Lake and Watershed Management Plan Update for Silver Lake

February 2014

Submitted to:
Silver Lake Watershed Commission
Perry, NY

Submitted by:
F. X. Browne, Inc.
Lansdale, PA

www.fxbrowne.com

Table of Contents

Appendices

List of Tables

List of Figures

Executive Summary

Silver Lake is an 831-acre lake in Wyoming County, New York. The Silver Lake watershed encompasses 10,216 acres. Land use consists primarily of agriculture activities. Silver Lake is used for swimming, boating, fishing, nature appreciation and education, and aesthetics. The lake is also a potable water supply. Nuisance growths of aquatic macrophytes (plants) and algae have hampered recreational use of the lake in recent years.

F. X. Browne, Inc. prepared a Lake and Watershed Management Plan for Silver Lake in 1991, which has served as a guideline for managing the lake and watershed. The 1991 study was conducted as part of a New York State Department of Environmental Conservation (DEC) grant to the Silver Lake Commission for a comprehensive management plan for Silver Lake and its watershed, and was designed in accordance with procedures used in Phase I Diagnostic-Feasibility studies conducted under state and federal Clean Lakes Programs.

According to the 1991 Management Plan, the mean in-lake concentration of phosphorus was 0.036 mg/L. The lake experienced algae blooms during late summer, and based on Trophic State Indices, the lake appeared to be slightly eutrophic. Although no point sources of pollution existed, nonpoint sources were identified, and agricultural lands were determined to contribute the majority of phosphorus loads to the lake. Lake management recommendations included lake dredging, benthic mats, mechanical harvesting of aquatic weeds, agricultural management, septic system management, stormwater management, streambank and roadway restoration, and development of educational materials and ordinances. During the 23 years since the original Watershed Management Plan, the Silver Lake Commission has made significant progress in managing the water quality in Silver Lake.

Silver Lake has participated in the New York State CSLAP lake monitoring program for many years. As part of CSLAP, a limited number of water quality samples were collected in Silver Lake during the summers of 1986-1991, 1995-1997, and 2006-2012. According to the 2012 CSLAP data, Silver Lake can be characterized as meso-eutrophic based on water clarity (mesotrophic), total phosphorus (eutrophic) and chlorophyll *a* (eutrophic).

Based on background research, lake water quality data, and detailed watershed investigations, the following conclusions can be made about Silver Lake and its watershed:

Conclusions

In 2010 a TMDL Study was performed for the Silver Lake Watershed. Based on the TMDL report, total phosphorus must be reduced by 2,124.4 lbs/year, or 59 percent, to meet water quality goals.

1. More than two-thirds of the watershed area consists of agricultural land uses. Forested land makes up approximately 22 percent of the watershed and is located in patches throughout the watershed and along some of the stream corridors. Developed land makes up a total of approximately seven percent of the watershed area and is primarily located

along the eastern and western shores of the lake. Stormwater runoff from agricultural land is the major source of sediments and nutrients entering Silver Lake.

2. Silver Lake is meso-eutrophic based on in-lake total phosphorus concentrations, chlorophyll a concentrations, and Secchi disk transparency readings.

3. During 2012, blue-green algae populations in Silver Lake were moderate in the summer months and consisted mainly of *Anaebena.* Blue-green algae populations increased significantly in September. Based on DEC CSLAP data open water microcystin levels are low in Silver Lake; however, concentrations of microcystin levels in shoreline blooms are very high with an average concentration of 257.7 ug/L over the past several years.

4. Macrophytes in Silver Lake are excessive and include the non-native plant Eurasian milfoil and the native plant tape grass.

5. Based on dissolved oxygen and temperature profiles measured in 1990 through 2009, bottom waters in Silver Lake are anoxic, or devoid of oxygen, for most of the summer season. This lack of oxygen means that fish are unable to survive in the cooler bottom waters of the lake. Also, when bottom waters are devoid of oxygen, phosphorus, manganese, and iron are released from the bottom sediments. The phosphorus becomes an additional source of food for more algae growth, especially when the lake mixes in the fall.

6. Calcium concentrations in Silver Lake are high which makes the lake highly susceptible to zebra mussels. Zebra mussels have been in the lake since about 2006.

7. The Silver Lake Commission and the Wyoming County Soil and Water Conservation District have been working together with farmers in the watershed to develop Nutrient Management Plans and implement agricultural BMPs. Good progress has been made, but additional work is necessary to reduce phosphorus loads to the lake in accordance with the 2010 TMDL.

Recommendations

The following recommendations are provided to help improve the water quality in Silver Lake. Both in-lake and watershed management options are discussed.

In-Lake Restoration Recommendations

1. The excessive macrophytes, namely Eurasian milfoil, in Silver Lake should be controlled either by the herbicide Renovate or by weed harvesting.

2. Spot dredging in the northern and southern ends of Silver Lake should be considered. Not only would dredging remove nutrient rich sediments from the lake, it would also remove macrophytes (milfoil) from the lake. A dredging feasibility study should be

conducted to determine the exact areas for dredging, the chemical makeup of the sediments, and potential areas for sediment disposal. In addition, the outlet channel should be dredged as outlined in the 2010 Dredging Feasibility Study.

3. A large volume of bottom water in Silver Lake is anoxic. Hypolimnetic aeration of Silver Lake should be considered as it would increase the dissolved oxygen concentration in the bottom waters of the lake while maintaining the cool temperature of the bottom water. This will improve and expand habitat for a cold water fishery and will also keep phosphorus, manganese, and iron from being released into the water column.

4. A batch alum treatment should be considered for Silver Lake to reduce the phosphorus concentration in the lake water and to seal the bottom sediments. A batch alum treatment may last for 10 years or more and has an immediate impact on the water quality of the lake. Since a batch alum treatment does not do anything to increase the dissolved oxygen in the bottom lake water, the combination of an alum treatment with hypolimnetic aeration would be an ideal solution for Silver Lake.

5. Although the zebra mussels in the lake cannot be completely eradicated, control measures such as chlorination, filtration and mechanical scraping at the potable water intake structure can be implemented to reduce the impact of the mussels on the intake structure.

<u>Watershed Restoration Recommendations</u>

1. The implementation of agricultural BMPs should continue throughout the watershed. The Wyoming County Soil and Water Conservation District should continue to work with farmers to help reduce nutrient and sediment loads to Silver Lake. Increasing riparian buffers along streams that flow through agricultural lands should be a priority. The Silver Lake Commission should be a strong advocate to encourage farmers and the Conservation District to work on priority projects. The 2014 Farm Bill was recently passed and the Agricultural Conservation Easement Program (ACEP) received a funding increase of $1.2 billion. Since the new Farm Bill contains money for farmers to install and maintain conservation areas along streams that run through their farm fields, farmers should be encouraged to take advantage of these programs. Better stream buffers have the greatest potential the reduce sediment and pollutant loadings to Silver Lake.

2. Severely eroded streambanks in the Silver Lake watershed should be stabilized and restored using bioengineering streambank restoration methods. Although the TMDL does not include streambank erosion as a source of phosphorus to Silver Lake, there have been many studies that indicate that streambank erosion is a significant source of both sediments and nutrients. The SLA, the SLC, and the Wyoming County Soil and Water Conservation District should work with property owners to stabilize

eroded streambanks and shorelines throughout the watershed. Grant or loan money may be available from the Clean Water State Revolving Fund to help finance stormwater management projects, including streambank erosion protection projects.

3. Stormwater runoff from any new development in the watershed should be properly controlled and stormwater management measures should be designed, constructed, and maintained in accordance with all current NYS DEC regulations. The Silver Lake Commission should ensure the lead agency that reviews and new development plans in the watershed makes sure that all stormwater management regulations are followed.

4. Homeowners around the lake and in other residential areas in the watershed should be educated about not using phosphorus rich fertilizers on their lawns. Lawn fertilizers can runoff yards and be a significant source of nutrients to lakes.

5. Stormwater runoff controls should be installed throughout the watershed, and especially around the lake, at individual residences. Homeowners should be encouraged to install rain barrels and rain gardens. Rain barrels collect stormwater runoff from rooftops. The stored water can be used to water flower and vegetable gardens when it is not raining. During larger rain events, discharges from rain barrels should be directed to a grassed area where the stormwater can be infiltrated into the ground rather than running directly into the swales and the lake. Rain barrels can be purchased on homeowners can make their own rain barrel.

   Rain gardens can be installed by individual homeowners to treat stormwater runoff from their rooftop and driveways. Rain gardens can be an aesthetically pleasing way for homeowners to combine stormwater management and landscaping on their properties. Stormwater is directed to the rain garden where it infiltrates into the soil, providing water and nutrients for the plants. Excess stormwater is stored in this area and can continue to be used by the plants days after a rain event.

6. Shoreline buffers around Silver Lake are lacking in some areas where homeowners mow their lawns right down to the water's edge. A 5 foot minimum no-mow buffer along the shoreline should be maintained. Shoreline plantings and low bushes can be an aesthetically pleasing option that will help filter stormwater runoff and provide excellent wildlife habitat around the lake.

7. Homeowners should be encouraged to wash cars and trucks on grassy areas, if possible, or use commercial car washes. This practice will reduce the amount of phosphorus and detergent that runs into Silver Lake and its tributaries.

8. Dirt and gravel roads in the Silver Lake watershed are a significant source of sediments and nutrients that can enter Silver Lake. Dirt and gravel roads should be properly maintained to minimize sediment and nutrient transport.

1.0 Introduction

1.1 Background and Purpose of Study

Background

Silver Lake is an 831-acre lake in Wyoming County, New York. The Silver Lake watershed encompasses 10,216 acres. Land use consists primarily of agriculture. Silver Lake is used for swimming, boating, fishing, nature appreciation, education, and aesthetics. The lake is also a potable water supply. Nuisance growths of aquatic macrophytes (plants) and algae have hampered recreational use of the lake in recent years. In 1991, F. X. Browne, Inc. prepared a Lake and Watershed Management Plan for Silver Lake. This Plan has been used for the past 20 years as a guide to help maintain and improve the water quality of Silver Lake.

Description and Purpose of Current Study

The Silver Lake Commission, Silver Lake Association, Wyoming County Soil and Water Conservation District, Cornell Cooperative Extension, and others have collaborated to reduce pollutant loadings to Silver Lake and to monitor lake water quality for the past 20 years. This project includes water quality monitoring, water quality trend analyses, bathymetric (water depth) mapping, macrophyte mapping, watershed investigations for nonpoint source pollution problem areas, and the development of a revised Watershed Management Plan with a goal of updating lake and watershed management recommendations for Silver Lake and its watershed, in order to guide cooperative decision-making for the next 20 years.

1.2 Existing Studies and Lake Reports

1991 Water Quality Data and Management Plan

F. X. Browne, Inc. prepared a Lake and Watershed Management Plan for Silver Lake in 1991, which has served as a guideline for managing the lake and watershed. The 1991 study was conducted as part of a New York State Department of Environmental Conservation (DEC) grant to the Silver Lake Commission for a comprehensive management plan for Silver Lake and its watershed, and was designed in accordance with procedures used in Phase I Diagnostic-Feasibility studies conducted under state and federal Clean Lakes Programs. Silver Lake and its tributaries were monitored between January of 1990 and April of 1991. Watershed characteristics were analyzed in order to prepare a hydrologic and pollutant budget for Silver Lake.

According to the 1991 Management Plan, the mean in-lake concentration of phosphorus was 0.036 mg/L. The lake experienced algae blooms during late summer, and based on Trophic State Indices, the lake appeared to be slightly eutrophic. Although no point sources of pollution existed, nonpoint sources were identified, and agricultural lands were determined to contribute the majority of phosphorus loads to the lake. Lake management recommendations included lake dredging, benthic mats, mechanical harvesting of aquatic weeds, agricultural management, septic system management, stormwater management, streambank and roadway restoration, and development of educational materials and ordinances.

In the years since the completion of the 1991 Water Quality Data and Management Plan, the Silver Lake Commission has:

- Assisted area farms in completing Agricultural Best Management Practices (1990 to present).
- Completed the Silver Lake Watershed Emergency Plan (1994).
- Assisted Cornell Crest Dairy Farm with a concrete manure storage facility (1995).
- Compiled the Silver Lake Reference Material & Informational Database (1996).
- Conducted a Silver Lake Watershed Monitoring Study (1997).
- Compiled Silver Lake Watershed survey (1998).
- Completed safety improvements at S. Federal St. Dam (1999).
- Conducted monitoring and sampling programs in conjunction with Wyoming County Soil and Water (2000 through 2002).
- Assisted Pingrey Farms with bunk silo leachate control project (2001).
- Received a mini-grant through the Wyoming County Soil & Water for Silver Lake Outlet Clean Up project (2002).
- Updated the Silver Lake Watershed Emergency Plan (2003).
- Conducted soil borings at the Silver Lake Outlet (2008).
- Participated in the New York State CSLAP lake monitoring program (1986-2013).
- Planned Silver Lake Outlet Sediment Removal Project (2009-on-going).

Throughout this process, the Silver Lake Commission has made important alliances with the following entities:

- Silver Lake Association (SLA)
- Wyoming County Soil and Water Conservation (SWCD)
- National Resources Conservation Services Agency (NRCS)
- Farm Service Agency (FSA)
- NYS Department of Environmental Conservation DEC)
- Cornell Cooperative Extension Service
- Wyoming County Farm Bureau.

Annual CSLAP Reports

The New York State Citizens Statewide Lake Assessment Program (CSLAP) was established in 1985 as a cooperative program between the New York State Department of Environmental Conservation (NYSDEC) and the New York Federation of Lake Associations (NYSFOLA). CSLAP is a volunteer monitoring program designed to provide long-term monitoring data for the state database for lakes. Volunteers trained by NYSDEC and NYSFOLA conduct bi-weekly sampling for a 15-week period between May and October using standardized sampling and processing techniques and equipment. Water samples are collected either from a single site at the deepest part of the lake or from both the surface and the greatest depths of the lake. Samples are then analyzed in the field and in the lab for standard lake water quality indicators. The CSLAP program focuses on eutrophication indicators such as nutrients, chlorophyll a, water color, pH, conductivity, and water temperature. Calcium samples and macrophyte samples are occasionally collected and evaluated as well. Volunteers also provide qualitative assessments of water quality, recreational conditions, and variations in aquatic plant coverage using standardized ranking scales.

As part of CSLAP, a limited number of water quality samples were collected in Silver Lake during the summers of 1986-1991, 1995-1997, and 2006-2012. According to the 2012 CSLAP data, Silver Lake can be characterized as meso-eutrophic based on water clarity (mesotrophic), total phosphorus (eutrophic) and chlorophyll *a* (eutrophic). An evaluation of potable water parameters indicate that deepwater potable water intakes may be impaired based on elevated manganese levels that exceed state water quality standards. The CSLAP dataset is inadequate to evaluate the use of the lake for potable water and serves only as an indicator of possible impairment.

Phytoplankton is not typically monitored as part of the CSLAP program; however, microcystin levels in the lake have been occasionally monitored. Microcystin levels in the open water areas are very low and do not indicate a problem. However, some microcystin levels along shoreline areas (within observed blooms) have been detected with average concentrations of 257.7 ug/L. Microcystin levels for contact recreation should be below 20 ug/L.

2008 Lake Classification and Inventory study

The New York State Department of Environmental Conservation (NYSDEC) established a statewide Lake Classification and Inventory (LCI) focusing on identifying water quality problems related to eutrophication, invasive aquatic plants, or use impairments. Silver Lake was sampled in 2008 as part of the Lake Biomonitoring pilot project for the LCI. Most of the data was comparable between the LCI and the CSLAP program. Additionally, the LCI conducted depth profiles which show oxygen depletion in Silver Lake below 7 to 8 meters (23 to 27 ft).

2008-2009 Silver Lake Monitoring Report

The Wyoming County Soil and Water Conservation District (WCSWCD) is a member Finger Lakes – Lake Ontario Watershed Protection Alliance (FL-LOWPA) and seeks to promote projects that will enhance water quality. In 2008 and 2009, through this alliance, the WCSWCD collected and analyzed water quality samples, compared historical water quality assessments and made recommendations to further develop the Silver Lake monitoring program. As part of this study, the Conservation District collected lake samples and both dry weather and wet weather stream data. Stream data indicate that there are elevated concentrations of nutrients and sediments entering the lake during rain events. Additionally, the District computerized and graphed much of the existing water quality data at this time.

