

Mirror and Shadow Lakes Management Plan

2012

This lake management plan was developed to provide guidance to protect desirable conditions, address existing problems, and prevent future problems in the Mirror and Shadow Lakes ecosystems.

Friends of Mirror and
Shadow Lakes and
Lake Management
Planning Committee



Prepared by J. McNelly and N. Turyk, Center for Watershed Science and Education, UW-Stevens Point



Contents

Table of Figures	3
Introduction.....	4
Mirror and Shadow Lakes – Their Setting	5
Mirror and Shadow Lakes - Their History.....	5
Mirror and Shadow Lakes – Their People.....	7
A Plan for the Lakes’ Water Quality and Land Management	8
Surface Watersheds.....	8
Groundwater Watersheds.....	10
Water Quality	11
Shorelands	16
Aquatic Plants and Aquatic Invasive Species.....	23
Fisheries in Mirror and Shadow Lakes.....	27
Recreation	30
Communication/Organization	32
Appendices	34
Appendix A Aerator for Mirror Lake.....	35
Appendix B Shoreland Surveys.....	37

Table of Figures

Figure 1. Land uses within the Mirror and Shadow Lakes surface watersheds.	9
Figure 2. Surface watershed boundaries and land uses. Mirror and Shadow Lakes, Waupaca, WI 2000	10
Figure 3. Land use within the Shadow and Mirror Lake groundwater watershed.....	11
Figure 4. Citizen survey results of perceived water quality in Mirror and Shadow Lakes.....	11
Figure 5. Spring and fall overturn total phosphorus (ug/L) in Mirror and Shadow Lakes.....	13
Figure 6. Survey of Mirror and Shadow shoreland showing vegetation ranging in height from 0.5-3 feet (an enlarged map is displayed in the Appendix).	19
Figure 7. Citizen survey results of perceived aquatic plant growth in Mirror and Shadow Lakes.	24
Figure 8. Citizen survey results of perceived change in fishing quality in Mirror and Shadow Lakes.....	27
Figure 9. Citizen survey results of fishing experience in Mirror and Shadow Lakes.	27
Figure 10. Citizen survey results of recreational activities on Mirror and shadow Lakes.....	30

Introduction

Mirror and Shadow Lakes are drainage lakes that are located within the City of Waupaca in Waupaca County. Because of their proximity to a city park and the city center, local residents and visitors enjoy them daily throughout the year. They are appreciated by those who use them for their natural beauty, peace and tranquility, wildlife viewing, and quiet recreational opportunities including walking, fishing, biking, and canoeing/kayaking.

Our vision for the management of Mirror and Shadow Lakes is that the lakes will have excellent water quality and wildlife habitat that is in balance and harmony with human activity on the lakes

The purpose of this lake management plan is to provide guidance to protect current conditions that are desirable, address existing problems, and prevent future problems to the Mirror and Shadow Lakes ecosystems. This plan was created by a committee of dedicated citizens and professionals from the City of Waupaca, UWSP Center for Watershed Science and Education (CWSE), and the Wisconsin Department of Natural Resources while considering input from more than 346 citizens and lake users that participated in an opinion survey. A citizen survey was conducted to gather information on citizens' values, opinions, and perceived issues with Mirror and Shadow Lakes prior to the planning process. The survey was sent to all residences within the City of Waupaca, was distributed at the Shadow Lake beach, and was available at the City office. Two thousand three hundred surveys were distributed with a response rate of approximately 15%. This lake management plan was constructed using water quality data collected as part of a lake study conducted by CWSE on Mirror and Shadow Lakes in 2001-2003, citizen water quality monitoring data, aquatic invasive species information collected by Golden Sands Resource Conservation and Development, and shoreland and aquatic vegetation surveys conducted by the CWSE in the summer of 2011. The planning committee for the Mirror and Shadow Lakes management plan met over a year to learn about the lakes and discuss management strategies with professionals, create a vision for the lakes, and identify the necessary actions needed to achieve (need a descriptor of) water quality and wildlife habitat that is in balance and harmony with human activity in Mirror and Shadow Lakes.



Mirror and Shadow Lakes – Their Setting

Information in this section was taken from the Mirror and Shadow Lakes Study and the citizen survey responses. The background information was provided from the Mirror and Shadow Lakes, Waupaca, Wisconsin: An Interpretive Analysis of Water Quality (Turyk, et al, 2004) helps to give us an understanding of Mirror and Shadow Lakes and their ecosystems.

A healthy lake ecosystem is comprised of many components that include in-lake habitat and vegetated shorelands that support aquatic plants, fish, wildlife, good water quality and quantity, absence of aquatic invasive species and more. These components are not only found in lake but also extend to where the water meets the land and beyond into the watershed. Mirror and Shadow Lakes are a reflection of the health and activities that occur in the lakes, near the shores, and in the watersheds.

Mirror and Shadow Lakes are surrounded by the City of Waupaca, which has a population of approximately 6000 residents. The Tomorrow or Waupaca River flows one mile north of the lakes and the Crystal River flows one quarter mile to the south. Roads surround both the lakes and residential development occurs along the majority of the land adjacent to the Lakes. South Park, a city park, is located on the west side of the lake and provides public access to the lakes, a boat landing, a swimming beach, picnic areas, and washroom facilities. The City of Waupaca has a municipal well located on the east shore of Mirror Lake and Lakeside Memorial Park cemetery perches on the northwestern shore of Shadow Lake.

Mirror Lake is an oblong groundwater drainage lake residing in a kettle pothole, which is a bowl-like depression. Mirror Lake covers 13 acres, has a maximum depth of 43 feet, and an average depth of 25 feet. The littoral zone (area where rooted aquatic plants grow) is small because of the steep lake bed that quickly descends to greater depths. A renovated channel on the southern shore drains Mirror Lake's water to Shadow Lake. Shadow Lake is a 43 acre drainage lake with a maximum depth of 41 feet and an average depth of 17 feet. Hills exist on Shadow Lake's northern expanse and slope into wetlands along the southern shore. Shadow Lake has a dredged channel that outflows to the Crystal River. Mirror and Shadow Lakes are both fed by groundwater through springs.

Mirror and Shadow Lakes - Their History

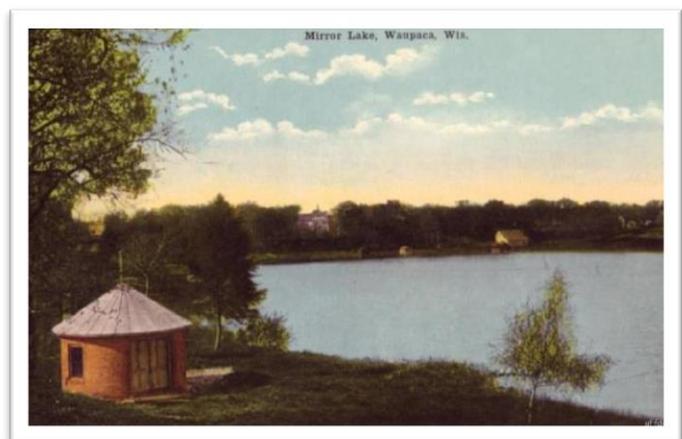
Possin (1973) found that Mirror and Shadow Lake's basins were formed in the outwash plain of the receding Green Bay Lobe of the Cary ice sheet that developed in Pleistocene glaciations about 12-14,000 years ago. As this ice sheet melted or wasted back northward large blocks of ice separated from the main glacier and remained in the newly laid glacial sediment. Deposited ice melted within the sediment and formed glacial lakes, often called "kettle lakes" because of the lakes morphological resemblance. Around Mirror and Shadow Lake, glacial deposits and outwash sediment of medium to coarse grained sand compose the top 50-100 ft of soil and overlay 50 ft of glacial till, which is a variable mixture of soil, pebbles, rocks, and boulders. Underneath lies the parent material composed of crystalline granite bedrock.

The lakes bottoms are composed of outwash that has been overlain with brown fibrous peat and marl sediment that have been formed and deposited by the lakes themselves. Peat occurs along the shores in abundance and especially on the west shore of Mirror Lake. Peat is underlain by a marl layer that extends out into the deeper areas and at the greatest depths a thin layer of organic muck has been deposited on top of the marl (Possin 1973).

Mirror and Shadow Lake have a long cultural history dating back to pre-settlement when Native Americans used the area for encampment (Garrison and Knauer 1983). In the 1850s, European settlers came to the region and began development. By 1901 streets surrounded Mirror Lake and during the 1920s, water issues developed with Mirror and Shadow Lake's nearby wells and surrounding groundwater as the city strove to obtain more water while maintaining a healthy drinking water network for the growing city. Problems included well clogging due to the regions fine sands and decreased water quality in Mirror Lake that created the need for treatment in order to for Mirror Lake to continue serving as a source of drinking water (Alvord and Burdick, 1921). Mirror Lake's wells are still present on Mirror Lake's shores today, but contribute only to the City's water supply on a much reduced scale. Well number 1 on Mirror Lake's western shore is completely out of use. Well number 2 on the eastern shore of Mirror Lake and Well number 3 located west of Washington St. are still both in use. By 1935 nearly all residences were established on Mirror Lake and deterioration of the lake's water quality lead to the failure of Mirror and Shadow Lakes stocked trout fisheries by the mid 1950s (Possin 1973). Alterations in drawings and air photos show that sometime between the 1930s and 1950s an outflow was dredged at the south end of Shadow Lake to allow access from the Crystal River. Around the same time, a wetland inflow was channelized on Shadow Lake's northwestern shore to transport stormwater drainage from the city. In the 1960s the land adjacent to the east shore of Shadow Lake was developed as both lakes took up residence in the growing City of Waupaca, WI (Garrison and Knauer 1983).

In the mid 1970s a study of Mirror and Shadow Lakes confirmed that cultural eutrophication was occurring. Consistent with studies elsewhere, runoff from streets, lawns, and rooftops were found to be adding nutrients and metals to Mirror and Shadow Lakes causing enhanced algal and aquatic plant growth and decreased dissolved oxygen concentrations. Data showed that reducing the amount of nutrients and metals in the lakes was necessary and led to the diversion of storm sewers away from the lakes in 1976. Then, in 1978, aluminum sulfate was applied to the lakes to reduce internal phosphorus loading (aluminum forms a precipitate with phosphorus that can reduce its availability to aquatic plants and algae). The storm sewer diversion was estimated to have reduced external phosphorus loading by 58-65% for both lakes and aluminum sulfate application reduced in-lake phosphorus concentrations from 90 mg/L in Mirror Lake and 33 mg/L in Shadow Lake to 20 to 25 mg/L in both lakes (Garrison and Knauer 1981). Along with these treatments, Mirror Lake has been aerated during the winter to prevent low winter dissolved oxygen concentrations.

