

## 2.0 Introduction

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This report describes the results of the Use Attainability Analysis (UAA) for the Lake Holiday, Wing Lake, and Lake Rose chain of lakes in Minnetonka, MN. The UAA provides the scientific foundation for a lake-specific best management plan that will permit maintenance of, or attainment of, the intended beneficial uses of Lake Holiday, Wing Lake, and Lake Rose. The UAA is a scientific assessment of a water body's physical, chemical, and biological condition. This study includes both a water quality assessment and prescription of protective and/or remedial measures for Lake Holiday, Wing Lake, Lake Rose, and the tributary watershed. The conclusions and recommendations are based on historical water quality data, the results of an intensive lake water quality monitoring in 2008, and computer simulations of land use impacts on water quality in Lake Holiday, Wing Lake, and Lake Rose using watershed and lake models calibrated to water quality data collected in 1993, 1999, and 2008. Water quality goals for the lake have not been defined by the Nine Mile Creek Watershed District (NMCWD), but Wing Lake and Lake Rose are subject to the Minnesota Pollution Control Agency's (MPCA) shallow lakes criteria resulting from their listing on the draft 2010 Impaired Waters 303(d) List. In addition, best management practices (BMPs) were evaluated to compare their relative effect on total phosphorus concentrations and Secchi disc transparencies (i.e., water clarity). Management scenarios were then assessed to determine attainment or non-attainment with the lake's beneficial uses and water quality goals.

### 2.1 Public Perception of Water Quality in Lake Holiday, Wing Lake, and Lake Rose

Surveys were sent to residents of the Holiday-Wing-Rose Chain of Lakes watershed in the fall of 2008, in an effort to better understand the current and desired uses of these lakes, as well as local residents' perceptions regarding lake water quality. Two separate surveys were developed. Residents that live on or near Lake Holiday, Wing Lake, or Lake Rose received a more extensive survey (two pages) inquiring about lake use, perceptions about lake water quality, aquatic plant management, and willingness to implement responsible lawn care practices to reduce pollutant loading to the lakes. A one-page survey was sent to residents that live within the Holiday-Wing-Rose Chain of Lakes watershed, but not directly on or near a lake, inquiring about lake use and willingness to implement responsible lawn care practices. A summary of the number of surveys that were sent and completed is provided in the table below. An overall return rate of 31 percent was achieved.

**Table 2-1 Summary of Surveys sent and returned**

	<b>Number of Surveys Sent</b>	<b>Number of Surveys Completed</b>	<b>Percent of Surveys Returned</b>
Lake Holiday Residents	22	6	27 %
Wing Lake Residents	31	15	48 %
Lake Rose Residents	74	40	54 %
Watershed Residents	800	230	29 %
<b>Overall</b>	<b>927</b>	<b>291</b>	<b>31 %</b>

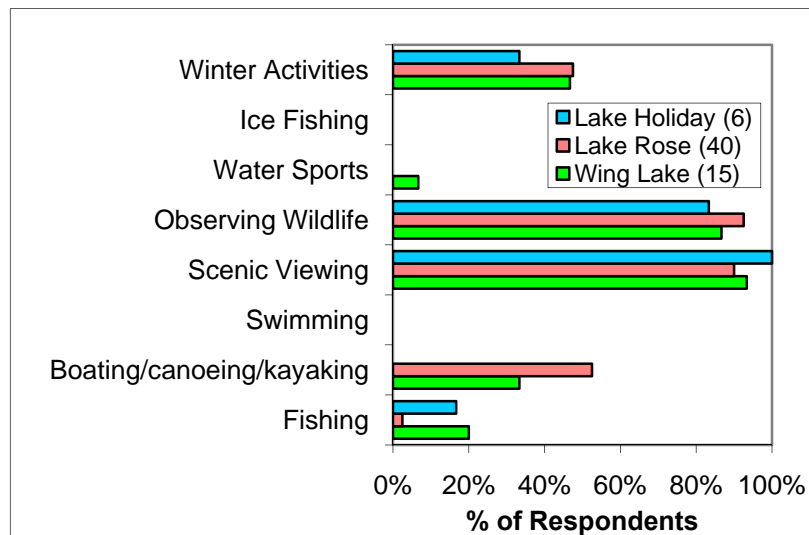
**2.1.1 Survey Results**

The responses from the returned surveys have been tabulated, and the results are summarized in this section. The summary includes 1) a summary of survey results from residents that live on/near Lake Holiday, Wing Lake, or Lake Rose, 2) a summary of survey results from watershed residents, 3) a summary of survey results from lake and watershed residents regarding lawn care practices, and 4) a summary of additional comments provided by survey respondents.

**2.1.1.1 Results from Residents that Live on/near Lake Holiday, Wing Lake, or Lake Rose**

**1. How do you/have you used the lake?**

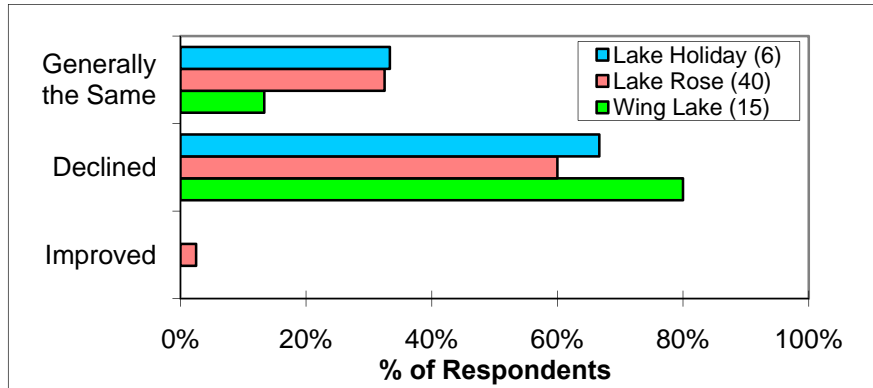
Most of the respondents (over 80% for each lake) indicated that observation of wildlife and general scenic viewing were the activities most often enjoyed on Holiday, Wing, and Rose Lakes. Winter activities (ice skating, cross country skiing, etc) were also common on each lake.



**Figure 2-1 Lake Uses of Residents that Live on/near Lakes**

**2. Has water clarity improved, declined, or remained basically the same since you have lived on/near the lake?**

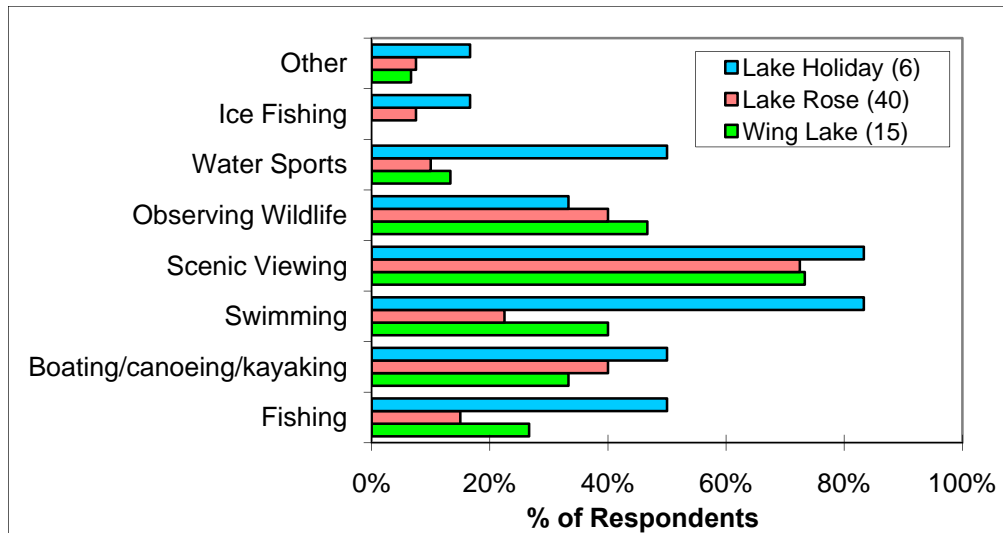
The majority of respondents (between 60% and 80%) feel that water clarity has declined since they've lived on/near the lake.