2010 Silver Lake Total Maximum Daily Load

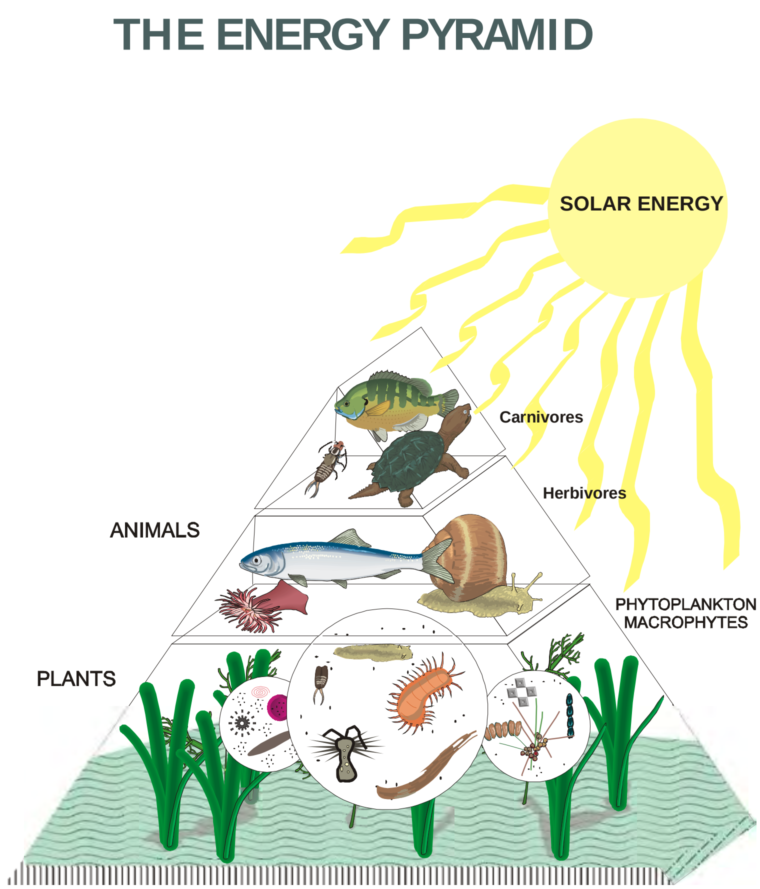
The US EPA develops TMDLs under Section 303(d) for all pollutants violating water quality standards in impaired waterbodies. A TMDL determines the maximum amount of a given pollutant that can exist within a waterbody before that waterbody fails to meet existing water quality standards. The 2010 TMDL study for Silver Lake estimates that a mean annual external total phosphorus load of 3,610 lbs/yr of total phosphorus enters Silver Lake, the vast majority of which (84 percent) comes from agricultural land. The NYS DEC guidance value of 20 ug/L for total phosphorus concentrations in lakes is the TMDL water quality target for Silver Lake. The maximum annual phosphorus load that will maintain compliance with the phosphorus water quality goal of 20 ug/L in Silver Lake is a mean annual load of 1,650 lbs/yr. The TMDL recommends that a 59 percent reduction in total phosphorus loads be achieved via a reduction in phosphorus loads from septic systems, agricultural management, stormwater management, and public education.

1.3 Lake Ecology Primer

Ecological Cycle

Note: A lake and watershed glossary is provided in Appendix A for reference purposes.

In a lake, a basic ecological cycle exists. Aquatic plants like algae (microscopic aquatic plants) and macrophytes (large aquatic plants) require nutrients such as phosphorus and nitrogen along with sunlight to grow. Small aquatic animals such as invertebrates (rotifers, protozoa, etc.), snails and insects eat the algae and reproduce. Small forage fish eat the small animals, and, in turn are eaten by larger game fish and other animals. This relationship is called the ecological, or energy pyramid. In a healthy lake, this ecological system exists in proper balance.



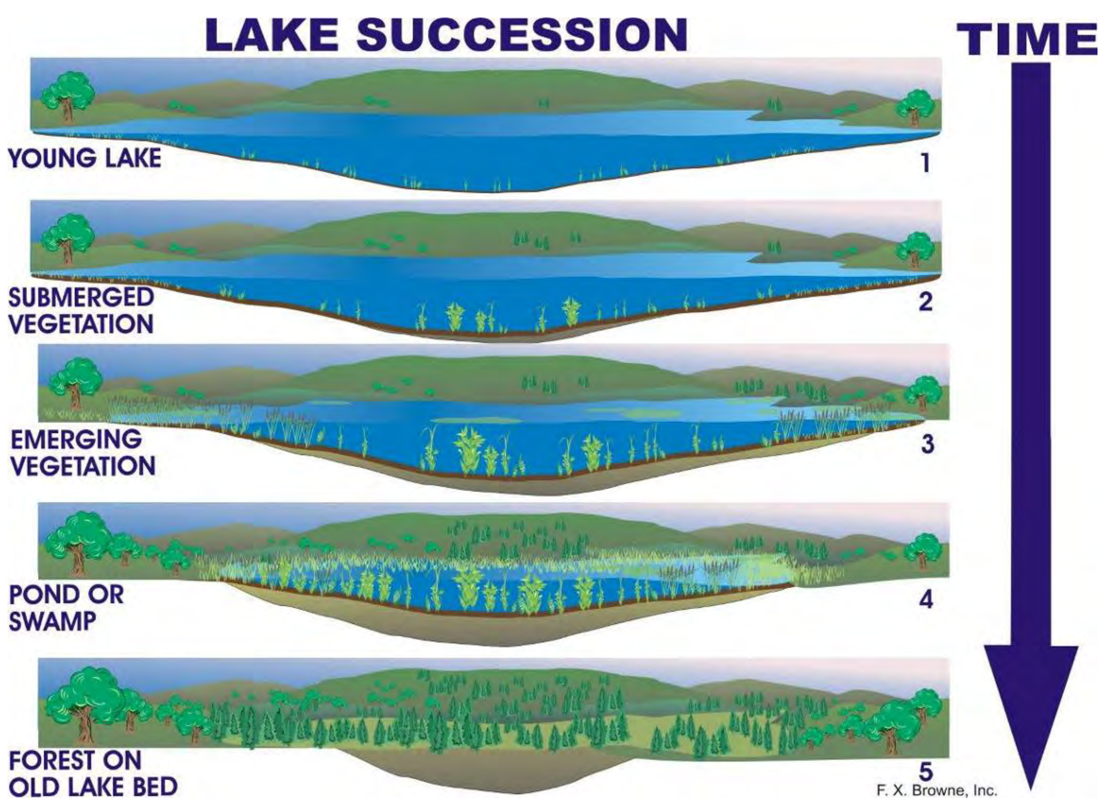
When too many nutrients enter a lake, the algae and/or large aquatic plants grow to a point of excess. With a larger population of algae one would expect a nice, large population of fish. However, in reality the excessive plant life is not transferred up the food chain. The small aquatic animals do not eat much of the excess algae (they do not like some of the algae, especially the blue-green algae). Therefore, algae and other plants build up in the lake and destroy the ecological balance of the lake ecosystem. This can result in a reduction in the fish population. It often results in a change in the type of fish found in the lake.

In order to understand the processes that occur in a lake, we must first understand the concept of lake succession or aging.

Lake Succession Over Time

All lakes go through an aging process called ecological succession. Succession is a natural process whereby a lake starts out as an “ecologically” young lake with little vegetation, few nutrients, clear water, and very little unconsolidated (loose) sediment on the bottom. It should be noted that ecological age is different than chronological age. The chronological age is simply the number of years a lake has existed. The ecological age, on the other hand, is a measure of the physical, chemical, and biological conditions of a lake. A lake may be chronologically young (i.e. built only 3 years ago), but it could be ecologically old.

As a lake ages, more nutrients and sediments enter the lake from the surrounding watershed. Usually, the additional nutrients, such as phosphorus and nitrogen, cause an increase in the amount of algae and aquatic weeds. The additional sediment entering the lake settles to the bottom of the lake, increasing the amount of sediment on the lake’s bottom.



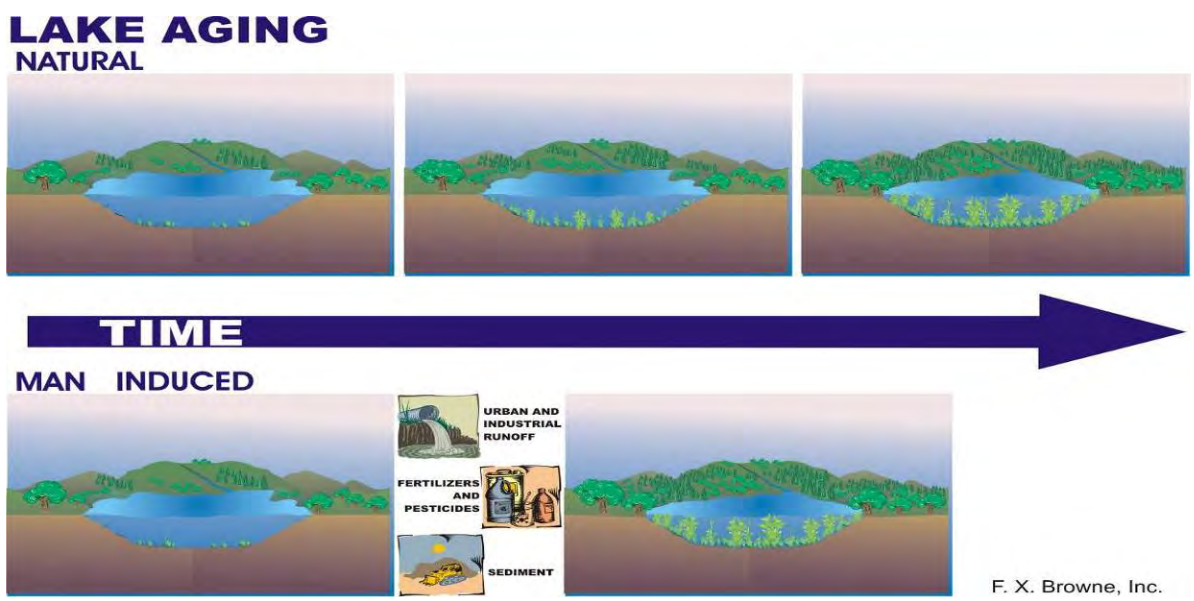
Thus as a lake ages, it slowly starts to fill up with sediments, algae and aquatic weeds. Initially, the aquatic vegetation is submergent vegetation, beneath the water surface. As the lake fills up further with sediment, emergent vegetation appears above the water surface.

The process is further accelerated by the increase of organic nutrients derived from dead plants and animals as the number of organisms increase within the lake. This process, called succession or aging, causes the lake to fill in and become shallower. As succession continues, the types of animals and plants within the lake's ecosystem also begin to change. Game fish such as bass, pike, and pan fish may be replaced by rough species such as carp, suckers, and bullheads. Rough fish are better adapted to live in a lake that is relatively old on the time scale of succession. As the process of filling in continues, eventually the lake or pond becomes a herbaceous and shrub/scrub wetland. If conditions are right, a forested wetland takes over. Depending on environmental conditions, the process of natural succession may take hundreds or even thousands of years.

Lake Aging

Lake succession or aging is a natural process that occurs in all lakes. However, the influence of human activities in the watershed can significantly accelerate the aging process. The lake aging process is accelerated by:

- Wastewater Treatment Plant Discharges
- Agricultural Activities (cropland and pastureland)
- Developed Land
- Malfunctioning Septic Systems
- Construction Activities
- Roadways
- Streambank Erosion
- Landfills



Human activities in a watershed can add sediments and nutrients such as phosphorus and nitrogen to a lake, resulting in accelerated aging or "cultural eutrophication".

Lake Classification

Lakes are classified by the amount of nutrients (or food) contained in the lake. The Greek word for food is "trophic". Therefore, we classify lakes by their "trophic" or food/nutrient state. Such as:

Oligo = little (little nutrients)
Meso = medium (medium nutrients)
Eu = too much (too much nutrients)

The trophic state refers to the "ecological" age of the lake, not its chronological age. Therefore, an oligotrophic lake is a lake that is ecologically young. Lakes are classified by nutrient level and the presence of aquatic plants as described below.

Oligotrophic lake
- ecologically young lake
- low level of nutrients
- low population of algae and aquatic plants

Mesotrophic lake
- ecologically middle-aged lake
- moderate level of nutrients
- moderate population of algae and aquatic plants

Eutrophic lake
- ecologically old lake
- high level of nutrients
- high population of algae and aquatic plants

Lake Problems

Excessive nutrients entering a lake from its watershed cause algae blooms, excessive aquatic plants (macrophytes), lake siltation (settling of sediments in lake, loss of lake volume and capacity), and fishery problems (low dissolved oxygen levels reduce the amount of habitat for coldwater fish). This results in loss of recreational and other lake uses, and can reduce property values around the lake.

Lake problems are caused by point sources and nonpoint sources of pollution. Point sources are wastewater treatment plant discharges. Nonpoint sources cannot be traced to a specific origin, but seems to flow from many different sources.

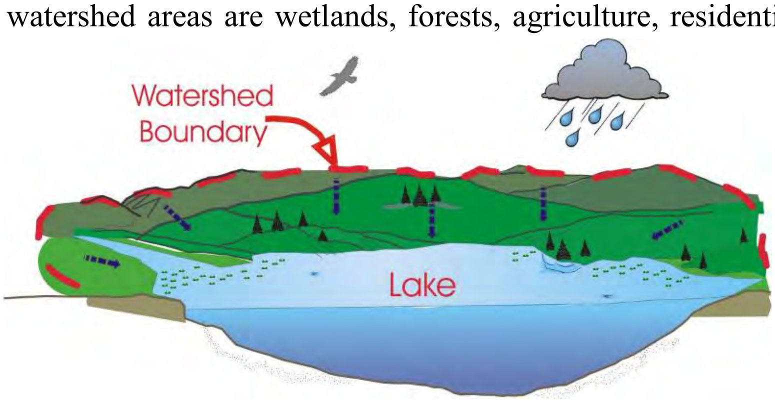
Nonpoint Source Pollution

Nonpoint source pollution involves three natural processes: stormwater runoff, erosion and sedimentation. Rainwater or snowmelt water flowing across land and entering rivers and lakes is known as stormwater runoff. The force of runoff breaking up the soils and detaching individual soil particles is termed erosion. The soil particles are eventually deposited into nearby streams and rivers. This process is called sedimentation. Although a natural part of the water cycle, runoff, erosion and sedimentation have been artificially accelerated by the way humans have chosen to develop land, leading to pollution.

Almost all nonpoint source pollution is caused by stormwater runoff and erosion. Leaky septic systems are also considered nonpoint sources. Rainwater and melting snow run over residential lawns, construction projects, streets, and farm fields, picking up pollutants such as soil particles, chemicals and nutrients, and carrying them into nearby water bodies. Nonpoint source pollution also occurs from infiltration of pollutants into the ground. Pollutants originating from landfills, abandoned mines, underground storage tanks and septic tanks are possible groundwater pollution sources.

Lake and Watershed Management

A watershed is that area of land that drains directly into a lake. A watershed is best envisioned as a funnel with a glass at the bottom representing a lake. Anything that falls into the funnel will find its way into the glass. Potential sources of water to lakes are streams (tributaries), surface runoff (overland flow from lakeside properties), groundwater (interflow), and precipitation. The water quality of these water sources are greatly influenced by watershed characteristics including soils, geology, vegetation, topography, climate, and land use. Typical land uses encountered in watershed areas are wetlands, forests, agriculture, residential, commercial, and industrial. With regards to water quantity, larger watershed areas contribute larger volumes of water to lakes and vice versa. For this reason, getting to know a lake's watershed and the activities that go on in the watershed are of primary concern to the individuals that manage and enjoy the lake.



Lake management refers to the practice of maintaining lake quality such that attainable lake uses can be achieved (Jones et. al, 2001). Management of a lake is integrally related to management of the surrounding watershed. Watershed management is the process of protecting the lakes, streams, and wetlands in the watershed from point and nonpoint source pollution. It is accomplished by developing an understanding of key factors that affect the water quality of lakes, streams and wetlands and by following a plan of action to prevent, reduce, or minimize those activities within a watershed that may negatively impact water quality. Watershed management consists of many diverse activities including controlling point and nonpoint source pollution, monitoring water quality, adopting ordinances and policies, educating stakeholders, and controlling growth and development in a watershed.

Lake Protection and Restoration

Depending on the physical traits of the lake and watershed, and the quality of the incoming water, certain lakes are suited for particular uses. It can sometimes be difficult to manage a lake for conflicting uses; for example, trout fishing and motorboat racing. A lake cannot be all things to all people, and it can be difficult and expensive to force a lake to support a specific use when it is unrealistic to do so. It is important, therefore, when undergoing a lake protection or restoration project, to set specific goals that are based on a thorough investigation of the lake and its watershed. Lake protection is defined as "The act of preventing degradation or deterioration of attainable lake uses." Lake protection projects are usually undertaken by municipalities or lake associations who fear their lake will suffer from the adverse effects of encroaching development. Lake restoration refers to the act of bringing a lake back to its attainable uses (Jones, et. al., 2001). It is important to be realistic in one's expectations for lake restoration. Nonpoint sources of pollution in a watershed can be difficult to detect and control, and without proper watershed management, lake restoration efforts can fail. A comprehensive watershed management plan should be designed and implemented involving as many watershed stakeholders as possible for best success in lake restoration projects. In any lake project, educating watershed citizens about how their activities affect the lake can be extremely helpful.

2.0 Lake and Watershed Characteristics

2.1 Water Resources

The water resources in Silver Lake watershed are important to the economy and well-being of the watershed residents. Silver lake is a Class A lake, meaning the best intended use for the lake is potable water, contact recreation such as swimming, and non-contact recreation such as boating and fishing. The lake is used by both watershed residents and visitors. Most of the shoreline is bordered by residential homes, and a state boat launch islocated along the southwest shoreline.

Silver Lake provides potable water to the Village of Perry, the Town of Perry, the Town of Castile, the Villages of Mount Morris, Leicester, and Letchworth State Park. Water from Silver Lake flows through an eleven-mile water supply line to Lake Leroy where it is used to augment supplies in Lake LeRoy in case of drought. In addition, Silver Lake water is used for agricultural irrigation.

Silver Lake State Park, located at the southern end of the lake, is an undeveloped park used for recreation. Silver Lake is the primary feature which has attracted summer visitors to the area for many years and provides an ideal location for lakeside vacation cottages. Park visitors and cottage owners use the lake for swimming, boating, fishing, and aesthetic enjoyment.

2.1.1 Silver Lake

Silver Lake is a glacial lake, similar in shape to the eleven Finger Lakes which lie to the east. It is situated with its 3 mile length running northeast-southwest, and is approximately one-half mile wide. Most of the land surrounding the lake is developed with year-round homes and seasonal cottages. Portions of the northern shoreline and southern shoreline are undeveloped. There are eight inlets into the lake, the largest of which is Silver Lake Inlet, located at the north end of the lake. The inlet is located approximately 500 feet of the outlet, where there is a controllable outlet dam. Water exits Silver Lake either over the spillway or through a water supply line. Spillway water becomes Silver Lake Outlet which flows into the Genesee River and eventually into Lake Ontario.

