower. These plants are still important for fish cover, but indicate the area has been impacted by settlement.

Having used the Floristic Quality Assessment on Loveless' plant community, it is important to note that the FQA describes the level of disturbance on the lake. The plant community of Loveless Lake as a whole has adapted to this disturbance level and is now acting as a system. The macrophytes present in Loveless Lake are able to survive in the conditions at hand given the nutrient level, depth of water, substrate type, and the light level penetrating the water. The natural balance has been met for a eutrophic lake. Coontail and Elodea, common in Loveless Lake, provide quality habitat as they have evolved to fit this specific niche. They are growing where they should be based on light, substrate, depth, etc. The biological potential of a disturbed, eutrophic lake will not be the same as an undisturbed lake.

The aquatic plant community should continue to be monitored to ensure a healthy ecosystem and gauge the effectiveness of management techniques. Any more major disturbance to the macrophyte community of Loveless Lake could be detrimental to its ecosystem. The aquatic plant community of Loveless Lake is an invaluable part of the lake's ecosystem, particularly to invertebrates and fish. In order to protect the lake, the aquatic plant community needs to be protected and restored.

Another measure of habitat for fish and aquatic wildlife is the amount of coarse woody debris in the riparian area. Coarse woody debris (CWD), such as fallen logs and limbs, supply a structure and hiding places for fish, habitat for insects which provide food, sunning locations away from predators for small animals, and place for floating plants to root. CWD has increasingly been discovered as prime habitat and essential for the aquatic community. While measurements were not taken on Loveless Lake during this grant, residents should be aware of the ecological impact of removing coarse woody debris and woody shrubs from the shoreline and into the water.

Several state and local laws regulate shoreline vegetation. NR 107, administered by the Wisconsin DNR, governs the chemical treatment of aquatic plants. Chemical management shall be allowed in a manner consistent with sound ecosystem management and shall minimize the loss of ecological values in the water body. The State of Wisconsin requires that any herbicide treatment be covered by a DNR permit. Improper dosages, using the wrong chemical for the existing plant community, or inappropriate application could cause harm to the aquatic plant community and to the applicator.

NR 109 governs the manual or mechanical treatment of aquatic plants. Aquatic plants are a vital and necessary component of a healthy aquatic ecosystem. Hand pulling, raking, or other mechanical removal of aquatic plants is allowed within a 30-foot width perpendicular to the shore. This distance includes the area under and adjacent to a dock. NR 109 is designed to balance the needs of lake residents for boating and swimming access with those of habitat protection, and was not intended to allow unlimited removal of aquatic vegetation; but, instead carefully considers cumulative impacts to the lake ecosystem, and reduces the risk of the spread of invasive species. If it is decided that an alternate area of the lake should be cleared for recreational access, the aquatic vegetation cannot be removed until the other area has fully been restored with native vegetation to a proper density.

NR 115 was created to establish statewide minimum standards including minimum lot sizes, how far structures must be set back from water's edge, and limits on removing trees and other vegetation. Local rules may be more stringent than state standards. In Polk County, the County Lake Classification laws rule the setback distance, minimum lot size and width. Information on this can be obtained from the Polk County Zoning Department or Land and Water Resources Department. (See www.co.polk.wi.us/departments.) NR 115 also establishes the minimum buffer width to be 35 feet from the OHWM. Chapter 30 discusses the regulations regarding navigability. For more information on state regulations regarding aquatic plants, see http://www.dnr.state.wi.us/org/water/fhp/lakes/aquaplan.htm.

Phosphorus Modeling

The Wisconsin Lake Modeling Suite (WiLMS), developed by the Wisconsin Department of Natural Resources, was used to model the current condition in Loveless Lake watershed, a forested watershed condition, and a projected development condition. Phosphorous is the key parameter in the modeling scenarios because it is the limiting nutrient for algal growth in Loveless Lake. Water quality data collected during 2002 and past Self Help data was used to estimate in-lake phosphorus.