**Figure 2-2 Survey Results: Perception of Changes in Lake Water Quality among Residents that Live on/near Lakes**

**3. Which lake uses do you feel are impaired by the lakes' water clarity?**

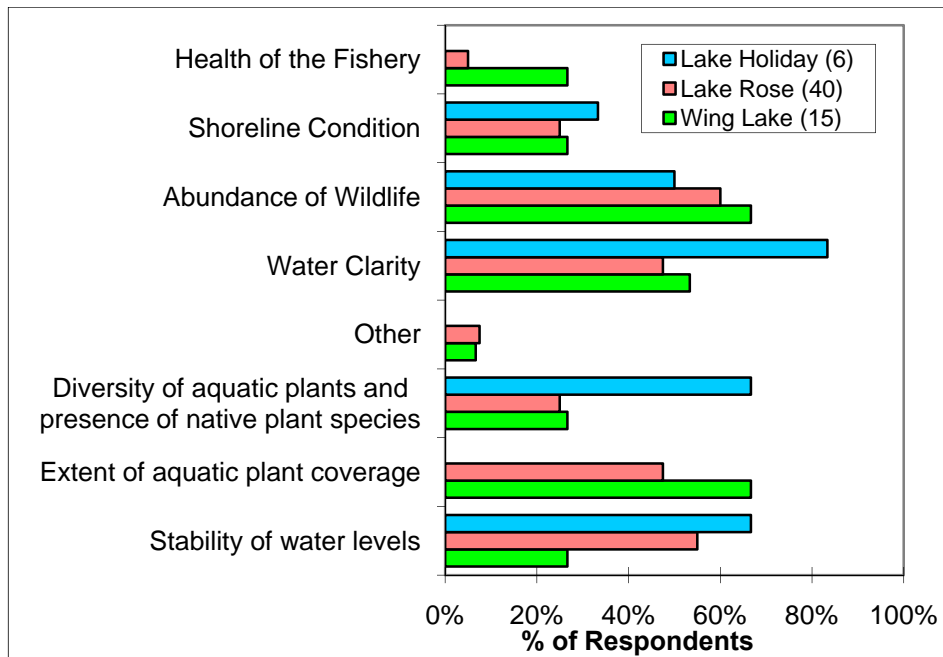
Respondents felt that nearly all lake uses have been impaired to some extent by the lakes' water clarity.



**Figure 2-3 Survey Results: Impairment of Lake Uses Perceived by Residents that Live on/near Lakes**

**4. What do you think are the three most important criteria for judging the overall quality of the lake?**

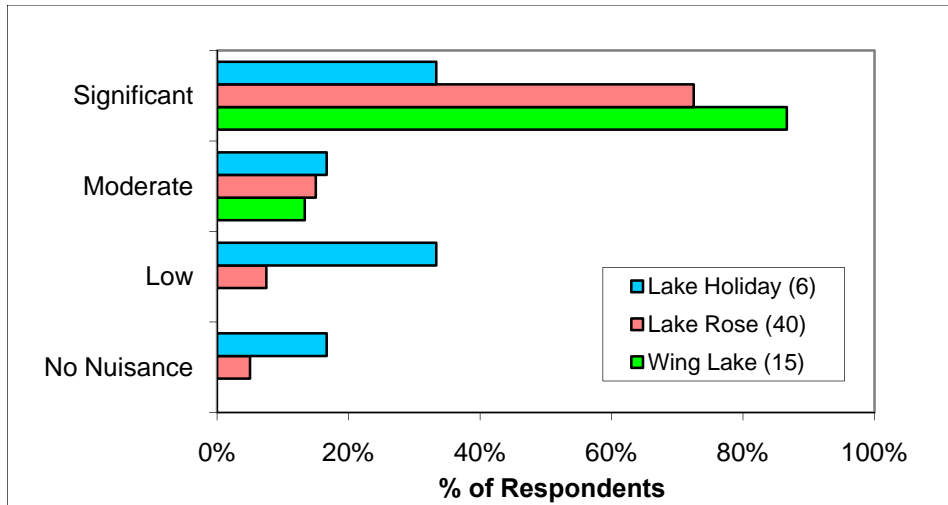
Respondents from Lake Holiday indicated that water clarity (83%), diversity of aquatic plants and presence of native plant species (67%), and stability of water levels (67%) were the three most important criteria for judging the overall quality of their lake. Respondents from Lake Rose indicated that abundance of wildlife (60%), stability of water levels (55%), water clarity (48%), and extent of aquatic plant coverage (48%) were the most important criteria for judging the overall quality of their lake. Respondents from Wing Lake indicated that abundance of wildlife (67%), extent of aquatic plant coverage (67%), and water clarity (53%) were the three most important criteria for judging the overall quality of their lake.



**Figure 2-4 Survey Results: Important Criteria for Evaluating Overall Lake Quality**

**5. In general, do you consider aquatic plants to be at nuisance levels (e.g. they restrict your use and/or enjoyment of the lake)?**

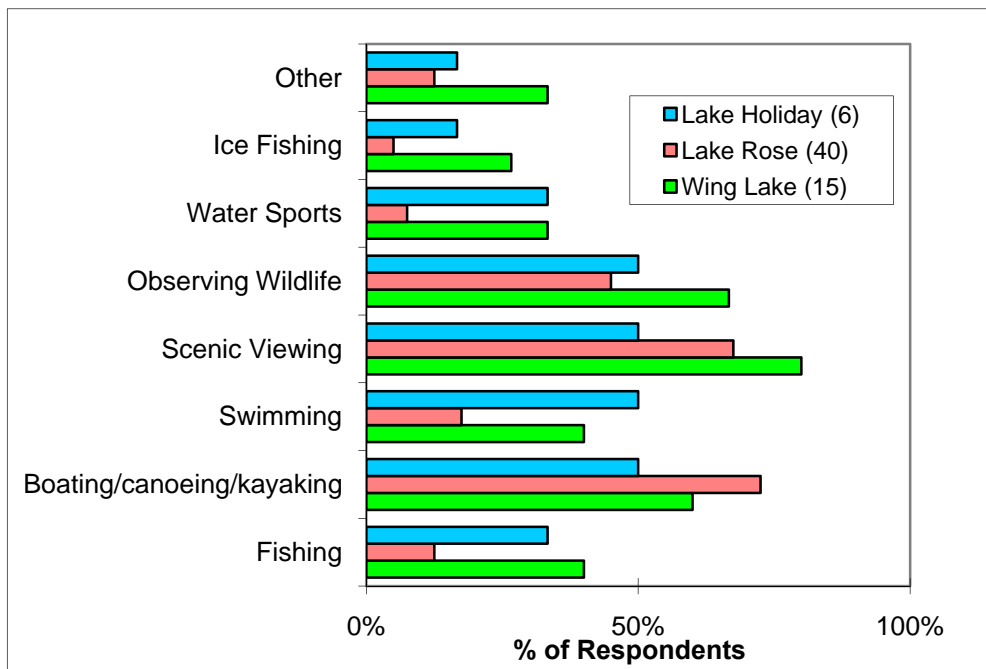
The majority of respondents on Lake Rose (73%) and Wing Lake (87%) consider aquatic plants to be at nuisance levels. The responses from Lake Holiday residents varied widely between significant nuisance and no nuisance.