Around 2000, water quality monitoring was conducted by Adopt-a-Lake Program participants and Dave Furstenburg's Waupaca Learning Center students. These volunteer participants, the City of Waupaca Department of Public Works, the City of Waupaca's Lakes District, and the Wisconsin Department of Natural Resources (WDNR) gathered four years of information about each lake. Concern arose with when low dissolved oxygen concentrations were found in Mirror Lake. In February 2001, Mirror Lake suffered a winter fish kill. Mirror Lake is now aerated in the fall and spring to support dissolved oxygen levels. Water quality monitoring continues on both lakes by local citizens who submit data to the WDNR and have samples analyzed at the UWSP Water and Environmental Analysis Lab (WEAL).

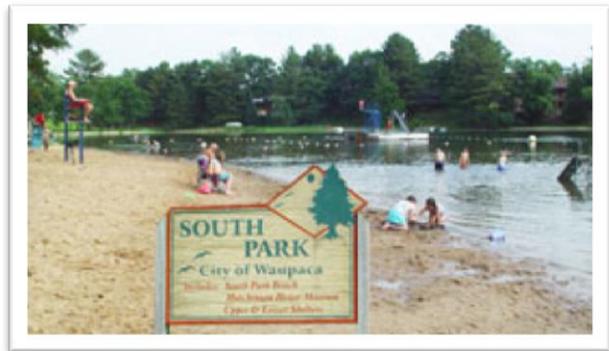


Mirror and Shadow Lakes – Their People

With Mirror and Shadow Lakes lying in the heart of the City of Waupaca, their proximity makes them an important asset to the culture and lifestyle for city residents and visitors. Results from the survey confirmed that Mirror and Shadow Lakes, along with the adjacent city park, provide a variety of recreational opportunities for citizens throughout the year including swimming, fishing, boating, picnicking, hiking, and enjoying nature. The lakes are heavily used by local residents along with visitors from other areas.

Of all the surveys returned 45% (157) lived outside of either watershed but in Waupaca, 33% (114) lived within one of the watersheds but not on the lake, 8% (29) did not live within a watershed or Waupaca, 6% (21) lived on Mirror Lake, and 6% (19) lived on Shadow Lake. The remaining 2% (6) didn't respond to the question. Twelve percent (40) of all survey respondents are riparian landowners on either Mirror or Shadow Lakes. When respondents were asked where they traveled from to use the lakes, 61% (65) traveled from within the city of Waupaca, 11% (12) from the town of Farmington, 7% (8) from the town of Waupaca, 6% (6) from the town of Dayton, 3% (3) from New London/Manawa, 3% (3) from the Amherst Area, 2% (2) from the Fox Valley, 2% (2) from the Stevens Point Area, 2%(2) from Plover, 2% (2) from Lola/Scandinavia, 1% (1) from the Town of Lind, and 1% (1) from out of state. Forty-three percent of respondents have lived or recreated on the lakes for more than 20 years, 24% 11-20 years, 13% 6-10 years, 18% 1-5 years, and 3% less than a year.

Of the surveys that were handed out at the beach, 55%(27) respondents did not live in either of the watersheds or within the city of Waupaca, 18%(9) lived outside of both the watersheds but lived within the city of Waupaca, 14% (7) lived within one of the lakes watersheds, 6% (3) lived on Shadow Lake and 6% (3) lived on Mirror Lake. The top three areas that people traveled from to use the lakes were the town of Farmington (23%), the town of Dayton (15%) and the town of Waupaca (10%). The large percentage of people surveyed at the beach were not local but obviously used the lakes. These may be an important group of people to reach out to with information regarding the lakes; however these lake users may require a different method of receiving materials as they are not local.



A Plan for the Lakes' Water Quality and Land Management

Most people interpret the water quality in a lake by visuals such as how murky it is, how much algae or aquatic plants they see, or through sense of smell if odors are present. Managing water quality involves taking measurements in the lake and collecting samples for analysis. Interpreting the results involves looking at what is happening in a lake as well as what is happening on the landscape.

Mirror and Shadow Lakes are receiving water from direct precipitation on the lakes, from surface runoff during rainstorms and snowmelt, and from groundwater inflow. Shadow Lake is also receiving water from Mirror Lake and a wetland channel draining from the northwest. The lakes are losing water to groundwater and the channel draining to the Crystal River from Shadow Lake. Understanding how water gets to and from a lake is important because different sources of water impact the amount of time water stays in a lake, its water quality and chemistry and thus, the aquatic plants and biota in an aquatic system. During snowmelt or a precipitation event water moves across the surface of the landscape towards lower elevations such as wetlands, lakes and rivers, or internally drained areas (where water on the surface recharges groundwater). The capacity of this landscape to hold water and filter particulates ultimately determines the water quality, habitat, and in-stream erosion. Simply put, the more the landscape can hold water during a storm, the slower the water is delivered to the streams and the greater the ability to filter the runoff.

As water moves across the land surface, particles are picked up and travel with the flow. Surface water runoff is partially filtered when plants divert and slow water movement causing sediment and associated nutrients to be deposited or absorbed. The best plant filters (buffers) consist of a combination of trees, shrubs, and deeply rooted perennial vegetation. This vegetation also provides essential habitat for many animals that inhabit or use lake shorelines. Although some of the land around the lakes contains this type of vegetation, one layer or another is missing from much of the landscape. Bluegrass (sp. *Poa*) is the predominate vegetation, and its short height, flexibility, and shallow rooting depth do not provide good sediment filtration (UW-Extension, 1999).

Surface Watersheds

A surface watershed is the land area where runoff from precipitation drains to water bodies before it can infiltrate into the ground. Surface watersheds with large amounts of steeply sloped land, stream inflows to the lake, and a large percent of impervious surface (buildings, roads, compacted soil) deliver additional surface runoff by averting infiltration into the soil and by funneling water directly to the lake. The surface watersheds for Mirror and Shadow Lakes were determined using the high topographic points around the lakes and evaluating maps showing the networks of natural and man-made inflows that feed or divert water to/from the lakes. By the nature of Mirror and Shadow's location within the city, their surface watersheds both include large amounts of impervious surfaces. According to impervious surface estimates made in 2004, 17.4% of Mirror Lake's surface watershed and 29.3% of Shadow Lake's surface watershed was comprised rooftops, driveways, sidewalks, roads, and other impervious surfaces. These high percentages result in increased runoff, reduced groundwater (that feeds the lakes during dry periods), and impacts the fishery. Although it would be impractical to remove most of these features, there are many practices that can be put in place to handle storm water that would reduce negative impacts to water quality.

Alteration of the natural surface watersheds of both Mirror and Shadow Lake have occurred. Due to increased efficiency of local storm water systems, large quantities of water are diverted away from the lakes. Mirror Lake's surface watershed has been reduced to 34 acres with residential development covering approximately

60% of its watershed. The dominant land uses in Shadow Lake watershed are residential development encompassing approximately 33% of the watershed (Figure 1). The remaining land uses in each watershed are graphed below.

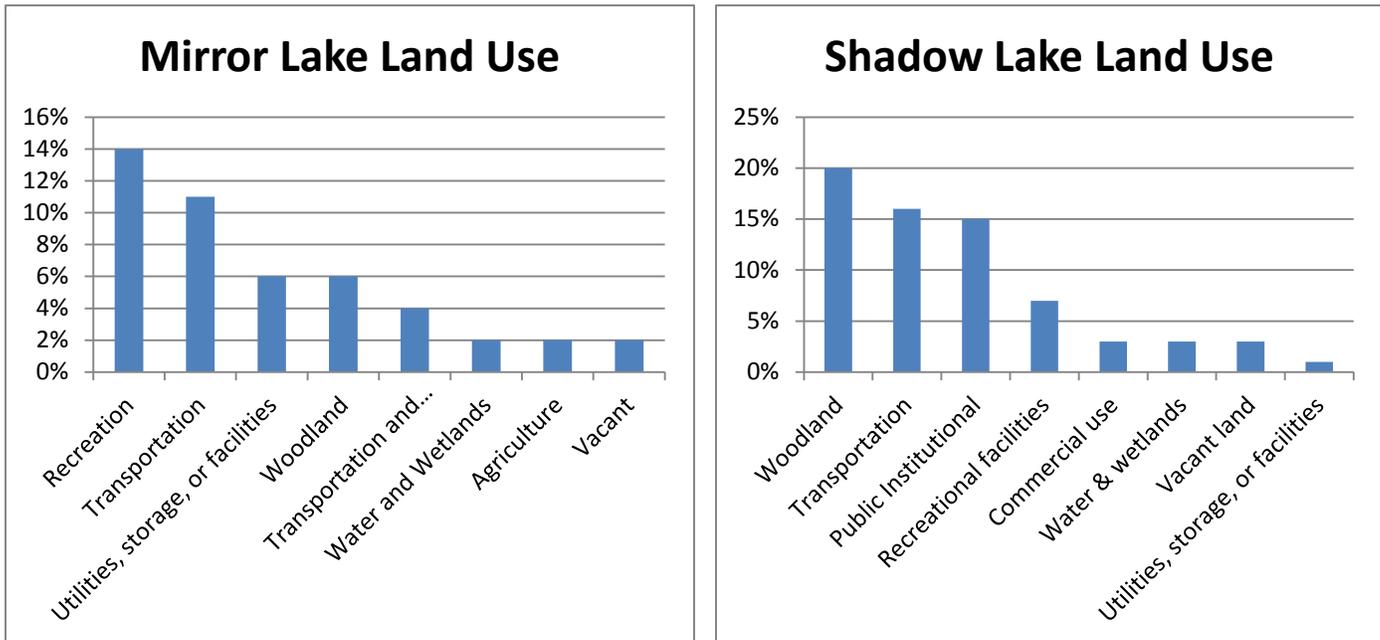


Figure 1. Land uses within the Mirror and Shadow Lakes surface watersheds.

