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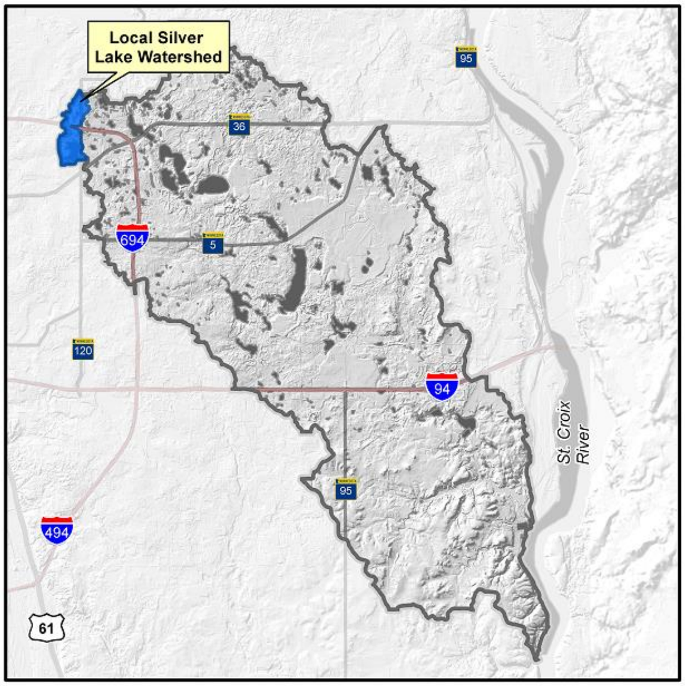
5.1 Silver Lake Watershed Management Plan

5.1.1 General Information



Silver Lake Local Watershed Information	
Tributary Area (acres)	436 (317 excluding lake surface area & landlocked areas)
MDNR-Designated Basins within Watershed	62-89W, 62-88W, 62-87W, 62-1P
Downstream Watershed	Long Lake
Silver Lake Information	
MDNR Designation	62-0001P
Approximate Surface Area (acres)	76
Approximate Mean Depth (feet)	7.4
Approximate Maximum Depth (feet)	18
Approximate Volume Below Discharge Elevation (acre-feet)	561
Discharge Elevation[1]	988.78
Outlet Type	Metal "V" Notch Weir
MDNR Ordinary High Water Level (OHW)[1]	989.84
100-Year Flood Level[1]	991.0
VBWD "Allowable Fill" (cubic yards/lineal foot of shoreline) (See Section 4.7)	1.4
VBWD Management Classification	High Priority

[1] Elevations in NAVD88 vertical datum

Silver Lake is directly west of Century Avenue (T.H. 120) in the Cities of North St. Paul and Maplewood. Silver Lake is the most intensely used lake in the VBWD.

The lake's intensive use is due primarily to the two parks located adjacent to the lake. Silver Lake Park on the south shore is owned by the City of North St. Paul and includes a public swimming beach, a fishing pier, and an extensive picnic area. Joy Park on the north end is owned by the City of Maplewood and contains three picnic areas, a fishing pier, and a public boat launch, which also provides winter access.

The primary recreational uses of Silver Lake are swimming and fishing. A 1978 Minnesota Department of Natural Resources (MDNR) recreational use survey estimated the lake supports fishing at the rate of 76 person-hours per acre, twice the regional average. The installation of a boat access in 1984 significantly increased fishing pressure. Other recreational uses include waterskiing, canoeing, and passive uses such as aesthetic viewing.

Figure 5.1-1 shows the Silver Lake tributary area. The tributary area of Silver Lake is nearly fully developed, and includes parts of Century College in Mahtomedi and White Bear Lake, medium-density residential housing and commercial areas in White Bear Lake, mostly natural and park areas in

Maplewood, and mostly medium-density residential housing in North St. Paul. Current and ultimate development land use conditions for Silver Lake are shown on Figure 5.1-2.

There is a lake improvement association within the Silver Lake watershed. The Silver Lake Improvement Association (SLIA) is a non-profit organization that promotes programs to enhance water quality, recreational use, and the natural beauty of Silver Lake. The SLIA provides information about shoreline best management practices and coordinates treatment of aquatic invasive species in Silver Lake.

5.1.2 Water Quality Management Plan

Silver Lake is classified as a shallow lake by the Minnesota Pollution Control Agency (MPCA). Silver Lake currently does not meet the MPCA's water quality standards for shallow lakes (see Table 5.1-1), but is not yet included among the list of impaired waters in Minnesota.

Silver Lake is classified as a High Priority waterbody according to the VBWD's waterbody classification system (see Section 4.1 – Water Quality), due to the presence of a statistically significant declining trend in water quality in recent years (see Table 4.1-1). The VBWD has a non-degradation water quality policy which sets "action triggers" for all of its major waterbodies. Section 4.1 – Water Quality discusses the action triggers in more detail. Action triggers for VBWD lakes consider the following water quality parameters (summer average) relative to MPCA water quality standards and prior water quality data (i.e., trend analysis):

- Secchi disc depth
- Total phosphorus
- Chlorophyll *a*

Because Silver Lake has a public access and is one of the most intensely used lakes in the VBWD and the region, the VBWD will give it a higher priority for implementing water quality protection and/or improvement projects than other lakes with less intensive use and/or lakes without public accesses. During Plan development, Ramsey County expressed its support for an aggressive management strategy to protect and improve water quality in Silver Lake.

5.1.2.1 Water Quality Implementation Plan

Specific water quality implementation tasks for Silver Lake include the following:

1. The VBWD will monitor the water quality of Silver Lake and perform the actions discussed in Section 4.1 – Water Quality for High Priority water bodies. Since Ramsey County conducts an annual water quality monitoring program for Silver Lake, VBWD will not duplicate water quality sampling programs on the lake. The VBWD may conduct more intense monitoring on the lake as needed based on actions recommended in Table 4.1-6. The

VBWD will request that a copy of all water quality monitoring reports conducted by others for Silver Lake be sent to VBWD.

The VBWD will evaluate the average summertime water quality (total phosphorus, chlorophyll a, and Secchi disc transparency) and compare it to applicable water quality standards (Table 4.1-1) and applicable action triggers (described in Section 4.1.7.5). Currently, there is a significant degrading trend phosphorus concentration (increase) and Secchi disc transparency (decrease) in Silver Lake. Based on Table 4.1-6, the VBWD will perform Survey Level plus Supplemental Water Quality Monitoring in the near future.

2. The VBWD will evaluate and implement the appropriate recommendations identified through the VBWD watershed restoration and protection strategy (WRAPS) study (see Section 4.1.6.1.2). As part of the WRAPS study, the VBWD estimated the phosphorus contribution from the surficial watershed, atmospheric deposition, internal loading from sediment, and curlyleaf pondweed. The WRAPS study identified the following potential management practices to improve Silver Lake water quality:

    - Enhanced treatment of discharge from a wetland within the SLV-10 subwatershed in the City of North St. Paul (see Figure 5.1-1)
    - Installation of small scale stormwater best management practices (BMPs) in residential areas around Silver Lake (in cooperation with the City of North St. Paul)
    - Continued operation of the Silver Lake aeration system (operated by Ramsey County)
    - Fishery survey(s) in cooperation with the MDNR to determine the extent of rough fish influence on internal loading
    - Continued implementation of VBWD rules and regulations

    The implementation strategies for Silver Lake include the following potential efforts that may be considered if the strategies listed above do not achieve the desired effect on Silver Lake water quality:

    - Restore native aquatic vegetation (including alum treatment and temporary restrictions on motorized watercraft use and temporary limits on herbicide application)
    - Selective treatment of curlyleaf pondweed and Eurasion watermilfoil following establishment of native vegetation

    For Silver Lake, the VBWD will consider implementing the following:

a. More intense monitoring to better estimate how much phosphorus is entering the lake, and ultimately, determine the feasibility and cost-effectiveness of improvement options identified through the WRAPS study.

b. Evaluating the feasibility of enhanced treatment and small scale stormwater BMPs within the watershed tributary to Silver Lake. The VBWD's BMP cost-share program may provide opportunities for private landowners to implement water quality improvements. Collectively, many small residential BMPs may have a significant impact on the cumulative phosphorus loading to Silver Lake.

c. Evaluating the need for and feasibility of biomanipulation of Silver Lake. High populations of bottom-feeding (benthivorous) fish or high populations of stunted bluegills can increase internal phosphorus loading in lakes by mobilizing phosphorus fixed in bottom sediments. The VBWD and MDNR will coordinate to perform fish surveys to determine the impact from benthivorous fish. If these species are identified as a significant source of internal phosphorus loading, the VBWD and MDNR will explore the possibility of manipulating the biological food chain (i.e., biomanipulation) in Silver Lake as a means to improve the lake's water quality. These biomanipulation methods could include the use of rotenone or another chemical (e.g., those that target a particular size of fish) applied to the lake (most likely by the MDNR) to eliminate undesirable fish species, predator fish would be stocked in the lake (also most likely by the MDNR), and the lake would be aerated to prevent winterkill. Alternative fish management options are also available; more detailed investigation is necessary before designing any biomanipulation activities. If biomanipulation appears to be an appropriate method to improve water quality, the VBWD will explore possible partnerships with the MDNR on such projects.

d. If necessary, the VBWD will cooperate with the MDNR and others to reduce internal loading in Silver Lake through the restoration of native vegetation. This may include an in-lake aluminum sulfate (alum) treatment of Silver Lake. In-lake alum provides a long-term control of the phosphorus release of lake sediments (see Section 4.1 – Water Quality). An in-lake treatment could be effective for up to ten years, depending upon how well the watershed nutrient sources have been reduced. When alum is applied to shallow lakes, the improved water clarity usually results in increased (and often undesired) aquatic plant growth. This can be exacerbated by the presence of aquatic invasive plant species. The VBWD will need to consider improved water clarity versus increased aquatic plant growth before moving forward with alum application projects on these lakes.

   The VBWD will cooperate with others to manage invasive macrophytes (aquatic plants) in Silver Lake. The SLIA has coordinated localized treatment of Eurasian watermilfoil and curlyleaf pondweed in recent years (most recently in 2014). Treatment of areas containing dense, monospecific growths of Eurasian watermilfoil with an aquatic herbicide (2,4-D, Triclopyr, or low concentrations of Aquathol® K) is recommended to protect the Silver Lake's native plant community. The VBWD will provide technical support for the treatment of aquatic plants, possibly including point-intercept macrophyte surveys.

As the VBWD considers implementing Silver Lake water quality improvement projects, the VBWD will obtain more detailed information regarding the internal loading component of the lake's nutrient budget, which will include the biological portion of the budget (e.g., plants, fisheries). The VBWD will share this information with MDNR staff and determine the appropriateness of in-lake treatment methods to improve water quality. The VBWD Managers recognize that new technology and/or methods may become available for improving water quality and will investigate new methods when considering water quality improvement projects.

3. The VBWD will continue to implement its Rules and Regulations (2013, as amended) in the Silver Lake watershed. The VBWD Rules address water quality performance standards for development and redevelopment projects, as well as required vegetated buffers around VBWD lakes, streams, and wetlands. The VBWD Rules and Regulations are included in this Plan as Appendix A-4.5.

4. The VBWD will address a ditch erosion and sedimentation problem discussed in Section 5.1.2.2 by continuing its erosion monitoring program. The VBWD will work with the City of Maplewood to implement potential projects at the time of planned redevelopment and/or road reconstructions. The VBWD will cooperate with the property owner if the property owner demonstrates a desire to address the ditch erosion issue. If a project is implemented, the VBWD will consider opportunities for grant funding.

5.1.2.2 Water Quality Issues

The City of North St. Paul surveyed residents as part of their water management planning process in 1989 and identified issues including sedimentation at inlets, extensive in-lake vegetation, high nutrient loading, and poor water clarity.

In 2005, the VBWD designed a bioretention facility which was constructed by the City of North St. Paul for a small watershed that had previously been contributing untreated stormwater to Silver Lake. The bioretention area was built in 2005 with a MetroEnvironment Partnership grant from the Metropolitan Council and treats 66 acres of the southern and western portions of the Silver Lake watershed. The *Silver Lake Watershed and Bioretention Area Watershed Monitoring and Modeling Report* (Barr, 2008b) reported that the bioretention area provides a significant (50%) reduction in the total phosphorus loading and a more significant (90%) reduction in the total suspended solids loading to Silver Lake from the treated watershed. The VBWD performed a survey of the bioretention basin in 2013 to assist the City of North St. Paul in determining if modifications to the basin are necessary. The City of North St. Paul is currently responsible for maintaining the Silver Lake bio-retention area.

VBWD, North St. Paul, Maplewood and Ramsey County are all aware of an intercommunity issue involving a ditch erosion problem upstream of Silver Lake. Located in North St. Paul, the ditch drainage system carries water from a wetland in Maplewood, north of Silver Lake, to the northwest shore of Silver Lake. This ditch is located completely within the limits of one property owner. The ditch is eroding and a sediment delta is forming in Silver Lake at the ditch outfall. The approximately 2 acre wetland in the City of Maplewood lies north of Lake Boulevard/Joy Road (Ramsey County Road 109) and west of Lydia Avenue. As part of a road improvement project in 1990-1991, the City of Maplewood replaced the wetland's outlet pipe under Lake Road. The new pipe was placed at the same elevation, and is approximately the same size as the old outlet pipe. However, the old outlet pipe was partially blocked with sediment, thus creating a flow restriction. The flow restriction was relieved when the new pipe was installed. As a result, the wetland water level dropped and, according to the property owner, more water discharges into the ditch, causing more erosion. As a result of discussions with VBWD and the City of North St. Paul, the City of Maplewood agreed to place a restriction at the upstream end of the outlet pipe from the wetland to help reduce flow rates in the ditch and to raise the water level in the wetland. VBWD has not been able to confirm if the City of Maplewood completed this work. However, reducing the outflow may not be enough to eliminate the erosion problem.