This large 831 acre lake is primarily spring-fed. The watershed area to lake surface area of 12.3:1 is relatively small and indicates that watershed management practices could effectively reduce the sediment and nutrient loads entering the lake.

A complete listing of morphometric and hydrologic characteristics of Silver Lake is summarized in Table 2.1.

Table 2.1 Morphometric and Hydrologic Characteristics of Silver Lake	
Watershed Area	10,216 acres (excluding lake)
Lake Surface Area	831 acres
Lake Volume	5,995 million gallons
Retention Time	1.2 years
Average Depth	22.6 feet
Maximum Depth	36.0 feet
Drainage Basin Area: Lake Surface Area Ratio	12.3:1

Silver Lake is included o the New York State 2002 Section 303(d) List of Impaired Waters. A TMDL study was conducted in 2010 which recommends a 59 percent reduction in total phosphorus.

2.1.2 Streams and Wetlands

The main tributary to Silver Lake is identified as Silver Lake Inlet. It has a dendritic drainage pattern that makes up approximately half of the drainage area to the lake and contributes 46 percent of the flow to Silver Lake. This streams flows primarily through agricultural land before emptying into Silver Lake along the northern shore. Seven smaller tributaries drain into the lake along the western and southern shores and contribute the remaining 54 percent of the surface flow to the lake.

There is a large wetland at the southern end of the lake in Silver Lake State Park and a smaller wetland at the north end of the lake between Perry and West Perry along Silver Lake Inlet. Several smaller wetlands are located throughout the watershed.

2.1.3 Groundwater

Throughout western New York, the concentration of dissolved solids in ground water increases with depth, and all water below some depth is too salty for most uses (Randall, 1979). In some parts of Wyoming County, such as the Dale Valley, salt is mined by pumping fresh water through brine wells to salt beds at depths of about 1,300 feet. Salt dissolves in the water and the resulting brine is forced back to the land surface under pressure.

Most of the Silver Lake watershed is underlain by till or by lacustrine very fine sand, silt, or clay, or by bedrock. Small patches of unconsolidated aquifers less than 0.5 square miles may underlie the area. It is not expected that groundwater in these small aquifers contribute significantly to Silver Lake. However, there is significant concern about the quality of water in these small aquifers, as groundwater from some wells in the Perry and Castile area contain very high nitrate levels which exceed the drinking water standard of 10 milligrams per liter (Hurd, 1989).

A very large unconfined aquifer of sand and gravel with high transmissivity and a saturated thickness of greater than ten feet underlies the southwestern section of the watershed, adjacent to Silver Lake, and continues southwestward, through Silver Springs and Castile to Eagle, Freedom, and Franklinville. This aquifer has potential well yields of greater than 100 gallons per minute (Miller, 1988). This type of aquifer is recharged rapidly by water that infiltrates through the permeable overlying material to the zone of saturation. Because Silver Lake is immediately adjacent to this aquifer, groundwater and lake water are free to mix. USGS water quality data taken in 1964 from wells in this aquifer show moderate hardness levels (130 to 180 milligrams per liter as calcium carbonate), pH values between 7.5 and 8.1, low nitrate levels (0.05 milligrams per liter), and moderate iron content (0.5 to 2.9 milligrams per liter).

2.2 Land Resources

The drainage basin for Silver Lake has an area of 10,216 acres and lies within the Appalachian Uplands physiographic province. The Appalachian Uplands is a plateau that is moderately dissected by streams. Streams within the Silver Lake watershed do not occupy deep, narrow valleys, typical of watersheds to the northwest of Silver Lake, but flow at levels closer to the plateau summit.

2.2.1 Topography

The Silver Lake watershed lies in an area between valleys which consists of rolling uplands and flat-topped hills. Landforms are the result of the action of the ice that entirely covered the county during the last continental glaciation and to postglacial stream cutting. The long, narrow, configuration of many upland hills (drumlins) across the northeastern part of the county is the result of molding by glacial ice. The highest elevation in the watershed is 1,700 feet at Oak Hill, near Silver Lake State Park on the southwest edge of the watershed. The lowest elevation is 1,350 feet at the outlet of Silver Lake.

2.2.2 Geology

The Silver Lake watershed is underlain by bedrock of the Upper Devonian age. The stratum of bedrock is almost horizontal with a slight dip to the south of approximately 60 feet per mile. Major rock formations in the watershed are the Java Group, consisting of sandstone and shales, and the West Falls Group, made up of sandstone, shales, and some siltstone.

Wyoming County was completely covered by ice during the Wisconsin glacial stage of the Pleistocene epoch. Two substages can be recognized in Wyoming County: the Binghamton drift sheet and the Valley Heads drift sheet. Glacial till associated with the Valley Heads drift sheet is evident in the Silver Lake watershed. Till is an unsorted mixture of clay, silt, sand, and stones transported and deposited by glacial ice. The glacial till ranges in color from brown to gray with olive hues, reflecting the influence of material that came from glacial scouring of middle and upper Devonian rock strata. Glacial drift includes till, but also consists of the sorted and unsorted materials deposited by streams flowing from glaciers. Glacial drift in Wyoming County is variable in thickness. It is thick in drumlin-type landforms in the northeastern part of the county and is thin on many exposed slopes on the plateau.

2.2.3 Soils

Most of the soils in the Silver Lake watershed are formed in glacial till, and most of the glacial till soils in the watershed belong to the Bath-Mardin association, with smaller areas of the Conesus-Lansing association and Lordstown-Tuller-Arnot association. Areas immediately north and south of Silver Lake belong to soils formed in glacial outwash kames, terraces, and flood plains. Most of this area belongs to the Halsey-Palms-Papakating association, except for a small section near Oak Hill which is part of the Howard-Chernango association.

The dominant soil association in the Silver Lake watershed is the Bath-Mardin association, formed in deep glacial till derived mainly from sandstone and shale. The soils are deep, well drained and moderately well drained, and have a medium-textured subsoil. This association is on undulating to rolling hilltops in the north-central and east-central sections of the county.

The next most common association in the Silver Lake watershed is the Halsey-Palms-Papakating association, formed on glacial outwash terraces and flood plains. The soils are deep, very poorly drained and poorly drained, contain a medium amount of lime, and have a moderately coarse textured to moderately fine textured mineral subsoil or an organic layer. This association is in depressional pockets of the higher valleys and includes mucky areas adjacent to Silver Lake. Wet soils are dominant, but mounds and bars of gravelly drier soils are common. Some areas of this association have been developed for wetland wildlife habitat and conservation areas. Few areas of this association can be drained enough to be used for any other purpose because of the lack of suitable outlets.

Many soils in the Silver Lake watershed are in need of special management techniques to control erosion or deal with excess water. Conesus, Madrid, Bath, Mardin, Lordstown, and Fremont/Hornell soils on steeper slopes are subject to erosion, and need erosion control management techniques. Soils which exhibit wetness, poor drainage, and excess runoff include Mardin, Langford, Appleton, Volusia, Tuller, Halsey, Ellery, Sun, Lyons, Wayland, Wallkill, Alden, and Palms soils.

Almost all soils in the Silver Lake watershed are severely limited for use as septic tank absorption fields. The few soils in the watershed which have slight to moderate limitations for this use can exhibit seasonally high water tables or show potential hazard of pollution.

2.3 Watershed Land Use

Land use was evaluated for the development of the 2010 Silver Lake TMDL using digital aerial photography and geographic information systems (GIS) datasets. More than two-thirds of the watershed area consists of agricultural land uses. Forested land makes up approximately 22 percent of the watershed and is located in patches throughout the watershed and along some of the stream corridors. Developed land makes up a total of approximately seven percent of the watershed area and is primarily located along the eastern shore of the lake and along Perry Center Road (Route 20A) which crosses through the northern portion of the watershed.

Table 2.2 and Figure 2.1 illustrate the distribution of land use/land cover in the Silver Lake watershed (Source: The Cadmus Group, Inc., 2010). Land use/land cover has not changed significantly over the past 20 years; however, it does appear that there is slightly more residential (low intensity development) in the watershed.

Table 2.2
Land Use/Land Cover in Silver Lake Watershed

Land Use Category	Acres	Percent of Watershed
Open Water (excl. Silver Lake)	9	0.09%
Hay and Pasture	3,846	37.65%
Cropland	3,297	32.27%
Low Intensity Development	754	7.38%
High Intensity Development	9	0.09%
Forest	2,210	21.63%
Wetlands	91	0.89%
Total	10,216	100.00%

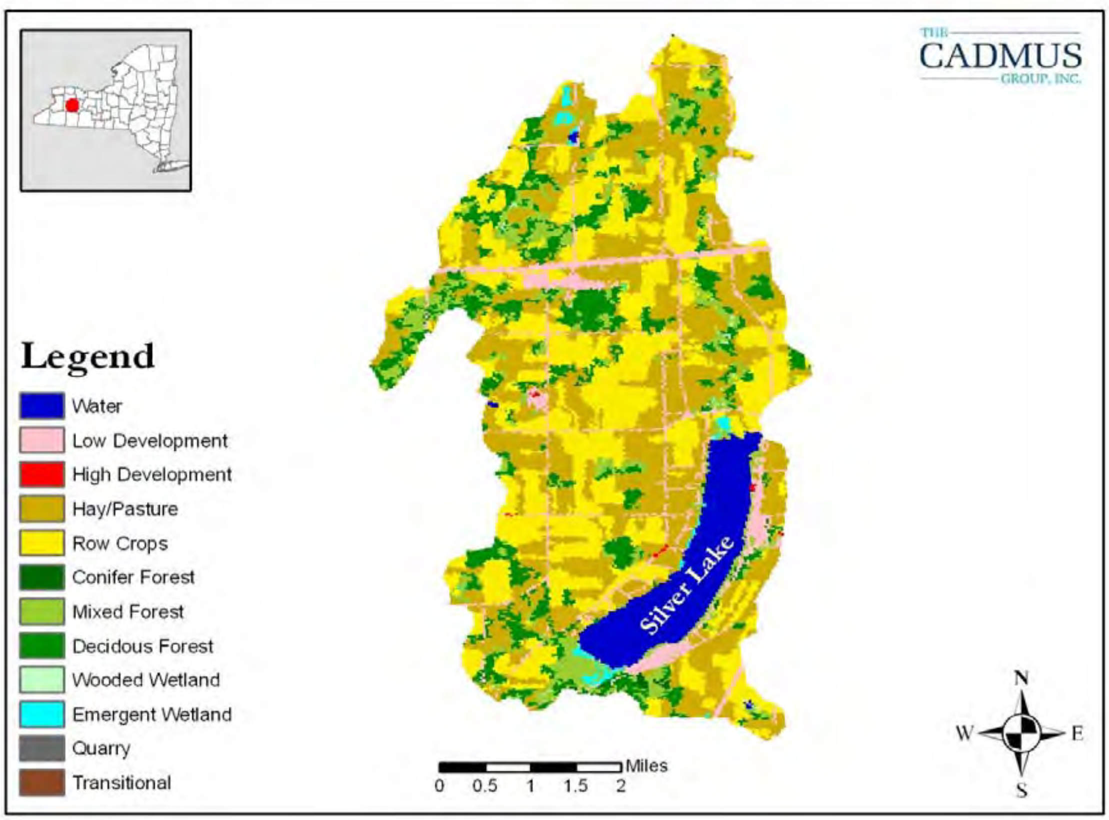


Figure 2.1 Land Use/Land Cover in Silver Lake Watershed
(Source: The Cadmus Group, Inc., 2010)

3.0 Silver Lake Water Quality Assessment

The Silver Lake Association has participated in the CSLAP Program for many years. Silver Lake Association volunteers have been trained to collect lake samples and to send them to a certified laboratory for analysis of standard lake water quality parameters. Each year the NYSDEC prepares an annual report that includes the current year's water quality data and also evaluates lake water quality trends.

Additional assessments in 2012 included phytoplankton and zooplankton analysis, a bathymetric survey, sediment quality analysis, and a macrophyte assessment. Results of the 2012 water quality assessments and a discussion of historical water quality trends are described in the following sections.

3.1 2012 Water Quality Assessment and Historical Trends

CSLAP sampling was conducted on Silver Lake from 1986 to 1991, 1995 to 1997, and 2006 to 2012. CSLAP volunteers collected lake water samples throughout the growing season each sampling year. Water samples were analyzed at a certified laboratory for phosphorus, several forms of nitrogen, chlorophyll *a*, water color, pH, conductivity and water temperature. This report focuses on the total phosphorus, chlorophyll *a*, Secchi disk transparency which are the standard eutrophication indicators that the EPA and the NYS DEC use to characterize lakes. The annual CSLAP reports provide an excellent evaluation of all water quality parameters that are monitored each year.

Eight samples were collected from May 31, 2012 through September 13, 2012 by Silver Lake Association volunteers. Surface samples are collected at a depth of 1.0 meter, and bottom samples are collected at a depth of 10 meters and sent to the CSLAP laboratory for analysis. The 2012 CSLAP report contains the most current results as well as background data and historical trends.

Additional data evaluated in 2012 and discussed in this section include phytoplankton and zooplankton samples collected by CSLAP volunteers and sent to Dr. Ken Wagner of Water Resource Services for analysis. An updated bathymetric survey and macrophyte survey were also conducted in 2012, and results are provided in this report.

Water quality data for 2012 are located in Appendix B.

3.1.1 Dissolved Oxygen and Temperature

In late spring or the beginning of summer, deep temperate lakes develop stratified layers of water, with warmer water near the lake's surface (epilimnion) and colder water near the lake's bottom (hypolimnion). As the temperature difference becomes greater between these two water layers, the resistance to mixing increases. Under these circumstances, the epilimnion (top water) is usually oxygen-rich due to photosynthesis and direct inputs from the atmosphere, while the hypolimnion (bottom water) may become depleted of oxygen due to oxygen being consumed by organisms decomposing organic matter at the lake bottom. If low dissolved oxygen levels occur near the lake bottom, sediments may release significant amounts of nutrients (primarily orthophosphorus and ammonium) back into the lake, thereby allowing for more nutrients for algae and aquatic plant growth.

Temperature and dissolved oxygen profiles were measured quarterly, at two sampling locations in 1990 as part of the 1991 Water Quality Data and Management Plan. The highest dissolved oxygen concentrations for bottom waters in Silver Lake occurred in April and September when the water column was mixed. The lowest dissolved oxygen levels were recorded in January and July. Oxygen depletion in 1990 was observed at a depths ranging from 5 to 11 meters (16.5 to 36 feet). Thermal profiles were measured again in 2008 as part of the 2008 Lake Classification and Inventory Survey which found oxygen depletion below 7 to 8 meters (23 to 27 feet). The Silver Lake Association owns a hydrolab and has collected dissolved oxygen and temperature profile data throughout the growing season at 5 sampling locations at a depth of 10 feet and 20 feet. In 2010, oxygen depletion was measured at depths as shallow as 20 feet in July, and the anoxic zone during the rest of the 2010 sampling period was deeper than the 20-foot sampling depth. In 2012, no anoxic zone was measured at any of the sampling stations, and it is assumed that the anoxic zone was greater than the 20 foot maximum sampling depth. Additional dissolved oxygen and temperature data, found in files from the Conservation District, indicate that at a depth of 10 meters, the dissolved oxygen concentration is generally less than 1 mg/L during the summer months.

3.1.2 Phosphorus

Phosphorus and nitrogen are major nutrients required for the growth of algae and macrophytes in lakes. Dissolved reactive phosphorus, nitrate nitrogen, and ammonia nitrogen are regarded as the dissolved inorganic nutrient forms most readily available to support aquatic growth. In most lake systems, phosphorus is the limiting nutrient and therefore is the nutrient which controls the amount of aquatic plant growth (vascular plants and algae). Because of the importance of phosphorus with respect to phytoplankton growth, phosphorus is usually the nutrient targeted by lake managers for reduction. Phosphorus most commonly enters a lake via sediment in stormwater runoff. Other sources of phosphorus include atmospheric deposition (rain and snow) and onsite wastewater disposal (septic) systems.

Total phosphorus represents the sum of all forms of phosphorus. Total phosphorus levels are strongly affected by the daily phosphorus loads that enter the lake. Total phosphorus concentrations in Silver lake during the 2012 growing season ranged from a low of 0.016 mg/L to a high of 0.045mg/L. Based on criteria set forth by the New York State Department of Environmental Conservation (NYS DEC), a lake system is classified as eutrophic when the average seasonal total phosphorus concentration exceeds 0.020 mg/L. Average total phosphorus levels for the 2012 growing season were 0.026 mg/L, which corresponds to a eutrophic classification with regards to total phosphorus. Figure 3.1 shows the mean total phosphorus concentrations in Silver Lake from 1986 through 2012 and indicates that the lake is consistently eutrophic with respect to total phosphorus.

Mean total phosphorus concentrations in Silver Lake over the past 26 years range from a high of 0.056 milligrams per liter (mg/L) in 1986 to a low of 0.025 mg/L in 1997. Total phosphorus concentrations were at or above the total phosphorus eutrophic criterion for all sampling events.