**Figure 2-5 Survey Results: Degree of Nuisance of Aquatic Plants**

**6. Which lake uses are affected by the aquatic plants?**

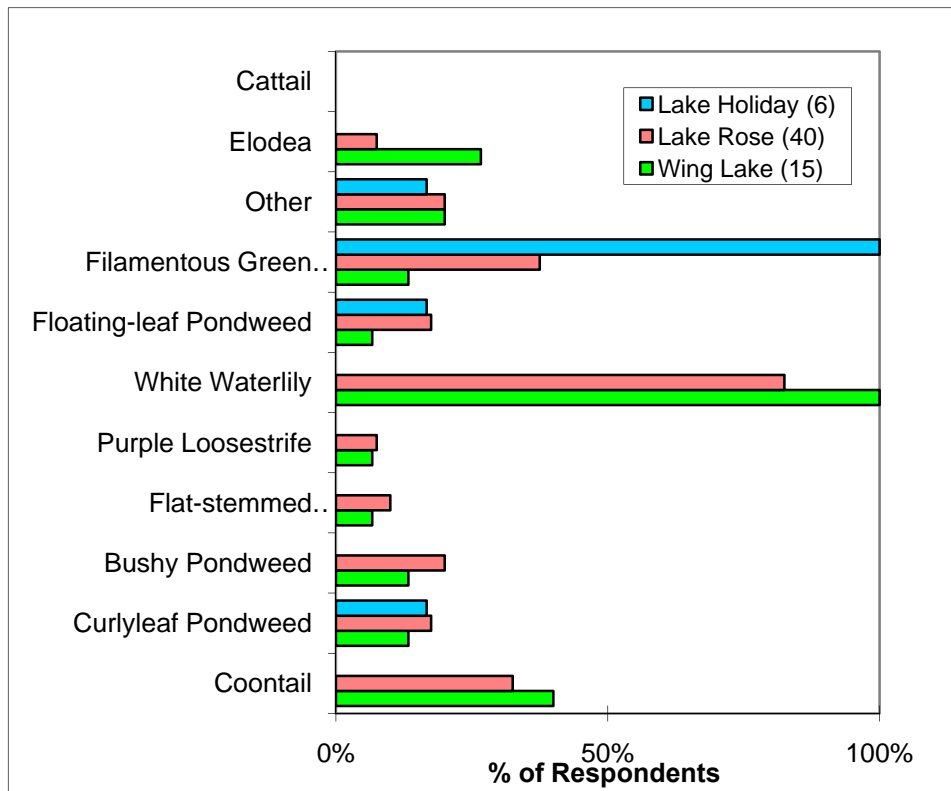
Respondents felt that nearly all lake uses have been affected to some extent by the aquatic plants. Overall, the respondents indicated that the uses most affected are boating/canoeing/kayaking, scenic viewing, and observing wildlife.



**Figure 2-6 Survey Results: Lake Uses Impacted by Aquatic Plants**

**7. What types of aquatic plants do you feel are most problematic to your use/enjoyment of the lake?**

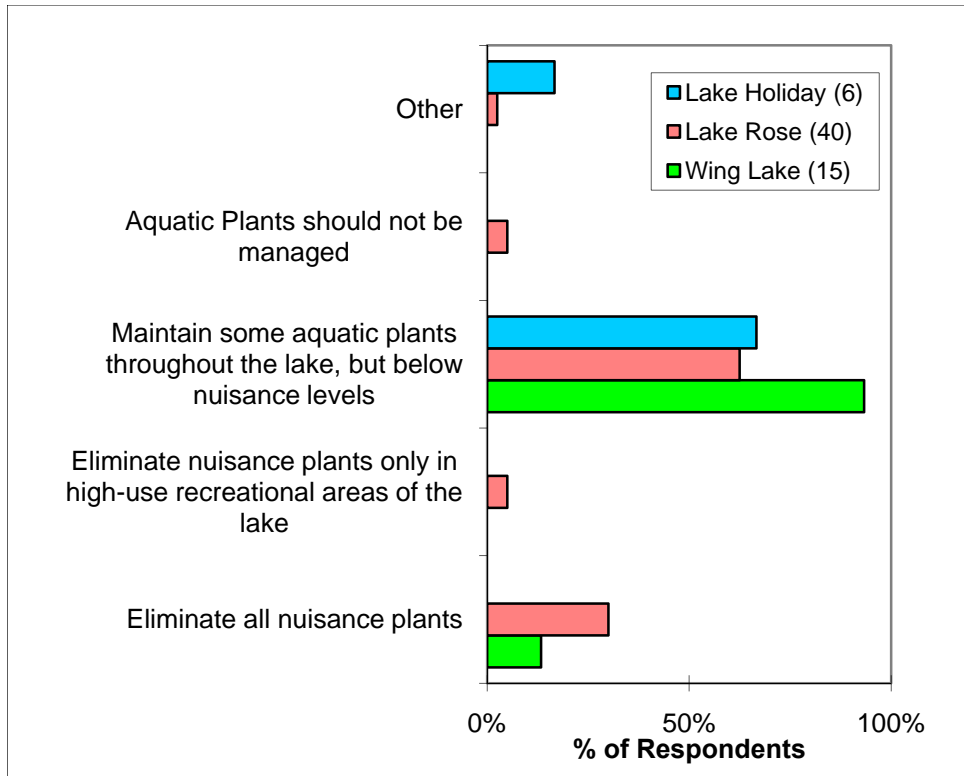
Respondents from Lake Holiday overwhelmingly indicated that algae are the most problematic aquatic plant (100%). The majority of respondents from Lake Rose indicated that white waterlily are the most problematic aquatic plant (83%), with many also indentifying algae (38%) and coontail (33%) as a significant problem. Respondents from Wing Lake overwhelmingly indicated that white waterlily are the most problematic aquatic plant (100%), with many also indentifying coontail (40%) and elodea (27%) as a significant problem.



**Figure 2-7 Survey Results: Identification of Most Problematic Aquatic Plants**

**8. If aquatic plants were managed, what do you believe would be realistic goals to accomplish for the lake?**

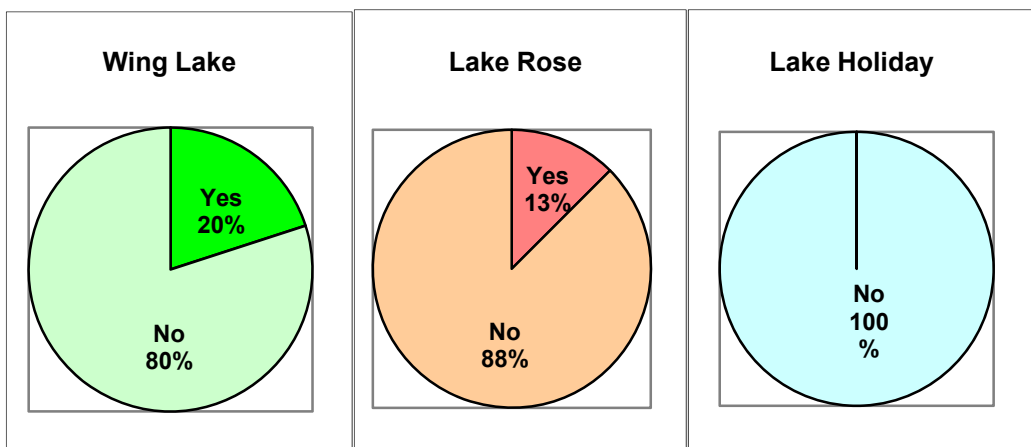
The majority of respondents (greater than 60% for all lakes) indicated they believe maintenance of some aquatic plants to below nuisance levels is a realistic outcome of aquatic plant management. 30% of respondents from Lake Rose listed elimination of all nuisance plants as a realistic goal.