In response to this issue, the VBWD performed a study to evaluate the ditch erosion in 2007. The study recommended that the VBWD cooperate with the City of Maplewood to implement drainage improvements concurrent with any redevelopment or road reconstruction performed in the area. The VBWD will consider additional ditch stabilization measures if the property owner demonstrates a desire to participate in such efforts. If the ditch is still eroding and is the major contributor of sediment to the sediment delta, VBWD will consider initiating a project to address the erosion problem prior to planned reconstruction or redevelopment opportunities. Results of water quality modeling performed for Silver Lake are presented in Appendix A-5.1.

5.1.2.3 Water Chemistry Data

Water quality monitoring has been performed on Silver Lake since 1954. Ramsey County has conducted most of the sampling, including annual sampling since 1984. The VBWD conducted water quality sampling in 1973 and 1999. Water quality samples are typically analyzed for total phosphorus and chlorophyll a, and Secchi disc transparency (see Appendix A-4.1 – Water Quality Background Information). From 2000 to 2014, the summer average total phosphorus concentration has exceeded the MPCA's shallow lakes water quality criterion (60 ug/L) in five summers (see Figure 5.1-3).

The most recent 10-year average summer water quality data is presented relative to applicable MPCA and VBWD water quality standards in Table 5.1-1. Water quality observed within the last 10 years identifies statistically significant degrading trends in Silver Lake water quality (see Section 5.1.2.3). Detailed water quality data are shown in Figure 5.1-3.

The water chemistry of Silver Lake does not meet MPCA's standards for shallow lakes, as shown in Table 5.1-1 and Figure 5.1-3. During the 10-year period of 2005 to 2014, Silver Lake's summer average concentrations exceeded MPCA Secchi disk standards twice, chlorophyll a standards seven times, and total phosphorus standards five times. Phosphorus encourages algae growth; see Section 4.1 – Water Quality for more information.

Table 5.1-1 Summary of Silver Lake summer average water quality (2005 – 2014)

Parameter	Units	10-year Average (2004-2013)	Trend in Average	MPCA Standard
Total Phosphorus	ug/L	74	Increasing (degrading)	60
Chlorophyll *a*	ug/L	22.8	None	20
Secchi Disc Depth	m	1.41	Decreasing (degrading)	1.0

Graphical depictions of Silver Lake's historical water chemistry are shown in Figure 5.1-3. Statistical analysis of the last 10 years of data identified that the summer average Secchi disc depth decreased (worsened) at a rate of 0.11 meters per year. By a similar analysis, phosphorus concentrations increased (degraded) in the lake at a rate of 11 ug per year. The lake has also seen increases in chlorophyll *a* over the last ten years, but that trend is not statistically significant. Summer average total phosphorus and chlorophyll *a* observed in 2014 were better than the 10-year average. Summer average total phosphorus in 2014 was 59 ug/L (versus a 10-year average of 74 ug/L and values over 100 ug/L in 2012 and 2013). Summer average chlorophyll *a* was 11 ug/L in 2014, compared to a 10-year average of 23 ug/L. Summer average Secchi disc depth in 2014 (1.4 m) was similar to the 10-year average.

The recent trends in water quality are abrupt, as can be seen in Figure 5.1-3. From approximately 1990 until 2005, water quality steadily improved and would have met MPCA's shallow lake standards. The MDNR believes the water quality improvement observed at that time was associated with a change in the lake's fish population. Prior to 1978, the lake was subject to seasonally low oxygen levels resulting in winterkills. Frequent winterkills prevented the establishment of a gamefish population and enabled a large black bullhead population to flourish in the lake. Since 1978, however, winter aeration has enabled a gamefish population to become established in the lake. The gamefish population controlled the bottom-feeding bullheads and panfish, both of which contribute to degraded water quality by disturbing lake sediment and reintroducing phosphorus into the water column (see Appendix A-4.1). Boat traffic on the lake may also be responsible for disturbing lake sediment and reintroducing phosphors. Historically, drought conditions have also contributed to periods of improved water quality. Drought conditions during 1987 through 1989 reduced nutrient loading to the lake, which improved its water quality.

In 2007, the SLIA, in conjunction with MDNR and VBWD, began implementing chemical treatments in the lake to control invasive plant species, based on annual point intercept surveys. The chemical treatments have occurred every year since 2007, including whole lake treatments in 2007 and 2008, and targeted treatments in subsequent years. These treatments have had a negative effect on water quality. The dead plant mass that results from the treatment is not removed, and decays in the lake. The decaying plant matter releases excess phosphorus into the water column, fueling growth of excess suspended algae. The excess algae then contributes to the demonstrated loss in visibility and increase is chlorophyll-a in the water. Going forward, VBWD will be evaluating options for restoring Silver Lake's previously excellent water quality.

5.1.2.4 Biological Data

Several types of biological data have been compiled and evaluated for Silver Lake, in addition to physical and chemical parameters. Macrophyte (aquatic plant), phytoplankton (non-rooted floating plants – algae), zooplankton (microscopic aquatic animals), and fisheries data provide insight into the ecological quality of Silver Lake.

5.1.2.4.1 Fisheries

Silver Lake is extensively managed by the MDNR. Initial management consisted of monitoring winter oxygen levels. A winterkill occurred during the winter of 1974 through 1975, after which the lake was restocked with bluegill adults, walleye fry, and largemouth bass fry. The walleye fry stocking was successful.

In the last ten years, the MDNR has stocked the following fish species in Silver Lake:

- Walleye (fry, fingerlings, and yearlings)
- Yellow perch
- Channel catfish
- Tiger Muskellunge

Table 5.1-2 shows the results of the 2012 fisheries surveys.

Table 5.1-2 Results of 2012 MDNR Fishery Survey of Silver Lake

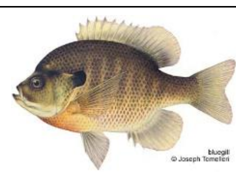
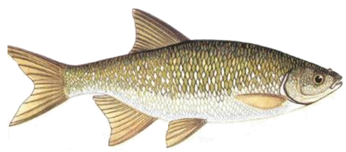
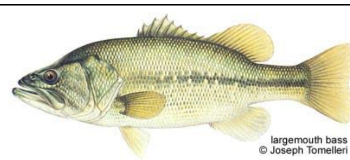
Fish Species	**Numbers**	**Photograph** (Not to Scale)
Bluegill	549	
Hybrid Sunfish	56	
Pumpkinseed Sunfish	16	
Northern Pike	13	

Table 5.1-2 Results of 2012 MDNR Fishery Survey of Silver Lake

Fish Species	**Numbers**	**Photograph** (Not to Scale)
Yellow Bullhead	14	
Yellow Perch	3	
Black Crappie	126	
Golden Shiner	66	
White Sucker	4	
Largemouth Bass	3	
Black Bullhead	41	
Yellow Bullhead	14	
Tiger Muskellunge	1	

The MDNR estimates that the establishment of a gamefish population in Silver Lake has caused a dramatic decline in the bullhead population in the lake, due to the effects of competition between fish species, and improved water quality. Prior to 1985, the large numbers of bullheads in the lake added nutrients to the water by stirring up bottom sediments and excreting nutrients into the water. The MDNR reports that trapnet catches of bullheads declined from 130 in 1980, to 19.5 in 1985, to 1.5 in 1990 to 0.2 in 2000.

The MDNR has determined a fisheries-use classification for Silver Lake in accordance with the MDNR's An Ecological Classification of Minnesota Lakes with Associated Fish Communities (1992). Silver Lake is classified as a Class 40 lake. A Class 40 lake is a northern pike-panfish lake. This lake class indicates the lake should maintain a water transparency as measured by Secchi disc of 1.5 meters (4.8 feet) or greater. Transparencies less than this value will result in less than ideal water quality conditions for the lake's fishery. While the average summer Secchi disc transparency depths of Silver Lake were greater than 1.5 meters from 1985 through 2006, summer average Secchi disc depths have averaged 1.4 meters over the ten years from 2005-2014. The data indicate water quality improvement is needed to support the lake's fisheries-use classification. Figure 5.1-3 shows the average and minimum summer Secchi disc transparency depths for Silver Lake.

Fish consumption advisories have been issued for fish caught from Silver Lake. Pregnant women and children under age 15 should limit their meals of fish from Silver Lake to one meal per week. The general population should limit its consumption of walleyes from Silver Lake to one meal per week. The advisories are for mercury.

The MDNRs LakeFinder website includes the most current data on fish stocking and surveying in Silver Lake and is available at: http://www.dnr.state.mn.us/lakefind/index.html

5.1.2.4.2 Macrophytes (Aquatic Plants)

The VBWD performed macrophyte surveys of Silver Lake on June 24, 1999, August 26, 1999, June 13, 2005, and June 1, 2007. Appendix C-5.1 includes information from the 1999 and 2007 macrophyte surveys. The VBWD collects macrophyte data to identify the conditions of plant growth throughout the lake. Macrophytes are the primary producers in the aquatic food chain, converting the basic chemical nutrients in water and soil into plant matter through photosynthesis, which becomes food for all other aquatic life. Macrophytes can impact the recreational use of a waterbody and are critical to the ecosystem as fish and wildlife habitat. Additionally, the MDNR has performed aquatic plant surveys of Silver Lake following in-lake herbicide treatments, including surveys performed in 2005, 2011, and 2012.

In each VBWD survey, a diverse plant community was found wherever the water depth was less than fourteen to fifteen feet. Most of the lake is less than ten feet deep and approximately 99 percent of the lake is shallow enough for plant growth (Osgood, 1997). The lake's plant community consisted of twelve individual species in 2007. These species are common to Minnesota lakes and provide good habitat for the fish and aquatic animals living within the lake.

Despite the favorable attributes of the lake's plant community, the growth of two exotic (non-native) species, curlyleaf pondweed (*Potamogeton crispus*) and Eurasian watermilfoil (*Myriophyllum spicatum*) is of concern.

Eurasian watermilfoil was first observed in Silver Lake on September 28, 1992. Its growth was noted in localized areas at about 20 different locations within the lake. This exotic plant has few natural enemies or controls. Its ability to regrow from small fragments and out-compete native aquatic plant species enables it to spread rapidly. Dense growths of Eurasian watermilfoil may result in habitat degradation, prevent or make navigation difficult, and are an aesthetic nuisance.

Because of concerns that Eurasian watermilfoil would increase in coverage and density in Silver Lake, plant harvesting was discontinued with the discovery of Eurasian watermilfoil since it proliferates from small plant fragments. Instead, herbicide treatment to try to eradicate growths of Eurasian watermilfoil from Silver Lake were performed in 1992 and 1993. Each growth area of Eurasian watermilfoil was chemically treated with 2,4-D in both years. No Eurasian watermilfoil plants were found after the treatment, which appeared to be successful. However, the plant eventually reappeared and spread throughout the lake.

Following the reinfestation of the lake with Eurasian watermilfoil, an Aquatic Plant Management (APM) Plan was prepared for Silver Lake, *Strategies and Actions for Managing Eurasian Watermilfoil and Other Nuisance Aquatic Plants in Silver Lake* (Ramsey County) (Osgood, 1997). The APM Plan concluded:

- While Eurasian watermilfoil had spread to locations around the entire lake in 1996, it had not grown in densities to cause an increased nuisance over that already caused by abundant native plants.

- Harvesting was discontinued with the discovery of Eurasian watermilfoil and chemical controls occurred from 1993 through 1997.

- Following infestation by Eurasian watermilfoil, coontail (*Ceratophyllum demersum*) became more prominent and northern milfoil (*Myriophyllum sibiricum*), bushy pondweed (*Najas spp*.), Chara (*Chara spp*.), and white water lily (*Nymphaea odorata*) declined significantly.

- Algal growth in Silver Lake was lower than predicted by available nutrients. This suggested that some factor was depressing the abundance of algae and keeping the water clear. It is possible that this factor was related to the predominance of aquatic plants in Silver Lake (e.g., nutrient uptake by attached algae growing on aquatic plants and/or nutrient uptake by coontail, a plant without roots that derives nutrients from water).

In 1999, the VBWD found Eurasian watermilfoil wherever the water depth was less than fourteen or fifteen feet (see Appendix C-5.1). Plant densities ranged from light to heavy, but were light to moderate in most areas of the lake. Four areas on the north and west sides of the lake noted heavy growths of Eurasian watermilfoil, and native species were not present in heavy growth areas. In all other areas of the lake, the native plant community appeared to be successfully competing with Eurasian watermilfoil.