Table 8 summarizes the annual external loading estimates to Loveless Lake given the three scenarios. With the present level of development in Loveless Lake watershed, an estimated 130 pounds of phosphorus are entering the lake each year. If the entire watershed were developed to have a house density of approximately 1 house per 2 acres, the phosphorus loading was estimated to be 124 pounds per year. This total phosphorus-loading estimate may be lower because the model assumes paved surfaces. However, the water column concentration of phosphorus is still affected by the increased volume of surface runoff. If the Loveless Lake watershed was entirely undeveloped and completely forested, the phosphorus loading to the lake is estimated to be 54 pounds annually. Obviously, a more natural state is healthier for the lake.

The water column phosphorus concentration was also modeled using the Vollenweider Shallow Lake Model (1982) as it appeared to be the best “fit” for Loveless Lake. The Vollenweider model calculates an estimated growing season average phosphorous concentration in the water column (mg/m^3).

The model predicted that a forested watershed for Loveless Lake would have a phosphorus concentration of 18 ug/L. Modeling the current condition of Loveless Lake’s watershed gives a water column concentration of 33 ug/L. However, the observed concentration in Loveless Lake was 42.1 ug/L. A developed watershed was predicted to have a water column concentration of 38 ug/L. An overall in-lake phosphorus concentration of 18 ug/L is a potential management goal (however unlikely, as described below). Such a level would likely increase water clarity and ensure a quality lake for generations.

Table 8. Phosphorus Estimates for Three Scenarios in Loveless Lake Watershed

Condition	Total P loading (lbs annually)	Water Column Concentration (P in mg/m^3 or ug/L)
Present	130	33
Forested	54	18
Developed	124	38

The projected development condition bodes grim for Loveless Lake. The predicted 38 ug/L in-lake phosphorus concentration will likely bring more algal blooms and consequently more internal loading due to reduced oxygen at the water/sediment interface as plant matter decays. The projected development condition assumes that all forestland (24% of the Loveless Lake watershed) will be converted into low density rural residential (approximately 1 house per 2 acres). Although it may be unlikely that all the existing forest land will be converted to such a land use, it is not unreasonable to assume that at least 40% of the developable forest land and crop land will eventually be low density rural residential. Under the current zoning law, it is possible for such a conversion to occur.

Restoring the watershed to a forested condition and reducing the in-lake phosphorus concentration to 18 ug/L is an unlikely scenario based on both environmental and economic restraints. However, it is heartening to know that limiting nutrient inputs to the lake will likely result in improvements. Therefore, the lake was modeled at 12%, 20% and 45% reductions in external phosphorus loading, which showed improvements in both water column phosphorus concentration and phosphorus loading to the lake. Such reductions may be possible through the implementation of best management practices, shoreline restoration, wetland restoration, or some combination of these management options. Limiting horsepower and/or implementing speed limits on the lake could also further reduce internal phosphorus loading. Such activity resuspends sediment and, consequently, nutrients and makes them available to plants and algae.

Controlling the population of *Potamageton crispus* (curly leaf pondweed) would also help curb the effects of internal loading. The Nurnberg model for estimating gross internal loading predicted a contribution of approximately 3% of the total phosphorous in the water column is from internal sources. However, this model does not take into account the presence of the exotic species curly leaf pondweed in the lake. Curly leaf pondweed emerges from the lake bottom earlier than native species and dies and decays earlier in response to warm water temperatures, depriving the lake of dissolved oxygen. Because of this life cycle and boat traffic on the lake, the internal loading of Loveless Lake is likely much higher than the model indicates and should be further investigated.

A 45% reduction of phosphorous loading from external sources would significantly affect total phosphorous concentrations in Loveless Lake (89.8 lbs of loading and a water column concentration of 24 ug/L). Such a reduction would classify the lake as mesotrophic, and an improvement in water clarity may be noticeable as the lake chemistry would shift towards that of forested watershed conditions.