**Figure 2-8 Survey Results: Realistic Goals for Aquatic Plant Management**

**9. Have you removed or attempted to remove aquatic plants along the shoreline?**

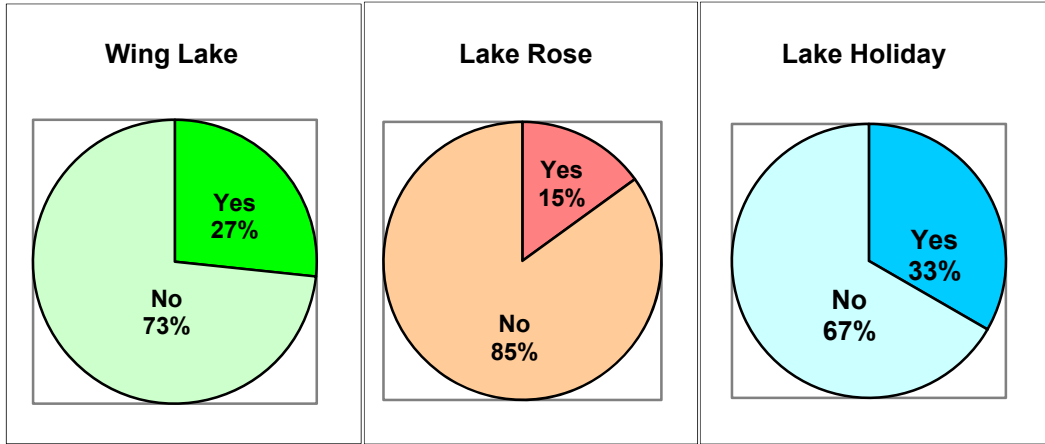
Only 20% of Wing Lake respondents and 13% of Lake Rose respondents have removed aquatic plants along their shoreline. No respondents from Lake Holiday have removed aquatic plants.



**Figure 2-9 Survey Results: Aquatic Plant Management Performed by Lake Residents**

**10. Are you opposed to chemical use to remove aquatic plants in your lake?**

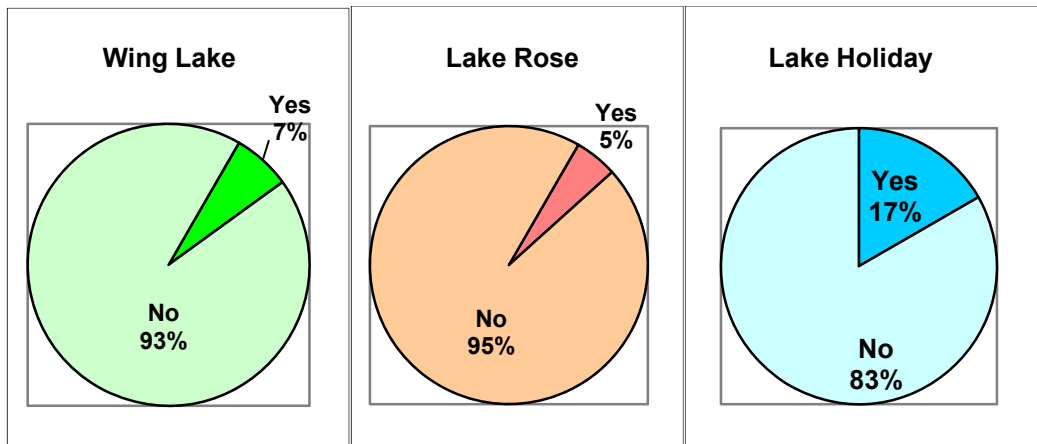
Between 15% and 33% of respondents indicated they are opposed to chemical use to treat/remove aquatic plants from the lake.



**Figure 2-10 Survey Results: Use of Chemicals for Aquatic Plant Management**

**11. Are you opposed to mechanical harvesting of aquatic plants in your lake?**

Between 5% and 17% of respondents are opposed to mechanical harvesting of aquatic plants from the lake.

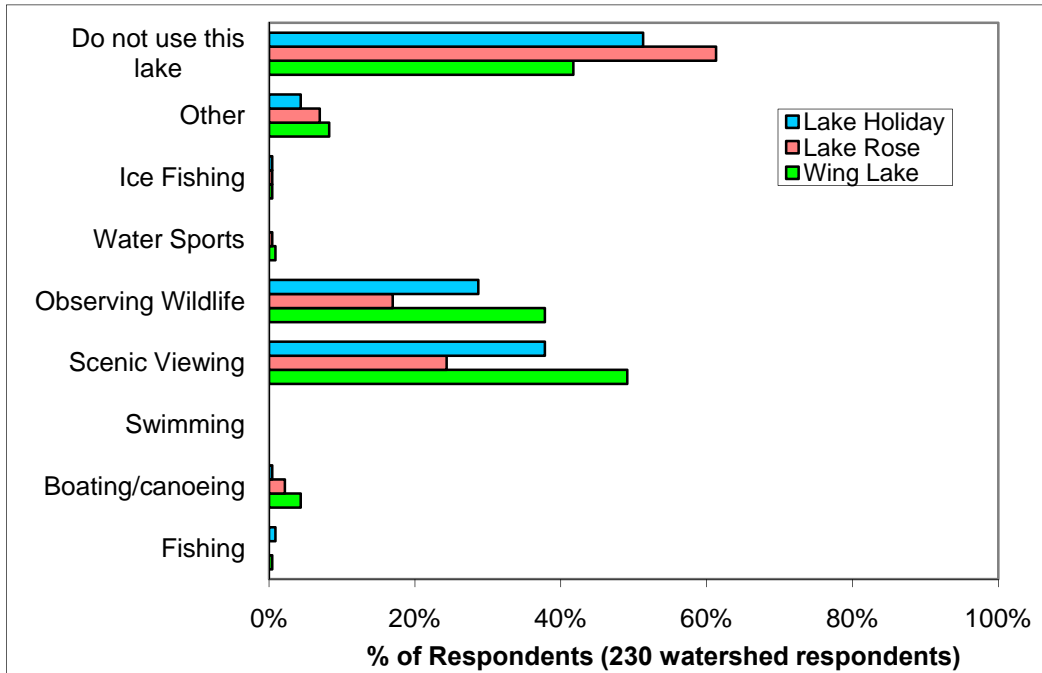


**Figure 2-11 Survey Results: Use of Mechanical Means for Aquatic Plant Management**

**2.1.1.2 Results from Watershed Residents**

**12. How do watershed residents use Holiday, Wing, and/or Rose Lakes?**

The most common use of the lakes by watershed residents is for observing wildlife and scenic viewing. Common uses in the 'Other' category included winter activities (skating, cross country skiing, etc).