In addition to surface water runoff, three streams/channels deliver or remove surface water to/from Mirror and Shadow Lakes. They include:

- The channel between Mirror Lake to Shadow Lake is located on Mirror Lake’s south/southwest side and flows into Shadow Lake near the swimming beach.
- A large wetland complex drains to Shadow Lake. It enters the lake on its northwest shore. The inflow is a drainage channel that originates 1.5 miles northwest of Shadow Lake where the channel receives drainage from some of Waupaca’s residential streets and housing units.
- The channel from Shadow Lake to the Crystal River is located on the south/southwest shore of Shadow Lake; it transports water from Shadow Lake to the Crystal River. The outflow was constructed as an access point from Shadow Lake to the Crystal River for access by fisherman, canoeists, and other lake users

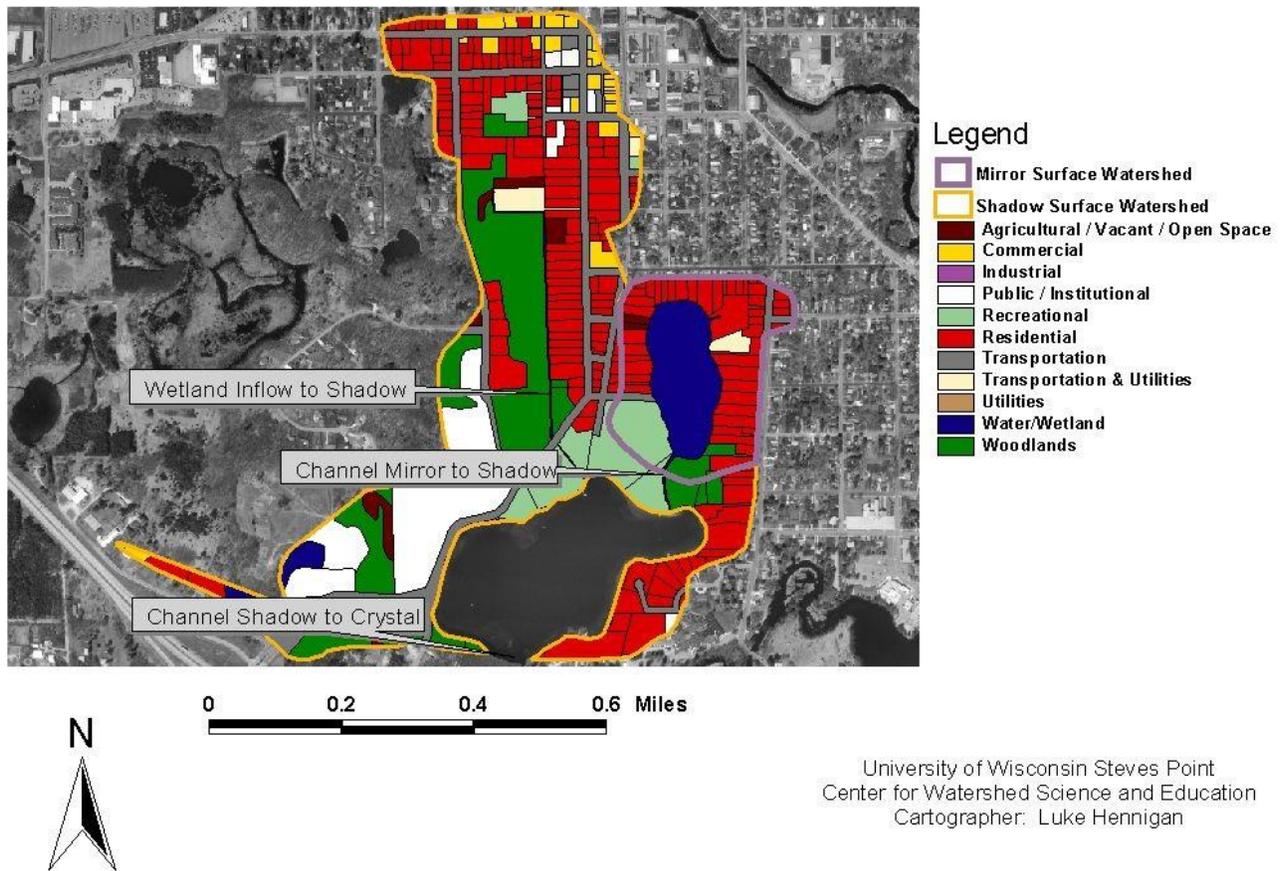


Figure 2. Surface watershed boundaries and land uses. Mirror and Shadow Lakes, Waupaca, WI 2000

Groundwater Watersheds

The groundwater watershed is the area of land where precipitation infiltrates to the groundwater and moves down gradient to the lakes. The groundwater watershed for Mirror and Shadow Lakes extends 4-5 miles west of Waupaca and encompasses approximately 3.4 square miles of land area. Approximately 1/3 of this area discharges to Mirror Lake and 2/3 of the area discharges to Shadow Lake (Figure 2).

The primary land uses in the Mirror and Shadow Lake groundwater watershed are residential which comprises 27% of the watershed and forested which makes up 26%. The balance of the watershed land uses are agricultural or vacant (18%), water or wetlands (12%), commercial development (7%), public or institutional facilities (4%), recreational (2%), transportation (2%), and the remaining 2% is used by industries and utilities (Figure 2).

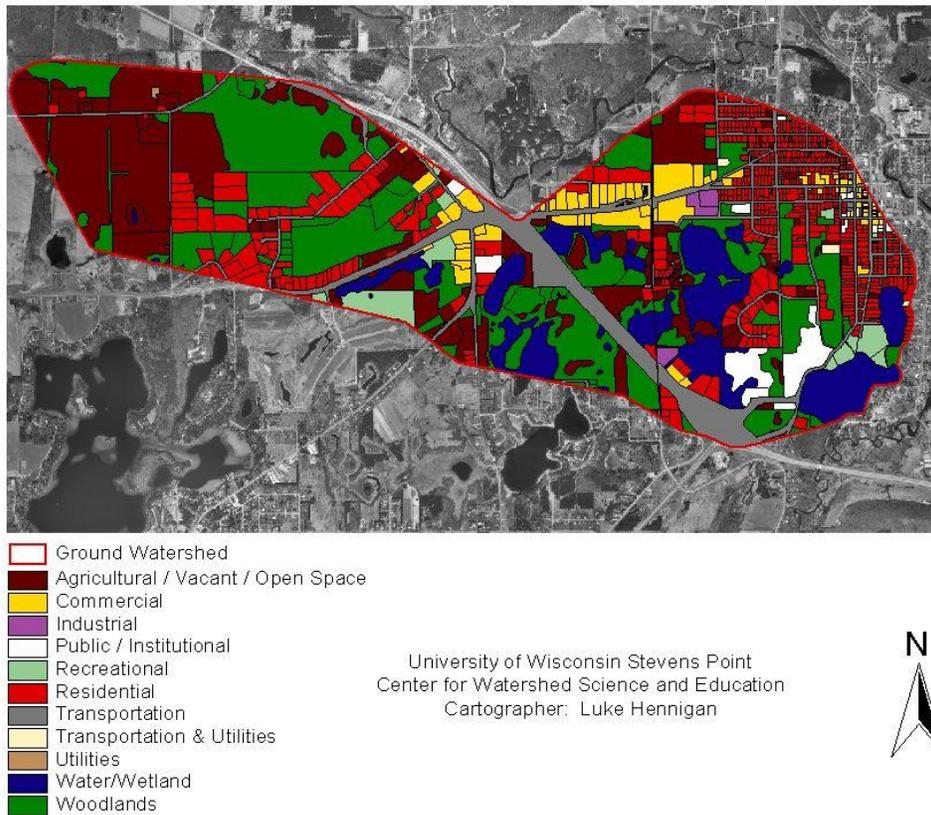


Figure 3. Land use within the Shadow and Mirror Lake groundwater watershed.

Water Quality

When respondents were asked about the water quality in Mirror and Shadow Lakes, most of the people felt the water quality was good.

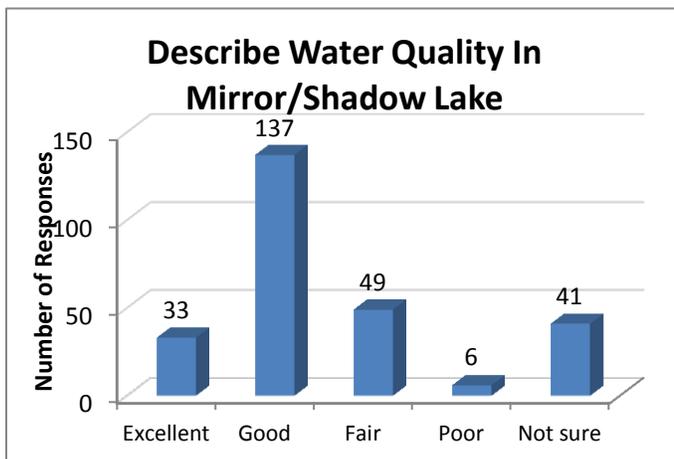


Figure 4. Citizen survey results of perceived water quality in Mirror and Shadow Lakes.

Survey respondents felt that water quality had a major impact on both the economy and their personal enjoyment of the lakes. The majority of people surveyed felt that water quality hasn't changed over the period that they were familiar with the lakes. Sixty-four percent of all respondents weren't sure if there was a difference in water quality between Mirror and Shadow Lakes. Respondents felt that the top causes for a decline in water quality would be excess algae, excess aquatic plants, storm water runoff, fertilizer use, and herbicide use. The perceived causes for a decline in water quality can be used to address if these are actual concerns in the watershed or not and may serve as a guide for educational outreach.

The assessment of water quality in a water body involves a number of measures including temperature, dissolved oxygen, water chemistry, chlorophyll *a*/algae. Each of these measures play a part in Mirror and Shadow Lakes overall water quality. A water quality study was conducted in the lakes by CWSE in 2002/03 and in an effort to develop a long term dataset and watch for changes in quality, citizens from the Friends of Mirror/Shadow Lakes group have continued to monitor the lakes water quality.

Temperatures in Mirror and Shadow Lakes are generally mixed in the late fall and spring and stratified throughout the summer and winter. However, because of its shape and steep sides, Mirror Lake does not always mix from top to bottom in the fall, which would replenish oxygen throughout the lake. When mixing doesn't occur and there is heavy snowpack throughout the winter, much of the water can become devoid of oxygen. To ensure sufficient oxygen is available for fish, the City operates an aerator beginning in early October until ice in, early December, and then again for two weeks after ice out in the spring (see Appendix A for details). In Mirror Lake, the measured dissolved oxygen was usually plentiful in the upper 20 feet of the Mirror Lake, except in November, when the dissolved oxygen dips slightly below 5 mg/L. The dissolved oxygen in Shadow Lake was always plentiful in the upper fifteen feet. Below those depths, during some times of the year water lacks enough oxygen to support some biota.

Water clarity is a measure of how deep light can penetrate the water. It is an aesthetic measure and is related to the depth that rooted aquatic plants can grow. Water clarity can be affected by sediment, algae, and color in water. Clarity measurements in Mirror Lake ranged from five to twelve feet. Clarity measurements in Shadow Lake ranged from five to fifteen feet. The spring and fall months had the best water clarity in both lakes and the summer had the poorest. Fluctuations in water clarity throughout the summer are normal as algae and aquatic plant populations and sedimentation increase and decrease. Changes in water quality are best determined with long-term records; these measurements should be continued.