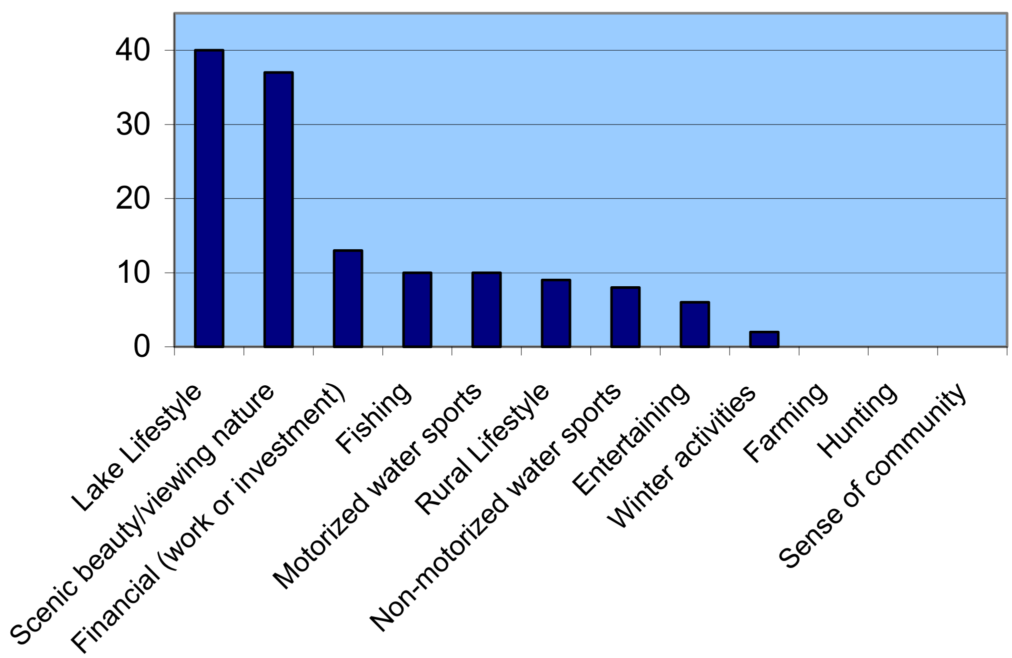
Sociological Landowner Survey

A 17-question survey was sent out to 106 landowners within the Loveless Lake surface watershed. Forty-five (45) people responded and returned their survey for a 42% response rate. The complete survey and the results can be found in Appendix H.

Of the respondents, 35% have owned property on or near the lake for less than 10 years. Forty percent (40%) have owned property for more than 20 years on Loveless Lake, which gives a mix of newcomers with long-time owners. The average property is occupied 69-140 days, with the most common response being 29–60 days per year. Of those days, an average of 2.4 people reside on Loveless Lake.

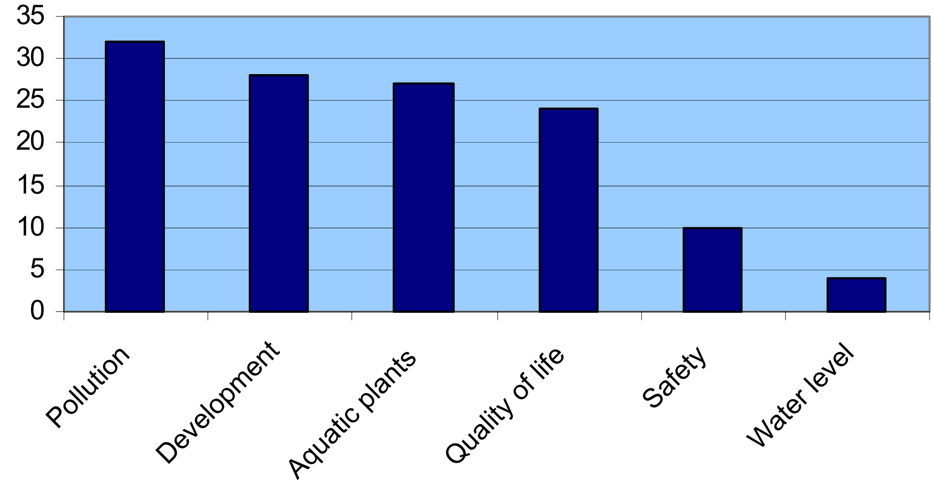
The following responses were ranked as the most important reason to own property on or near Loveless Lake. Lake lifestyle, scenic beauty/viewing nature, and financial (work or investment) were the top reasons among the respondents to own property.