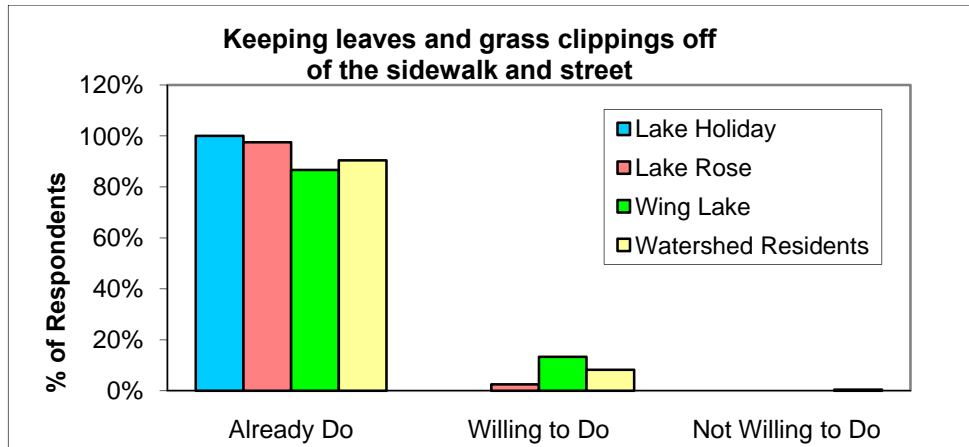


**Figure 2-12 Survey Results: Lake Uses among Watershed Residents**

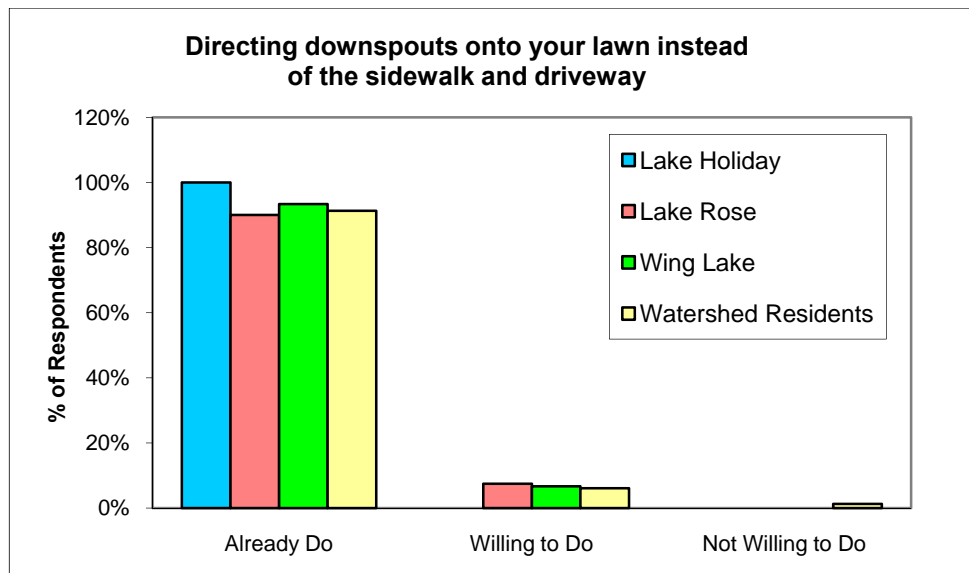
**2.1.1.3 Results from Lake and Watershed Residents Regarding Lawn Care Practices**

**13. Which of the following practices are residents willing to do to help decrease phosphorus and sediment loads to their local lakes/wetlands?**

The overwhelming majority of respondents indicated that they already do keep leaves and grass clippings off of the sidewalk and street. The overwhelming majority of respondents indicated that they already do direct their downspouts to their lawn instead of the sidewalk and driveway.

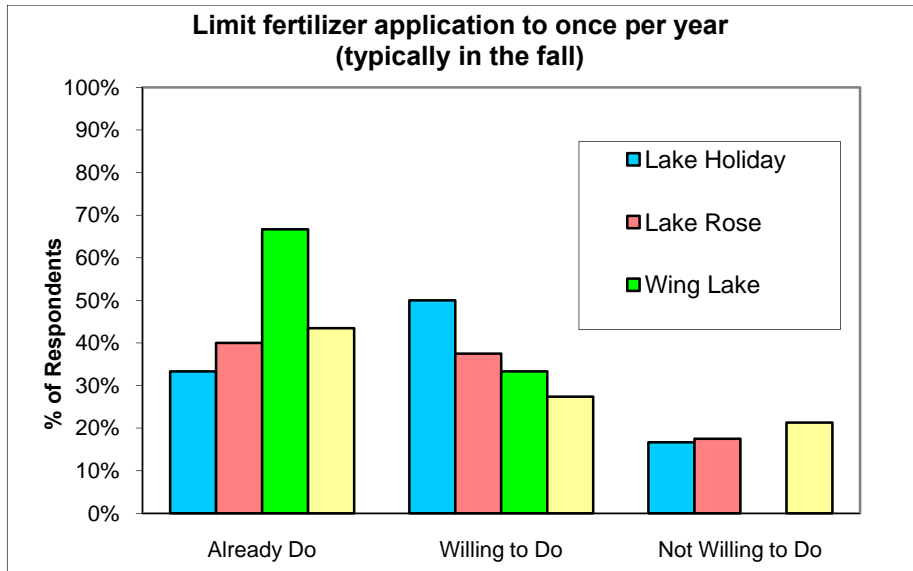


**Figure 2-13 Survey Results: Willingness to Manage Leaves and Grass Clippings**

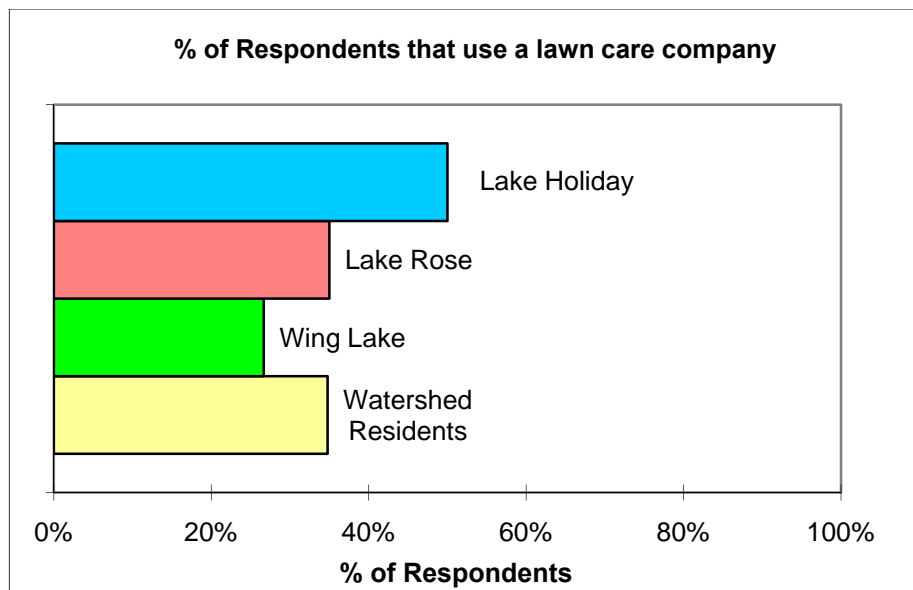


**Figure 2-14 Survey Results: Directing Downspouts to Pervious Areas**

The majority of respondents indicated that they either already do or are willing to limit fertilizer applications to once per year. 21% of watershed resident respondents, 18% of Lake Rose resident respondents, and 17% of Lake Holiday respondents indicated that they are not willing to limit fertilizer application to once per year.