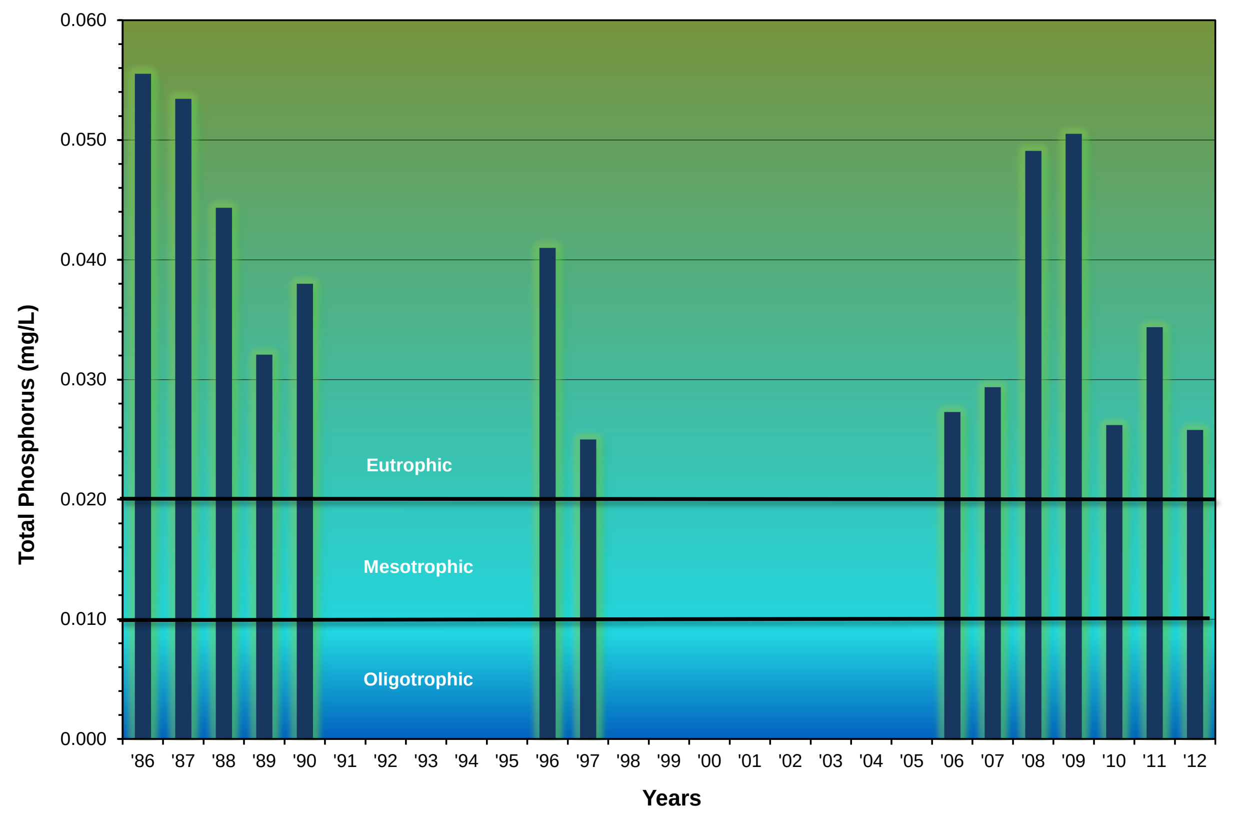


Figure 3.1 Mean Total Phosphorus Concentrations in Silver Lake (1986-2012)

3.1.3 Chlorophyll *a*

Chlorophyll *a* is a green pigment used by plants to convert sunlight to chemical energy during photosynthesis. Chlorophyll *a* constitutes about 1 to 2 percent of the dry weight of planktonic algae, so the amount of chlorophyll *a* in a water sample is an indicator of phytoplankton biomass.

The U.S. EPA has established a classification criterion for chlorophyll *a* concentrations in lakes. According to this classification, lakes that have seasonal average chlorophyll *a* concentrations of between 4 and 10 µg/L are indicative of mesotrophic conditions, and lakes with seasonal average chlorophyll *a* concentrations greater than 10 µg/L are considered to be eutrophic. The average chlorophyll *a* concentration in Silver Lake in 2012 was 5.24 µg/L. Therefore, according to the U.S. EPA criterion, Silver Lake is classified as mesotrophic in 2012 based on chlorophyll *a* concentrations.

Chlorophyll a concentrations in Silver Lake over the past 26 years range from a high of 57.5 micrograms per liter (ug/L) in 1987 to a low of 5.24 mg/L in 2012, as shown in Figure 3.2. There are no significant long term trends.

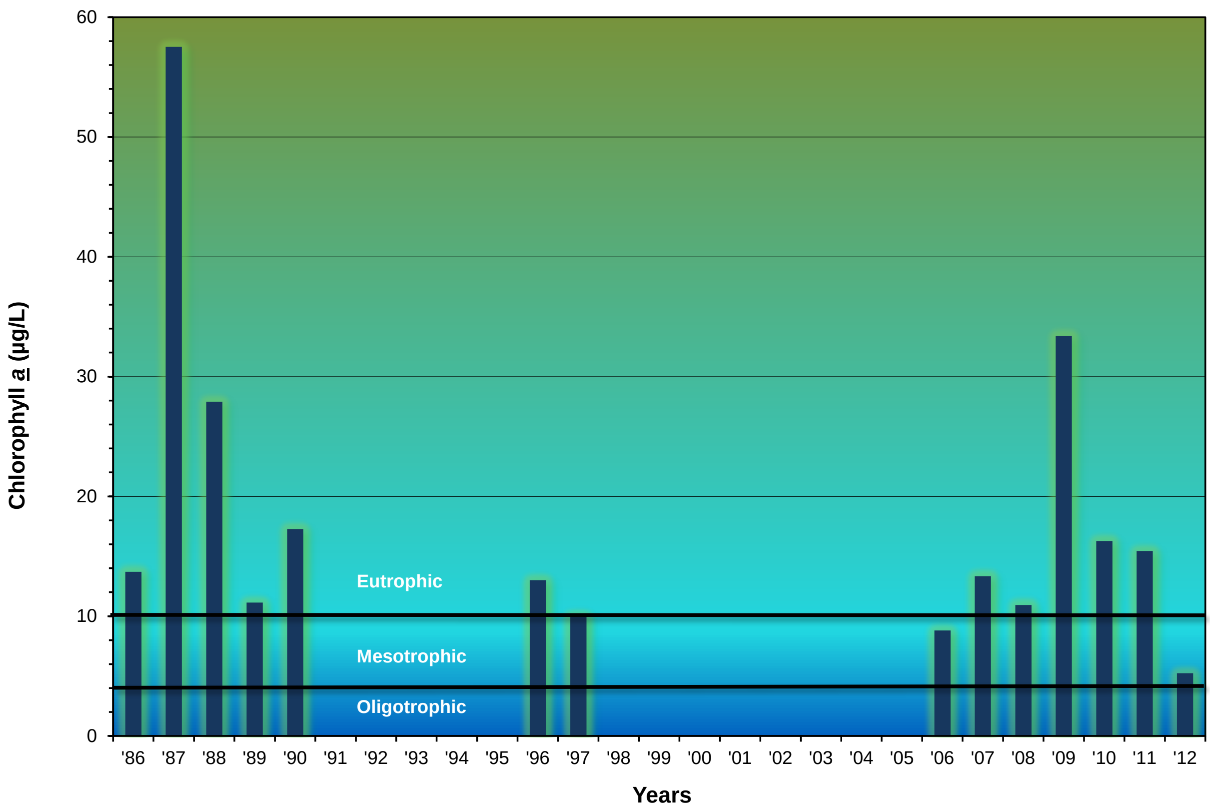


Figure 3.2 Mean Chlorophyll *a* Concentrations in Silver Lake (1986-2012)

3.1.4 Secchi Disk Transparency

Secchi disk transparency is an indirect measurement of the total amount of organic and inorganic turbidity in a lake. This measurement is obtained by lowering a 20-centimeter white or white and black patterned disk, known as a Secchi disk, into the water column until it can no longer be clearly seen and then recording the depth from the surface to where the disk is suspended. Higher Secchi disk readings represent higher water transparency. Transparencies less than 2.0 meters are considered to be indicative of eutrophic conditions by the US EPA. Transparencies ranging from 2.0 to 4.8 meters are considered to be indicative of mesotrophic conditions, and transparencies that are greater than 4.8 meters are considered to be indicative of oligotrophic conditions.

Secchi disk transparency during the 2012 growing season ranged from a low of 2.2 meters to a high of 5.8 meters. The average transparency for the season was 3.4 meters, classifying Silver Lake as mesotrophic in terms of transparency.

Mean transparency in Silver Lake over the past 26 years range from a high of 3.8 meters in 1997 to a low of 1.5 meters in 1998, as shown in Figure 3.3. Mean transparency values were evenly distributed above and below the EPA transparency eutrophic criterion throughout the sampling period. The three lowest transparency values occurred in the first three sampling years, 1986, 1987, and 1988; while recent sampling has shown improvement for each of the past 4 years, 2009, 2010, 2011, and 2012. As a whole, however, the transparency values have been variable and there are no significant long term trends; however, there has been a general increase in transparency since 2007. This may be a result of zebra mussels that are present in the lake.

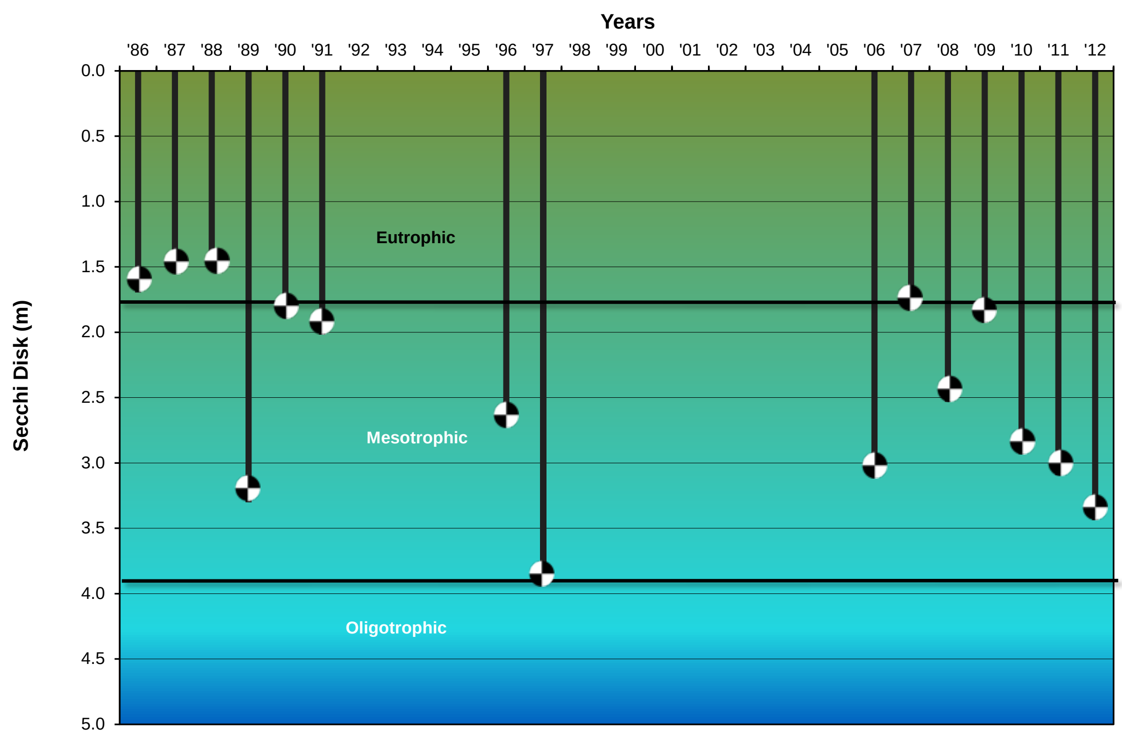


Figure 3.3 Mean Secchi Disk Transparency Readings in Silver Lake (1986-2012)

3.1.5 Trophic State Index

The Carlson's Trophic State Index (TSI) was used to quantify the trophic status of Silver Lake. Summer average values for total phosphorus, chlorophyll a, and Secchi depth were logarithmically converted to a scale of relative trophic state ranging from 1 to 100. Values greater than 50 are indicative of eutrophic conditions, according to the US Environmental Protection Agency. The 2012 TSI value for phosphorus in Silver Lake was just over 50, indicating eutrophic conditions. The 2012 TSI values for chlorophyll a and transparency were both within the mesotrophic criterion. Overall, Silver Lake can be characterized as meso-eutrophic, moderately to highly productive, based on transparency, chlorophyll a, and total phosphorus.

The CSLAP dataset has indicated meso-eutrophic conditions at Silver Lake from 2008 to 2012. Prior to 2008, the data usually indicated eutrophic conditions. Lake productivity continues to increase through late summer and early fall each year.

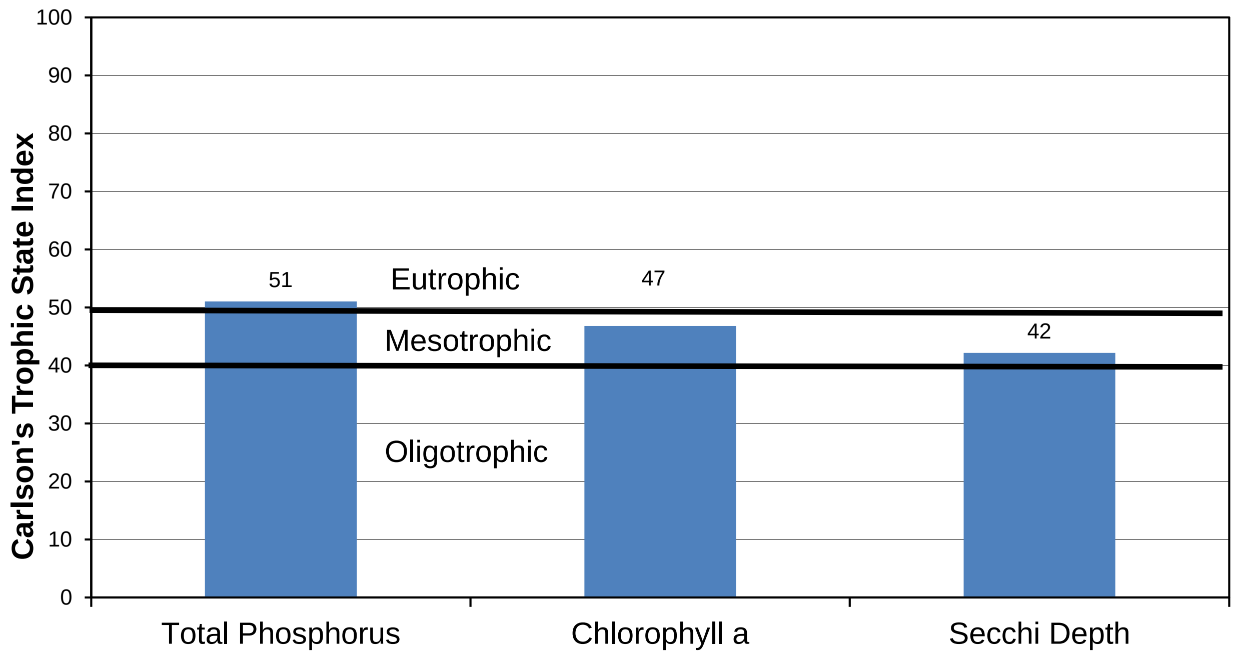


Figure 3.4 2012 TSI Values for Silver Lake

3.1.6 Phytoplankton and Zooplankton

Phytoplankton are microscopic algae that have little or no resistance to currents and live free floating and suspended in open water. Their forms may be unicellular, colonial, or filamentous. As photosynthetic organisms (primary producers), phytoplankton form the foundation of the aquatic food web and are grazed upon by zooplankton (microscopic animals) and herbivorous fish (plant-eating fish).

A healthy lake should support a diverse assemblage of phytoplankton represented by a variety of algal species. Excessive phytoplankton growth, which typically consists of a few dominant species, is undesirable. Excessive growth can result in severe oxygen depletion in the water at night, when the algae are respiring (using up oxygen) and not photosynthesizing (producing oxygen). Oxygen depletion can also occur after an algal bloom when bacteria grow and multiply using dead algal cells as a food source. Excessive growths of some species of algae, particularly members of the blue-green group, may cause taste and odor problems, release toxic substances to the water, or give the water an unattractive green soupy or scummy appearance.

Planktonic productivity is commonly expressed by enumeration and biomass. Enumeration of phytoplankton is expressed as cells per milliliter (cells/mL). Biomass is expressed on a mass per volume basis as micrograms per liter (µg/L). For this study, phytoplankton were identified to genus and counted. Using enumeration data and the mean cell size, the biomass of each genus was determined.

During the 2012 sampling period, six taxa (groups) of phytoplankton were identified in Silver Lake including Bacillariophyta (diatoms), Chlorophyta (green algae), Cryptophyta (cryptomonads), Cyanophyta (blue-green algae), Euglenophyta, (euglena) and Pyrrophyta (dinoflagellates). Phytoplankton data is provided in Appendix C.

As shown in Figure 3.5, the phytoplankton population in Silver Lake during 2012 was dominated by Cyanophyta (blue-green algae) for most months during the growing season as in past years. The peak total phytoplankton density (expressed as density of algal cells per milliliter of lake water) occurred in September when counts were 38,715 cells/mL. During July and August, phytoplankton densities were relatively low and less than 10,000 cells per milliliter.