In 1999, the VBWD survey identified light growths of curlyleaf pondweed in most areas of the lake. Native vegetation appeared to be successfully competing with the curlyleaf pondweed and preventing increases in its density and coverage, which is atypical of most lakes containing this plant. Typically, once a lake becomes infested with curlyleaf pondweed, this plant typically displaces native vegetation, thereby increasing its coverage and density. Curlyleaf pondweed begins growing in late August, grows throughout the winter at a slow rate, grows rapidly in the spring, and dies in early summer. Native plants that grow from seed in the spring are unable to grow in areas already occupied by curlyleaf pondweed, and are displaced by this plant. Silver Lake's plant community includes two native species, coontail (*Ceratophyllum demersum*) and elodea (*Elodea anadensis*), that grow throughout the winter and spring period and likely contributed to preventing the spread of curlyleaf pondweed in Silver Lake. The coverage and density of curlyleaf pondweed did not warrant concern based on the 1999 survey results.

The VBWD performed another macrophyte survey in June 13, 2005 to evaluate changes in concentration of Eurasion watermilfoil and curlyleaf pondweed in Silver Lake. The VBWD survey found that curlyleaf pondweed's density and coverage had increased since 1999 (see Appendix C-5.1). Eurasian watermilfoil was found throughout the lake, and plant densities were much, much heavier than in 1999. The coverage at the southern end of the lake was extremely dense (see Appendix C-5.1). The MNDR also performed an aquatic plant survey in 2005; the MDNR found Eurasian watermilfoil in the southern points of their survey and noted curlyleaf pondweed in some of the northern sampling points.

In 2007, the SLIA, in conjunction with MDNR and VBWD, began chemical treatments in the lake to control invasive plant species. The chemical treatments included whole lake treatments in 2007 and 2008 and targeted treatments in subsequent years. The VBWD survey performed in June 2007 after the whole lake treatment. The VBWD survey noted that Eurasian watermilfoil was present, but decayed (see Appendix C-5.1). The 2007 survey did not identify curlyleaf pondweed. After meeting with the SLIA and discussing treatment options, the VBWD agreed to fund half of the $36,000 needed to treat the curlyleaf pondweed in the lake in 2009.

Herbicide treatment of aquatic invasive species has had a negative effect on chemical water quality in Silver Lake. Following treatment, the dead plant biomass decays within the lake, releasing nutrients otherwise unavailable to algae. These treatments likely have contributed to the deterioration of water quality observed since the mid-2000s (see Section 5.1.2.3).

In January 2010, the VBWD held meetings with members from the MDNR, the City of North St. Paul, the SLIA and its chemical applicator, and Ramsey County. The purpose of the meeting was to discuss the Silver Lake water quality and aquatic plant data. The MDNR did not allow a whole lake treatment of the aquatic plants in 2010 because it wanted time for the native vegetation to reestablish.

The DNR and Ramsey County continued to monitor the lake's aquatic plants and water quality throughout 2010.

The MDNR performed point-intercept surveys of Silver Lake in 2011 and 2012 at the request of the VBWD to evaluate the effectiveness of the herbicide treatments. The MDNR identified Eurasian watermilfoil at 40 percent of sample locations in 2011 and 68% of sample locations in 2012. Curlyleaf pondweed was identified at 5 percent of sample locations in 2011 and 8 percent of sample locations in 2012.

Management of invasive species within Silver Lake may impact other waterbodies as well. Curlyleaf pondweed turions (similar to seeds) and Eurasian watermilfoil fragments can flow downstream and infest downstream lakes. The VBWD will continue to monitor the presence of these species in downstream lakes, including Long, DeMontreville, and Olson

5.1.2.4.3 Phytoplankton (Non-Rooted, Floating Plants – Algae) and Zooplankton (Microscopic Aquatic Animals)

The VBWD has collected phytoplankton and zooplankton samples from Silver Lake in 1999. Appendix D-5.1 and Appendix E-5.1 show the information from the 1999 samples (April 9, May 10, June 8, June 22, July 6, July 19, August 9, August 23, September 7, September 21, and October 12).

Phytoplankton derive energy from sunlight and use nutrients dissolved in lake water. They provide food for several types of animals, including zooplankton, which in turn are eaten by fish. A phytoplankton population in balance with the lake's zooplankton population is ideal for fish production. An inadequate phytoplankton population reduces the lake's zooplankton population and adversely impacts the growth of the lake's fishery. However, excess phytoplankton, especially blue-green algae, can interfere with recreational usage of a lake and is considered problematic.

A late summer algal bloom, dominated by green algae, was observed in Silver Lake during 1999. Despite the algal bloom, the lake's 1999 water transparency was generally good, ranging from a low of 1.0 meter to a high of 3.9 meters during the summer. Lowest measurements occurred in the late summer during algal blooms. The data suggest the lake's beneficial uses are currently supported by the lake's phytoplankton community. However, management of the lake's algae is warranted to prevent increased algal blooms and possible interference with the lake's beneficial uses.

The lake's zooplankton community is dominated by small-bodied forms. While these animals provide food for the lake's panfish community, they are unable to control the lake's algae community due to their small size. Because fish predation generally determines the numbers of large- and small-bodied zooplankters in a lake, increasing the numbers of large-bodied zooplankters is unrealistic. Because zooplankton grazing will not control the lake's phytoplankton community, phosphorus loading to the lake solely determines Silver Lake's algae community. Hence, phosphorus management will provide the best management measures for the lake's phytoplankton community.

5.1.3 Water Quantity Management Plan


Silver Lake Outlet

Runoff from the Silver Lake watershed enters the lake from storm sewer outfalls and culverts at various points along the lakeshore. The outlet from Silver Lake is a V-notch weir located on the west side of Century Avenue (T.H. 120) on the east side of the lake. The outlet elevation of the lake is Elevation 988.78 (NAVD88 datum, based on a 2008 Ramsey County Survey). Water from the lake flows east under Century Avenue (T.H. 120) to a large DNR protected wetland (#82-0375W) in the Greens of Silver Lake development, located in the City of Oakdale. Silver Lake water level data from 1925 to the present is available from Ramsey County and are shown in Figure 5.1-4 (NAVD88 vertical datum). The MDNR's ordinary high water elevation (OHW) for Silver Lake is 989.84 feet (NAVD88 vertical datum, or 989.57 feet in 1912 datum). The Federal Emergency Management Agency (FEMA) 2010 Flood Insurance Study (FIS) identifies the 100-year flood elevation of Silver Lake as 991feet (NAVD88 vertical datum); note that FEMA rounds to the nearest foot. More recent hydrologic model results (by Oakdale and VBWD) show the 100-year flood elevation of the lake to be approximately 0.5 foot lower.

Since Silver Lake is tributary to the VBWD’s flood control project (Project 1007), it is important that the VBWD not allow modifications to the Silver Lake outlet that would negatively affect the proper functioning of the flood control project. It is also important that there be no increases to the Silver Lake flood elevation. As a result, the VBWD has no plans to modify the lake outlet and will manage Silver Lake so that its 100-year flood elevation is maintained at its current level, which is Elevation 991.0, according to the Federal Emergency Management Agency (FEMA) 2010 Flood Insurance Study, or Elevation 990.5, as modeled by the City of Oakdale and the VBWD. The *City of North St. Paul Water Management Plan* (North St. Paul Plan) states that although the Silver Lake outlet is located in the City of Oakdale, the City of North St. Paul has been assuming responsibility for maintenance of the outlet. The City of North St. Paul will continue to maintain the outlet, as the outlet structure is critical to minimizing the impact of flooding on homes in North St. Paul.

The VBWD’s goals for Silver Lake are to:

- Address future intercommunity water quantity issues.
- Address existing flooding problems on Silver Lake.
- Prevent future flooding problems on Silver Lake.

In 2013, the National Oceanographic and Atmospheric Administration (NOAA) published Atlas 14, Volume 8 (see Section 4.7.6). Atlas 14 contains updated precipitation data for Minnesota and supersedes data sources used in the modeling and flood level determination of Silver Lake. In 2015, the VBWD will update its hydrologic-hydraulic modeling of the Silver Lake watershed. Updated modeling will incorporate the most recent precipitation data (see Section 4.7.7) which may increase 100-year flood levels relative to the existing flood insurance rate maps (FIRMs).

5.1.3.1 Water Quantity Issues

Some homes adjacent to the lake experienced basement flooding in 1984 and 1985 when the lake rose above Elevation 989.5. Whether this was entirely due to the lake elevation is not clear. In 2013, the VBWD used updated topographic data to determine if structures located around Silver Lake were actually below the 100-year flood elevation. That study found no homes with entry elevations below 990 feet, but identified 11 homes that may be impacted if the water level is between 991 and 992 feet. It is possible that homeowners may benefit from having the FIS maps revised to show a 100-year flood elevation below 991 feet. The VBWD will cooperate with the City of North St. Paul if the City petitions FEMA to alter the 100-year flood elevation or remove homes from the mapped floodplain via the Letter of Map Amendment (LOMA) or Letter of Map Revision (LOMR) processes. The VBWD will continue to enforce the 991.0 flood level until such actions are performed (or until results of additional modeling indicate a different 100-year flood level, see Section 5.1.3).

Drawdown of Silver Lake occurs quickly compared to downstream lakes. This means that the lake does not hold excess stormwater long enough to be of significant value in reducing downstream flooding. Although the lake drains quickly, residents are very sensitive to small changes in lake level. In 1989, the City of North St. Paul surveyed residents as part of their water management planning process and the survey results identified water level control as an issue. As noted in the North St. Paul plan, water level concerns (either too high or too low) received the most attention.

5.1.4 References

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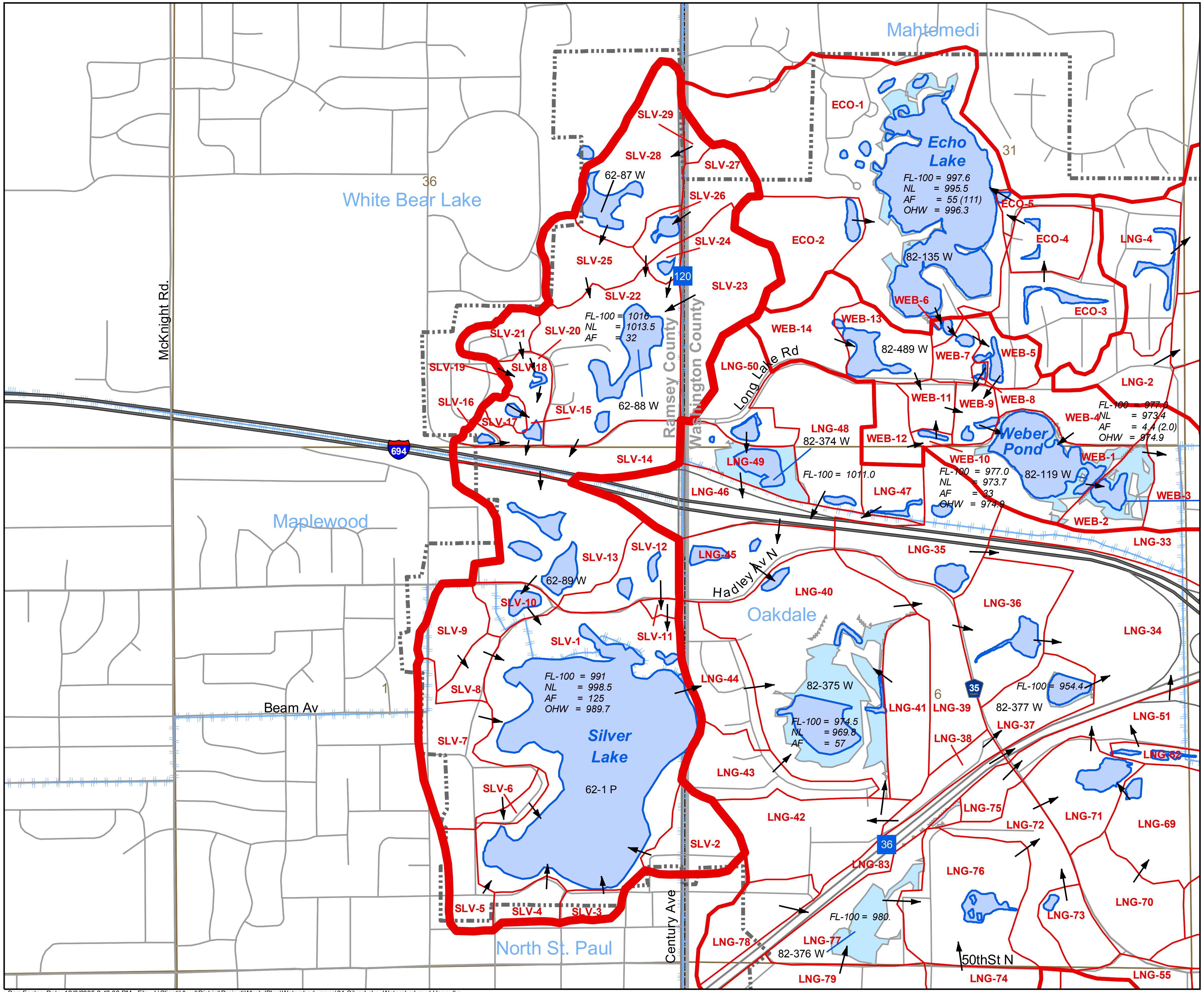