Figure 13. What are the most important reasons that you own property on or near Loveless Lake?



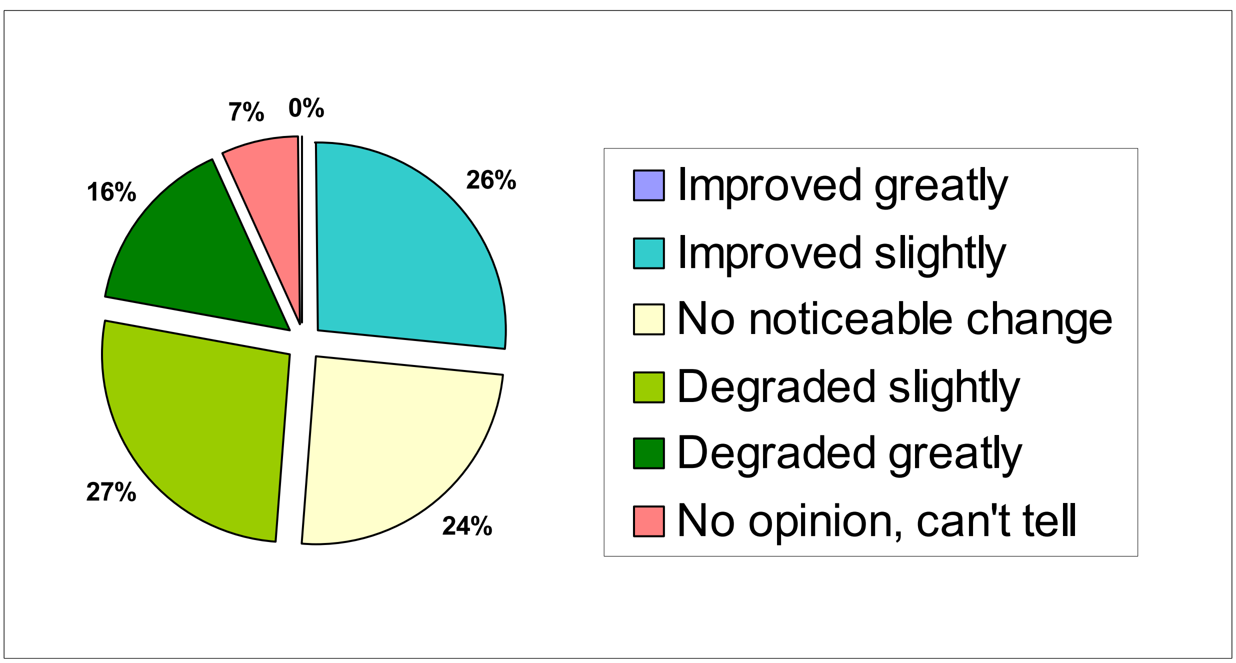
The biggest concerns regarding Loveless Lake are pollution, development, and aquatic plants, as ranked by the respondents.

Figure 14. What concerns you most about Loveless Lake?



The respondents had mixed perceptions of the water quality on Loveless Lake. Twenty-six percent (26%) described the change in water quality as improved slightly. Twenty-four percent (24%) noticed no change. Twenty-seven percent (27%) felt Loveless Lake's water quality degraded slightly, and 16% felt it degraded greatly. No respondent felt the lake water quality improved greatly.

Figure 15. Since you have lived on or near the lake, how would you describe the change in water quality?



As compared to other lakes in the region, 39% of the respondents felt Loveless Lake had average water quality. Thirty percent (30%) describe Loveless Lake's water quality as definitely above average.

Figure 16. How would you describe the current water quality of Loveless Lake as compared to other lakes in this area?