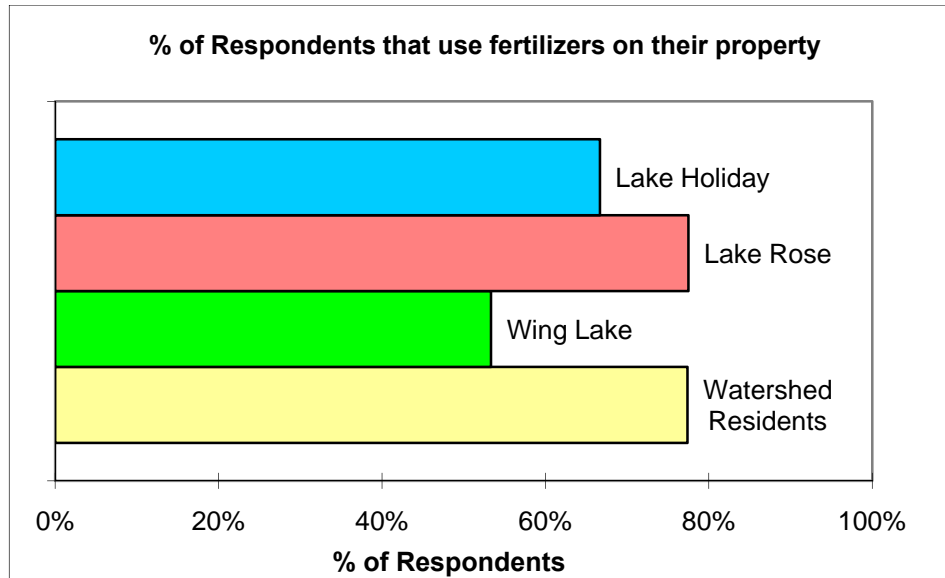


**Figure 2-15 Survey Results: Willingness to Limit Fertilizer Use**

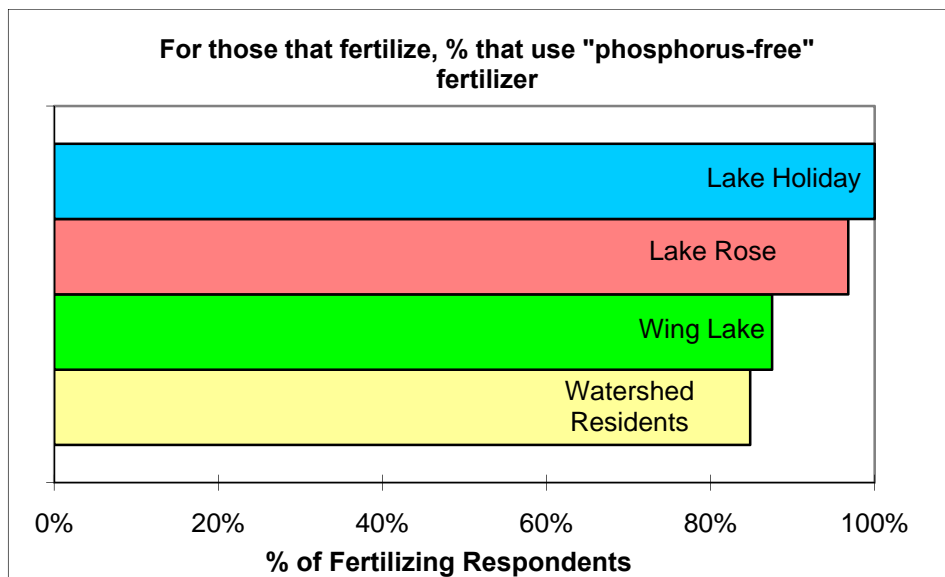


**Figure 2-16 Survey Results: Residents Who Use Professional Lawn Care**

Between 27% and 50% of respondents use a lawn care company. Between 53% and 77% of respondents use fertilizers on their property. Among the respondents that use fertilizer, between 85% and 100% use "phosphorus-free" fertilizer.



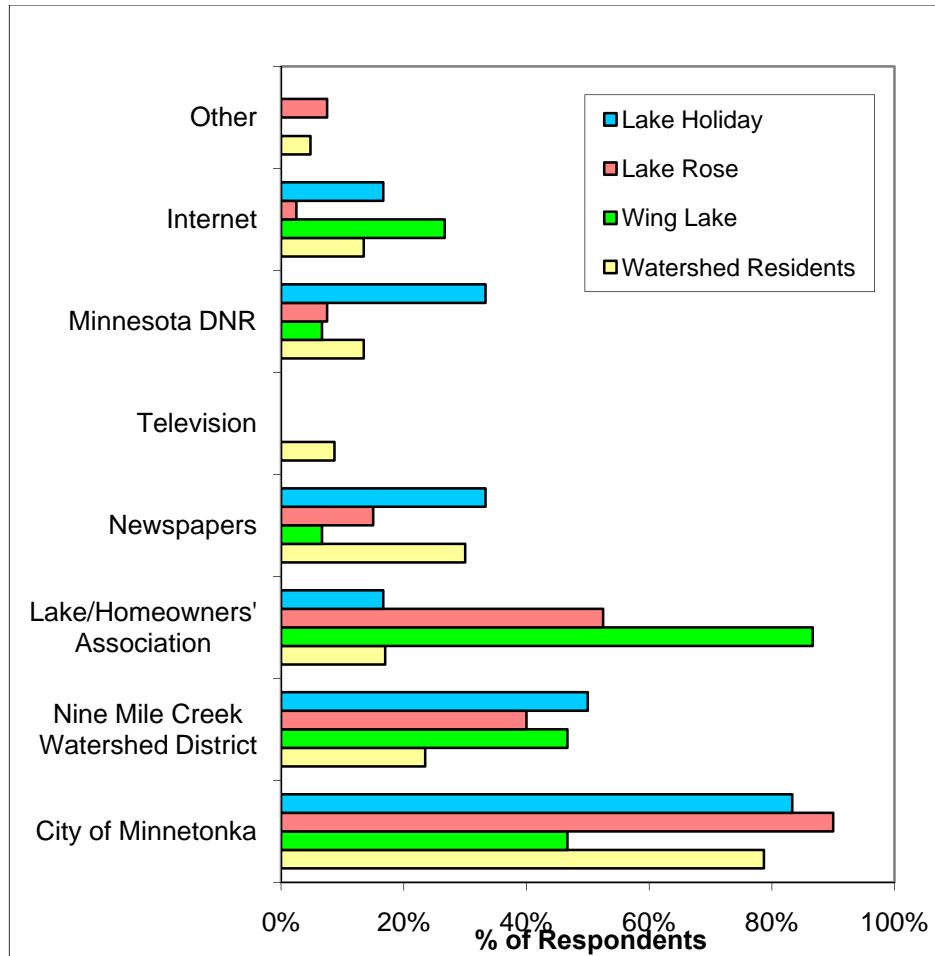
**Figure 2-17 Survey Results: Residents Who Use Fertilizer**



**Figure 2-18 Survey Results: Residents Who Use Phosphorus-Free Fertilizer**

**14. Where do residents get information on matters pertaining to your nearby lakes?**

The most common source of information on nearby lakes is the City of Minnetonka (47% - 90%). Other commonly identified sources are the Nine Mile Creek Watershed District (23% - 50%) and lake/homeowners' associations (17% - 87%)



**Figure 2-19 Survey Results: Sources of Information on Local Lakes**

## 2.1.2 Compilation of Survey Comments

### 2.1.2.1 Survey Comments from Residents that Live on/near the Lakes

In addition to quantitative results, several residents that live on or near the lakes provided comments (both general and regarding specific survey questions) and questions in their responses. One respondent included a picture post card from 1911 showing a Minneapolis street car traveling east on old County Rd #3 from Excelsior past Wing Lake (north). To the right along tree line would be what is Highland Road (see [Figure 2-20](#)). Those comments and/or questions are included below:

- “lake was lowered making it shallower than before which made more weeds grow. This was brought up at council meeting but nothing was done!” (*Lake Holiday Resident*)
- “When we first moved here ('71), I was tempted to add other colors of water lilies (red, yellow, pink) to the few white ones. So glad I didn't. Now the white lilies choke our end of

the lake so that mid-summer many ducks, geese, egrets and blue herons leave. Very sad and frustrating!” (*Lake Rose Resident*)

- “in early 70s our neighbor had a dock and pontoon with motor. They would take it to the middle and swim. City low trucks would clean 3 rinks on the lake too. Sad that these opportunities are gone.” (*Lake Rose Resident*)
- “Several years ago, the city cut a foot off the drainage pipe for lake rose. The shoreline has receded over 50 feet from my lot since then, giving me nothing but mud to look at. In the same period, the water lilies have taken over the lake. We no longer capture the spring runoff, allowing the lake to all but dry up by fall. I have not seen a snapping turtle in my yard since they cut the pipe.” (*Lake Rose Resident*)
- “I would also like to recommend raising the overflow gate. Our water level is way too low” (*Lake Rose Resident*)
- “Thank you for conducting this survey” (*Lake Rose Resident*)
- “presently a group is being formed to promote Lake Rose Cleaning” (*Lake Rose Resident*)
- “the DNR makes cleaning up this lake impossible. Their permits are a joke. They don’t care about scenic beauty, wildlife, or water quality. They love lilies, that’s it.” (*Wing Lake Resident*)
- “at one time our children as well as others in the neighborhood would play and float around on various vessels catching turtles, and exploring the open water areas” (*Wing Lake Resident*)
- “regarding water clarity, I don’t believe algae ever was a problem creating a murky green appearance on Wing Lake, prior to current conditions of Wing Lake. The water itself always seemed reasonably clear” (*Wing Lake Resident*)
- “one year the DNR planted Wing Lake with largemouth bass, 4” size fingerlings. Prior to the plant a boat with electrical gear killed off all other living fish at end of growing season – bass were netted out – some bass continued to live and many fished along the road.” (*Wing Lake Resident*)
- “at one time we would observe far more bird life – such as ducks (diverse) canvas backs-Red heads. Bluebills, golden eyes, teal, more mallards, some osprey and rare occasion bald eagle. We now see more blue heron, egrets, am bittern, fewer gulls” (*Wing Lake Resident*)



**Figure 2-20 Minneapolis street car traveling east past Wing Lake**

### **2.1.2.2 Survey Comments from Watershed Residents**

In addition to quantitative results, several watershed residents provided comments (both general and regarding specific survey questions) and questions in their responses. Those comments and/or questions are included below:

- Question 3 - “in the spring with broadleaf herbicide. I apply when grass has grown to prevent granules from washing into street drains”
- “P.S. I see many homeowners mow their lawns with the grass clippings left in the street. If people are aware of this (it’s hard not to be in this day and age) can they be fined?”
- “lawn care customers of lawn care companies should insist that the streets and driveways are blown off to put over applied fertilizer back on the lawn. I never see this done when granular materials are applied. I do it on a regular basis for me 200 lawn care customers
- Question 1 – question if they use lake rose – comment “would if there were a way to access it. There is park land indicated on maps but there does not appear to be any entry points”
- Question 1 – “neither Holiday nor Wing Lake should be called lakes but swamps thanks to storm sewer projects. They both stink!”