LEGEND

- Silver Lake Watershed
- Major Watershed Divide
- Subwatershed Divide
- SLV-1 Subwatershed Designation
- 62-1P DNR Protected Waters Designation
- Subwatershed Contributing Runoff
- Overflow Path from Landlocked Watershed (Non-Contributing Subwatershed)
- Overflow Path from Semi-Landlocked Watershed
- Lakes, Ponds, Wetlands, Approximate Normal Water Surface Level
- Lakes, Ponds Wetlands, Approximate 100 Year Flood Surface Level
- FL-100 100 Year Flood Level
- NL Normal Level
- AF Acre Feet of Storage at 100 Year Flood Level
- OHW DNR Established Ordinary High Water Elevation

Project 1007

- Catch Basin
- Manhole Cover
- Open Channel
- Pipe
- MN-DOT Pipe
- Section Lines
- VBWD Legal Boundary
- Municipal Boundary
- County Boundary

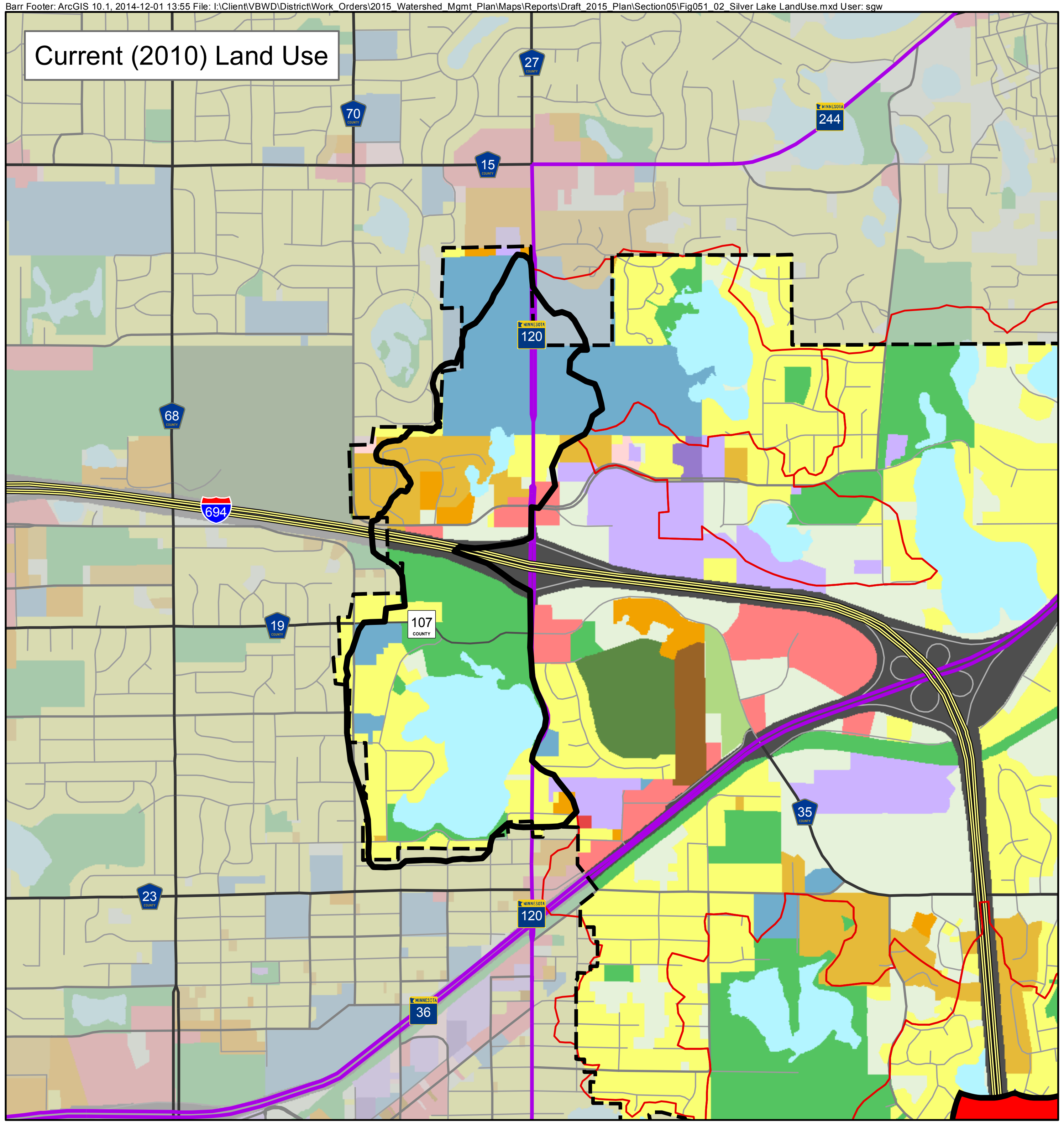
Landlocked: Basin does not overflow using VBWD simplified method for calculating its 100-year flood level or using a more detailed analysis, such as the 1% probability flood level.

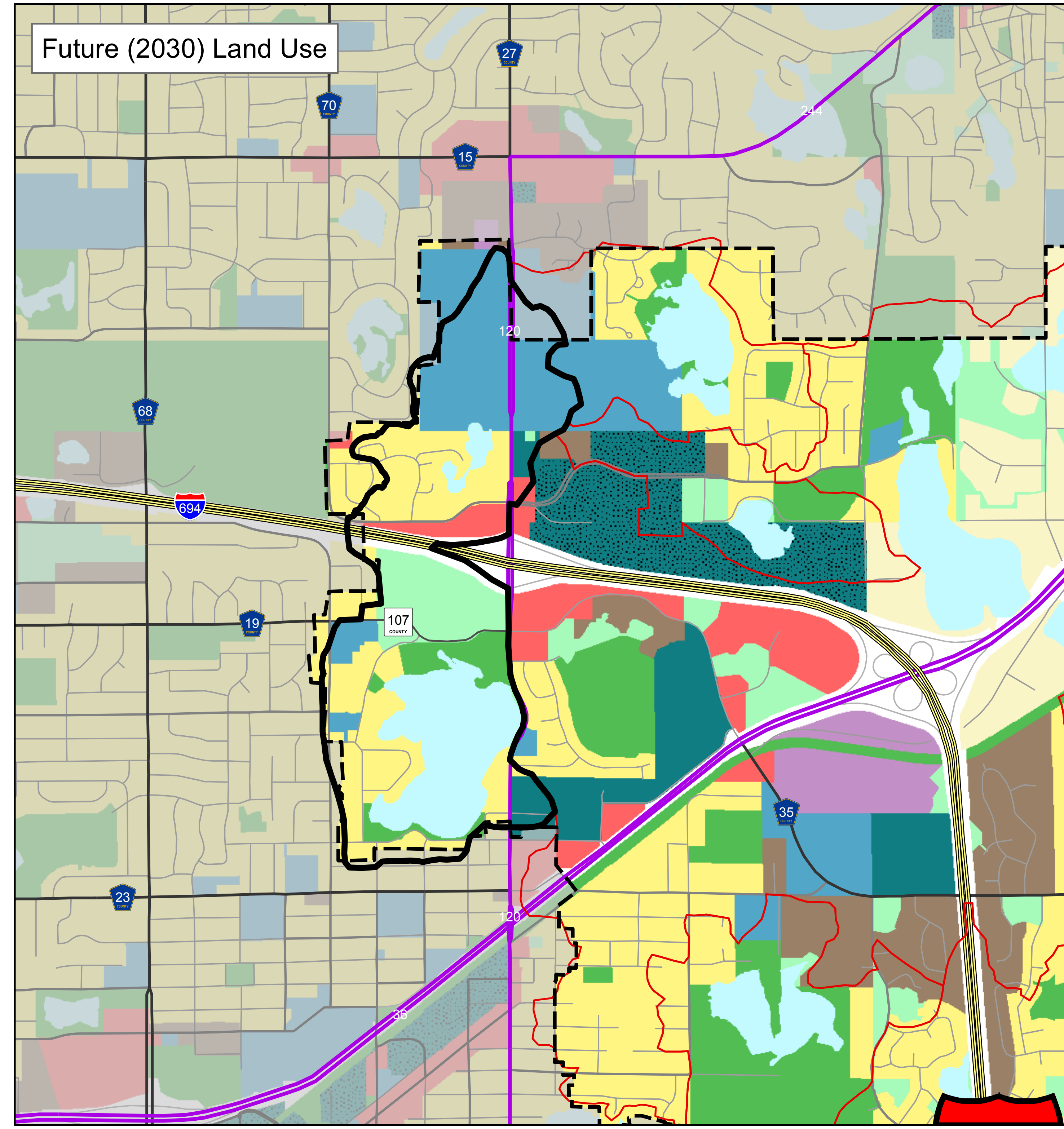
Semi-Landlocked: Basin does not overflow in the 100-year 24-hour rainfall total or the 100-year 10-day snowmelt event, but does overflow when calulating its 100-year flood level based on the VBWD simplified method or the 1% probablility flood level.

Figure 5.1-1

SILVER LAKE WATERSHED
Valley Branch Watershed District

Barr Footer: ArcGIS 10.1, 2014-12-01 13:55 File: I:\Client\VBWD\District\Work_Orders\2015_Watershed_Mgmt_Plan\Maps\Reports\Draft_2015_Plan\Section05\Fig051_02_Silver Lake LandUse.mxd User: sgw





Current (2010) Land Use

- Farmstead
- Seasonal/Vacation
- Single Family Detached
- Manufactured Housing Park
- Single Family Attached
- Multifamily
- Retail and Other Commercial
- Office
- Mixed Use Residential
- Mixed Use Industrial
- Mixed Use Commercial and Other
- Industrial and Utility
- Extractive
- Institutional
- Park, Recreational or Preserve
- Golf Course
- Major Highway
- Railway
- Airport
- Agricultural
- Undeveloped
- Water
- Silver Lake Subwatershed
- Major Subwatershed Boundary
- VBWD Legal Boundary

Future (2030) Land Use

- Agricultural
- Rural or Large-Lot Residential
- Single Family Residential
- Multifamily Residential
- Commercial
- Industrial
- Institutional
- Mixed Use
- Multi-Optional Development
- Park and Recreation
- Open Space or Restrictive Use
- Rights-of-Way (i.e., Roads)
- Railway (inc. LRT)
- Airport
- Vacant or Unknown
- Open Water
- Silver Lake Subwatershed
- Major Subwatershed Boundary
- VBWD Legal Boundary

Feet

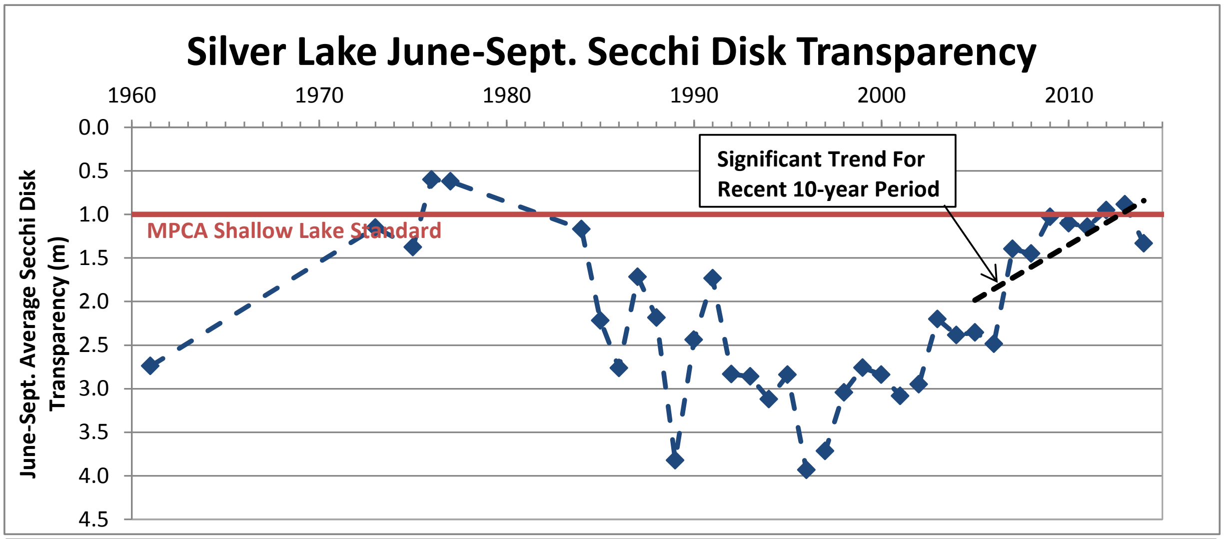
2,000 0 2,000 4,000

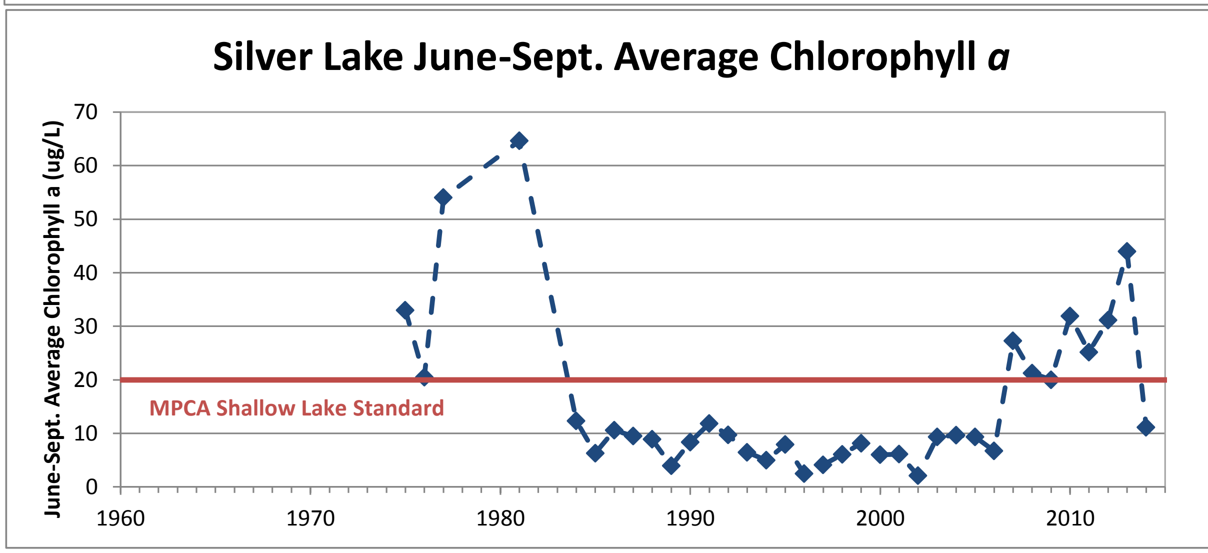
1 inch = 2,000 feet

Source: Metropolitan Council 2010

Figure 5.1-2

SILVER LAKE WATERSHED
CURRENT (2010) AND FUTURE (2030) LANDUSE
2015-2025 Watershed Management Plan
Valley Branch Watershed District