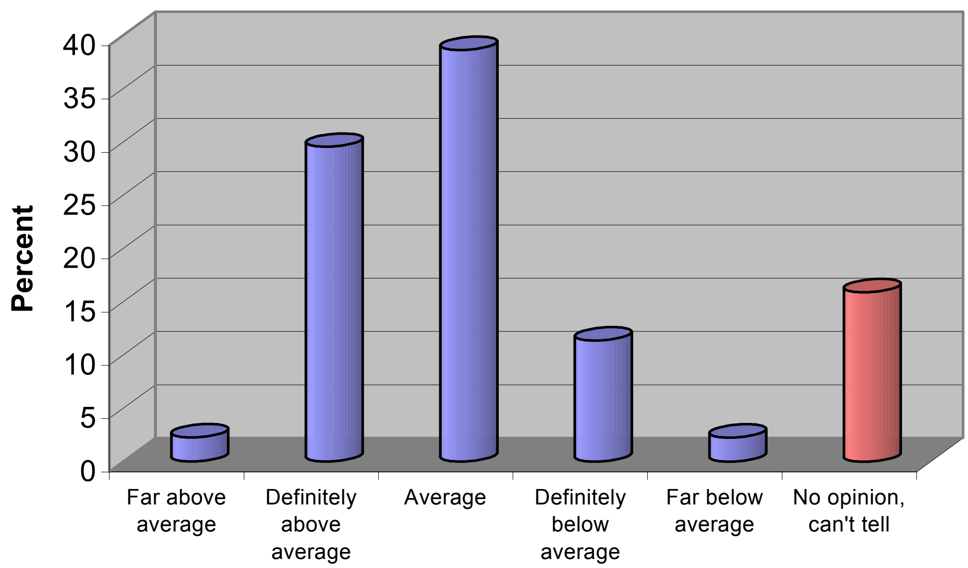
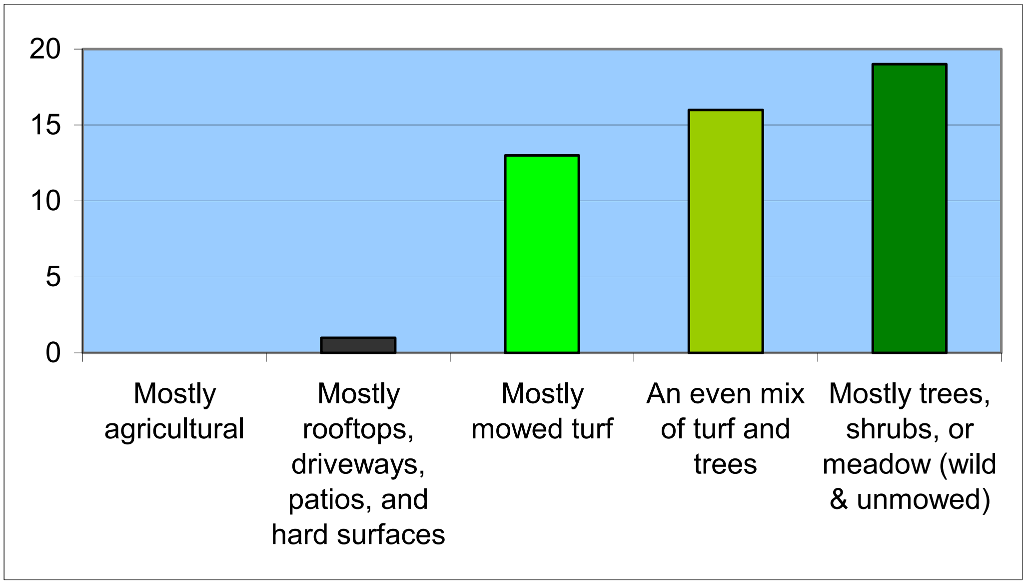


Figure 17 evaluates the land use of residents' property. Nineteen (19) respondents indicated their property is mostly trees, shrubs, or meadow. Sixteen (16) respondents have an even mix of turf and trees. Thirteen (13) respondents have mostly mowed turf for land cover, and one (1) respondent indicated they have mostly rooftops, driveways, patios, and hard surfaces for land cover.