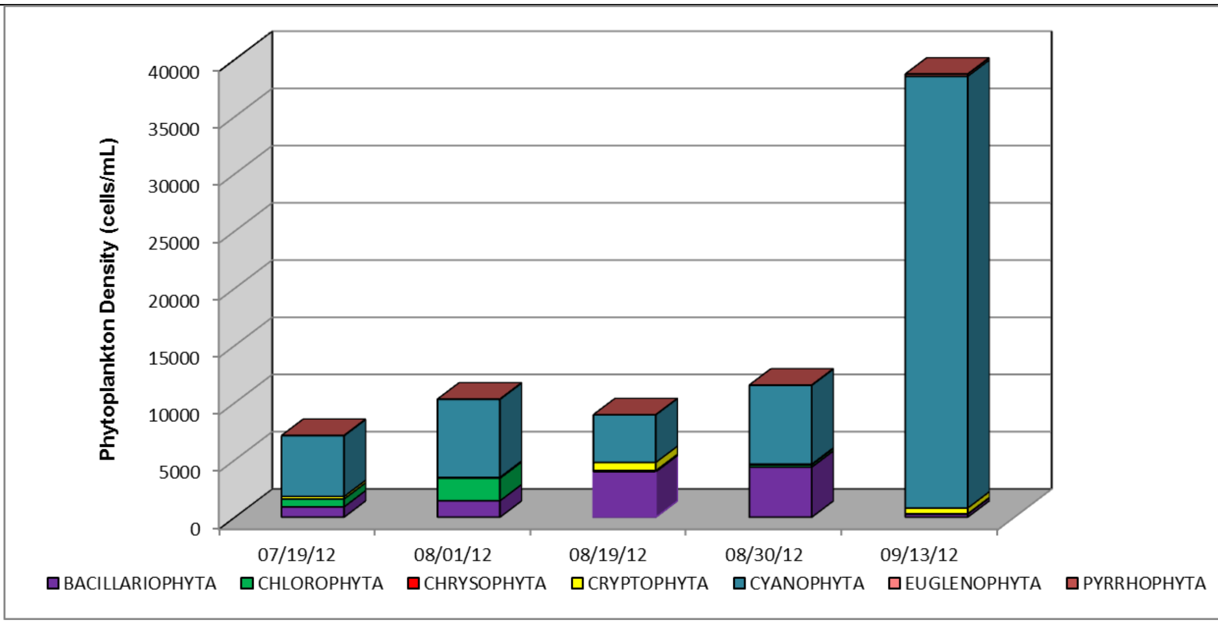


Figure 3.5 Phytoplankton Density in Silver Lake in 2012

The phytoplankton biomass (expressed as micrograms of algae per milliliter of lake water) was also dominated by blue-green algae. The peak total algae biomass in Silver Lake during 2012 was 9,975 µg/L in September, as shown in Figure 3.6.

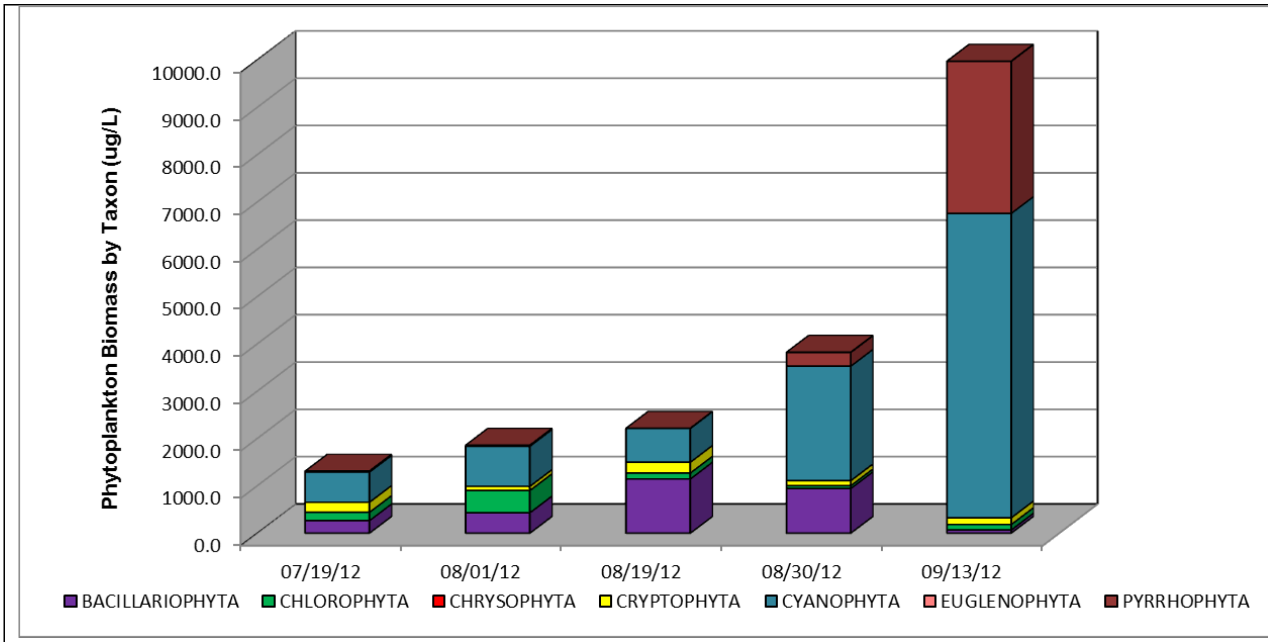


Figure 3.6 Phytoplankton Biomass in Silver Lake in 2012

Zooplankton are the intermediate stage in the lake food web, feeding on phytoplankton and in turn being fed upon by fish. Primary algae grazers are the cladocerans, *Daphnia* in particular. Rotifers are also general filter feeders. Some zooplankton are carnivorous, particularly the cyclopoid copepods and feed on other zooplankton. The type and number of zooplankton within a lake can have a significant impact on water quality. If the cladocerans that feed on algae are reduced by fish predation, then a lake can have an increased dominance of algae, particularly small green algae that these zooplankton prefer.

Zooplankton densities in Silver Lake in 2012 are illustrated in Figure 3.7. Zooplankton numbers were relatively low in Silver Lake in 2012, ranging from 14.9 organisms/mL up to 70.0 organisms/mL. The zooplankton community consisted predominantly of filter-feeding rotifers and carnivorous copepods. Cladocerans were the least dominant zooplankton, but were made up primarily of algae-grazing *Daphnia*; protozoans and other zooplankton were not observed.

Zooplankton biomass is determined based on the actual sizes of the organisms. Although there were many more rotifers than cladocerans, the rotifers are very small in comparison so the biomass of the rotifers is lower than other types zooplankton with similar or smaller densities. The cladocerans, while only 13 percent of the total zooplankton density, makes up nearly 60 percent of the zooplankton biomass due to their larger size. Zooplankton biomass in Silver Lake in 2012 is illustrated in Figure 3.8.

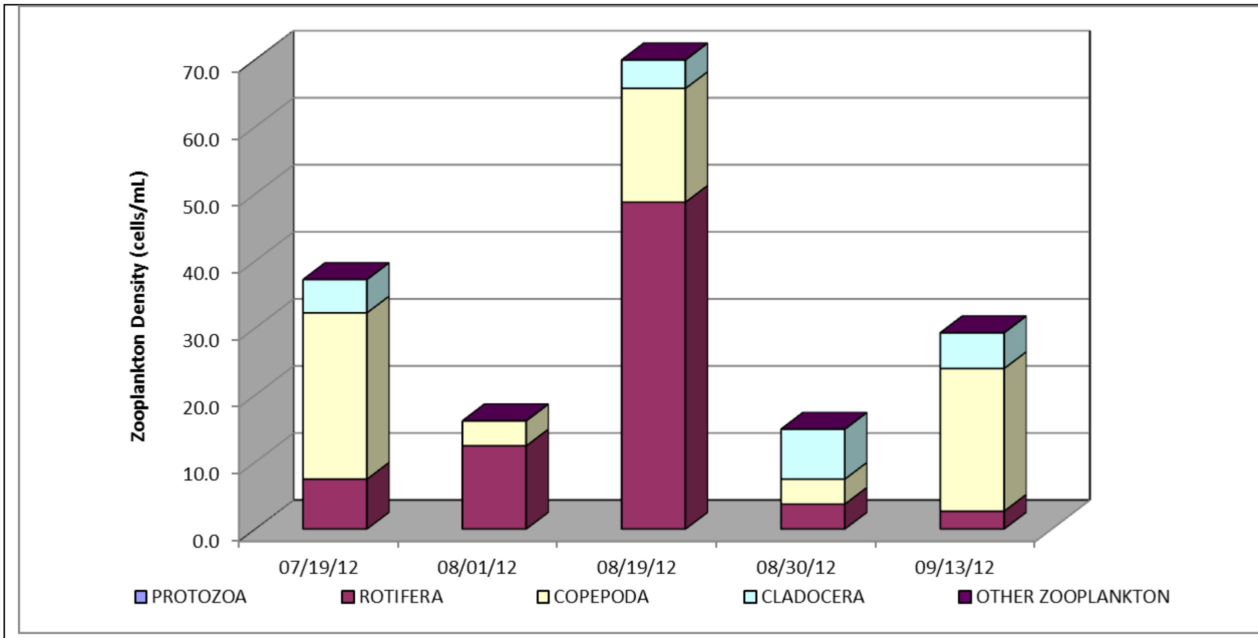


Figure 3.7 Zooplankton Densities in Silver Lake in 2012

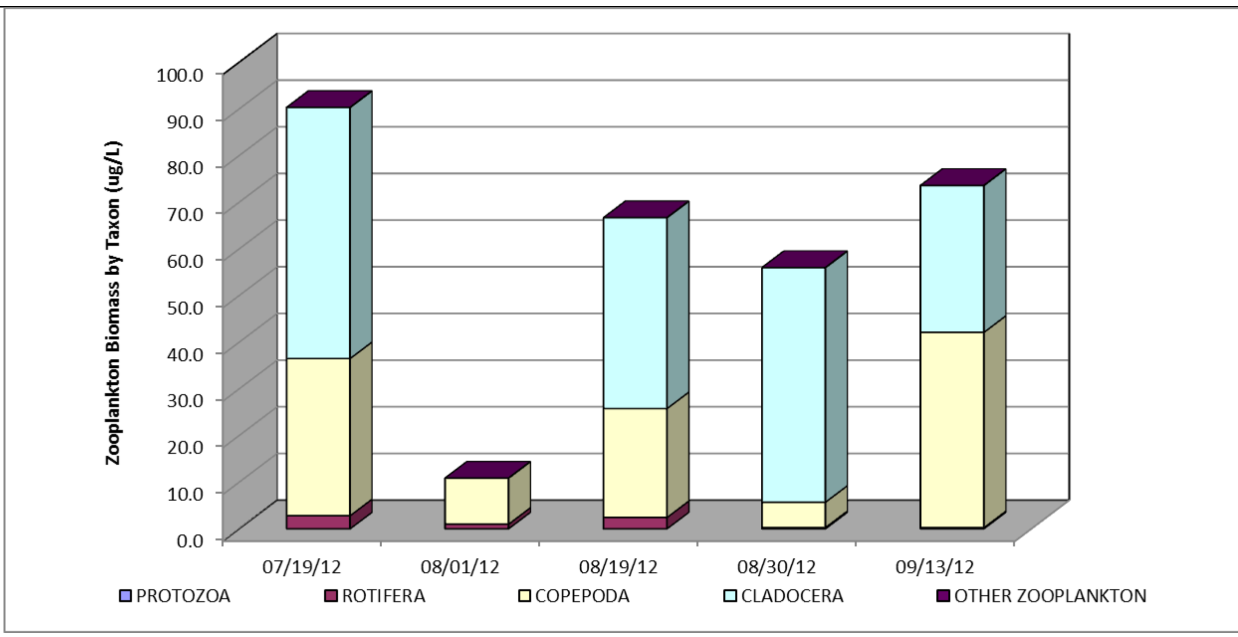
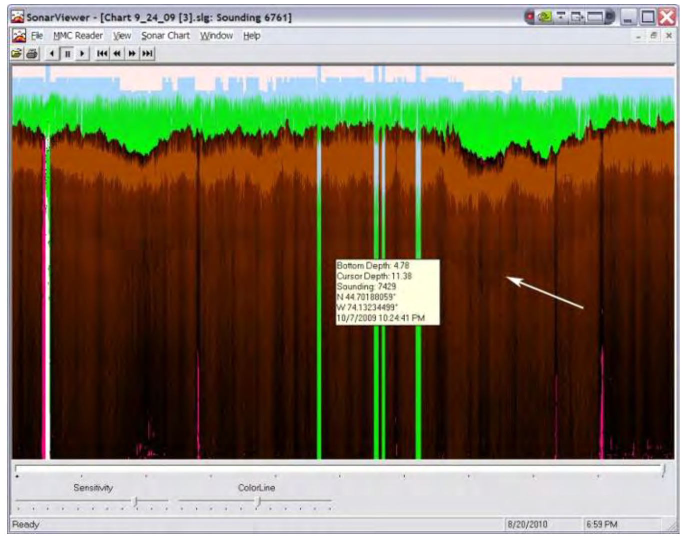


Figure 3.8 Zooplankton Biomass in Silver Lake in 2012

Zooplankton data is provided in Appendix D.

3.2 Bathymetric Survey

Methodology



Color-adjusted sonar chart showing secondary return for sediment thickness

Data on lake depth and sediment were collected on August 28th and 29th, 2012 using an Eagle/Lowrance FishElite 480 Digital Recording Sonar with GPS Mapping capabilities. This unit uses 12 channel GPS WASS technology with an external antenna to deliver horizontal mapping accuracies within 1 – 2 meters. Information on geo-location is digitally stored with each sonar reading. With the sonar unit installed on a boat, a series of transects were made along the general contours of the lake, roughly parallel to the shoreline. Adjustments were continually made to the sonar's controls to compensate for changes in water depth, submerged aquatic plant cover, and bottom sediment composition in order to ensure the best possible signal return of the lake bottom. The sonar charts were read into SonarViewer and water depth was exported into spreadsheets for pre-processing of location data and creating of a database (dBase IV) file.

Since the exported files do not automatically contain secondary return data (sediment thickness), these have to be read directly off of each chart. Color and sensitivity is adjusted individually for each chart to make the secondary return visible. The mouse cursor is then used to bring up the relevant information and the data are then entered into the spreadsheet next to the corresponding sounding number. This figure shows an adjusted chart that has been colorized to distinguish water (blue), plants (green) and lake bottom (brown), as well as to indicate the secondary return (arrow). The critical data displayed in the box are the sounding number, bottom (water) depth, and cursor (secondary return) depth. The depth of the secondary return is then subtracted from the water depth to yield sediment thickness. Lastly, these database files of GPS coordinates and corresponding depth and sediment measurements were entered into ArcGIS to produce maps of Silver Lake.

Once in ArcGIS, depth/sediment thickness points were projected onto the screen and contours were created by heads-up digitizing of each contour polygon, essentially hand-drawing each contour by zooming into the lake outline with overlain depth points and sketching each contour outline to conform to depths displayed on the computer monitor.

Results

Bathymetric and sediment thickness contours are shown in Figures 3.9 and 3.10. The bathymetric and sediment contours were used to calculate lake and sediment volumes using the "volume of frustrum of a circular cone" methodology. The formula in solid geometry for calculating the volume of a frustum of a circular cone has been applied by limnologists and fisheries biologists to compute the volume of a lake. This formula is:

$$V = \frac{1}{3}H\left(A1 + A2 + \sqrt{A1 \, x \, A2}\right)$$

Where:

V = volume of water
H = difference in depth between two successive depth contours
A_1 = area of the lake within the outer depth contour being considered
A_2 = area of the lake within the outer depth contour being considered

The procedure consists of determining the volumes of successive layers of water (frustums) and then summing these volumes to obtain the total volume of the lake. The total acreage of the lake, digitized from high-resolution aerial photographs, was 831 acres. The lake volume was 5,995 million gallons, and the sediment volume was 2,833,185 cubic feet or 104,933 cubic yards. This sediment volume may be somewhat low because it was not possible to obtain bathymetric and sediment thickness data near the main lake inlet/outlet area and the southern end of the lake due to the shallow depths, thick plant growth, and limitations of the fathometer. Therefore the darker brown, thicker sediments in these areas, shown in Figure 3.10, most likely extend closer to the lake shore.

3.3 Sediment Quality

Sediment samples were collected from the lake at two sampling locations, as described in Table 3.1, on August 28, 2012. The results indicate that the sediments in Silver Lake contain high concentrations of nitrogen and phosphorus. The high phosphorus concentrations in the sediments, along with the high iron and manganese concentrations, indicate that internal release of phosphorus during anoxic (zero oxygen) conditions in the bottom waters of the lake is probably a significant source of phosphorus that results in increased algal growth in the lake, and internal release on iron and manganese makes the bottom waters of the lake not desirable as a potable water source.