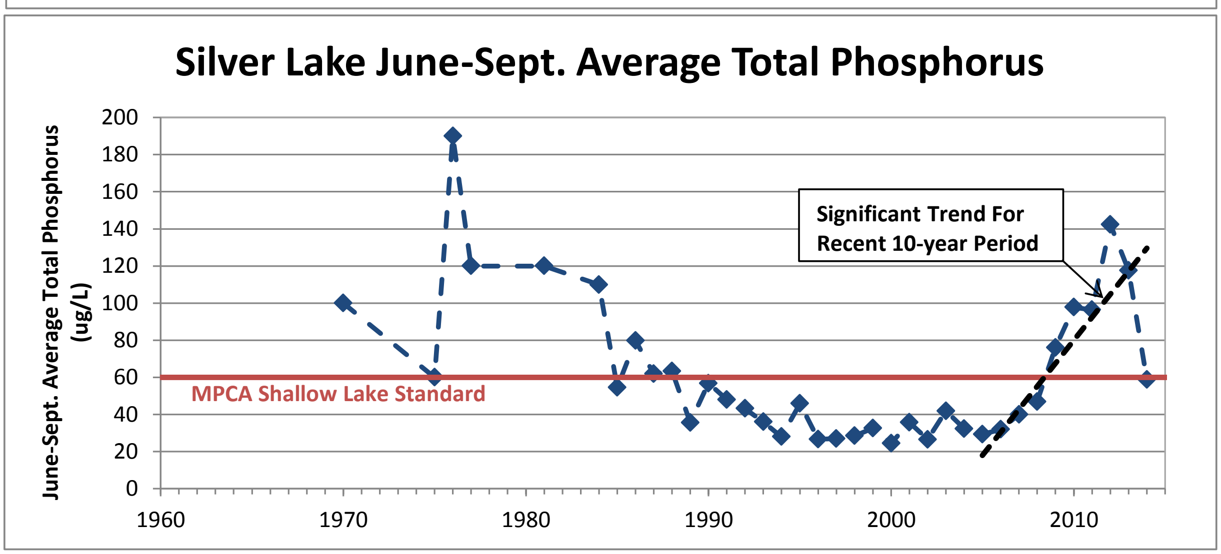


Figure 5.1-3

Silver Lake Water Quality
2015 - 2025 Waterhsed Management Pla
Valley Branch Watershed District

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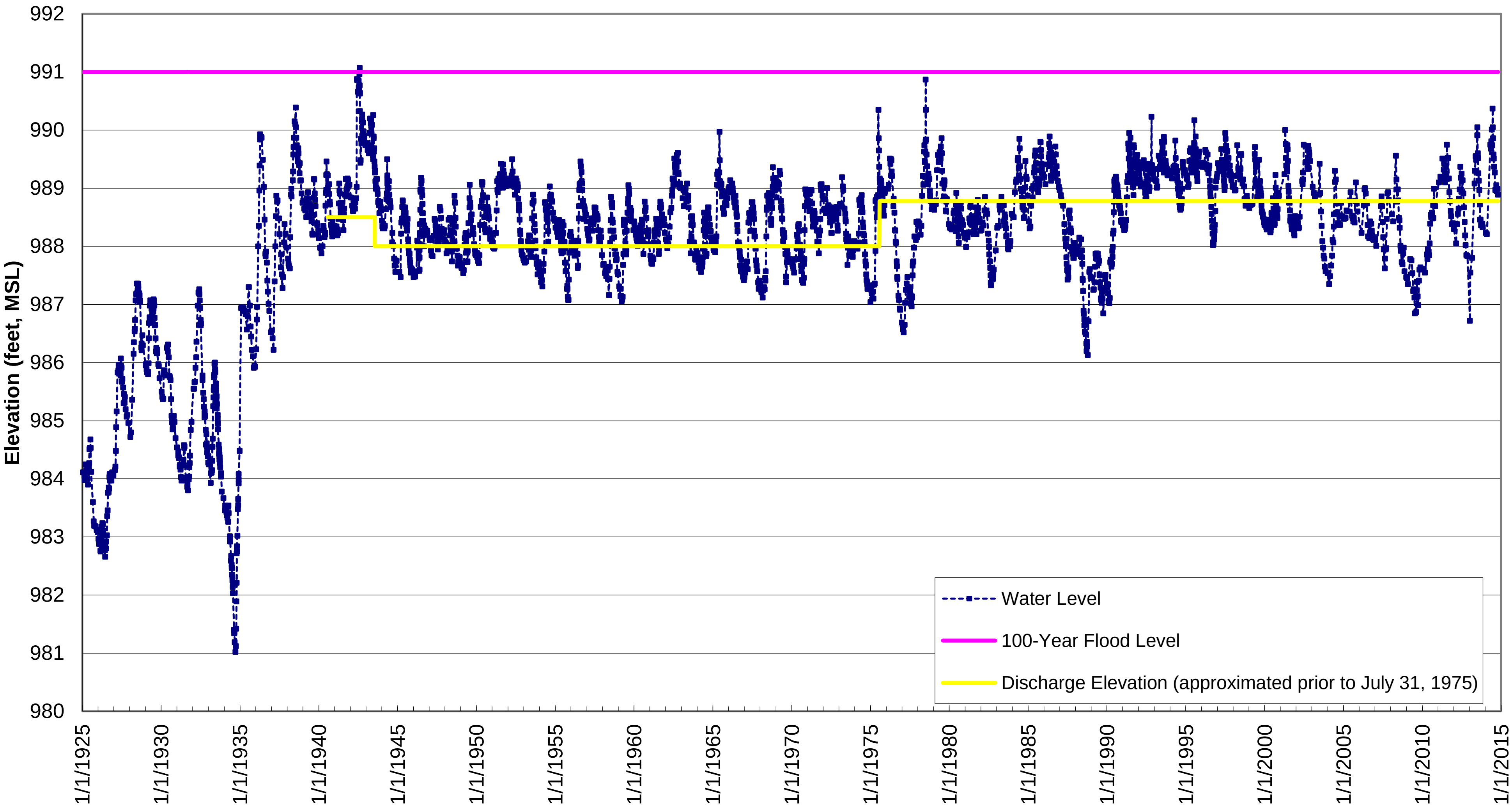


All values in NAVD88 vertical datum.
Add 0.27 feet to convert from 1912
datum to NAVD88 datum.

Figure 5.1-4

SILVER LAKE WATER LEVELS
Valley Branch Watershed District

Appendix A-5.1 Additional Water Quality Information

Appendix A-5.1 Additional Water Quality Information

MINLEAP Modeling

The Minnesota Lake Eutrophication Analysis Procedure (MINLEAP) is intended to be used as a screening tool for estimating lake conditions and for identifying "problem" lakes. MINLEAP is particularly useful for identifying lakes requiring "protection" versus those requiring "restoration" (Heiskary and Wilson, 1990). In addition, MINLEAP modeling by has been done 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).

Results of MINLEAP modeling done by the VBWD in 2000 for Silver Lake suggests that the lake could achieve "better" water quality than is currently observed (Heiskary and Lindbloom, 1993). MINLEAP predicts a growing season mean total phosphorus concentration of approximately 42 µg/L versus 29–142 µg/L (observed in the last ten years); a chlorophyll *a* concentration of approximately 15 µg/L versus 7–23 µg/L (observed in the last ten years); and summer average transparency of 1.6 meters versus 0.9–2.5 meters observed in recent years. The predicted phosphorus concentration has a standard error of 16 µg/L, which means that the applicable MPCA water quality standard of 60 µg/L for total phosphorus is within the range of what is realistically attainable for Silver Lake.

Vighi and Chiaudani Method

Vighi and Chiaudani (1985) developed another method to determine the phosphorus concentration in lakes that are not affected by anthropogenic (human) inputs. As a result the phosphorus concentration in a lake resulting from natural, background phosphorus loadings can be calculated from information about the lake's mean depth and alkalinity or conductivity. Alkalinity is considered more useful for this analysis because it is less influenced by the modifying effect of anthropogenic inputs.

Based on the method developed by Vighi and Chiaudani (1985) using the long-term average alkalinity values from the main basin of Silver Lake, the predicted phosphorus concentration from natural, background loadings should be 24 µg/L. This predicted concentration is much less than the applicable MPCA water quality standard of 60 ug/L. This indicates that the MPCA shallow lakes criterion is attainable, given the appropriate phosphorus loadings.

Watershed Restoration and Protection Strategy (WRAPS)

Silver Lake is included in the VBWD WRAPS study, which addressed several VBWD waterbodies. One of the key components of the WRAPS study is to understand the sources of phosphorus contributing to the existing nutrient loading. Sources evaluated for Silver Lake in the WRAPS study (and the associated percentage of phosphorus loading during the growing season) include:

- internal loading (48 percent)
- watershed runoff (21 percent)
- aquatic vegetation (28 percent)

- atmospheric deposition (3 percent)

Modeling Methods

The P8 (Program for Predicting Polluting Particle Passage through Pits, Puddles and Ponds) Urban Catchment (computer) Model (Version 3.4) was used to estimate watershed runoff and total phosphorus loads from the Silver Lake watershed. Noncontributing areas of the watershed, as identified by the VBWD, were not included in the P8 model. In-lake modeling for Silver Lake was accomplished through the creation of a mass balance model that tracks the flow of both water and phosphorus through the lake for the critical water quality growing season as well as the year prior (to establish a steady-state initial condition)

The key input parameters for the in-lake mass balance model included direct precipitation data, evaporation data, runoff loads from the lake's watershed (as predicted by the P8 model), the lake storage and outlet rating curve, estimated groundwater exchange, and in-lake water quality monitoring data. Additional data, including sediment core data and macrophyte survey information, were used to verify that model estimates of internal phosphorus loading were reasonable.

Implementation Plan

There is no one dominant source of nutrient loading to Silver Lake, and significant portions of the nutrient loading to Silver Lake come from external and internal sources. Implementation strategies for Silver Lake recommended in the WRAPS study include:

- Continue to implement the VBWD rules
- Evaluate opportunities for enhanced treatment of discharge from the wetland in subwatershed SLV-10 (in cooperation with the City of North St. Paul)
- Continue to target small scale BMPs and buffers in residential areas around the lake
- Continue routine monitoring of water quality and macrophytes
- Work with the MDNR to perform fishery surveys of Silver Lake

The WRAPS study also recommended the following implementation items for future consideration following the implementation of the above items:

- Cooperate with the MDNR and City of North St. Paul to restore native vegetation (e.g., alum treatment, temporary restrictions on motor boat activity, temporary limits on herbicide application)
- After vegetation re-establishment, selectively treat curlyleaf pondweed and Eurasion water milfoil.

Appendix B-5.1 Additional Fishery Information

Appendix B-5.1 Additional Fishery Information

The DNR 2000 Lake Survey Report indicates:

- Bluegill, pumpkinseed, and hybrid sunfish were the most abundant fish captured, but most were small in size, with less than ten percent over six inches long.
- Black crappie were present in low numbers with only a few over 8 inches long.
- Yellow perch were below the median for this lake type and nearly half of the yellow perch caught were over nine inches long.
- Largemouth bass were moderately abundant with most fish measuring 12-16 inches long.
- Walleye numbers (3.5/gillnet) were within the historical range (2.0-5.5/gillnet) and averaged over 20 inches in length.
- Northern pike were present in higher numbers than any other year Silver Lake was surveyed. All fish were age IV or less and most were under 25 inches long.
- Two tiger muskellunge were sampled. Both were from the 1998 stocking and were approximately 24 inches long.
- Yellow bullhead numbers reached historic highs in this survey, but were average for this type of lake. One-third of all fish were over 12-inches long. Black bullhead numbers were low.
- White sucker were present in moderate numbers, ranging in size from 15-18 inches.