- “over the years, Wing Lake has been given very little attention by the City of Minnetonka and the 9 Mile Creek Watershed District. With the new interest in proper eco-systems in the area, Wing Lake is finally getting some professional help from several layers of government. Having lived in the area for 35 years, I am somewhat familiar with what has gone on regarding Wing Lake. Some years ago, Wing Lake was drained to put a storm sewer under the lake. Some plants were taken down (willow trees) along the Highland Road shoreline never to be replaced. There was no effort to create a vegetated buffer along that shoreline at that time. Because Highland Road was once a gravel road, there is a sandbar at the bottom of the Highland Hill. Any runoff going down the Highland Road incline goes into the lake at that place. As you point out in your brochure, Wing Lake is a shallow lake. As a result, lily pads cover a good portion of the lake. Enclosed is a photo (Figure 2-21) of a lily pond in a Chicago park area similar to Wing Lake. But what a difference. There are rocks along the shoreline, a walking trail, trees and other vegetation and a buffered shoreline. Wing Lake could be like this with some planning and leadership. I’m sure you will get the cooperation you need from nearby residents to implement any plans you might proposed. Let’s go for it!”



**Figure 2-21 Lily Pond in the Chicago Area**

- “more than storm runoff goes into Lake Holiday. We have taken walks around the lake regularly – especially in the summer, and have seen and smelled raw sewage going into the lake on the north end-large amounts of soap suds were evident and methane gas – sewer gas – was emitting from the sewer drain near the lake. It is always full of runoff down there. We have been concerned about the lakes in our neighborhood for a long time. One day I sat there on a bench resting from my walk late this summer-early fall-and the smell from the lake itself was unbearable. We enjoy watching the Herons, Egrets, Geese, Ducks and other friends of the wild like turtles, etc. at the lake. Thank you for taking action to clean up and care for this important resource.”

- “you must have a lot of money to throw away – no wonder the tax payers are getting taxed out of their homes”
- “Street sweeping in sub-watersheds draining to these lakes should occur more than once per year, I.E. 3 times – Spring, Summer, Fall”
- Question 1 – Lake Rose – “We use the lake a lot in the winter.” Canoeing – “occasionally, more in the past. Too shallow/mucky over grown but beautiful because of this”
- “I/we really like the wildness of Lake Rose. We walk along it almost daily. The level dropped a few years after we moved in and since it has been hard to canoe from the public side. But that is ok. It is a lovely place.”
- Question 4 – other – “Neighbors and people who live along the shore and watching it change since it was drained. I have lived here on this street for over 40 years. Don’t let our lovely lake turn into a marsh!!!!”
- “My wife and I would be very opposed to having our tax dollars used to upgrade the water quality of Holiday, Rose and Wing Lake as proposed by the nine-mile creek watershed. Our streets need paving and upgrading before using tax dollars to fund a project that will only benefit people living on the lakes by increasing their property values. If the people who live on the lakes want them improved, let them pay for it! It is absurd to upgrade these lakes to the quality to allow fishing, swimming and boating. ”
- Question 1 – “You need not use these lakes to be impacted. Their current condition is a travesty.”
- “Regulate the commercial applicators. You don’t need 4 treatments to have a healthy lawn”
- “How much harm is being done to our water by golf course chemical treatments?”

## **2.2 Purpose and Process of the UAA**

The intent of the UAA is to provide a means by which the effects of various watershed and lake management strategies can be evaluated. To evaluate management strategies, it is first necessary to identify the intended uses of the lake in question. With these uses in mind, appropriate water quality goals for the lake can be established and reviewed. Once the intended uses and corresponding goals for the lake have been identified, it becomes possible to evaluate lake and watershed management strategies.

The UAA employs a watershed runoff model and a lake water quality model; the lake water quality model predicts changes in lake water quality based on the results of the watershed runoff model. Using these models, various watershed and lake management strategies can be evaluated to determine

their likely effects on the lake. The resulting lake water quality can then be compared with the water quality goals for the lake to see if the management strategies are able to produce the desired changes in the lake. Using the tools of the UAA, the cost-effectiveness of the management strategies can also be evaluated.

## **2.3 Watershed and Lake Water Quality Modeling Tools**

Central to the water quality analysis is the use of a water quality model that predicts the amount of pollutants that reach a lake via stormwater runoff. This UAA uses a P8 model (Program for Predicting Polluting Particle Passage through Pits, Puddles and Ponds; IEP, Inc., 1990) to estimate phosphorus loading from stormwater runoff. P8 models have been used in several NMCWD studies (Barr, 2007).

The P8 model requires hourly precipitation and daily temperature data; long-term climatic data can be used so that watersheds and BMPs can be evaluated for varying hydrologic conditions. To properly develop and calibrate the model also requires an accurate assessment of land use and impervious percentages, pond system morphology, flow routing, and lake water quality. After supplying the required input data, the P8 model was used to estimate both the water and phosphorus loads introduced from the entire watershed of Lake Holiday, Wing Lake, and Lake Rose.

The phosphorus and water loads were estimated with P8 for 1992-93, 1998-99, and 2007-08. Those three years represent wet, average, and dry climatic conditions, respectively. The results of the runoff modeling were entered into a separate in-lake mass balance model so that the phosphorus concentrations in Lake Holiday, Wing Lake, and Lake Rose could be estimated. The in-lake mass balance models for Lake Holiday, Wing Lake, and Lake Rose were linked to account for the transfer of water between the lakes via pumping or gravity outlet. The in-lake phosphorus concentrations modeled for 1993, 1999, and 2008 were compared to observed phosphorus concentrations from those years to calibrate the in-lake models for each lake and ensure that each was producing reasonable results. The calibrated model was then used to estimate phosphorus loads and concentrations with varying climatic regimes and BMP scenarios. Details of the modeling results and a discussion of management opportunities are presented later in this report.

When evaluating the results of the modeling, it is important to consider that the results provided can be assumed to be more accurate in terms of relative differences than in absolute results. The model will predict the percent difference in phosphorus reduction between various BMP scenarios in the watershed fairly accurately. It also provides a realistic estimate of the relative differences in

phosphorus and water loadings from the various subwatersheds and major inflow points to the lake. However, since runoff quality is highly variable with time and location, the phosphorus loadings estimated by the model for a specific watershed may not necessarily reflect the actual loadings, in absolute terms. Various site-specific factors, such as lawn care practices, illicit point source discharges and erosion due to construction are not accounted for in the model. The model provides values that are considered to be typical of the region, given the land uses identified for the watershed in question.

## **2.4 Scope**

This UAA evaluates current and future conditions for Lake Holiday, Wing Lake, and Lake Rose. As a result, the watershed analysis intrinsic to the UAA focuses on the local watersheds to each of those lakes.

## **2.5 General Framework of the UAA**

Several steps were necessary for the evaluation of the watershed, lake, and management initiatives conducted for this UAA. Those steps are outlined in the sections that follow.

### **2.5.1 Identification of Goals and Expectations**

To evaluate lake management strategies, it is first necessary to establish the criteria against which outcomes can be measured.