Table 3.1
Sediment Quality Data in Silver Lake

Sampling Location	Total Solids (%)	Organic Matter (%)	Total Phosphorus mg/Kg Dry	Total Nitrogen mg/Kg Dry	Iron Mg/Kg Dry	Manganese mg/Kg Dry
#1 – North End of Lake	20.04	19.7	450	1,718	95,500	2,830
#2 - Mid Lake	10.98	10.8	870	3,409	85,300	2,050

GPS Coordinates: #1 – 42^{o}42'44.4"N, 78^{o}1'29.5"W; #2 – 42^{o}42'11.7"N, 78^{o}1'34.2"W

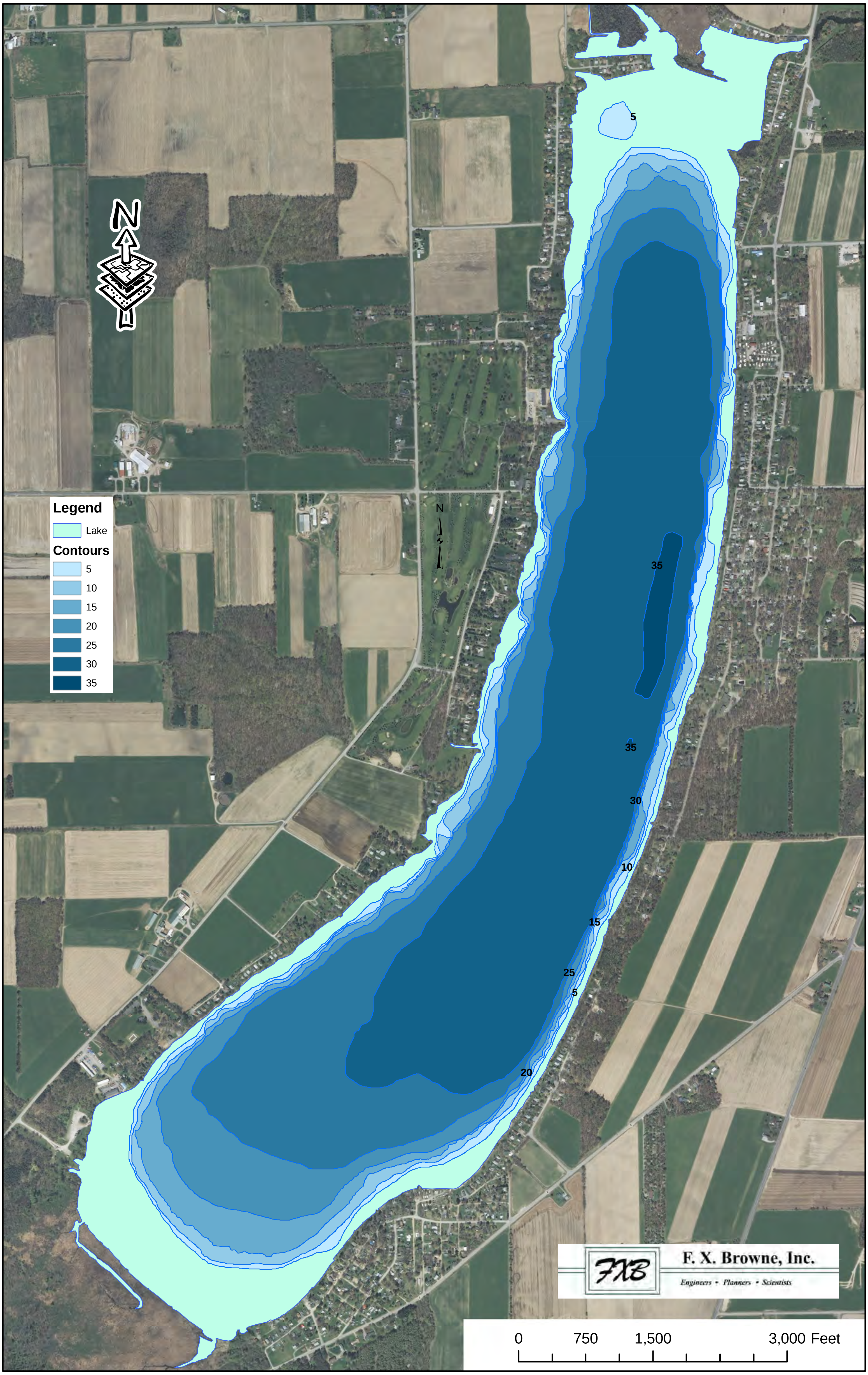


Figure 3.9 Bathymetric Map of Silver Lake, NY August 2010

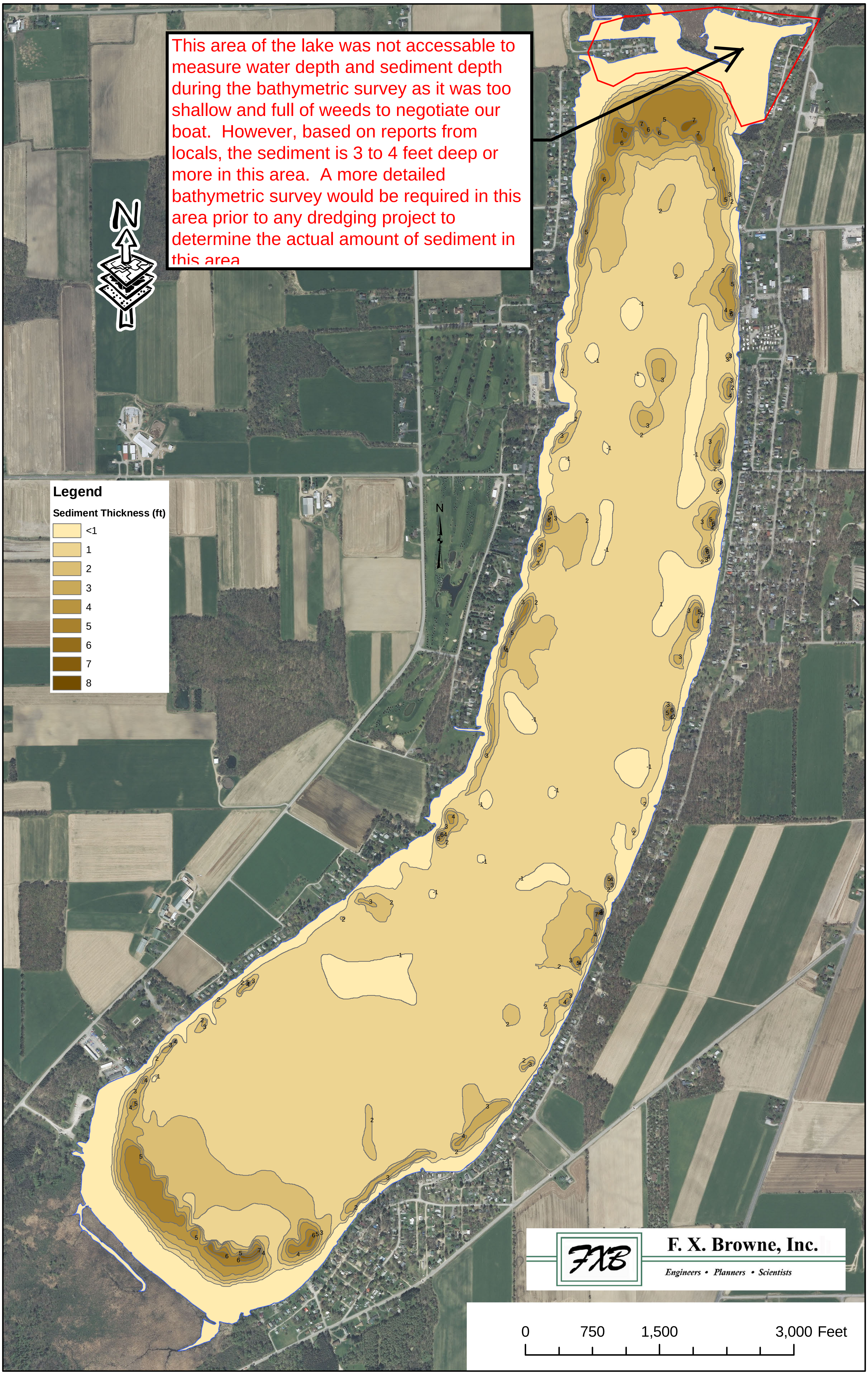


Figure 3.10 Sediment Thickness Map of Silver Lake, NY August 2010

3.4 Outlet Sediment Thickness

In 2009, the Village of Perry conducted a preliminary feasibility study for sediment removal in the Silver Lake outlet. The study determined that the outlet contained approximately 20,000 cubic yards of sediment clogging the channel, with a total capital cost for removal of $339,000 (Clark Paterson Lee, 2010). During our macrophyte survey, the channel was found to be choked with macrophytes to the extent that it was impossible to traverse the channel. See Appendix F for a copy of the outlet sediment thickness map.

3.5 Macrophyte Assessment

A macrophyte survey of Silver Lake was conducted on August 29, 2012. Six different types of plants were identified and mapped in the lake including tapegrass, Eurasian milfoil, pondweed, bladderwort, coontail, and yellow water lily, as shown in Figure 3.11. Other macrophytes may be present is small numbers along the shoreline, but were not observed during this survey. The native plant *Valesneria Americana*, commonly called tapegrass, and the non-native plant *Myriophyllum spicatum*, commonly called Eurasian milfoil, are co-dominant, are at nuisance levels, and essentially ring the entire lake. The tapegrass is closer to the shoreline in shallower water while the Eurasian milfoil is further from the shore and grows in deeper water, up to a depth of about 15 feet.

3.6 Zebra Mussels

Zebra mussels are small freshwater mussels that are native to southern Russia. The mussels get their name from the striped pattern that is commonly seen on their shells. They are relatively small, about the size of a finger nail, and can cause big problems in lakes. Zebra mussels are filter feeders and filter about a gallon of water a day. They consume phytoplankton, zooplankton, and other particles in the water. This is why the clarity in zebra mussel invested lakes sometimes improves.

Zebra mussels live for about four to five years. Female zebra mussels can produce over 1 million eggs each year. Baby zebra mussels float around for several weeks and then settle onto any hard surface they can find. Zebra mussels are very sharp and can cut people's feet; therefore, water shoes are recommended in areas that have a lot of mussels. They cover the undersides of docks, boats, motors, anchors, pipes, etc.

Silver Lake is highly susceptible to zebra mussel infestation. Zebra mussels need 12 mg/L of calcium to grow and 20 mg/L of calcium to thrive. The long-term average calcium concentration in Silver Lake is 36.4 mg/L (*2012 CSLAP Report*), so there is more than enough calcium for zebra mussels to grow in Silver Lake. Zebra mussels were first identified in Silver Lake in the mid 2000's and continue to grow and spread throughout the lake. During our 2012 survey, zebra mussels were identified in several locations (mainly on docks) around the lake.

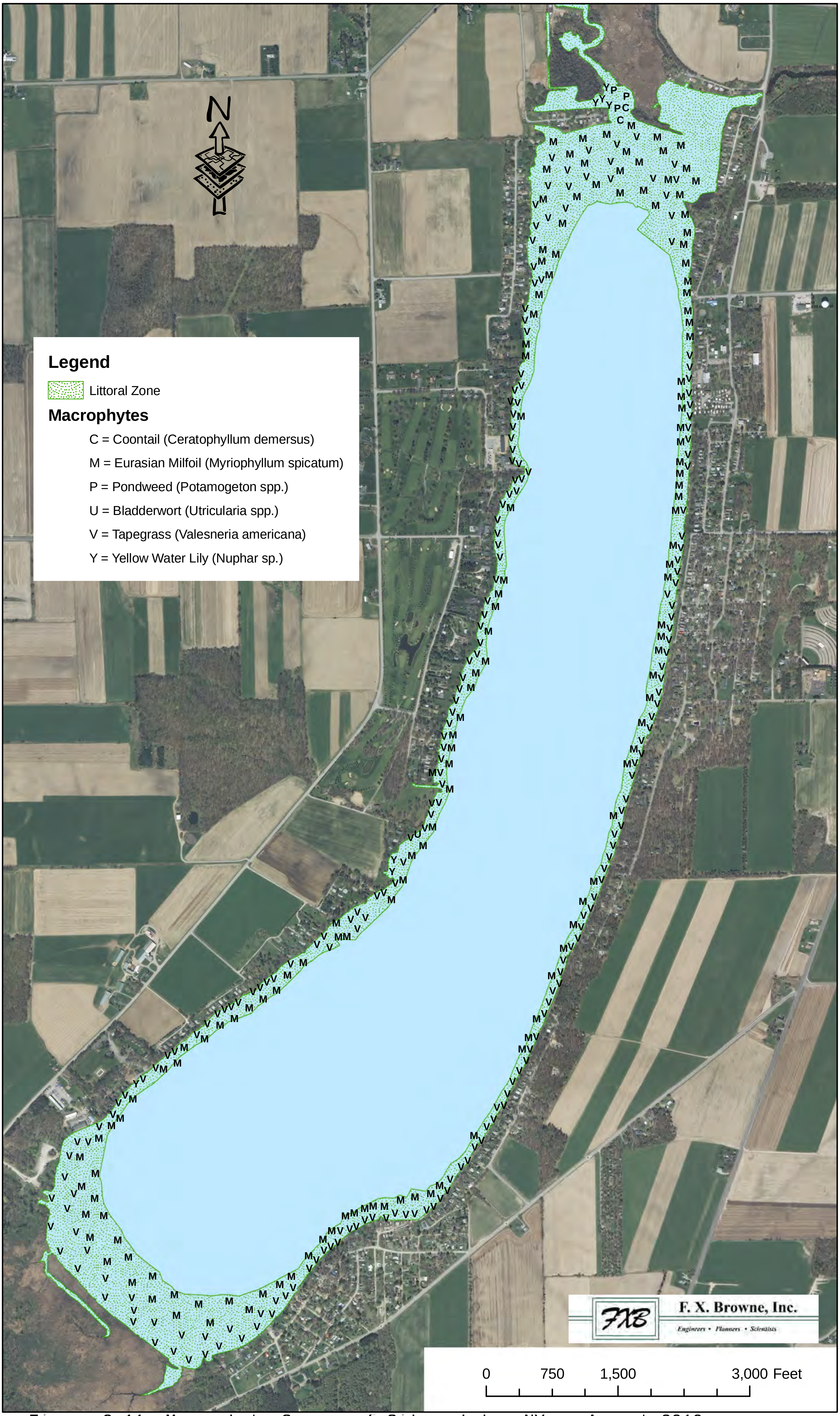


Figure 3.11 Macrophyte Survey of Silver Lake, NY August 2010

4.0 Watershed Investigations

Pollutants can enter a lake from both point and nonpoint sources. Point sources are defined as all permitted wastewater effluent discharges within a watershed. All other pollutant sources within a watershed are classified as nonpoint sources. Nonpoint sources can contribute pollutants to a lake through inflow from tributaries, direct runoff, direct precipitation on the lake surface, internal loading from lake sediments, leaching from septic tanks, and groundwater inputs.

There are no known point sources of pollution in Silver Lake watershed. The following sections discuss non-point source problem areas identified during watershed investigations and recommendations for each of these problem areas.

In October of 2009, the Wyoming County Soil and Water Conservation District identified three areas of concern within the Silver Lake watershed. F. X. Browne, Inc. revisited those areas of concern and identified nine additional problem areas during watershed investigations in August of 2012.

4.1 Watershed Nonpoint Source Problem Areas

The predominant land use in the Silver Lake watershed is agricultural, comprising approximately 70 percent of the total land area of the watershed. Agricultural activities in the watershed are the primary source of nutrient loads to the lake. The drinking water supply as well as the recreational uses and aesthetics of Silver Lake are impacted by nutrients (phosphorus) and algal growth that reduce clarity.

Discussion with the Roadway Supervisors for the Town of Castille and the Village of Perry indicated that the problem of nutrients and sediment in the lake was exacerbated when mechanized agricultural practices were introduced into the watershed and many of the hedgerows were removed. The hedgerows often separated the fields and pastures from the streams that drained into the lake and prevented runoff of sediment and nutrients into the streams.

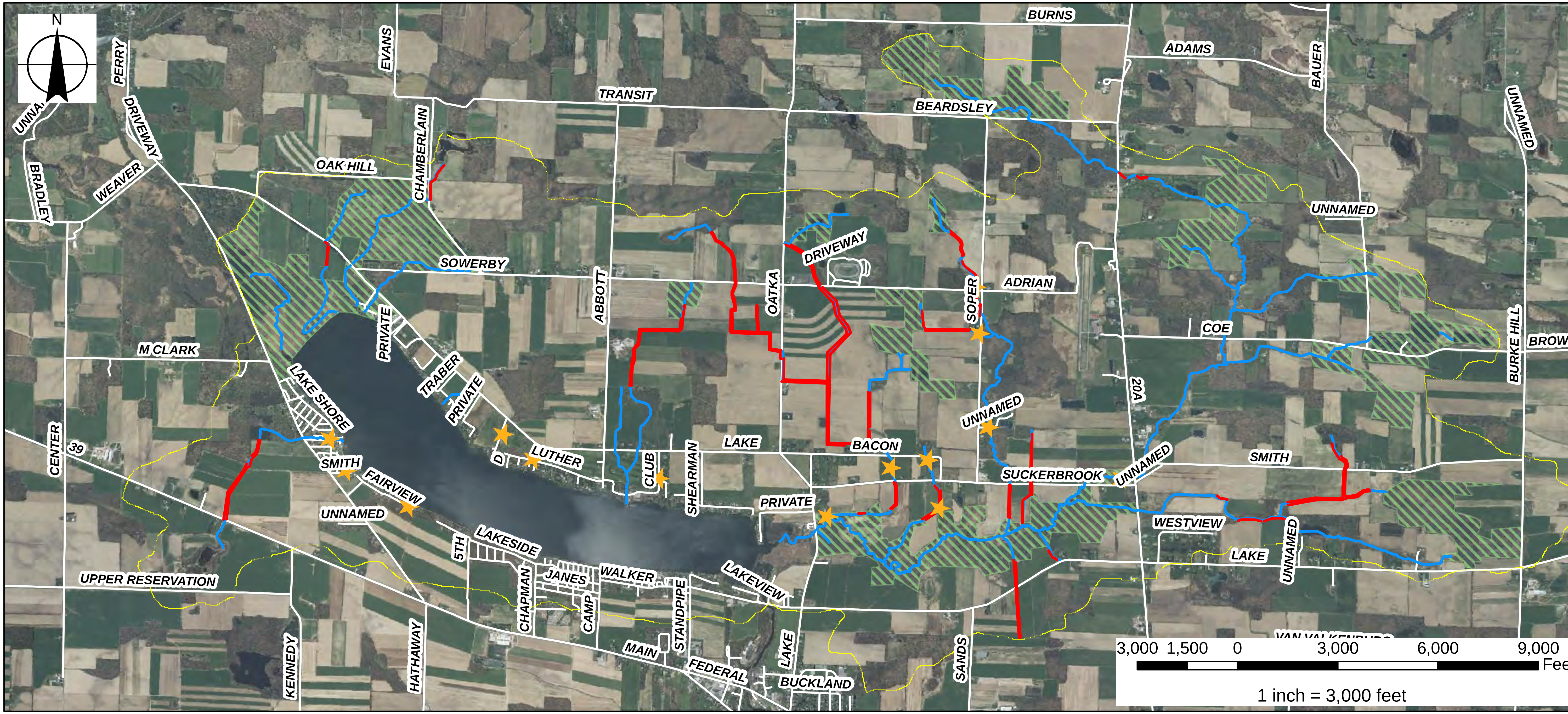
Stream banks in the Silver Lake watershed are relatively stable or stabilizing except in some of the headwater areas where steeper slopes have moderate erosion problems due to lack of vegetation on the steep side slopes. Sites where erosion problems are most evident are located downstream of stream channels with the least amount of riparian buffers. The stream channels in these locations indicate higher velocities and potentially greater flows. Some residents have attempted to alleviate these erosion problems by lining channels with rip-rap or other similar measures.