The DNR 2012 Lake Survey Report indicates:

- Bluegill, pumpkinseed, and hybrid sunfish were the most abundant fish captured during this survey. Most bluegill were small, with less than 2% over 6 inches long. Pumpkinseed and hybrid sunfish were also very small with average sizes of 4.13 and 4.54 inches respectively.
- Black crappie are present in high numbers but small in size, with only one fish larger than 8 inches. Black crappies had and an average size of 6.35 inches.
- Yellow perch numbers were below the median for lakes of this type. Yellow perch size ranged from 5.67 to 6.57 inches with an average size of 6.1 inches.
- Walleye were not sampled during this survey, but have been observed in previous surveys in low to modest numbers.
- Largemouth bass were moderately abundant with most fish measuring 8-16 inches long.

- Northern pike were sampled in moderate numbers but less than the previous survey of this lake (2005) in which northern pike were sampled at all-time highs for abundance. All fish had an average size of 25 inches long.

- One tiger muskie was sampled; this fish corresponds to a stocking event in 2008. This lone tiger muskie was 32 inches long and weighed slightly more than 6 lbs.

- Yellow bullheads were observed in moderate but average numbers for this type of lake. Yellow bullhead sizes ranged from 7.5 to almost 11 inches.

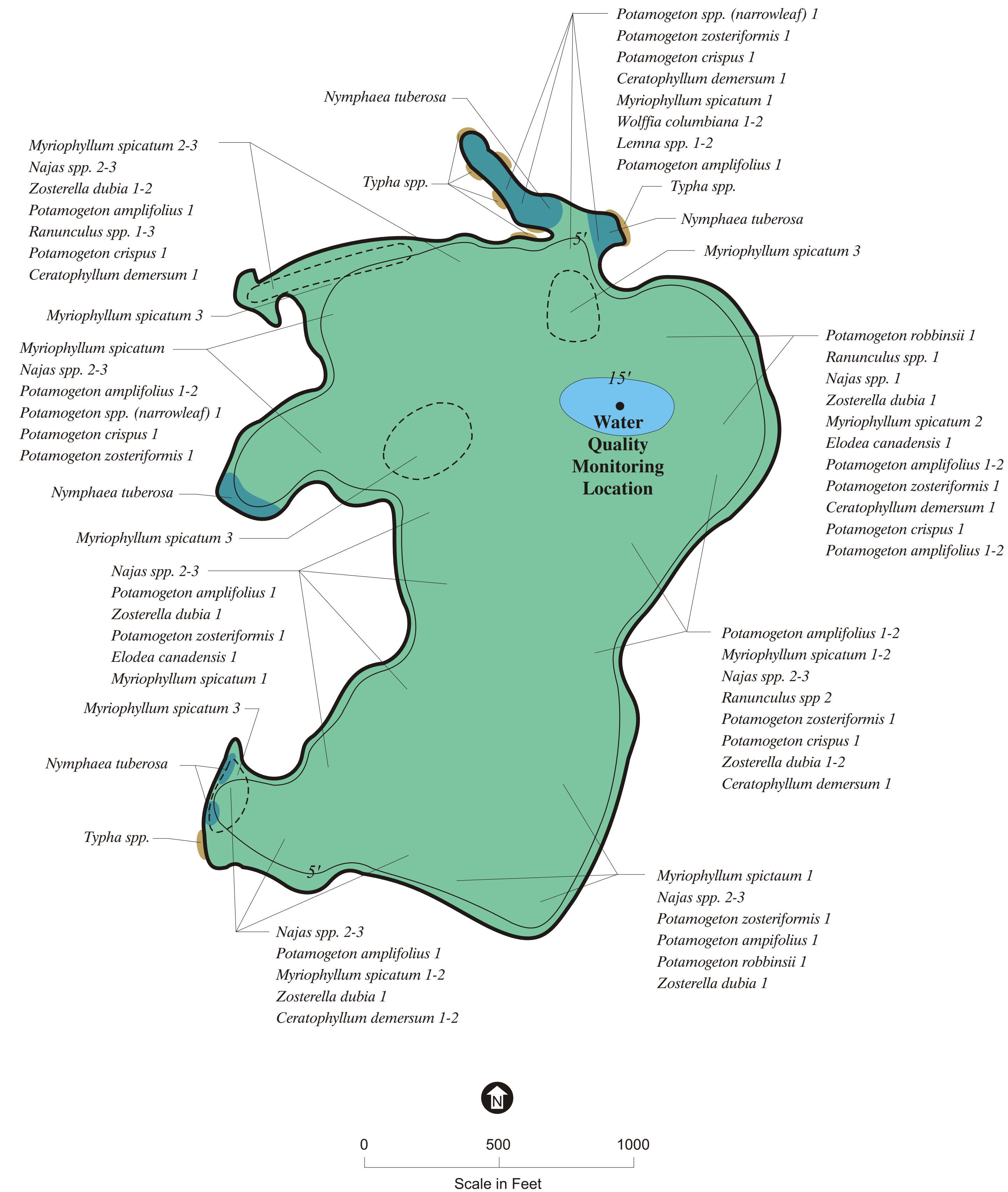
- Black bullhead were found in low number during this survey. White sucker were also present in low numbers, ranging in size from 15-18 inches.

- Despite annual stockings from 1996 to 2003 and a 2008 stocking, channel catfish continue to be found in low abundance in Silver Lake as measured by catch rate, with one channel catfish observed during this survey. This single fish measured over 25.5 inches and weighed 6.4 lbs and was from the 2008 stocking.

Appendix C-5.1 Additional Macrophyte Information

- No macrophytes found in water > 14-15 feet
- Macrophyte densities are greater near shoreline, Lemna trisulca throughout lake
- Macrophyte densities estimated as follows: 1 = light; 2 = moderate; 3 = heavy

	Common Name	Scientific Name
Submerged Aquatic Plants:	Coontail	*Ceratophyllum demersum*
	Large-leaf pondweed	*Potamogeton amplifolius*
	Curlyleaf pondweed	*Potamogeton crispus*
	Flatstem pondweed	*Potamogeton zosteriformis*
	Leafy/Narrowleaf pondweed	*Potamogeton spp. (narrowleaf)*
	Robbins' pondweed	*Potamogeton robbinsii*
	Eurasian water milfoil	*Myriophyllum spicatum*
	White water buttercup	*Ranunculus spp.*
	Bushy pondweed and naiad	*Najas spp.*
	Water stargrass	*Zosterella dubia*
	Elodea	*Elodea canadensis*
Floating Leaf:	White waterlily	*Nymphaea tuberosa*
	Watermeal	*Wolffia columbiana*
	Duckweed	*Lemna spp.*
Emergent:	Cattail	*Typha spp.*
No Aquatic Vegetation Found:		
	Dense Area of Myriophyllum spicatum	



SILVER LAKE
MACROPHYTE SURVEY
JUNE 24, 1999

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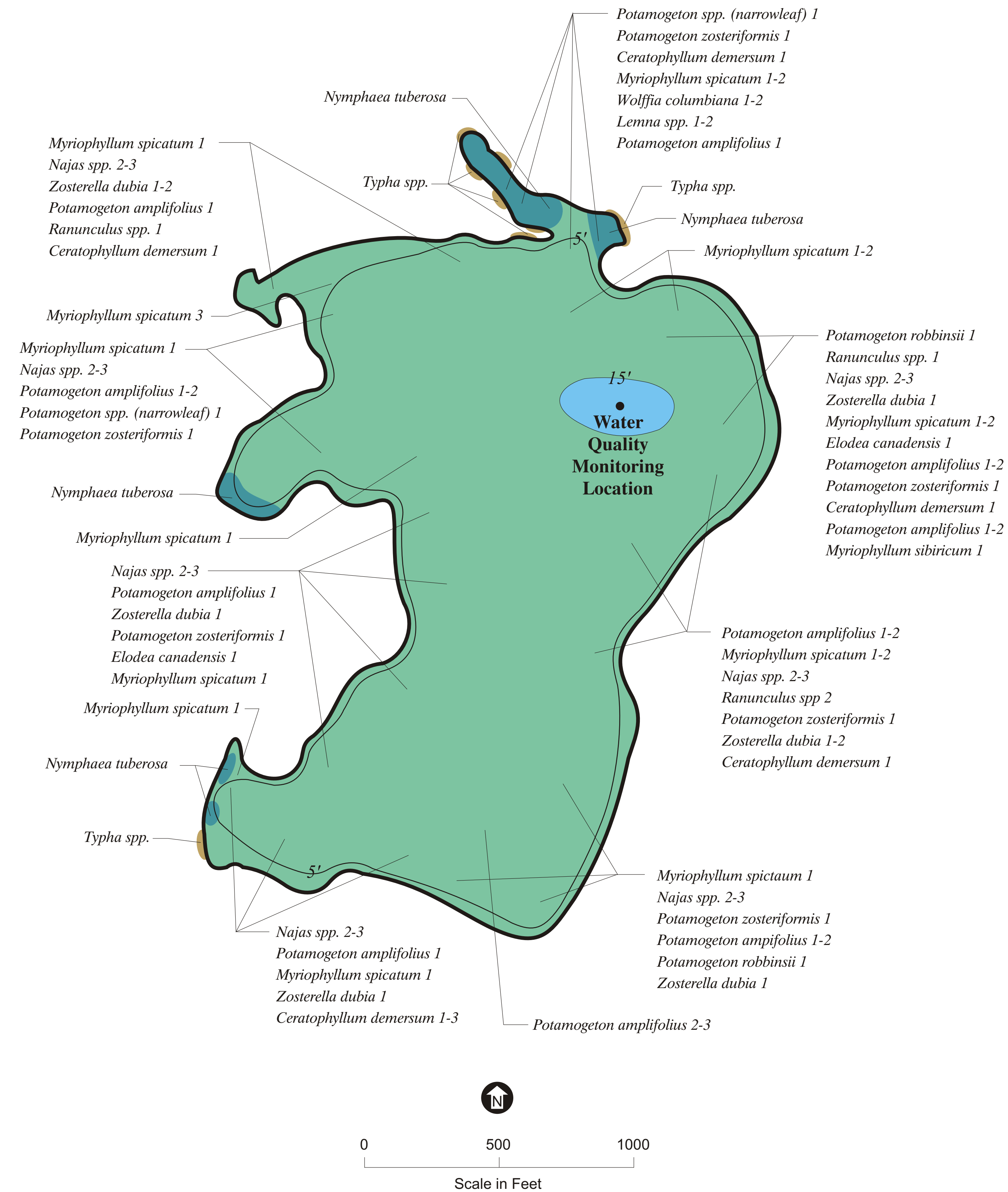
- No macrophytes found in water > 14-15 feet
- Macrophyte densities are greater near shoreline, Lemna trisulca throughout lake
- Macrophyte densities estimated as follows: 1 = light; 2 = moderate; 3 = heavy

	Common Name	Scientific Name
Submerged Aquatic Plants:	Coontail	*Ceratophyllum demersum*
	Large-leaf pondweed	*Potamogeton amplifolius*
	Flatstem pondweed	*Potamogeton zosteriformis*
	Leafy/Narrowleaf pondweed	*Potamogeton spp. (narrowleaf)*
	Robbins' pondweed	*Potamogeton robbinsii*
	Water stargrass	*Zosterella dubia*
	Eurasian water milfoil	*Myriophyllum spicatum*
	Northern water milfoil	*Myriophyllum sibiricum*
	White water buttercup	*Ranunculus spp.*
	Bushy pondweed and naiad	*Najas spp.*
	Elodea	*Elodea canadensis*
Floating Leaf:	White waterlily	*Nymphaea tuberosa*
	Watermeal	*Wolffia columbiana*
	Duckweed	*Lemna spp.*
Emergent:	Cattail	*Typha spp.*
No Aquatic Vegetation Found:		