Chlorophyll *a* is a measure of algae in Mirror and Shadow Lakes. In 2002/03 chlorophyll *a* concentrations in Mirror Lake ranged from 1.9 to 6.6 mg/L. Levels over 5 mg/L are considered to be elevated. The highest readings in Mirror Lake were collected in June 2001 and July 2003. In 2002 and 2003 Chlorophyll *a* concentrations in Shadow Lake ranged from 3.7 to 9.1 mg/L. The highest levels in Shadow Lake were collected in July 2003 and June 2003.

Nutrients (nitrogen and phosphorus) are important measures of water quality in lakes and rivers because they are used for growth by algae and aquatic plants. In Mirror and Shadow Lakes, both the phosphorus and nitrogen concentrations fluctuated throughout the year. In Mirror Lake, the phosphorus concentrations generally, exceeded the phosphorus criteria set by the Wisconsin DNR, while the phosphorus concentrations in Shadow Lake generally remained below the WDNR criteria. The nitrogen concentrations in both Mirror and Shadow Lakes were elevated.

Phosphorus is an element that is essential to most living organisms including plants. Sources of phosphorus can include naturally occurring phosphorus in soils, wetlands, and small amounts in groundwater. Sources from human influence include soil erosion, agricultural and residential runoff, septic systems, and animal waste. Several studies conducted by CWSE indicated that elevated concentrations of phosphorus are entering the groundwater at the north end of Mirror Lake. There are many potential sources of this phosphorus throughout the city, so despite several attempts to identify the source(s) none were confirmed.

In Mirror and Shadow Lakes, the aquatic plant and algal growth is most responsive to phosphorus due to its relative limited supply with respect to other nutrients necessary for growth. Increases of small amounts of phosphorus can result in increased abundance of aquatic plants and algae. Median total phosphorus (TP) concentrations for Mirror Lake in spring/fall have ranged from historically high levels of 81 ug/L in October 2006 to recent concentrations of 15 ug/L in April 2010 and 16 ug/L in November 2010. In Mirror Lake, the average overturn phosphorus concentration from 2001 to 2010 was 30 ug/L. Median total phosphorus (TP) concentrations for Shadow Lake in spring/fall have ranged from historically high concentrations of 36 ug/L in November 2005 to recent levels of 9 ug/L in April 2010 and 21 ug/L in November 2010. The average overturn phosphorus concentration from 2002 to 2010 was 25.1 ug/L. Phosphorus concentrations measured during the fall and spring turnover are representative of concentrations throughout the entire water column, as the water is mixed from top to bottom. Concentrations during the summer can change from the surface of the water to the bottom and from week to week depending on uptake and release from algae and aquatic plants.

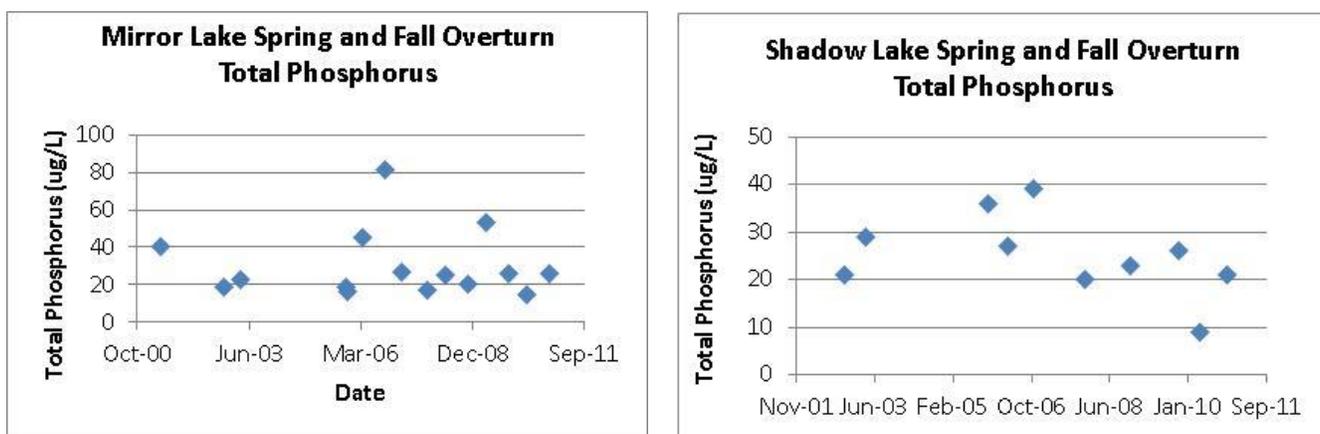


Figure 5. Spring and fall overturn total phosphorus (ug/L) in Mirror and Shadow Lakes.

Summer phosphorus data is not available for Mirror or Shadow Lakes after 2004. The average summer total phosphorus concentration (2001-2004) in Mirror Lake was 15 ug/L. The state’s phosphorus criteria for seepage lakes is a summer average of 20 ug/L; average summer concentrations at or above this value would result in noticeably degraded water quality. The average summer total phosphorus concentration (2002-2003) in Shadow Lake was 15.5 ug/L. The state’s phosphorus criteria value for drainage lakes is a summer average of 30 ug/L. Total phosphorus should continue to be monitored multiple times per year in both Mirror and Shadow Lakes to be sure that any changes in phosphorus concentrations can be observed and addressed prior to noticeable changes in algal and aquatic plant communities.

Earlier studies have shown high phosphorus groundwater entering Mirror Lake, especially on the north end where much of the groundwater inflow occurs. The 2005 study conducted by UWSP estimated that 90% of the phosphorus in Mirror Lake enters the lake via groundwater. Despite efforts to pin point the source of this high phosphorus groundwater, no source has been identified making it difficult to recommend a control.

Managing phosphorus in the Mirror and Shadow Lakes watersheds are key to protecting the lakes. Positive land management practices and land uses can result in good water quality in the lakes. Phosphorus inputs to the lakes can be controlled through the use of many different best management practices (BMP’s) that minimize the

movement of runoff, nutrients, and pesticides to the lakes. Agricultural BMPs that should be used throughout the watershed include the development of water quality-based nutrient management plans for agricultural land, only applying phosphorus and nitrogen from fertilizer or manure based on soil tests and for specific crops, providing cover on the landscape and/or appropriate mitigation when open soils are necessary during construction or cropping, use of cover crops, properly storing manure, and manure application only when the ground is not frozen. Similar concepts should be applied to the residential and urban areas within the watershed; following the phosphorus ban rules by only applying fertilizer only if soil tests indicate it is necessary, controlling sediment movement during construction or when soils are exposed, reducing runoff from impervious areas by installing rain barrels, rain gardens, maximizing native vegetation and minimizing the amount of turf in the landscape, etc.

Some of the near shore land management practices that can help to reduce the inputs of phosphorus to Mirror and Shadow Lakes include maximizing native vegetation (trees, bushes, and native grasses/flowers), eliminating the use of fertilizer, minimizing runoff/increasing infiltration, and minimizing and securing exposed soil. Much of the runoff originating in Mirror Lake’s watershed has been diverted away from the lake via storm sewers. This means that good land management practices by shoreland owners should have a positive impact on Mirror Lake. Practices should include the control of runoff to the lake (using rain barrels or rain gardens) in combination with erosion control practices and healthy shoreland vegetative buffers that include combinations of trees, shrubs, and most important, native grasses and flowers. Improvement of water quality in Mirror and Shadow Lakes can be maximized with thoughtful land use planning throughout the watershed. This includes diverting runoff to areas where it can infiltrate rather than directing it to the lakes, limiting withdrawal of groundwater, and controlling runoff, nutrient, and chemical inputs from new and existing developments and agriculture.

Our Vision:

Mirror and Shadow Lakes will retain their scenic beauty. The water quality of Mirror and Shadow Lakes will support a healthy lake ecosystem that provides recreational opportunities.

Goal 1: The water quality in Mirror and Shadow lakes will remain below the state phosphorus criteria for seepage (20 ug/L) and drainage lakes (30 ug/L) and there will be sufficient oxygen (DO) to support the fisheries in Mirror and Shadow Lakes.

Objective 1.1: Ensure that water quality goals are achieved and detect degrading water quality through routine monitoring.

Action	Lead person/group	Start/end dates	Resources	Progress
FOMSL will continue to monitor the lakes at least once a month (temperature and D.O. measurements) starting in October until turnover and at least once during	FOMSL	Ongoing	WDNR UWSP CWSE	

the winter and submit to WDNR SWIMS.				
If D.O. levels are below 5 mg/L in the upper 15 ft of Mirror Lake contact WDNR immediately.	FOMSL	As needed	WDNR	
Continue to conduct spring and fall overturn monitoring in Mirror Lake and in fall for Shadow Lake for conductivity, total phosphorus, soluble reactive phosphorus, ammonium, nitrate, total kjeldahl nitrogen, and chloride and submit data to WDNR SWIMS.	FOMSL	Ongoing	WDNR UWSP CWSE	
Continue to monitor water clarity from June to early September and collect samples for total phosphorus and chlorophyll a through the WDNR's CLMN program.	FOMSL	On going		

Active (Being worked on)
 Inactive (Not being worked on)
 Completed

Objective 1.2: Minimize impacts from properties that are near shore by controlling runoff, increasing infiltration, and maintaining vegetated shorelands. This will be accomplished by restoring the buffer on those properties with 5 ft. or less of buffer. Around Mirror Lake, we will restore 3% of vegetative buffer over ten years (2022). Around Shadow Lake, 20% of the target area is in South Park as addressed in the South Park Master Plan. The target for complete implementation of the Master Plan is within five years (2017). On the privately owned properties we will restore 3% over ten years (2022).

Action	Lead person/group	Start/end dates	Resources	Progress
Work with the city to review the shoreland zoning ordinance to protect in-tact shorelands and reduce shoreland runoff.	FOMSL City of Waupaca		UWSP-Ctr for Land Use Ed Waupaca LWCD	
Minimize erosion around the lakes.	FOMSL		Waupaca LWCD	
Work to minimize impacts from steep slopes.	FOMSL		Waupaca LWCD	
Control runoff by encouraging the use of rain barrels and rain gardens.	FOMSL City of Waupaca		Waupaca LWCD	
Provide information about the current building setbacks.	FOMSL City of Waupaca		City of Waupaca	

Active (Being worked on)
 Inactive (Not being worked on)
 Completed

Shorelands

Shorelands play an important role in a lakes ecosystem. Many creatures rely on shorelands for all or part of their life cycles as a source of food, a place to sleep or hide from predators, and to raise their young. Shoreland vegetation helps prevent shoreline erosion by buffering lake waves and slowing down runoff washing towards the lake from the land. Native flowers and grasses help by filtering pollutants flowing towards the lake and by using nutrients that might otherwise be consumed by algae and aquatic plants. Near shore aquatic plants use nutrients that might otherwise grow algae and the plants help to break up waves which in-turn reduces shoreline erosion. In addition, natural shorelines can also make it harder for aquatic invasive species to establish themselves in a lake, muffle noise from watercraft, and preserve privacy and natural scenic beauty.