Twelve problem areas were identified during watershed investigations and are summarized in Table 4.1. Detailed descriptions and photos of each problem area are located in Appendix E. Locations of identified problem areas are shown on Figure 4.1

Table 4.1 Problem Area Descriptions			
Site ID/Location	**Length**	**Description**	**Date**
Club Rd	650 ft	Eroded channel at West Lake Rd culvert beginning at Club Rd. Sediment is gravelly and unstable. Three driveway crossings and telephone pole along eroded channel.	10/27/2009 8/29/2012
Private Dr. 1	650-750 ft	Eroded channel along West Lake Rd beginning at culvert at Private Dr. 1. Banks are partially vegetated with erosion threatening the road at several locations and a golf cart bridge. Previous stabilization attempts ineffective.	10/27/2009 8/29/2012
Luther Rd	50 ft	Stabilization project completed in 2006. Minor repair work is needed.	10/27/2009 8/29/2012
Sucker Rd at Rt 20A and Suckerbrook Rd	450 ft	Moderately eroded stream banks up to 4-5 ft high. Debris and log jams exacerbating erosion problems. Sediment deposition causing stream flow to be disconnected.	8/28/2012
Unnamed Trib. to Sucker Brook at Soper and Adrian Rds	900 ft	Deficient riparian buffers and likely agricultural runoff into channel. Silty sediment deposition partially filling some culverts is evident in stream channels.	8/28/2012
Unnamed Trib. to Sucker Brook at driveway for 6725 Soper Rd	250 ft	Eroded stream banks up to 2-3 ft high. Undercutting and evidence of tree falls upstream and downstream of driveway.	8/29/2012
Unnamed Trib. to Sucker Brook at Bacon Rd (adjacent to 3271 Bacon Rd)	300 ft	Culvert at Bacon Rd recently repaired and downstream channel stabilized with rip-rap. Riparian zones consist of mowed lawns and tops of streambanks are bare soil.	8/29/2012
Unnamed Trib. to Sucker Brook between Bacon Rd and Suckerbrook Rd	750 ft	Most severe erosion of all sites observed in the watershed. Side slopes are very high and steep with very little vegetation. Row crops at top of right bank with very little riparian buffer. Large trees undercut with exposed roots at risk of falling and creating log jams.	8/29/2012
Suckerbrook and Silver Lake Inlet at Oatka Rd	750 ft	Minor to moderate erosion with some undercut banks in the inlet area. Areas of bare soil at entry points where watercraft are dropped into the stream. Riparian zone consist of mowed grass up to the edge of the stream. Algae bloom was evident along entire area of concern, pointing to excess nutrient runoff.	8/29/2012
Stormwater inlet by 4240 Fairview Road	50 ft	Bare and exposed soils at toe of slope and adjacent to storm drain that discharges into lake. Erosion evident on the gravel road.	8/29/2012
Stormwater inlet by 6793 N Hillcrest Dr	50 ft	Minor to moderate erosion in and around stormwater inlet that discharges into the lake. Efforts to stabilize with rip-rap appear ineffective.	8/29/2012
Unnamed Trib. to Silver Lake at Lake Shore Dr between East and West Springbrook Road	600 ft	Portions of the stream diverted through buried culverts, possibly completed recently. End sections of some culverts show evidence of gravel and sediment build up, indicating mild to moderate erosion in the stream channel.	8/29/2012

Figure 4.1: Nutrient and Erosion Source Area Map

Silver Lake Watershed, Wyoming County, New York



F. X. Browne, Inc.

Engineers • Planners • Scientists

Project No: NY1211-02
File Name: \Watershed Pollutant Source Map.mxd
Drawn By: JMD Checked By: MRM

NOTES:

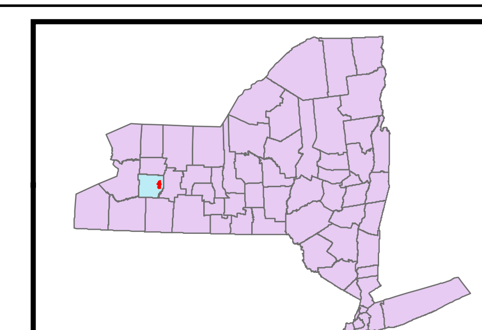
1. Data accuracy is limited to the accuracy and scale of the original data sources
2. This map are part of the Lake and Watershed Management Plan Project and should be used in conjunction with the compiled text.

SOURCES:

1. Silver Lake watershed, roads, and streams were obtained from NYSDEC & NYS GIS Clearinghouse.
2. Aerial imagery from WMS server maintained by NY USGS.
3. All other shapefiles created by F. X. Browne, Inc.

Legend

- Silver Lake Watershed
- Possible Erosion Source
- Deficient Riparian Buffer
- Streams
- Roads
- Preservation Areas



4.2 Watershed Problem Area Recommendations

Developed areas are confined mainly to the shorelines of Silver Lake in and around the Village of Perry and Town of Castile. These developed areas are generally low intensity and for the most part fairly rural. Field reconnaissance indicated only a few roadway ditch erosion sites and the Wyoming County Soil and Water Conservation District is adequately monitoring and surveying roadway ditches with erosion problems. The Conservation District has worked with the Towns to address these problems using erosion control matting and replanting the ditches to stabilize the erosion.

Additional BMPs should be implemented to address the problem areas identified during watershed investigations and further reduce nutrient loads from non-point sources to Silver Lake. Overall, the primary problem at each of the areas of concern is the high volume and velocity of stormwater flows. These fast, high volume flows erode and undercut the stream banks and threaten the integrity of instream culverts and road crossings. Because the land is largely agricultural in nature and not characterized by high impervious surfaces or concentrated discharges, deficient riparian buffers are a likely source of these fast stormwater flows. As indicated during watershed investigations, sites where erosion problems are most evident are located downstream of stream channels with the least amount of riparian buffers.

5.0 Management Recommendations and Strategies

Management alternatives for Silver Lake are divided into watershed management alternatives and in-lake management alternatives. The first priority in all management programs is to determine whether watershed management practices can be implemented to reduce the pollutants entering the lake. Because nonpoint source pollutants account for a large percentage of the nutrient and sediment loadings to Silver Lake, it is critical to continue focusing lake restoration efforts that focus on watershed controls. In addition to watershed controls, in-lake restoration measures may help to improve the water quality in Silver Lake, especially after watershed management alternatives have been implemented. Watershed management and in-lake restoration measures that should be considered for Silver Lake and its watershed are discussed in the following sections.

5.1 Watershed Management Recommendations

Watershed management recommendations for the Silver Lake watershed include the following:

1. Agricultural Management
2. Streambank Restoration
3. Protect and Restore Riparian and Wetland Areas
4. Stormwater Management
5. Homeowner Management Activities
6. Road and Trail Management

Each of the above watershed management recommendations are discussed in detail in the following sections.

5.1.1 Agricultural Management

The 1991 Silver Lake Watershed Management Plan and the 2010 TMDL Study identified agricultural activities as the primary source of nutrient loads to Silver Lake, and both studies recommended agricultural best management practices to reduce nutrient loadings for agricultural lands in the watershed. Since that time, the Silver Lake Commission and the Wyoming County Soil and Water Conservation District have assisted area farmers in completing Agricultural Best Management Practices throughout the Silver Lake watershed including a concrete manure storage facility at Cornell Crest Dairy Farm and a bunk silo leachate control project at Pingrey Farms. Many agricultural best management practices have been implemented; however, more work is still needed to control sediment and nutrient runoff from agricultural lands in the Silver Lake watershed.

The 2010 TMDL Report indicates that the current phosphorus load from agricultural lands in the watershed is 3,217.8 lb/year. The allocated load for agricultural lands is 1,170.1 lb/year which means than an additional 2,101.7 lbs/year (64%) of phosphorus load from agricultural lands must be controlled to meet the TMDL goal.

Agricultural land uses are predominantly hay and pasture or corn and soybean crops. Only one confined area feeding operation (CAFO) is located in the watershed. The Pingrey Farm CAFO appears to be well managed and there does not appear to be any issues with its discharges. Reconnaissance of the other agricultural areas indicates that the primary source of nutrients may be runoff from agricultural fields. Several agricultural fields within the watershed have very little separation between the edge of farm fields and stream banks, especially in fields where crops are grown. Pastures used for grazing livestock have better separation from streams and appear to be well fenced to prevent livestock from crossing or entering into streams.

Typical view of croplands adjacent to stream channel with deficient riparian buffer.

Many of the farms in the watershed are currently enrolled in the Agricultural Environmental Management (AEM) program and are actively trying to implement agricultural BMPs to improve water quality of stormwater runoff on their properties by working with the Wyoming County Soil and Water Conservation District. The implementation of agricultural BMPs, including development and implementation of nutrient management plans for individual farms, should continue. The establishment of conservation easements along streams in agricultural areas, especially crop fields, would help to filter stormwater runoff and reduce the amount of nutrients and sediments that enter the streams and ultimately Silver Lake. Conservation programs have been available in the past to provide incentives for farmers to install wider buffer areas in crop and pasture fields. The new 2014 Farm Bill was recently passed and overall, the funding for the program has decreased; however, the funding for the Agricultural Conservation Easement Program (ACEP) received a funding increase of $1.2 billion. Since the new Farm Bill contains money for farmers to install and maintain conservation areas along streams that run through their farm fields, farmers should be encouraged to take advantage of these programs. Better stream buffers have the greatest potential the reduce sediment and pollutant loadings to Silver Lake.

The Silver Lake Watershed Commission should be a strong advocate for continued installation of agricultural best management practices, especially enhanced stream buffers. The Commission should work with the Conservation District and landowners to implement projects.

5.1.2 Streambank Restoration

Streambank Erosion in the Silver Lake Watershed

Streambank erosion is typically a major source of nonpoint source pollution in many watersheds. Eroded streambanks are highly susceptible to continued and significant erosion which deposits sediments and nutrients directly into the streams and ultimately into Silver Lake. During rain events, stream flows and velocities increase, and erosion begins. Several streams flowing into Silver Lake have eroded streambanks and lack adequate vegetation. It is likely that other areas of streambank erosion exist along the tributaries on private land that could not be inspected as part of this project. Any additional areas of streambank erosions that are identified by either the Conservation District or the Watershed Commission should be documented and added to the list of problem areas.

Restoration of eroded streambanks is a cost-effective way to significantly reduce sediment and nutrient loadings to Silver Lake. By using bioengineering (vegetative) or a combination of bioengineering and structural engineering streambank stabilization techniques, the erosion problems can be corrected while the stabilized streambank can serve as a vegetative buffer and, in many cases, a restored riparian corridor. Riparian buffers along the streams will reduce the quantities of sediments and nutrients that enter the streams via stormwater runoff.

A variety of methods are available to stabilize eroded streambanks and reduce continued erosion and sedimentation. Some methods reduce the amount and velocity of water in the stream, others involve relatively high cost structural controls such as rip-rap and gabions, and still others involve relatively low-cost controls such as willow twigs, grasses, shrubs, or wetland vegetation. Lower cost, bioengineering approaches should be used wherever practical to stabilize the severely eroded streambank areas noted on the nonpoint source problem area map (Figure 4.1). Where warranted, a structural stabilization element should be included in the overall project design to ensure long term stabilization and to provide adequate protection against high stream flows and high flow velocities.

5.1.3 Protect and Restore Riparian and Wetland Areas

A riparian buffer is the area adjacent to streams, lakes, ponds and wetlands. This area is extremely important to the health of a water body, as it intercepts, slows and filters stormwater before it reaches the water. A wooded riparian buffer with a shrub and herbaceous layer is the most effective riparian buffer, while the least effective riparian buffer consists of mowed grass or no vegetation. The wider a riparian buffer is, the better it is for the health of a stream, lake or wetland.

Riparian buffer restoration consists of removing invasive species and/or undesirable vegetation and replanting with native trees, shrubs and herbaceous species. Among the benefits of these buffers is improved water quality, reduced soil erosion and stormwater runoff and improved wildlife habitat. In the Silver Lake watershed, it is important to increase the buffer widths along streams that flow through agricultural fields. Figure 5.1 illustrates the recommended minimum buffer widths to achieve specific objectives.

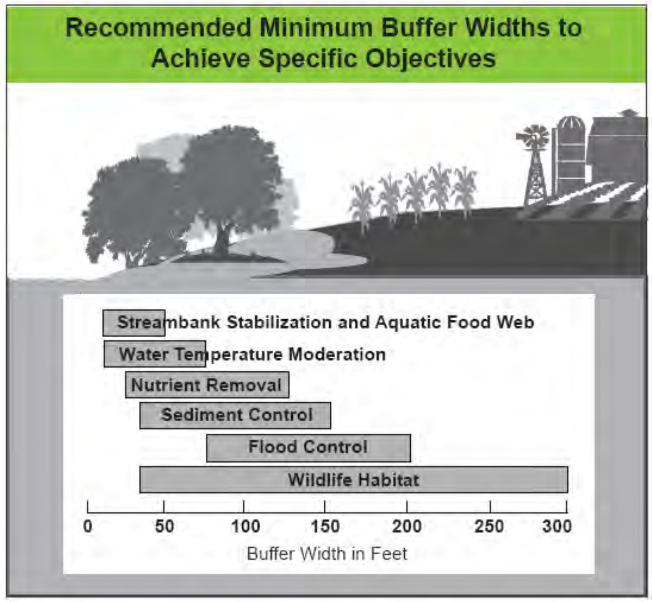


Figure 5.1 Buffer Widths and Objectives
Source: Virginia Department of Forestry

As indicated above in Section 5.1.1, the Silver Lake Commission and the Wyoming County Soil and Water Conservation District should work with watershed farmers to increase stream buffers throughout the watershed. Buffers of at least 150 feet on both sides of the stream would be preferable.

The shoreline of Silver Lake is highly developed with boat houses and docks along most of the shoreline. Homeowners around the lake should be encouraged to maintain at least a 5-10 foot vegetative buffer between mowed lawns and the lake, where applicable. Tall grasses, wildflowers, and shrubs can be planted to provide an attractive shoreline buffer.

5.1.4 Stormwater Management

Stormwater runoff from forested, agricultural, and developed areas contains high concentrations of sediments, nutrients, and other pollutants. Development activities result in increased impervious surfaces. This leads to an increase in both the volume and velocity of stormwater, and causes higher rates of erosion. Historically, stormwater management has focused on reducing the frequency and severity of downstream flooding by reducing the peak discharge from post-developed sites. This was typically achieved by storing water in large detention basins that offered little treatment. More recently, stormwater management has been redefined to include the removal of pollutants, thereby improving and protecting the quality of downstream waters. Increasing groundwater recharge by increasing stormwater infiltration is another important stormwater management goal. Innovative stormwater BMPs focus on stormwater infiltration to achieve flood control while removing pollutants and recharging groundwater.

Although land use in the Silver Lake watershed has not changed significantly over the past 20 years, new residential and commercial development could occur in the watershed in the future. New development in the Silver Lake watershed could adversely affect the condition of Silver

Lake depending on where the development occurs and how the stormwater is managed. If the development is located on pervious land such as existing forest or open space, the impervious area will be increased with the potential for an increase in stormwater runoff. The present New York State stormwater regulations, however, require that the post-development stormwater runoff be controlled for water quality, volume, and peak flow. If new development is planned properly and the stormwater management controls are engineered, constructed, and maintained properly, the post-development stormwater runoff should not have a significant adverse impact on the condition of Silver Lake.

Structural and non-structural stormwater management controls are required to control water quality, volume, and peak flow. All new and redeveloped properties are required in meet the DEC stormwater management requirements and include management practices such retention basins, detention basins, bioretention systems, sand filters, infiltration trenches, porous pavement, constructed wetlands, grassed waterways, vegetated swales, rain gardens, filter strips sand filters, and water quality inlets.

The Silver Lake Commission should ensure the jurisdictional agencies for future development(s) review plans carefully for compliance with all NYS DEC stormwater regulations.

The existing residential area on the eastern side of the lake does not have any structured or planned stormwater management. Runoff from streets and driveway basically flow directly to the lake without any treatment. A stormwater feasibility study should be conducted to identify opportunities for water quality treatment of stormwater runoff from these areas. Street sweeping may also be a good alternative for reducing sediment and nutrients from entering the lake. Collection of fall leaves (and composting them is a secure location) is also a good housekeeping tool to keep excess nutrients from washing into the lake in residential areas.