Figure 17. ***Is your property*****…mostly agricultural, mostly mowed turf, an even mix of turf and trees, mostly trees, shrubs, or meadow, or mostly rooftops, driveways, patios, and hard surfaces?**



When asked if respondents would be willing to provide financial support to Loveless Lake to maintain or improve the quality of the lake and its associated land resources, 74% indicated they would be willing, and 26% said they would not be willing. Of the 32 yes's (74%), 16 respondents indicated they would be willing to contribute $50-$100 per year, 7 respondents indicated $11-$50 per year, 7 indicated $101-$500 per year, and 3 responded $1-$10 per year.

Figure 18. Would you be willing to provide financial support to maintain or improve the quality of the lake and its associated land resources?

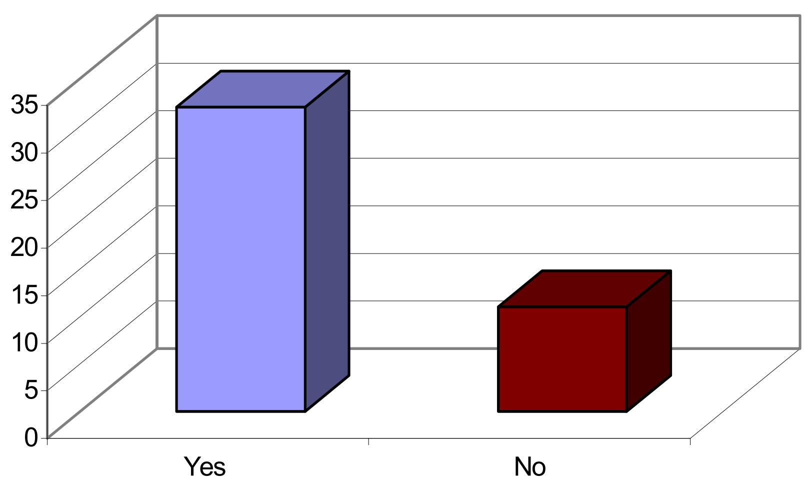
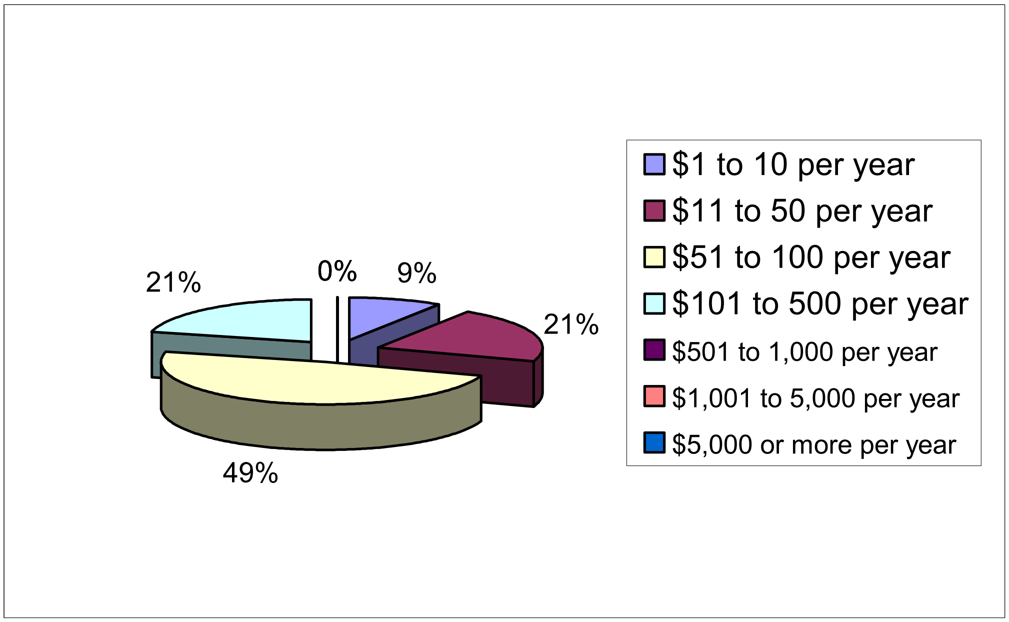


Figure 19. If you answered yes, how much would you be willing to contribute each year?