Vegetated shorelines are comprised of three different categories of vegetation; trees, shrubs, and tall native forbs/grasses. Ideally, all three types of vegetation should be present within the shoreline buffer or 35 feet inland from the water's edge, in order to be healthy and provide for better water quality and habitat.

Trees provide a canopy over the shoreland. This canopy slows precipitation as it falls to the ground, reducing its chance of causing runoff and erosion. Roots hold soil and help stabilize slopes by trapping and using precipitation that would otherwise run off. Around Mirror Lake, 13.6% of the shore lacks trees. Seven percent of the shore has trees present from 1 to 5 feet inland from the water's edge, eight percent has trees present 5-15 feet inland from the water, and 44% has trees present 15-35 feet from the water. Around Shadow Lake, only 4% of the shore lacks trees. Five percent of the shore has trees 1-5 feet inland from the water's edge, 34% has trees present at least 5 to 15 feet inland from the water, and 31% has trees present at least 15 to 35 feet inland from the water.

Shrubs provide some of the same benefits as trees to shorelands. Shrubs also offer habitat for wildlife and privacy for humans. Around Mirror Lake, eight percent of the shore lacks shrubs. Twenty-nine percent of the shores have shrubs 1-5 feet inland from the water, five percent have shrubs 5-15 inland from the water, and 55% of the shore has shrubs 15-35 feet inland from the water. Around Shadow Lake, 27% of the shores lack shrubs. Nine percent of the shores have shrubs present 1-5 feet inland from the water's edge, 40% of the shore has shrubs 5-15 feet inland from the water, and nine percent of the shore has shrubs 15-35 feet from the water.

Native grasses and forbs (flowers and herbs) are perhaps the most important layer of vegetation on the shoreline. They help to slow runoff, filter sediments, and utilize excess nutrients that could otherwise cause water quality problems. Forbs, along with trees and shrubs, also help prevent shores from erosion and provide important habitat for many creatures including frogs and turtles. This layer also reduces shoreland access to geese. During the survey, this layer was identified as vegetation ranging in height from 0.5-3 feet. Around Mirror Lake, 16% of the shore lacks a native forb/grass layer. Twenty percent of the shore has native forb/grasses present 1-5 feet inland from the water's edge, eight percent of the shore has native forb/grasses 5-15 feet inland from the water, 45% of the shore has native forb/grasses 15-35 feet inland from the water, and 11% of the shore has a forbs layer greater than 35 feet inland. Around Shadow Lake 15% of the shoreline lacks a tall grass/forbs layer; 26% percent of the shore has taller grass/forbs 1-5 feet inland from the water's edge, 55% of the shore has tall grass/forbs 5-15 feet inland from the water, and only 4% of the shore has forbs 15-35 feet inland. The distance of shoreline in each of these categories is displayed in Table 1 and the map of the vegetation that is 0.5-3 foot high is displayed in Figure 10.

Mowed lawn within the buffer zone often acts just as bare ground would. Lawn grass has shallow roots that don't help water to easily soak into the ground and during heavy precipitation events the grass blades can fold over flat and allow runoff to enter the lake with little filtration of sediment and other pollutants. Mowed lawn doesn't provide habitat for many creatures that are typically associated with lakes such as frogs and turtles. It encourages geese and other grazing animals by providing food and its open-scape is an invitation to geese as they are weary of going on shore where tall vegetation prevents them from seeing potential predators. Around Mirror Lake, 20% of the shore is mowed within the shoreland buffer and around Shadow Lake, 14% of the shore within the shoreland buffer is mowed.

Bare ground around a lake can be detrimental to the water quality. As precipitation hits bare ground it can pick up pollutants, debris, and sediment that can be carried to the lake and in turn, causing increased sedimentation that can cover plants and spawning beds and increase temperatures that can affect aquatic organisms such as fish. Mirror Lake had no barren ground on its shores and 12% of Shadow Lake shore had barren ground.

Table 1. Length of shoreline around Mirror and Shadow Lakes by depth of shoreland vegetation measured inland from the water's edge.

Grass and forb (0.5-3ft) vegetative buffer distance inland from shore	Mirror Lake shoreline length (ft)	Shadow Lake shoreline length (ft)
<1	693	940
1-5	861	1639
5-15	327	3424
15-35	1935	272
>35	471	0

Over the last few years shoreland residents and the City of Waupaca have taken steps to reduce the disturbance along stretches of the shoreline through native vegetation rain gardens and by encouraging vegetated buffers along the lakes. This shows good stewardship and efforts should be made to continue these improvements which will lead to better water quality and habitat.

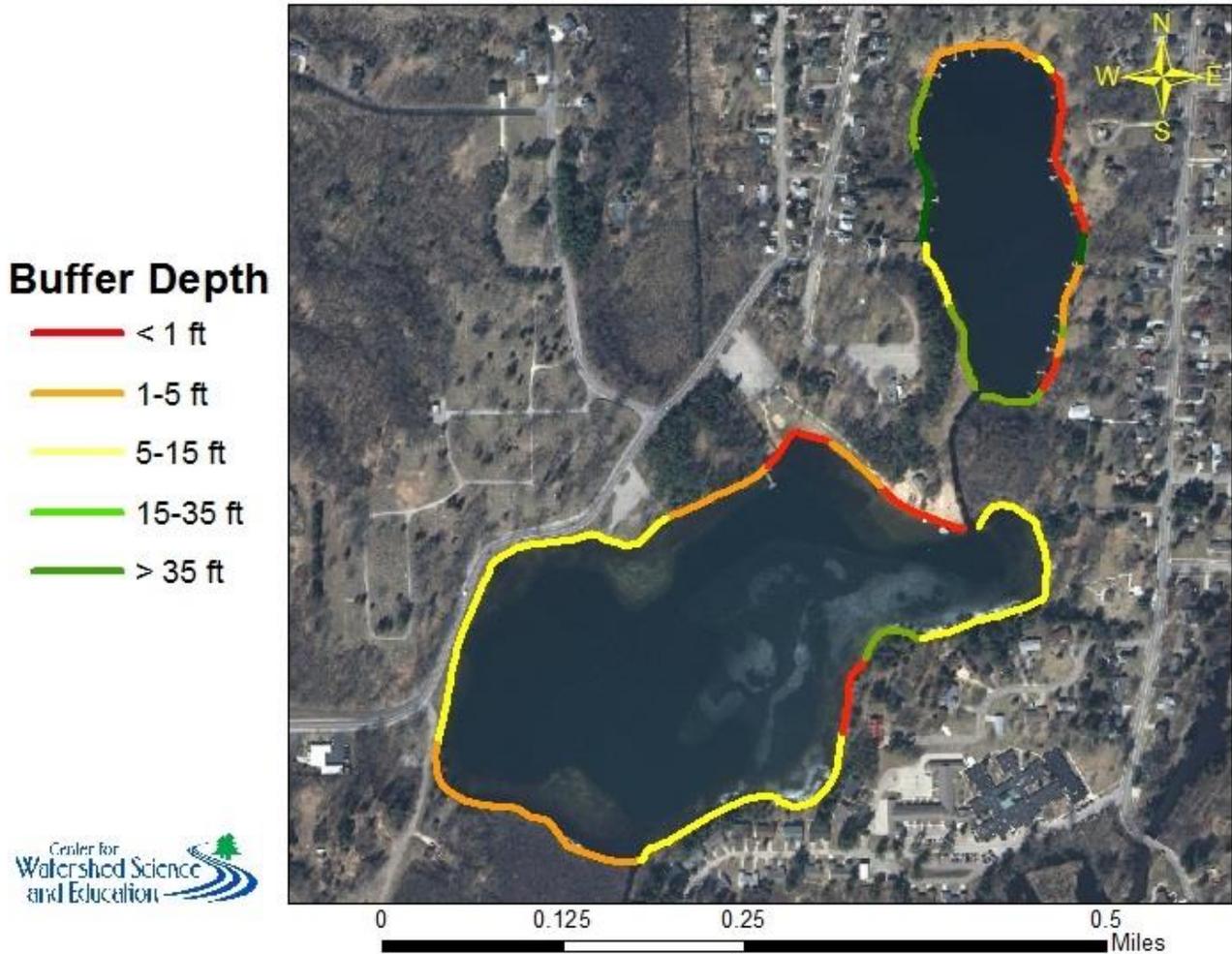
There have been concerns voiced about the large numbers of Canada Geese present on Mirror and Shadow Lakes. Geese find ideal habitat on the manicured lawns and parks around the lakes. These mowed areas provide excellent spring, summer, and fall forage for geese, as well as safe sites for geese because there are few predators present and those that are can be seen easily. The key to controlling the damage is to make the problem site less attractive to geese. One of the easiest and most effective methods to do this is through landscape modification. Landscape modification deters geese by restricting the ability of geese to move between water and the lawn without flying, by making the site appear to be potentially unsafe for geese, and by reducing the nutritional value provided by a lawn. Ways to restrict the movement of geese between the water and the shore and make the shoreline appear to be unsafe can be accomplished by planting shrubs, hedges, and/or tall native vegetation along the shoreline. Ways to reduce the nutritional value of a lawn include mowing and fertilizing the lawn as infrequently as possible or by planting a less palatable grass species. These landscape modifications can also have positive impacts on water quality and shorelines around the lake.

Surfaces such as roofs, driveways, roads, patios, and compacted soil increase the amount of runoff moving across the landscape towards Mirror and Shadow Lakes. Runoff that enters the lakes can carry a variety of pollutants into the water. Some of the negative impacts in the lakes due to additional runoff may include: increased nutrients (such as phosphorus), which can cause algae blooms and excessive plant growth, and increased amounts or changes in the type of sediment. This in turn can lead to cloudy or turbid water, sediment burying fish spawning areas and other critical habitat, and sediment transporting additional contaminants such as bacteria, debris, metals, and pesticides. More than 8-12% of unabated impervious surfaces near a lake can have detrimental effects on the fish species that can survive and reproduce in the lake.

According to the citizen survey, 40 of the 346 respondents owned shoreline property. Fourteen of those respondents who owned shoreline property indicated their shorelines were undeveloped or natural. Respondents indicated the depth of their shoreline buffers around Mirror or Shadow Lakes varied greatly. Only four respondents indicated their buffers were more than 35 feet in depth and only nine respondents answered whether they would consider changing their shoreline to include vegetation, with eight respondents saying yes and one saying no. Of the 42 respondents who answered, 88% were aware of Waupaca's shoreland ordinance, 12% were not.