SILVER LAKE
MACROPHYTE SURVEY
AUGUST 26, 1999

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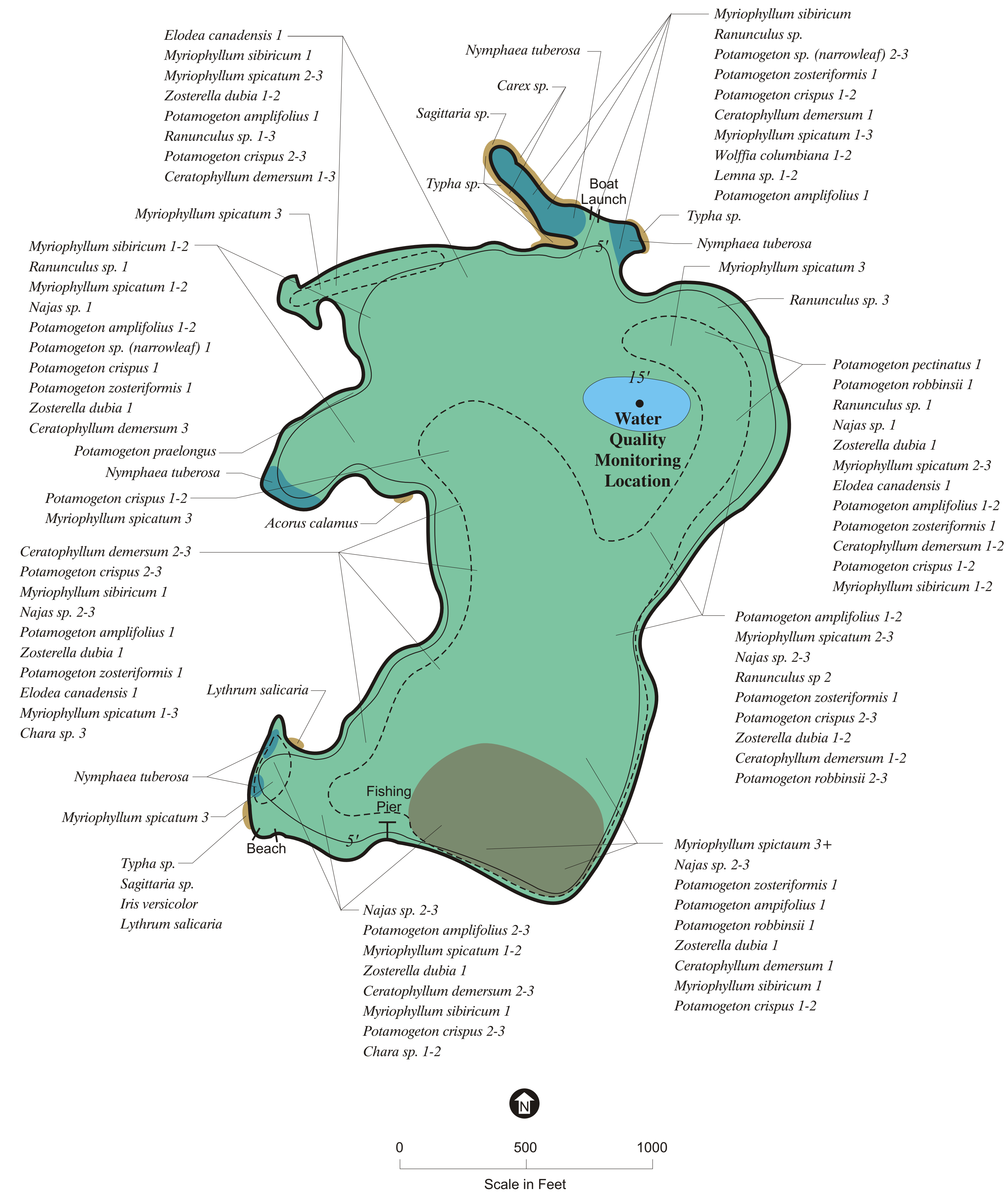
- No macrophytes found in water > 15-16 feet
- Macrophyte densities are greater near shoreline, Lemna trisulca throughout lake
- Algal mats present
- Macrophyte densities estimated as follows: 1 = light; 2 = moderate; 3 = heavy

	Common Name	Scientific Name
Submerged Aquatic Plants:	Coontail	*Ceratophyllum demersum*
	White stem pondweed	*Potamogeton praelongus*
	Large-leaf pondweed	*Potamogeton amplifolius*
	Curlyleaf pondweed	*Potamogeton crispus*
	Flatstem pondweed	*Potamogeton zosteriformis*
	Leafy/Narrowleaf pondweed	*Potamogeton sp. (narrowleaf)*
	Robbins' pondweed	*Potamogeton robbinsii*
	Eurasian water milfoil	*Myriophyllum spicatum*
	Northern water milfoil	*Myriophyllum sibiricum*
	White water buttercup	*Ranunculus sp.*
	Bushy pondweed and naiad	*Najas spp.*
	Water stargrass	*Zosterella dubia*
	Elodea	*Elodea canadensis*
	Muskgrass	*Chara sp.*
Floating Leaf:	White waterlily	*Nymphaea tuberosa*
	Watermeal	*Wolffia columbiana*
	Duckweed	*Lemna sp.*
Emergent:	Cattail	*Typha sp.*
	Purple loosestrife	*Lythrum salicaria*
	Arrowhead	*Sagittaria sp.*
	Blue flag	*Iris versicolor*
	Sweet flag	*Acorus calamus*
	Sedge	*Carex sp.*
No Aquatic Vegetation Found:		

Approximate Dense Area of *Myriophyllum spicatum*

Approximate Extremely dense Area of *Myriophyllum spicatum*



SILVER LAKE
MACROPHYTE SURVEY
JUNE 13, 2005

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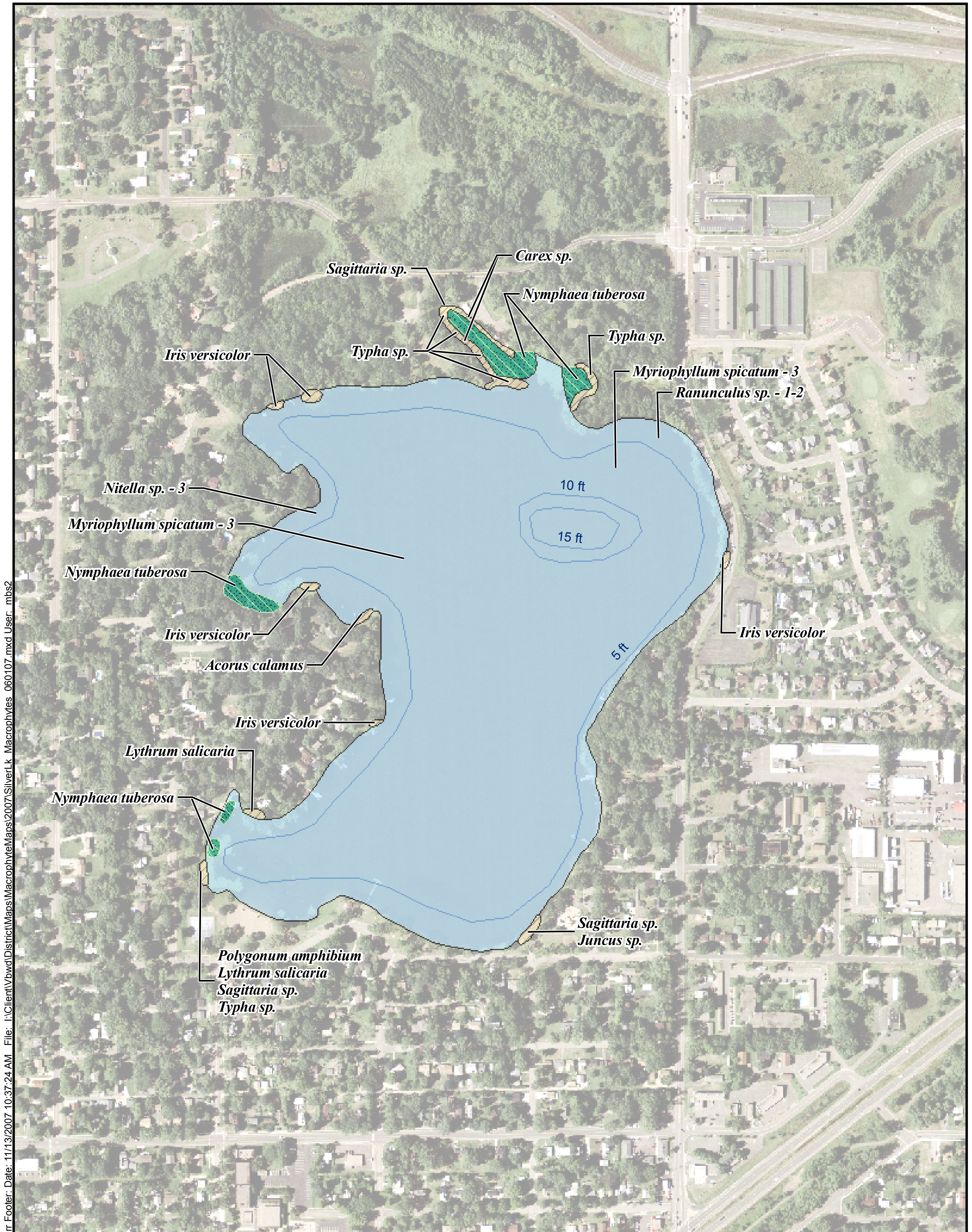


Legend

- Emergent Plants
- Floating Leaf Plants
- Submerged Aquatic Plants
- No Aquatic Vegetation

Submerged Aquatic Plants

Common Name	Scientific Name
eurasian watermilfoil	*Myriophyllum spicatum*
water crowfoot	*Ranunculus sp.*
stonewort	*Nitella sp.*

Floating Leaf Plants

Common Name	Scientific Name
white waterlily	*Nymphaea tuberosa*

Emergent Plants

Common Name	Scientific Name
arrowhead	*Sagittaria sp.*
blue flag iris	*Iris versicolor*
cattail	*Typha sp.*
common sweetflag	*Acorus calamus*
purple loosestrife	*Lythrum salicaria*
sedge	*Carex sp.*
soft rush	*Juncus sp.*
water knotweed	*Polygonum amphibium*

N

0 500 1,000 1,500
Feet

0 100 200 300 400
Meters

Imagery Source: 2006 AE

BARR

FIELD NOTES:
- Macrophyte densities estimated as follows:
  1=light; 2=moderate; 3=heavy
- Densities generally not noted for emergent and floating leaf plants
- It appears lake was sprayed, all plants dead or decaying
- Algal mats present
- Potamogeton amplifolius: dead
- Ceratophyllum demersum, Elodea sp., Chara sp., Nittella sp.: not healthy looking, densities not recorded
- Myriophyllum spicatum and Ranunculus sp. present but decayed

SILVER LAKE MACROPHYTE
SURVEY RESULTS
June 1, 2007
Valley Branch Watershed District

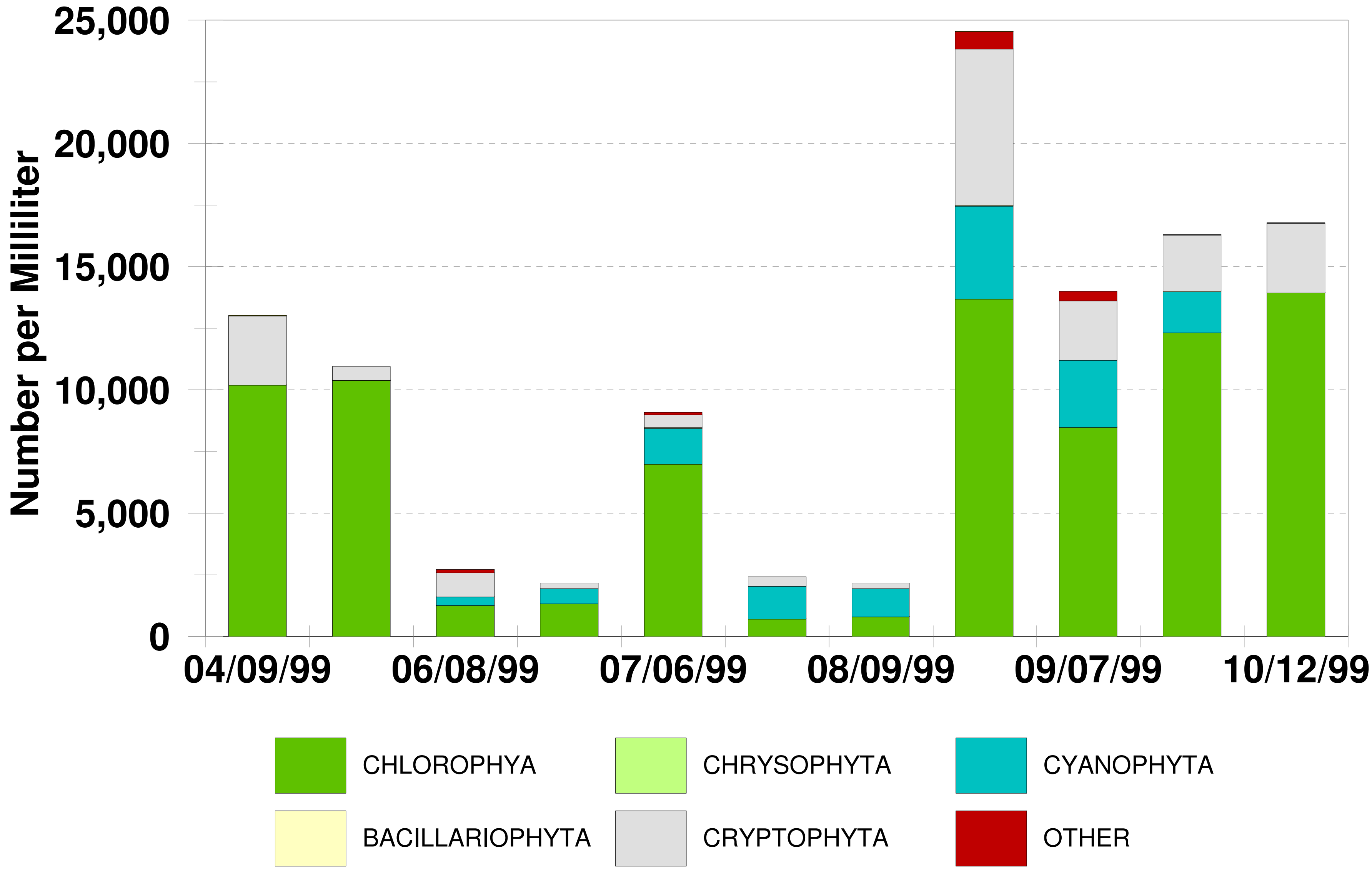
Appendix D-5.1 Additional Phytoplankton Information