Conclusions and Recommendations

The results of this initial study of Loveless Lake lead to the following conclusions and recommendations:

1) Loveless Lake receives surface runoff from a 450-acre surface watershed and groundwater from an 850-acre groundwater watershed in addition to precipitation on the lake surface. These sources of water can contribute nutrients and minerals to the lake. Excessive amounts of nutrients can increase biological productivity of the lake, reducing water clarity and oxygen levels.

2) The surface watershed has a mixture of residential, agricultural, and forested land. Residential and agricultural land can have high nutrient inputs to the lake through elevated levels of available nutrients (lawn fertilizers, septic systems, and pet wastes) and increased surface runoff from impervious areas (roof tops, driveways, walkways, etc.).

3) Surface runoff samples collected near the lake demonstrated high concentrations of suspended solids, nitrogen, and phosphorus. Efforts to reduce the flow of surface water during storms by enhancing filtration of runoff further upland should reduce nutrient flow to the lake. Additional sampling during baseflow and runoff events throughout the year would help to identify areas of greatest inputs.

4) Groundwater samples collected from seeps near the lake showed relatively high concentrations of nutrients, but may have been influenced by sediments and organic matter decomposition near the seep sites. Additional testing will be necessary to determine the importance of nutrient transport through groundwater in this watershed.

5) Water clarity, measured with a Secchi disk, decreased over the summer, suggesting an increase in algal growth potentially related to increased phosphorus input. Although this study did not examine the sources of phosphorus, the pattern of decreasing water clarity during the growing season is typical of shallow lakes that have internal contributions of phosphorus. It is also likely that nutrient loading resulted from runoff events throughout the summer.

6) Loveless Lake is a eutrophic lake that had a spring overturn phosphorus concentration of 24 ug/L, a season average of 39 ug/L, and an average trophic state index of 52 for 2002.

7) Loveless Lake has sufficient pH buffering so that it is not particularly sensitive to acid rain.

8) Sediment samples collected within the lake show approximately 10% organic matter. These organic-rich sediments may also be a source of phosphorus as the organic matter decomposes.

9) Eleven submergent aquatic plant species were identified in Loveless Lake during the macrophyte study. These include native plants and the exotic curly leaf pondweed. More information should be collected, and a comprehensive plant management plan

should be created for Loveless Lake. This plan would address aquatic plant goals for the lake including protection of critical habitats, navigational corridors to provide recreational access, measures to control exotic species, and species composition.

10) Continued water quality monitoring will help to detect changes in water quality that occur long term. Data collected during this study should be used to develop a lake management plan that addresses inputs of nutrients and sediment from near-shore and watershed-wide sources. Abatement of these nutrients will likely have an impact on water clarity.

11) Phosphorus modeling showed that restoring natural habitat throughout the entire watershed will help reduce phosphorus concentrations in the lake and improve water quality.

12) Measures taken to reduce sediment input including limiting development within the watershed, accounting for impervious areas, implementing best management practices, reducing boating activity, and cleaning road culverts and roadside ditches.

13) Loveless Lake is a fairly shallow lake at 20 feet (average depth is 15 feet.) Motorboat activity on the lake may disturb sediments, which provide nutrients to the lake water. The Loveless Lake Association may wish to address the amount of boat traffic on the lake to minimize sediment resuspension.

14) Discussion with the Balsam Township regarding the possibility of re-assessing the hydrology in the watershed is necessary. Storm water runoff should also be addressed to reduce sediment loading. Loveless Lake Association may wish to expand the project to address the Balsam Branch Watershed.

15) Construction projects on Loveless Lake should have erosion control practices in place to prevent sediment from entering the lake. Loveless Lake Association should work with new residents to inform them of the impacts of soil erosion and update them with the current water quality conditions of Loveless Lake to give them a realistic understanding of the lake.

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