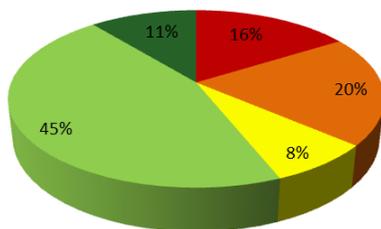
Figure 6. Survey of Mirror and Shadow shoreland showing vegetation ranging in height from 0.5-3 feet (an enlarged map is displayed in the Appendix).

Mirror and Shadow Lake Shoreline Survey August 2011



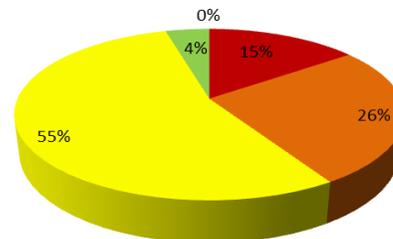
Mirror Lake vegetative buffer - distance inland from shore (ft)

■ <1 ■ 1-5 ■ 5-15 ■ 15-35 ■ >35



Shadow Lake vegetative buffer - distance inland from shore (ft)

■ <1 ■ 1-5 ■ 5-15 ■ 15-35 ■ >35



Our Vision:

Mirror and Shadow Lakes will have healthy shorelands to help protect water quality, habitat, and healthy ecosystems that allow for access and enhance the visual enjoyment of shoreland landowners and users, and discourage waterfowl access. Healthy shoreland vegetation will be protected and disturbed shoreland vegetation will be restored.

Goal 8: All shorelands (adjacent to the lake) around Mirror and Shadow Lakes will be vegetated with a 30 foot deep buffer while allowing for an access corridor of 30 foot in width for each parcel.

Around Mirror Lake, we will restore 3% of vegetative buffer over 10 years. Around Shadow Lake, 20% of the target area is in South Park, the need to improve which is addressed in the South Park Master Plan. The target for complete implementation of the Master Plan is within five years. On the privately owned properties we will restore 3% over 10 years.

Objective 8.1: Shore landowners around Mirror and Shadow Lakes will understand why the shore lands are important to the lake’s ecosystem and their roles in protecting these areas. They will make informed land management decisions that minimize their impacts to water quality and habitat.

Actions	Lead person/group	Start/end dates	Resources	Progress
Provide information to landowners on how to prevent soil erosion on steep shorelines around the lake.	FOMSL	Ongoing	UWEX Lakes WDNR	
Provide information about ways to protect and restore shoreland vegetation and why it is important.	FOMSL City of Waupaca	Ongoing	Waupaca LWCD UWEX Lakes	
Provide information on how to control stormwater on your own property.	FOMSL City of Waupaca	Ongoing	Waupaca LWCD UWEX Lakes	
Re-assess shoreline vegetation survey at least every five years.	FOMSL	2016	WDNR Consultant	

Active (Being worked on)
 Inactive (Not being worked on)
 ★ Completed

Objective 8.2: To the greatest extent possible, reduce the amount of storm water draining to Mirror and Shadow Lakes.

Actions	Lead person/group	Start/end dates	Resources	Progress
Support the use of bioretention ponds and swales to infiltrate water stormwater instead of it running off.	City of Waupaca FOMSL		Waupaca LWCD WI Ext Lakes	
Work to address and reduce the erosion and runoff coming down the hill by abandoned well #1 on the west side of Mirror Lake.	City of Waupaca		Waupaca LWCD WI Ext Lakes	

Work with the city to reduce erosion and runoff at the beach and in the city parks.	City of Waupaca FOMSL		Waupaca LWCD WI Ext Lakes	
Work to re-engineer the channel and restore the wetland upstream of Shadow Lake to retain sediment in the wetland.	City of Waupaca		Waupaca LWCD	
Re-work south side channel to catch runoff from parking areas, and possibly remove sediment as needed.				

Active (Being worked on)
 Inactive (Not being worked on)
 Completed

Objective 8.3: Protect undeveloped and vegetated areas around Mirror and Shadow Lakes.

Actions	Lead person/group	Start/end dates	Resources	Progress
Provide information to landowners and park managers about keeping vegetated buffers intact.	FOMSL City of Waupaca		Waupaca LWCD WI Ext Lakes	
Encourage the city to keep the existing buffers and increase them where feasible.	FOMSL City of Waupaca			
Encourage the city to enhance the shoreland zoning ordinance for Mirror and Shadow Lakes so that it addresses vegetative shoreland buffers	FOMSL		City of Waupaca Waupaca LWCD WI Ext Lakes	
Control purple loosestrife along the shorelines of Mirror and Shadow Lakes and adjacent areas	FOMSL	Ongoing	WDNR Local youth groups	

Active (Being worked on)
 Inactive (Not being worked on)
 Completed

Objective 8.4: Minimize impacts from properties that are near shore by controlling runoff, increasing infiltration, and maintaining vegetated shorelands.

Action	Lead person/group	Start/end dates	Resources	Progress
Work with the city to review the shoreland zoning ordinance to protect in-tact shorelands and reduce shoreland runoff.	FOMSL City of Waupaca		UWSP-Ctr for Land Use Ed Waupaca LWCD	
Minimize erosion around the lakes	FOMSL		Waupaca LWCD	
Work to minimize impacts from steep slopes.	FOMSL		Waupaca LWCD	
Control runoff by encouraging the use of rain barrels and rain gardens.	FOMSL City of Waupaca		Waupaca LWCD	
Provide information about the current building setbacks.	FOMSL City of Waupaca		City of Waupaca	

Active (Being worked on)
 Inactive (Not being worked on)
 Completed

Goal 9: All shorelands (adjacent to the lake) around Mirror and Shadow Lakes will be conducive to limit geese populations on the lakes.

Objective 9.1: Reduce and control the resident goose population

Actions	Lead person/group	Start/end dates	Resources	Progress
Provide information to shoreland owners about the direct relationship between mowed lawns and increased goose populations.	FOMSL	Ongoing	UWEX Lakes	
Encourage vegetative buffers to keep geese of yards. Track the progress in implementation.	FOMSL	Ongoing	WDNR	
Post signage prohibiting feeding wildlife in the parks.	City of Waupaca		FOMSL	
Use harassment methods to make the geese wary.	FOMSL		FOMSL	
Decrease nesting success of geese.	FOMSL		WDNR	

Active (Being worked on)
 Inactive (Not being worked on)
 ★ Completed

Aquatic Plants and Aquatic Invasive Species

A healthy aquatic plant community is comprised of a healthy diversity of native plant species. Aquatic plants such as lily pads play many important roles in aquatic ecosystems including providing habitat for aquatic and semi-aquatic organisms, food for fish, waterfowl, and other animals; use of nutrients that would otherwise be used by algae, and modifying/cooling water temperatures on hot days. It is important to maintain intact aquatic plant communities in the lakes. While it is important to maintain recreational opportunities on the lakes, a plan for the management of aquatic plants should be developed prior to any mechanized removal of plants.

According to the aquatic plant survey conducted in Mirror and Shadow Lakes in the summer of 2011, there were 17 species of aquatic plants in Mirror Lake and 25 species in Shadow Lake. Botanists and plant ecologists use a quantitative measure called the *Floristic Quality Index* (FQI) to express the "quality" of an aquatic plant community. This standardized tool replaces subjective assessments to provide a useful number for comparing various plant communities. FQI is not a stand-alone value, but is used together with other assessments to evaluate the quality of a lake community. The basis of the FQI calculation is the coefficient of conservatism (C), a value given to each species. Each native species has been assigned a value from 0 to 10, which represents the likelihood that this species will occur in relatively unaltered waterscapes. Aquatic plant species with high C-values are relatively specialized in their requirements, and thus are found in more limited habitats. The FQI for Mirror Lake is 19, with the mean C-value for plants species of 6. Coontail (*Ceratophyllum demersum*) was the species with the lowest C-value of 3 and yellow pond lily (*Nuphar advena*) had the highest C-value of 8. The floristic quality index for Shadow Lake is 23, with the mean C-value for plants species of 6. Coontail (*Ceratophyllum demersum*) and common waterweed (*Elodea canadensis*) were the species with the lowest C-values of 3 and Muskgrasses (*Chara*), slender waterweed (*Elodea nuttallii*), Nitella (*Nitella*), and common waterweed (*Utricularia vulgaris*) all had the highest C-values of 7. Statewide the average FQI value is 22.2 and the average C-value is 6.0. Mirror Lake has a slightly lower FQI than the state average and the same C-value as the state average. Shadow Lake has a slightly higher FQI value than the state average and a slightly lower C-value than the state average.

During the summer of 2011, the potentially aggressive invasive aquatic plant Eurasian water-milfoil (EWM) was found in Shadow Lake. The Friends of Mirror and Shadow Lakes partnered with Golden Sands RC&D to monitor for invasive species in the lake and at the boat landing. Because of the pre-established relationship the Friends of Mirror and Shadow Lake, Golden Sands RC&D, and the City of Waupaca were able to quickly mobilize efforts to chemically treat the plants and follow up with monitoring. At the end of the 2011 growing season, no additional EWM had been found in Shadow Lakes. Citizens and Golden Sands RC&D will continue to monitor for EWM on both lakes and will take measures to eradicate any EWM that is found.

During the citizen survey, when asked about the abundance of aquatic plants in Mirror and Shadow Lakes, respondent's answers varied. July and August were identified as the months with dense and choked plant growth, typical for Wisconsin Lakes. Fifty-four percent of respondents indicated that they never used a boat on the lakes, and while the majority of respondents indicated that they cleaned their equipment all the time there was still one percent that indicated they never cleaned their boats or equipment and the one percent are still able to spread invasive species.

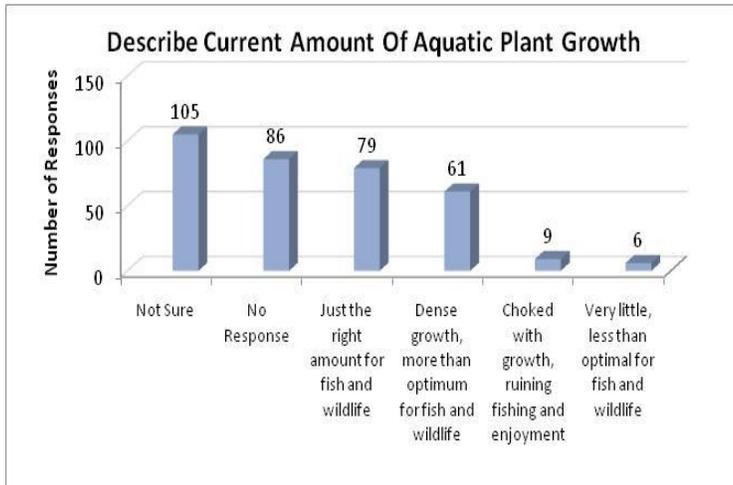


Figure 7. Citizen survey results of perceived aquatic plant growth in Mirror and Shadow Lakes.