SILVER LAKE

SAMPLE: 0-2 METERS (INT. TUBE)
STANDARD INVERTED MICROSCOPE ANALYSIS METHOD

DIVISION	TAXON	04/09/99 units/mL	05/10/99 units/mL	06/08/99 units/mL	06/22/99 units/mL	07/06/99 units/mL	07/19/99 units/mL	08/09/99 units/mL	08/23/99 units/mL	09/07/99 units/mL	09/21/99 units/mL	10/12/99 units/mL
CHLOROPHYTA (GREEN ALGAE)	*Actinastrum Hantzschii*	0	0	0	0	0	0	0	0	39	0	0
	Ankistrodesmus falcatus	0	0	0	0	0	0	0	42	78	0	0
	Ankistrodesmus Brauni	0	39	78	78	0	0	39	590	156	0	0
	Chlamydomonas globosa	10,198	10,385	1,132	1,210	6,598	429	508	12,221	7,066	12,347	13,976
	Coelastrum microporum	0	0	0	0	0	0	0	42	0	0	0
	Elakatothrix gelatinosa	0	0	0	0	0	39	0	0	0	0	0
	Oocystis parva	0	0	0	0	0	0	0	126	0	0	0
	Pandorina morum	0	0	0	0	39	0	0	42	0	0	0
	Quadrigula sp.	0	0	0	0	39	0	0	0	0	0	0
	Scenedesmus sp.	0	0	0	0	0	0	0	42	0	0	0
	Schroederia Judayi	0	0	0	39	312	273	234	379	0	0	0
	Sphaerocystis Schroeteri (Colony)	0	0	78	0	0	0	0	84	1,054	0	0
	Selenastrum sp.	0	0	0	0	0	0	0	0	39	0	0
	Tetraedron minimum	0	0	0	0	0	0	39	126	39	0	0
	Tetraedron muticum	0	0	0	0	0	0	0	0	39	0	0
	CHLOROPHYTA TOTAL	**10,198**	**10,424**	**1,288**	**1,327**	**6,988**	**742**	**820**	**13,695**	**8,511**	**12,347**	**13,976**
CHRYSOPHYTA (YELLOW-BROWN ALGAE)	**CHRYSOPHYTA TOTAL**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
CYANOPHYTA (BLUE-GREEN ALGAE)	*Anabaena affinis*	0	0	0	0	0	0	429	211	0	42	0
	Anabaena flos-aquae	0	0	312	312	781	0	39	506	547	421	0
	Anabaena spiroides v. crassa	0	0	0	0	78	0	39	0	664	464	0
	Anabaenopsis raciborski	0	0	0	0	0	0	0	0	39	0	0
	Aphanizomenon flos-aquae	0	0	0	0	0	1,054	0	506	508	42	0
	Coelosphaerium Naegelianum	0	0	0	39	312	156	156	84	78	0	0
	Merismopedia tenuissima	0	0	0	0	0	0	0	42	0	0	0
	Microcystis aeruginosa	0	0	0	156	195	39	351	843	742	126	0
	Microcystis incerta	0	0	0	39	78	39	117	1,433	78	84	0
	Oscillatoria limnetica	0	0	39	39	39	0	0	169	0	126	0
	Phormidium mucicola	0	0	0	39	0	0	0	0	39	337	0
	CYANOPHYTA TOTAL	**0**	**0**	**351**	**625**	**1,484**	**1,288**	**1,132**	**3,793**	**2,694**	**1,643**	**0**
BACILLARIOPHYTA (DIATOMS)	*Cocconeis placentula*	0	0	0	0	0	39	0	0	0	0	0
	Epithemia sp.	0	0	0	0	0	0	0	0	0	42	0
	Fragilaria crotonensis	0	0	0	0	39	0	0	42	0	0	0
	Stephanodiscus sp.	42	0	0	0	0	0	0	0	0	0	0
	BACILLARIOPHYTA TOTAL	**42**	**0**	**0**	**0**	**39**	**39**	**0**	**42**	**0**	**42**	**0**
CRYPTOPHYTA (CRYPTOMONADS)	*Cryptomonas erosa*	2,781	547	976	234	508	351	234	6,321	2,420	2,276	2,811
	CRYPTOPHYTA TOTAL	**2,781**	**547**	**976**	**234**	**508**	**351**	**234**	**6,321**	**2,420**	**2,276**	**2,811**
EUGLENOPHYTA (EUGLENOIDS)	*Euglena sp.*	0	0	0	0	0	0	0	42	78	0	0
	Trachelomonas sp.	0	0	0	0	78	0	0	674	195	0	0
	EUGLENOPHYTA TOTAL	**0**	**0**	**0**	**0**	**78**	**0**	**0**	**716**	**273**	**0**	**0**
PYRRHOPHYTA (DINOFLAGELLATES)	*Ceratium hirundinella*	0	0	117	0	0	0	0	0	117	0	0
	PYRRHOPHYTA TOTAL	**0**	**0**	**117**	**0**	**0**	**0**	**0**	**0**	**117**	**0**	**0**
	TOTALS	**13,021**	**10,970**	**2,733**	**2,186**	**9,096**	**2,420**	**2,186**	**24,567**	**14,015**	**16,308**	**16,787**

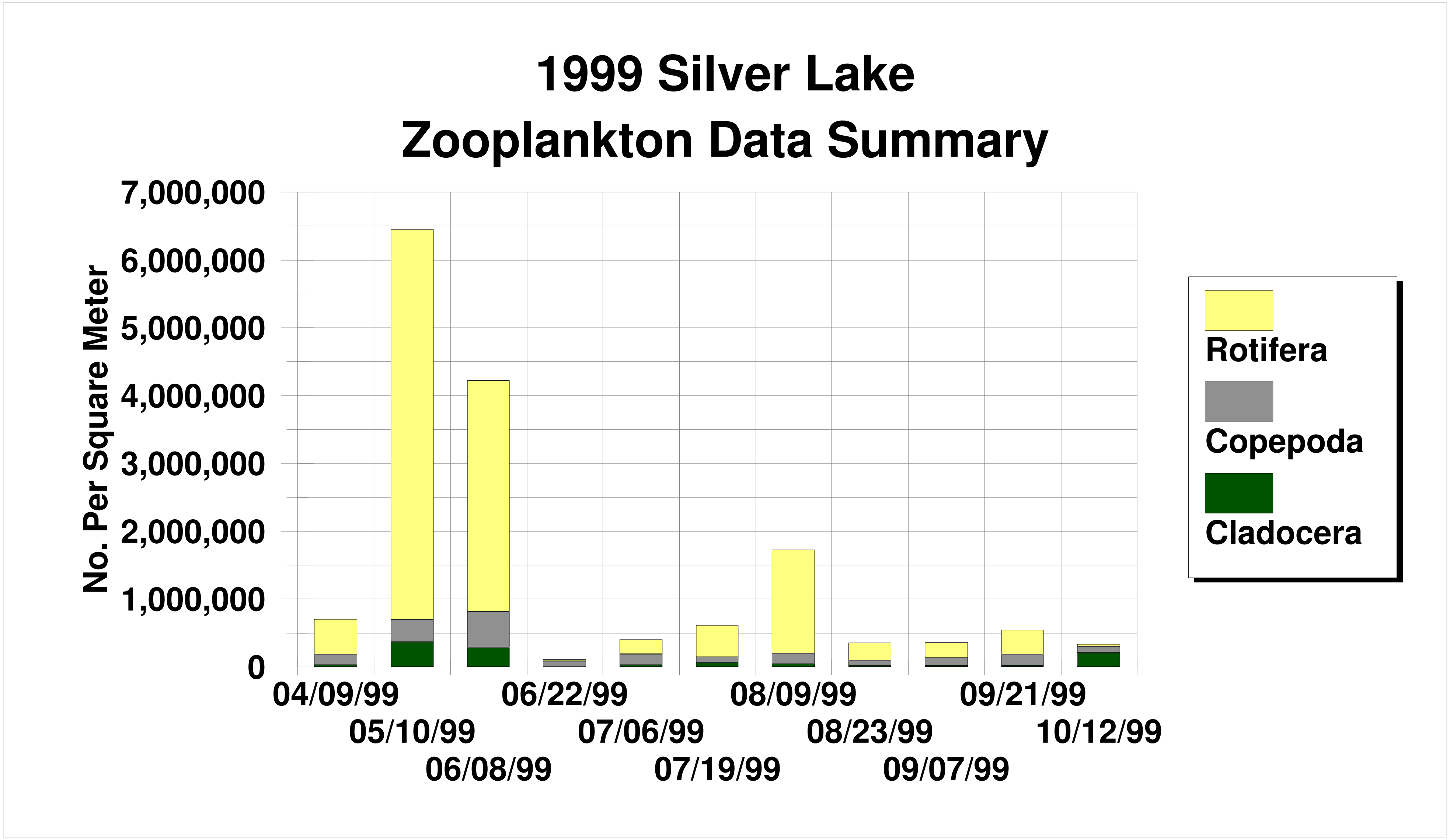
1999 Silver Lake Phytoplankton Summary by Division



Appendix E-5.1 Additional Zooplankton Information

ZOOPLANKTON IDENTIFICATION (Number per square meter)
Valley Branch Watershed District
PROJECT #: 23/82-207 V99 030
LAKE: SILVER

		SAMPLE DATE										
DIVISION	**TAXON**	**4/9/1999**	**5/10/1999**	**6/8/1999**	**6/22/1999**	**7/6/1999**	**7/19/1999**	**8/9/1999**	**8/23/1999**	**9/7/1999**	**9/21/1999**	**10/12/1999**
CLADOCERA												
	Daphnia galeata mendotae	0	0	2,266	0	2,229	0	0	2,425	0	0	2,008
	Daphnia ambigua/parvula	0	9,111	33,984	980	0	0	0	2,425	0	0	0
	Daphnia retrocurva	0	0	0	2,939	0	0	0	0	0	0	0
	Bosmina sp.	29,012	348,510	167,654	0	6,687	0	4,090	2,425	4,139	0	0
	Chydorus sp.	1,261	6,834	20,390	0	11,144	6,025	0	0	2,070	18,517	148,623
	Diaphanosoma sp.	0	4,556	33,984	2,155	8,915	54,227	47,039	16,974	12,418	0	0
	Ceriodaphnia sp.	0	0	29,453	1,176	0	0	0	0	0	0	4,017
	Simocephalus sp.	0	0	0	0	0	0	0	0	0	0	46,194
	Alona sp.	0	0	0	0	0	0	0	0	0	0	8,034
	SUBTOTAL	30,273	369,010	287,730	7,250	28,975	60,253	51,129	24,248	18,627	18,517	208,876
COPEPODA												
	Nauplii	131,184	120,726	480,306	74,654	142,647	40,168	112,484	46,071	93,134	123,444	44,185
	Cyclops sp.	18,921	166,282	11,328	196	6,687	0	2,045	2,425	8,279	14,402	36,152
	Mesocyclops sp.	1,261	2,278	6,797	1,666	2,229	16,067	8,181	9,699	12,418	30,861	8,034
	Diaptomus sp.	2,523	43,279	33,984	2,057	8,915	28,118	30,677	16,974	4,139	0	6,025
	SUBTOTAL	153,889	332,565	532,415	78,573	160,478	84,354	153,387	75,169	117,970	168,707	94,396
ROTIFERA												
	Kellicottia sp.	0	25,056	2,266	0	0	2,008	2,045	36,372	0	0	0
	Conochilus sp.	1,261	6,834	2,315,437	1,666	120,358	0	0	7,274	8,279	0	0
	Keratella cochlearis	306,517	5,102,363	156,326	784	20,060	22,093	151,342	80,018	175,920	290,094	14,059
	Keratella quadrata	74,422	20,501	4,531	196	0	0	0	0	0	0	0
	Polyarthra vulgaris	114,786	574,016	922,097	18,615	44,577	20,084	2,045	2,425	2,070	63,780	14,059
	Brachionus sp.	2,523	0	0	0	0	2,008	2,045	0	0	0	0
	Filinia longiseta	17,659	4,556	2,266	1,274	0	0	0	0	0	0	0
	Aplanchna sp.	8,830	18,223	2,266	0	28,975	421,768	1,265,953	99,417	16,557	4,115	6,025
	Trichocerca sp.	0	2,278	2,266	0	0	0	100,213	29,098	20,697	0	0
	SUBTOTAL	525,998	5,753,826	3,407,454	22,533	213,970	467,962	1,523,643	254,604	223,522	357,988	34,143
	TOTAL	710,160	6,455,401	4,227,599	108,357	403,423	612,568	1,728,159	354,021	360,119	545,212	337,414


1999 Silver Lake
Zooplankton Data Summary
No. Per Square Meter
7,000,000
6,000,000
5,000,000
4,000,000
3,000,000
2,000,000
1,000,000
0
04/09/99
05/10/99
06/08/99
06/22/99
07/06/99
07/19/99
08/09/99
08/23/99
09/07/99
09/21/99
10/12/99
Rotifera
Copepoda
Cladocera