#### **2.5.1.1 NMCWD Goals and Desired Uses**

The *Nine Mile Creek District Water Management Plan* (Barr, 2007) does not list specific water quality goals for Lake Holiday, Wing Lake, or Lake Rose. The NMCWD has not established a management strategy for any of these lakes. This UAA may be used to develop a management strategy for some or all of these lakes.

#### **2.5.1.2 MPCA Impaired Waters List**

The federal Clean Water Act requires states to define water quality standards, varying on the designated use of the water body. The MPCA has developed assessment methodologies, conducted extensive sampling of lakes, and ultimately derived ecoregion-based lake eutrophication standards for deep and shallow lakes for total phosphorus, chlorophyll *a*, and Secchi depths (MPCA, 2008). These standards are outlined in Minnesota Rules, Chapter 7050 (Standards for the Protection of Waters of the State). The MPCA has used the ecoregion-based total phosphorus guidelines in conjunction with Carlson's Trophic State Index (TSI) as a means to classify lakes relative to support of swimmable use in 305(b) assessments.

For shallow lakes in the North Central Hardwood Forests (NCHF) ecoregion (where the Holiday-Wing-Rose chain of lakes is located), the total phosphorus criteria established by the MPCA is 60 µg/L, which serves as the upper threshold for lake water quality. The chlorophyll *a* criterion requires concentrations less than 20 µg/L and for Secchi disc transparency, the criterion is not less than 1.0 meters. For lakes not meeting these standards, greater frequencies of nuisance algal blooms and reduced recreational uses are expected.

Not only does the federal Clean Water Act require states to establish water quality standards, it also requires the states to identify the waters that are impaired (or not meeting the established standards) and to develop plans to improve the quality of the impaired waters so that the standards are met. In response to these requirements, the MPCA developed the 303(d) Impaired Waters list. Every two years, the MPCA is required to publish an updated list of impaired waters that do not meet the state's water quality standards.

For all water bodies listed on the 303(d) Impaired Waters list, the MPCA must develop a Total Maximum Daily Load (TMDL) study for each pollutant that causes the water body to fail to meet the state water quality standards.

Wing Lake and Lake Rose are listed on the MPCA's 2010 draft Impaired Waters 303(d) List for impaired aquatic recreational use as the result of Nutrients/Eutrophication/Biological Indicators. As a result of this listing, the MPCA will be required to develop a TMDL for Wing Lake and Lake Rose to determine the necessary pollutant load reductions to meet the MPCA's shallow lakes criteria for this region. The expected TMDL study start date is 2013 with completion in 2018.

### **2.5.1.3 Baseline Water Quality Prediction Methods**

There are several tools available to estimate the potential water quality of lakes without or prior to anthropogenic (human) influence. The Minnesota Lake Eutrophication Analysis Procedure (MnLEAP) is intended to be used as a screening tool for estimating lake conditions and for identifying "problem" lakes. MnLEAP is particularly useful for identifying lakes requiring "protection" versus those requiring "restoration" (Heiskary and Wilson, 1990). In addition, MnLEAP has been applied in the past to identify Minnesota lakes which may be in better or worse condition than they "should be" based on their location, watershed area and lake basin morphometry (Heiskary and Wilson, 1990).

The MPCA has also reconstructed water quality from analysis of fossil diatoms contained in sediment cores obtained from some Minnesota lakes (Heiskary and Swain, 2004). As part of this

study, the MPCA found that there was good agreement between the phosphorus contained in diatom fossils and the Vighi and Chiaudani (MEI) model (1985) for lakes with background phosphorus concentrations of 30 µg/L or less. The Vighi and Chiaudani MEI model provides reasonable accurate estimates of pre-European settlement total phosphorus concentrations for lakes, based on current alkalinity or conductivity water quality measurements. Vighi and Chiaudani (1985) recommend using current measurements of alkalinity over conductivity measurements from lakes that are affected by anthropogenic (human) sources of phosphorus.

#### **2.5.1.4 Water Quality Trend Analyses**

Trend analyses of lake water quality data are completed to determine if a lake has experienced significant degradation or improvement during all (or a portion) of the years for which water quality data are available. Water quality data from the “summer” growing season (June-September) are compiled from previous investigations for each analysis. The summer-averages of the water quality data are used to determine water quality trends. Long term trends are typically determined using standard statistical methods (i.e., linear regression and analysis of variance).

For this report, the Mann-Kendall/Sen’s Slope Trend Test was used to determine water quality trends and their significance. To complete the trend test, the calculated summer-average must be based on at least four measured values during the sampling season, and at least five years of data are required. The NMCWD considers a lake’s water quality to have significantly improved or declined if the Mann-Kendall/Sen’s Slope Trend Test is statistically significant at the 95 percent confidence interval. Also, to conclude an improvement requires concurrent decreases in total phosphorus and chlorophyll *a* concentrations, and increases in Secchi disc transparencies; a conclusion of degradation requires the inverse relationship.

#### **2.5.2 Assessment of Current Conditions**

The condition of the lake’s watershed, biological communities, and water quality within Lake Holiday, Wing Lake, and Lake Rose was evaluated for this study.

The watershed analysis involved assessment of soil type, land use, and the impervious fraction of the land in the watershed. Land use assumptions were made based on the City of Minnetonka’s *Nondegradation Report* and supporting land use coverage GIS database. Subwatersheds were delineated based on LiDAR data for Hennepin County, District-wide 5-foot contours from the USGS and field verification where necessary. The storm sewer routing was determined using storm sewer information provided by the City of Minnetonka and the NMCWD. Stormwater pond storage data

was taken from the *City of Minnetonka Surface Water Management Plan* (Barr, 2009), the *Woodgate Pond Analysis for City of Minnetonka* (Barr, 2000), survey data collected as part of a City of Minnetonka pond inventory performed in 2008-09, as-built plan drawings, and topographic data. Based on the wetland inventories for the surrounding area, pond characteristics were estimated for the ponds that did not have survey information.

Biological communities were evaluated through consideration of past sampling of the lakes' phytoplankton, zooplankton, and macrophyte communities. Current lake water quality was assessed through examination of recent and historical water sampling data collected between 1993 and 2008, and including intensive monitoring completed in 2007-08 and . The data collected in 1993, 1999, and 2008 were also used in calibration of the current water quality model used in the UAA. For the calibration of the 1993 and 1999 models, the current watershed conditions were adjusted to account for the following changes that have occurred within the watershed: dredging of Woodgate Pond between 1999 and 2008, the addition of a Storm-cepter device in subwatershed prior to 2008, and the lowering of the Lake Rose outlet from 927.1 feet to 926.6 feet between 1993 and 1999.

### **2.5.3 Assessment of Future Conditions**

The watershed of Lake Holiday, Wing Lake, and Lake Rose are fully-developed and as a result, major changes in the overall type of land use within the watersheds are not likely.

The future conditions of Lake Holiday, Wing Lake, and Lake Rose will depend on the limited changes in land use, changes in water routing within the watershed (i.e. changes to the storm sewer system), and redevelopment within the watershed. Using this information, the P8 model was used to predict future watershed loading of the lake under various climatic conditions. The watershed loadings (water and nutrient loadings) were then used as inputs to the in-lake model to provide predictions of future water quality.

To assess future conditions, it was assumed that no changes would be made to the pumping capacity or strategy for Woodgate Pond or Lake Holiday. Future changes to the watershed and storm sewer network include the addition or modification of piped outlets to Subwatersheds 644, 648, and 639 in the Lake Holiday watershed and the addition of a piped outlet from Subwatershed 696A in the Lake Rose watershed.

### **2.5.4 Evaluation of Management Strategies**

Having modeled the watershed loading and lake response under assumed future conditions, it is possible to evaluate the potential impacts of various watershed and lake management strategies.

Several likely approaches to watershed and lake management were selected and evaluated under various climatic conditions. Costs of the strategies were estimated so that those costs could be compared to the in-lake benefits that the management initiatives are expected to provide.