Our Vision: Mirror and Shadow Lakes will have a healthy diverse native aquatic plant community. Aquatic invasive species will be identified quickly, and measures to eradicate/control them will be implemented as soon as possible.

Goal 2: Local citizens and lake users will be knowledgeable about aquatic plant communities in Mirror and Shadow Lakes and take appropriate actions.

Objective 2.1: Local citizens and lake users will have opportunities to learn about the aquatic plant communities in Mirror and Shadow Lakes.

Actions	Lead person/group	Start/end dates	Resources	Progress
Host identification workshop for native and invasive species.	FOMSL		Golden Sands RC&D WDNR	
Share native plant info on website.	FOMSL		WDNR City of Waupaca	
Press examples of actual plants from Mirror and Shadow Lakes.	FOMSL		Golden Sands RC&D	
Address possible recreation concerns with the aquatic plant community.	FOMSL		WDNR	
Routinely observe the channel between the lakes and take action if plants become a nuisance.	FOMSL		WDNR	

Goal 3: New aquatic invasive species (AIS) will be prevented from entering Mirror and Shadow Lakes.

Objective 3.1: Lake-users will be informed about the prevention of AIS.

Action	Lead person/group	Start/end dates	Resources	Progress
Create and implement an annual strategy for boat launch monitoring.	FOMSL City of Waupaca	Ongoing	Golden Sands RC&D	
Inform residents that volunteer hours leverage grant funding.	FOMSL	As needed	WDNR	
Include interested volunteers from Bethany Homes.	FOMSL			
Explore working with the Chain of Lakes to prevent the transfer of zebra mussels to Mirror and Shadow Lakes.	FOMSL		WI Extension Lakes WDNR Golden Sands RC&D	
Send a postcard to shoreland residents to solicit volunteer hours to monitor the boat launch and/or contribute to hire someone in their place.	FOMSL	Annual in spring		
Use grant money and donations to hire personnel to monitor at the boat launch. Boat launch monitoring should be focused on busy times (i.e. weekends and holidays).	FOMSL City of Waupaca			
Continue AIS signage at all boat landings.	City of Waupaca Parks			
Explore installing a boat cleaning sign at the boat landings.	City of Waupaca			
Present information about AIS to middle school classes and possibly during school workdays.	FOMSL		City Council Golden Sands RC&D	
Explore Park and Rec program or other educational program on invasive species science/lake study.	FOMSL City of Waupaca		UWSP EE Center WDNR	

Active (Being worked on)
 Inactive (Not being worked on)
 ★ Completed

Objective 3.2: Presence of aquatic invasive species will be identified early in Mirror and Shadow Lakes and necessary steps will be taken for eradication.

Action	Lead person/group	Start/end dates	Resources	Progress
Educate all riparian residents how to identify AIS in the lakes annually through identification workshops, informational materials, boat tours, etc.	FOMSL	Ongoing	WDNR WI Extension Lakes Golden Sands RC&D	

At least one riparian landowner (s) will be trained in identification, survey the lake annually for AIS, and can answer questions regarding identification of AIS.	FOMSL	Annually	WDNR Golden Sands RC&D	
Post the contact information about who can identify AIS on the FOMSL website.	FOMSL		City of Waupaca	
Share AIS info on the City website: location of invasives, pictures of common AIS. Website content and address will be advertised in the newsletter.	FOMSL		City of Waupaca WDNR WI Extension Lakes	
Update AIS rapid response plan annually and post on the website.	FOMSL		City of Waupaca	
Develop a partnership with Golden Sands RC&D to help fill gaps in boat landing monitoring and surveying .	FOMSL Golden Sands RC&D	2011	WDNR City of Waupaca	

Active (Being worked on)
 Inactive (Not being worked on)
 Completed

Objective 3.3: Rapid response plan will provide guidance to individuals on monitoring, identification, and dissemination of information regarding AIS in Mirror and Shadow Lakes

Action	Lead person/group	Start/end dates	Resources	Progress
Follow recommendations outlined in the Mirror and Shadow Lakes Rapid Response Plan.	FOMSL City of Waupaca	Ongoing		
Annually update the rapid response plan with any necessary changes.	FOMSL City of Waupaca	Annually		

Active (Being worked on)
 Inactive (Not being worked on)
 Completed

Goal 4: Manage the current aquatic invasive species present in Mirror and Shadow Lakes to prevent them from spreading.

Objective 4.1: Manage the aquatic invasive species in Mirror and Shadow Lakes

Action	Lead person/group	Start/end dates	Resources	Progress
Continue to survey EWM and CLP annually.	FOMSL		WDNR Golden Sands RC&D	
Treat EWM as needed.	FOMSL		WDNR Golden Sands RC&D	
If EWM persists for more than 2 years, create an aquatic plant management plan for Mirror and Shadow Lakes.	FOMSL City of Waupaca		WDNR Golden Sands RC&D	
Hand-pull CLP as soon as the turions have formed on the plants.	FOMSL		WDNR Golden Sands RC&D	

Active (Being worked on)
 Inactive (Not being worked on)
 Completed

Fisheries in Mirror and Shadow Lakes

Healthy lake ecosystems are valuable natural resources for all. A sustainable fishery is a sign of the health of the lake's ecosystem. This means the needs of the fish are met with little or no additional inputs or efforts. This balance can be achieved by ensuring there is sufficient near-shore woody habitat for fish and their food, aquatic plants for food, cover, and oxygen; and fishing rules designed to keep populations in balance. In the case of Mirror Lake, oxygen addition may be required in the winter to prevent fish kills during years that the lake does not over turn in the fall and when there is heavy snow cover.

The fisheries in Mirror and Shadow Lakes have historically been managed as a bass-bluegill fishery. Mirror Lake also receives an annual stocking of trout by the WDNR. Routine fish surveys have been conducted by the WDNR on both lakes during 1965, 1970, 1973, 1980, 2004, and 2008. In 1971, both Mirror and Shadow Lakes received a large chemical treatment to eradicate carp.

According to the results of the most recent fish surveys conducted in Mirror and Shadow Lakes, the fish community is relatively typical for headwater drainage lakes. Largemouth bass exhibited moderate to high abundance and good size. Bluegills exhibited moderate abundance, poor size structure, and slow growth. According to the WDNR fishery biologist, this may be due in part to overharvest of larger parental male bluegills.

Suggested management actions include maintaining largemouth bass and northern pike populations, decreasing bluegill abundance to improve size structure, maintain the trout stocking, and maintain native aquatic plants and enhance shallow woody habitat necessary for a healthy fishery.

When citizens were asked if they ice fished or open-water fished, the responses indicated that both lakes were used for fishing year-round. The respondents felt that the quality of fishing in Mirror and Shadow Lakes could be improved. Respondents were pretty evenly split when it came to the perceived change in fishing quality over time, except the two percent that indicated fishing quality had improved. The fish species most frequently caught was bluegill followed by largemouth bass, crappie, and pumpkinseeds. The top perceived causes for the decline in fishing quality were excess aquatic plants, excess algae, fertilizer use, storm water runoff, herbicide use, and heavy recreational use.

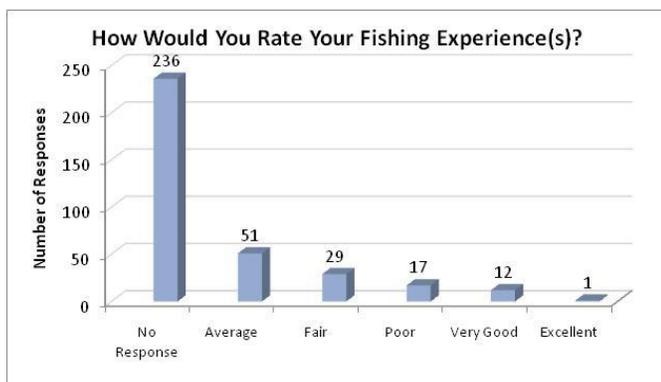


Figure 9. Citizen survey results of fishing experience in Mirror and Shadow Lakes.

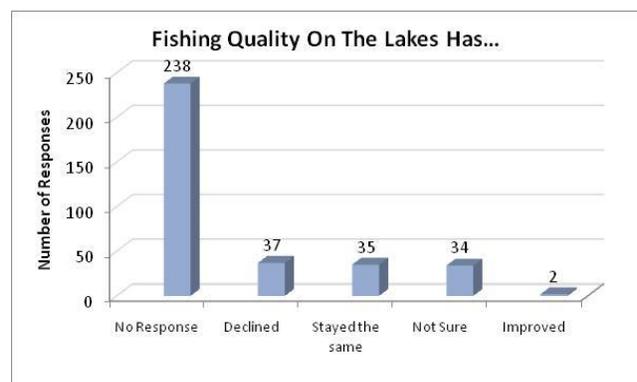


Figure 8. Citizen survey results of perceived change in fishing quality in Mirror and Shadow Lakes.

Our Vision:

We envision a healthy and sustainable fishery in Mirror and Shadow Lakes.

Goal 5: Strategies will be implemented to support a healthy fishery in Mirror and Shadow Lakes. We will know that we have achieved this goal when we have a balanced fish community.

Objective 5.1: Improve the fisheries habitat in Mirror and Shadow Lakes to achieve better reproduction.

Actions	Lead person/group	Start/end dates	Resources	Progress
Disseminate information about the importance of woody habitat in the lake for fisheries and about leaving a tree in the lake when it drops.(through door to door handouts).	FOMSL		WDNR WI Extension Lakes	
Provide information about the importance of the native plant community to the fishery.	FOMSL		WDNR	
Identify the best areas for habitat restoration. Install woody habitat demonstration projects in familiar public and private areas locations where people can view them. Very defined areas.	FOMSL		WDNR fishery biologist	
Identify areas that are devoid of aquatic plants and areas that already have woody habitat present using the 2011 aquatic plant and shoreland surveys.	FOMSL			

Active (Being worked on)
 Inactive (Not being worked on)
 ★ Completed

Objective 5.2: Work with the WDNR to develop sustainable fisheries management strategies for Mirror and Shadow Lakes.

Actions	Lead person/group	Start/end dates	Resources	Progress
Continue to work with the WDNR fisheries biologist on developing actions/regulations to improve bluegill sizes	FOMSL		WDNR fishery biologist	
Disseminate Information about which fish species can be expected in the lakes, which are naturally reproducing, which species are stocked, and identify aspects of healthy eco-systems in both lakes.	FOMSL		WDNR fishery biologist	
Post the fish survey report from WDNR on the website.	FOMSL		City of Waupaca	

Active (Being worked on)
 Inactive (Not being worked on)
 ★ Completed

Goal 6: Provide artificial support to achieve desired fisheries in Mirror and Shadow Lakes.

Objective 6.1: Continue the use of aeration in Mirror Lake to support the fisheries thorough periods of low dissolved oxygen.

Actions	Lead person/group	Start/end dates	Resources	Progress
Create a written procedure for the operation of the aerator in Mirror Lake, including the dates that the aerator is used each year. Procedure will be filed with the city and on the city website.	City of Waupaca			
Continue using aeration in Mirror Lake in the fall and spring at the 20 feet per UWSP recommendations (See procedure in Appendix A).	City of Waupaca		WDNR	
Monitor dissolved oxygen at least monthly throughout the entire year, including the winter and report the results to the WDNR database and City.	FOMSL		WDNR	

Active (Being worked on)
 Inactive (Not being worked on)
 ★ Completed

Recreation

Mirror and Shadow Lakes residents and users enjoy many recreational opportunities in, on, and near the lakes. Based on survey results, the most popular recreational activities on Mirror and Shadow Lakes included swimming/snorkeling, enjoying scenery, walking, fishing, and picnicking.

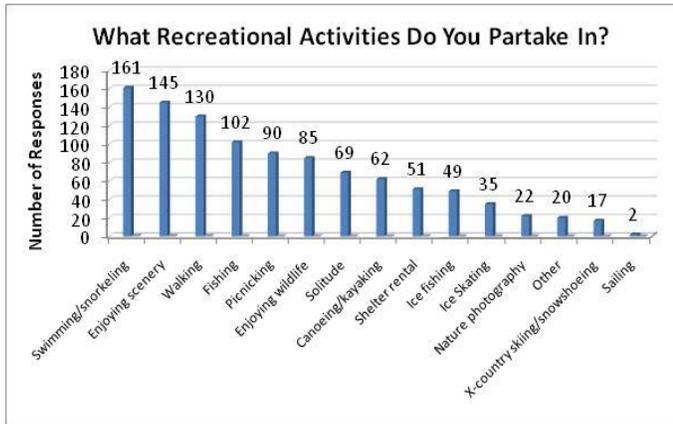


Figure 10. Citizen survey results of recreational activities on Mirror and shadow Lakes.

These are relatively quiet activities, so conflicts are not likely to be significant; however, the large number of people using the lakes may result in conflicts and recreational needs and uses of the lakes will likely continue to increase as populations and development in the area grows. Survey respondents indicated that usage of the lakes were primarily May through August (71%), although data showed that the lakes are used year round and during all days of the week. The presence of South Park enhanced the enjoyment of the lakes for the majority of respondents.

Our Vision:

Recreational opportunities for all ages will be preserved and the history associated with recreation on Mirror and Shadow Lakes will be honored and celebrated.

Goal 7: Recreational opportunities in, on, and near Mirror and Shadow Lakes will protect the healthy ecosystem and safety of lake users.

Objective 7.1: Ensure recreational opportunities exist on Mirror and Shadow Lakes for residents and lake users.

Actions	Lead person/group	Start/end dates	Resources	Progress
Work with the WDNR to install a properly engineered boat landing and piers on Mirror and Shadow Lakes.	City of Waupaca FOMSL		WDNR Local fishing clubs	
Explore installing a handicapped-accessible pier at Bowersox on Shadow Lake.	City of Waupaca FOMSL		WDNR Local fishing clubs	
Place covered, squirrel proof trash containers in the city park and at fishing piers to help with littering.	City of Waupaca			
Maintain public access for swimming on Shadow Lake.	City of Waupaca			

Active (Being worked on)
 Inactive (Not being worked on)
 Completed

Objective 7.2: Lake users will be informed of pertinent rules that are in place to protect the users and lake ecosystem.

Actions	Lead person/group	Start/end dates	Resources	Progress
Maintain signage at the boat landing that states that the entire lake is no-wake.	City of Waupaca		FOMSL	

Active (Being worked on)
 Inactive (Not being worked on)
 Completed

Objective 7.3: Maintain communication with Parks Department regarding plans for design changes in the park

Actions	Lead person/group	Start/end dates	Resources	Progress
Have a representative attend planning meetings.	City of Waupaca		FOMSL	

Active (Being worked on)
 Inactive (Not being worked on)
 Completed

Communication/Organization

Many of the goals outlined in this plan are focused on disseminating information to lake and watershed residents and lake users, ultimately to help them make informed decisions that will result in a healthy ecosystem in Mirror and Shadow Lakes that are enjoyed by many people. There is no single best way to distribute information to those that enjoy and/or affect the lakes so the planning committee has identified a variety of options to communicate with one another and in the community. Working together on common values will help to achieve the goals that have been outlined in this plan.

The Friends of Mirror and Shadow Lakes, in conjunction with the city and other partners, will take a leadership role to advocate for and protect the lakes.

Goal 10: FOMSL will use all available media to inform, educate, and advocate for Mirror and Shadow Lakes.

Objective 10.1: Provide educational opportunities for the public using a variety of communication methods

Action	Lead person/group	Start/end dates	Resources	Progress
Schedule at least one lake events per year.	FOMSL		UW-Extension Lakes	
Utilize monthly city water billing, the city website and Facebook to disseminate information.	FOMSL		City of Waupaca	
Publish and distribute topical information.	FOMSL			
Continue to host a FOMSL website on the city of Waupaca's website.	FOMSL		City of Waupaca	
Explore new methods of communication including facebook, electronic newsletter, etc.	FOMSL			
Explore using contact lists that are constructed to receive specific information.	FOMSL			

Active (Being worked on)
 Inactive (Not being worked on)
 ★ Completed

Objective 10.2: Maintain an active FOMSL organization

Action	Lead person/group	Start/end dates	Resources	Progress
Recruit any interested individuals to participate.	FOMSL			
Keep the FOMSL e-mail list current with interested persons about the lakes.	FOMSL			
Encourage members to attend the	FOMSL		UW-Extension	

Wisconsin Lakes convention.			Lakes	
Meet at least six times a year.	FOMSL			
Work with other lakes and river citizen organizations that have similar goals.	FOMSL		UW-Extension Lakes	
Work with elected city officials and staff.	FOMSL		City of Waupaca	
Distribute information through newspaper, radio, WINTV, and social media.	FOMSL			

Active (Being worked on)
 Inactive (Not being worked on)
 Completed

Goal 11: Keep the Mirror and Shadow Lakes management plan updated with current information

Objective 11.1: Update the lake management plan annually

Action	Lead person/group	Start/end dates	Resources	Progress
Ensure that the lake management plan meshes with other local management plans including the South Park Master Plan.	FOMSL		City of Waupaca	
Review the lake management plan annually in the winter months to make any necessary changes, updates.	FOMSL		City of Waupaca	

Active (Being worked on)
 Inactive (Not being worked on)
 Completed

Appendices

Appendix A Aerator for Mirror Lake

PROCEDURE for AERATOR IN MIRROR LAKE

May 15, 2013

It is the intention of the aerator to provide maximum oxygen to Mirror Lake over winter within the limits of public safety.

The Department of Parks and Recreation staff will:

Clean or change the filters in the compressor before starting the aerator in October.

Ascertain that signs warning of thin ice/open water are posted at the landing.

Turn the compressor on by October 15, annually. Verify that 3 sets of bubbles occur.

Document the action on Aerator Log, found on FOMSL web site.

Turn the compressor off when the lake is nearly covered with ice near the aerator.

Document on the log.

Park and Rec staff will test the dissolved oxygen (DO) in Mirror Lake monthly or as conditions permit through the winter. If the DO is less than 8mg/l at 15 feet, the aerator will be turned on.

Turn the aerator on as soon as thawing begins in Mirror Lake. Verify that 3 sets of bubbles occur.

Document on the log.

Turn the aerator off two weeks to a month later.

Document on the log.

August, 2012

HISTORY OF AERATOR IN MIRROR LAKE

July, 2012

With the passage of the amendments to the Clean Air Act in 1970, a study of the water quality of urban lakes was undertaken in Wisconsin. Mirror and Shadow Lakes in Waupaca were chosen at random to be included in the study.

Between 1971 and 1973, DNR staff and UW Extension staff worked on a study of the two lakes. As part of their study, in 1972, a large bubble aerator was installed on the bottom of Mirror Lake. The compressor was housed in the nearby well house on Junction Street.

In the Fall, 1973, the researchers reported the results of their study at a public meeting. They found that sewer runoff was contributing 50% of the phosphorous load and other nutrients in Mirror Lake and that 25% of the phosphorous and other nutrients was coming from groundwater running into the lake. To decrease the phosphorous in Mirror Lake, the researchers recommended that the city divert the storm sewer runoff to the Waupaca River and that aeration be continued.

In June, 1974, the Common Council formed a committee to seek federal and state funds to help with the cost of re-directing the storm sewers. In November, 1974, the City of Waupaca Inland Lake Rehabilitation and Protection District was formed.

In August, 1976, the project to divert storm sewer runoff was begun.

Residents recall that the aerator ran sporadically spring and fall through the 70's. Beginning in 2000, the aerator was turned on for a few weeks each spring and fall.

In 2001, a 4th grade teacher, Dave Furstenberg, organized his students into a Lake Watchers group. The students began monitoring secchi readings, water temperature and dissolved oxygen every two weeks to once a month from from April through November and occasionally in the winter months. They continued their study through April, 2003.

In the summer of 2003, the city contracted with the Center for Watershed Science and Education for a water quality study of both lakes. Recommendations from the study included continuing to aerate Mirror Lake during part of the year, especially in late fall prior to ice on and to start a Friends group. The Friends of Mirror and Shadow Lakes was formed the following year and took over responsibility for water quality monitoring.

In 2005, it was felt that the old aerator was not working well, a new ¾ hp High Volume, Low Pressure Compressor and Vertex Air Station (a small bubble type) was purchased and installed on the bottom of Mirror Lake. In October, 2008, Ted Johnson became the DNR Water Resource Biologist for our area. He came to a Friends meeting where he highly recommended raising the aerator to 20 feet, above the metalimnion, to avoid stirring up the phosphorous load from the bottom of the lake. In Spring, 2009, the aerator was raised up and now sits at the 20 foot depth.

Presently the aerator is run in the fall and spring but not throughout the winter. City staff are concerned that being an urban lake, the thin ice caused by aeration would serve as an "attractive nuisance" and would be a danger to public safety.

Appendix B Shoreland Surveys

Mirror and Shadow Lake Shoreline Survey August 2011

Buffer Depth

-  < 1 ft
-  1-5 ft
-  5-15 ft
-  15-35 ft
-  > 35 ft