5.1.5 Homeowner Management Activities

Watershed education and public participation are important aspects of any watershed management program. The development of environmental education programs designed for school-aged children and adults is an effective watershed management approach. Citizen involvement and practices benefiting the watershed should be publicized and encouraged. Positive practices include stormwater management, recycling of yard wastes, safe storage and disposal of toxic materials, farm conservation management planning, environmentally sound recreation behavior, and proper lawn and yard maintenance. Citizens should also be discouraged from using invasive plant species in their yard or garden landscaping. Training citizens to recognize and remove non-native invasive species in the watershed can have a positive impact on the spread of noxious weeds.

Residential areas can be significant sources of nutrient and sediment loading within a watershed. The 2010 Silver Lake TMDL Report indicates that approximately 38.1 lb/year of phosphorus is entering Silver Lake from developed lands. The TMDL allocates 28.6 lb/year of phosphorus to developed lands which means that phosphorus from developed lands must be reduced by 9.5 lbs/year.

Although homeowners and residential landowners often care about preserving natural areas, they may not always know the best ways to do so. Homeowners in the Silver Lake watershed should be made aware of ways they can help protect Silver Lake and the surrounding watershed from water quality degradation. Several homeowner practices are listed below that can be implemented as part of a public education program.

1. Homeowners with bare soils, construction sites, or dirt piles on their properties should be encouraged to re-vegetate the areas in order to reduce the erosion potential. Silt fences and other erosion and sedimentation controls should be implemented at all constructions sites, large or small.

2. Homeowners should be educated about the proper repair and maintenance of dirt and gravel driveways. They should be encourages to repair any driveway erosion, especially where it occurs on steep slopes.

3. Lawn fertilizer can be a significant source of nutrients to lakes and streams. Homeowners should test their soil for phosphorus and nitrogen concentrations so that they can minimize the amount of fertilizer that they add to their lawns. Homeowners can contact the Cornell Cooperative Extension office or visit http://cnal.cals.cornell.edu/ to obtain information on soil testing.

4. Shoreline homeowners should be discouraged from mowing their lawns up to the edge of the lake. A minimum of a five foot vegetative buffer should be left along the lake shore or streambank to provide erosion control and to filter nonpoint source pollution from entering the water. Planting the water's edge with native wildflowers and rushes has the added benefit of providing a habitat for wildlife, and discouraging nuisance waterfowl congregation.

5. Homeowners should be encouraged to wash cars and trucks on grassy areas, if possible, or use commercial car washes. This practice will reduce the amount of phosphorus and detergent that runs into Silver Lake and its tributaries.

6. Homeowners should be encouraged to clean up any pet waste that has the potential to be washed into Silver Lake during rain events. Animal wastes are very high in nutrients and bacteria.

Residential Stormwater Management Recommendations

There are several stormwater management opportunities for the areas in the watershed that are already developed with housing units. Rain barrels and rain gardens are options that individual homeowners can install on their property to help improve stormwater runoff quality, and at the same time improve the aesthetics of their property.

Rain barrels collect stormwater runoff from rooftops. The stored water can then be used to water flower and vegetable gardens when it is not raining. During larger rain events, discharges from rain barrels should be directed to a grassed area, a rain garden, or possibly a dry well. This way the stormwater is used and infiltrated into the ground rather than running directly into the swales and the lake. The cost of rain barrels can range from $50 to over $300, but a standard 55 gallon rain barrel typically costs about $100. If the Association bought rain barrels in bulk, they may get a better price that they could pass along to the homeowners. Another alternative is to build your own rain barrel. Information on building your own rain barrel can be found at the following website: http://www.extendonondaga.org/natural-resources/community-horticulture-and-gardening/rain-barrels/.

A flourishing rain garden.

This rain garden is two years old. Weeds have a hard time growing. Birds and butterflies are regular visitors to the garden.

A rain garden (bioretention basin) is a shallow surface depression planted with native vegetation to capture and treat stormwater runoff. The purpose of this BMP is to capture, treat and infiltrate stormwater. Rain gardens store and infiltrate stormwater runoff, which increases groundwater recharge and may decrease downstream erosion and flooding. Stormwater runoff water quality is improved by filtration through the soil media and biological and biochemical reactions within the soil and around the root zones of plants. Rain gardens improve water quality, reduce stormwater runoff and peak volumes, increase groundwater recharge, provide wildlife habitat and are aesthetically pleasing. Rain gardens can be installed by individual homeowners to treat stormwater runoff from their rooftop and driveways. Rain gardens can be an aesthetically pleasing way for homeowners to combine stormwater management and landscaping to their property. Stormwater is directed to the rain garden and provides water and nutrients for the plants. Excess stormwater is stored in this area and can continue to be used by the plants days after a rain event.

5.1.6 Road and Trail Management

Roads can have a negative impact on the natural community in watersheds. Roads change the hydrology of the watershed by redirecting water from its otherwise natural flow patterns. Roads increase nonpoint source pollution by increasing the amount of impervious surfaces, thereby preventing infiltration of stormwater into the ground. Roads also create an unnatural disturbance that promotes the growth of invasive plant species. Sediment washing from dirt and gravel roads or eroded roadsides can be a significant source of nonpoint source pollution in rural areas.

Traditional thinking in road maintenance has been to get water off of the roads and into low-lying areas such as streams by the quickest means possible. However, this results in excess nutrients and sediment entering streams. Inadequate drainage structures such as culverts can cause downstream erosion. All watershed roads should be properly graded and the road edges well vegetated.

Roadside erosion sites should be repaired using methods such as grassed swales, riprap swales, bank stabilization, bioengineering techniques, level spreaders, and other methods. Roadside swales should be properly maintained and should always be immediately stabilized if they are disturbed. Properly sized culverts at stream crossings and under driveways and cross streets are imperative, as well as adequate roadside drainage structures. Emergency procedures should be established to handle accidental spills such as cargo fuel or other materials. The use of ice melting materials, such as calcium chloride and magnesium chloride, is necessary on occasion to ensure safe driving conditions. These chemicals should be used only when necessary and only in amounts required to provide effective results.

Many of the same principles that apply to dirt and gravel road maintenance also apply to trail maintenance. Eroded soils and pet waste on trails can contribute significant amounts of nutrients and sediments to surface waters. The trails within the Silver Lake watershed should be maintained and inspected annually for erosion problems. American Trails, a nonprofit organization working on behalf of all trail interests, has some excellent trail maintenance information on their website at http://www.americantrails.org/resources/ManageMaintain/.

5.2 In-Lake Restoration Alternatives

In addition to the above watershed management recommendations, the following in-lake management measures should be considered to help improve the water quality of Silver Lake:

1. Algae and Plant Management
2. Dredging
3. Lake Aeration
4. Alum Addition

Each of the above in-lake restoration measures is described in detail in the following sections.

5.2.1 Algae and Plant Management

Nuisance levels of aquatic vegetation and algae blooms can create major problems for lake users. An overabundance of macrophytes (aquatic weeds) can interfere with recreation (fishing, boating and swimming) and can adversely affect aesthetics. However, it is important to remember that a certain amount of aquatic weeds are beneficial. Macrophytes protect the shoreline from erosion by dampening the force of waves and stabilizing soils. They provide animal habitat, cover, food, and spawning sites, and are critical to the ecology of a healthy lake. Lake management strategies must strike a balance between preserving a certain amount of macrophyte growth while allowing traditional lake uses to continue unimpeded. Macrophytes in Silver Lake are excessive and should be controlled. The following is a brief summary of some algae and macrophyte management techniques that may be used in Silver Lake.

<u>Chemical Algaecides and Herbicides</u>
Chemical algaecides and herbicides are often used as a band-aid approach to control undesirable algae and weed growth in lakes and ponds. Chemical treatments are costly, must be continuously added to the lake, and can cause a buildup of undesirable chemical compounds in the lake. In addition, when the algae and plants are killed, they sink to the bottom of the lake where they are broken down and serve as a nutrient source for additional algae growth. Alternative long-term methods of improving water quality (i.e. dredging, nonpoint source pollution BMPs, shoreline stabilization) are environmentally responsible ways to avoid the use of potentially harmful chemicals and are better alternatives for the long term.

During most of the summer season, there are no significant algae blooms, so the use of algaecides to kill algae does not appear to be warranted. In the past algal blooms have occurred in late summer (September).

The macrophyte population in Silver Lake is excessive. The native plant *Valesneria Americana*, commonly called tapegrass, and the non-native plant *Myriophyllum spicatum*, commonly called Eurasian milfoil, are co-dominant, are at nuisance levels, and essentially ring the entire lake. Eurasian milfoil can become very dense and can severely interfere with recreational activities. Eurasian milfoil has infested many lakes in New York State and is easily spread from lake to lake in bilge water from boats. Many lake associations have spent a significant amount of money to control and/or eradicate Eurasian milfoil. If an infestation is identified early, yearly hand harvesting of the plant is a highly effective method of control. However, if the infestation is left to spread throughout the lake, as it is in Silver Lake, hand harvesting is not feasible. Other methods to control the milfoil include chemical treatment and weed harvesting. Benthic mats are not recommended to control the milfoil populations in Silver Lake, but may be used around docks to clear areas for homeowners with boats.

Some of the newer herbicides are very environmental friendly. **Triclopyr** (3,5,6-Trichloro-2-pyridinyloxyacetic acid), more commonly known as Renovate OTF®, is a systemic, foliar herbicide in the pyridine group. It is used to control broadleaf weeds while leaving grasses and conifers unaffected. Renovate OTF® is a granular formulation, and it is used for control of Eurasian milfoil and other susceptible submerged weeds in ponds, lakes, reservoirs, and in non-irrigation canals or ditches that have little or no continuous outflow. Renovate is applied as either a surface or subsurface application. Rates should be selected according to the rate chart to provide a triclopyr concentration of 0.75 to 2.5 ppm in the treated water. Use higher rates in the rate range in areas of greater water exchange. These areas may require a repeat application. However, total application of Renovate3 must not exceed an application rate of 2.5 ppm of triclopyr for the treatment area per annual growing season.

TABLE 1

CONCENTRATION OF TRICLOPYR ACID IN WATER (PPM AE)

Area Treated (acres)	0.75 ppm	1.0 ppm	1.5 ppm	2.0 ppm	2.5 ppm
	Required Setback Distance (ft) from Potable Water Intake				
< 4	300	400	600	800	1,000
> 4 - 8	420	560	840	1,120	1,400
> 8 - 16	600	800	1,200	1,600	2,000
> 16 - 32	780	1,040	1,560	2,080	2,600
> 32 acres, calculate a setback using the formula for the appropriate rate	Setback (ft) = (800 * ln (acres) - 160)/3.33	Setback (ft) = (800 * ln (acres) - 160)/2.50	Setback (ft) = (800 * ln (acres) - 160)/1.67	Setback (ft) = (800 * ln (acres) - 160)/1.25	Setback (ft) = (800 * ln (acres) - 160)

Note: ln = natural logarithm

Example Calculation 1: to apply 2.5 ppm Renovate OTF to 50 acres:

Setback in feet = (800 x ln (50 acres)) - 160
= (800 x 3.912) - 160
= 2,970 feet

Example Calculation 2: to apply 0.75 ppm Renovate OTF to 50 acres:

Setback in feet = (800 x ln (50 acres)) - 160 / 3.33
= (800 x 3.912) - 160 / 3.33
= 892 feet

Typical quantities that are needed range from 54 to 270 pounds per acre, and costs range from $200 to $1000 per acres treated. The higher cost range is for spot treatments while the lower cost range is for larger coverage, as would be required for Silver Lake.

The advantages of Renovate include:

- One to two seasons of control
- Selective for Eurasian milfoil
- Renovate OTF carries no restrictions on recreational use such as swimming and fishing, or on livestock consumption of water from the treatment area.
- Renovate OTF can be used near active potable water intakes.

The disadvantages of Renovate include:

- Can create floating mats of dead or dying plants which should ideally be removed from the lake
- Like all herbicides, rapid die-off could cause oxygen depletion

<u>Weed Harvesting</u>

Weed harvesting is another option for controlling Eurasian milfoil in Silver Lake. Weed harvesting is a physical aquatic plant control method that offers lake managers a means of reducing nuisance aquatic plant growth without the environmental concerns often associated with chemical methods. Several commonly used weed harvesting practices exist, including mechanical weed harvesting, hydroraking and rototilling. Each of these practices involves using a machine to cut, rake, or till the weeds from the sediments and then remove the weeds from the lake for off-site disposal. The harvesting process tends to chop the plants into pieces. Invasive species such as Eurasian milfoil that multiply via fragmentation can actually be spread by harvesting, creating a greater aquatic plant problem than existed originally. However, since the Eurasian milfoil is already growing in most of the habitable areas of the lake already, this is not necessarily an issue. At Silver Lake, the most cost effective way to harvest milfoil would be to purchase a harvester and then hire a crew to harvest the weeds during July and August each year. The initial cost for the harvester would be approximately $150,000 to $200,000. Yearly operation costs would be about $800 per acre of milfoil that is harvested, and harvesting may be required up to three times per year. Harvested milfoil would need to be removed from the lake and composted.

Advantages of weed harvesting include:

- Harvesting results in immediate open areas of water.
- Removing plants from the water removes the plant nutrients, such as nitrogen and phosphorus, from the system.
- Harvesting as aquatic plants are dying back for the winter can remove organic material and help slow the sedimentation rate in a waterbody.
- Since the lower part of the plant remains after harvest, habitat for fish and other organisms is not eliminated.
- Harvesting can be targeted to specific locations, protecting designated conservancy areas from treatment.

Disadvantages of weed harvesting include:

- Harvesting is similar to mowing a lawn; the plant grows back and may need to be harvested several times during the growing season.
- There is little or no reduction in plant density with mechanical harvesting.
- Off-loading sites and disposal areas for cut plants must be available. On heavily developed shorelines, suitable off-loading sites may be few and require long trips by the harvester.
- Some large harvesters are not easily maneuverable in shallow water or around docks or other obstructions.
- Significant numbers of small fish, invertebrates, and amphibians are often collected and killed by the harvester.
- Harvesting creates plant fragments which may increase the spread of invasive plant species such as Eurasian watermilfoil throughout the waterbody.
- Although harvesters collect plants as they are cut, not all plant fragments or plants may be picked up. These may accumulate and decompose on shore.
- Harvesters are expensive and require routine maintenance.
- Harvesting may not be suitable for lakes with many bottom obstructions (stumps, logs) or for very shallow lakes (3-5 feet of water) with loose organic sediments.

- Harvesters brought into the waterbody from other locations need to be thoroughly cleaned and inspected before being allowed to launch. Otherwise new exotic species could be introduced to the waterbody.

Benthic Mats

Benthic mats, or bottom barriers, are a very effective physical method for controlling rooted aquatic plant growth in small areas. The mats are large sheets of fabric anchored to the lake bottom that prevent sunlight from reaching rooted aquatic plants. Plants trapped below the fabric are not able to grow up through the material or photosynthesize, and they eventually die. Benthic mats are non-toxic to the environment, and have limited impact on bottom-dwelling organisms or the surrounding habitats. The main disadvantage of benthic mats is that, compared to other control methods, benthic mats are expensive. The method is most economically feasible for isolated areas (e.g. around docks) or small stands of invasive plant species. Unlike other aquatic plant management techniques such as harvesting, the fragmentation and spread of invasive species is avoided with benthic matting. Areas with uneven bottoms, steep slopes, large rocks, embedded stumps, or large submerged logs are not good candidates for this control method, nor are areas with strong wave action or shallow waters with heavy boat traffic. In some cases gasses form under the mats from decaying organic matter and cause the mats to float.

5.2.2 Dredging

Based on the preliminary bathymetric survey conducted in August 2012, approximately 105,000 cubic yards of sediment have accumulated in Silver Lake. An additional 20,000 cubic yards of sediment have accumulated in the outlet channel above the dam at Federal Street, as indicated in the Preliminary Dredging Feasibility Study that was prepared by Clark Patterson Lee in January 2010. The accumulated sediment in the lake and outlet channel should be removed by dredging to increase lake volume and more importantly to remove the nutrient rich sediments that release phosphorus to the water under anoxic conditions. Phosphorus released from the sediments becomes available to fuel algae blooms. Since whole-lake dredging is probably not economically feasible, spot dredging in the inlet/outlet area in the northern portion of the lake and/or spot dredging in the southern end of the lake may be a more manageable project. Another advantage of dredging in Silver Lake would not only be the removal of nutrient rich sediments, but the removal of Eurasian water milfoil in the northern and southern ends of the lake.

Hydraulic Dredging (source WMGLD.com)

Two commonly-used methods exist for dredging freshwater lakes. These include mechanical dredging, during which material is manually removed with heavy equipment such as bulldozers and clamshell diggers, and hydraulic dredging, during which dredged material is “sucked” out of the lake using a device called a cutterhead. Mechanical dredging could be accomplished during lake drawdown, if possible, or using a clamshell digger if the water level cannot be lowered. Cranes with clamshell buckets can operate from the shoreline or from a barge to remove sediment without lowering the lake water level. Once the sediment is excavated, it is temporarily stored in a nearby disposal area for dewatering, or treated using a sediment de-watering unit. After de-watering, the solids can be transported to a proper disposal area, such as park lands or farm fields, or may possibly be sold as fill material. If the sediment is not sufficiently dewatered at the lake, watertight trucks must be used for transportation. Hauling sediment with high water content increases the project cost by increasing the volume of material that must be transported. Lake drawdown is not required for hydraulic dredging. Sediment disposal could be accomplished by identifying a nearby area for a sediment disposal basin or using a sediment de-watering unit to avoid the need for construction of costly disposal basins.

A formal dredging feasibility study should be completed in order to obtain more precise bathymetric, hydrologic, and cost information whether full-scale or spot dredging is being considered. Potential sediment disposal areas could include local farm fields and undeveloped lands, depending upon the chemical nature and quality of the dredged sediments. Based on sediment nutrient testing, the lake sediments contain high levels of total phosphorus and total nitrogen and may be beneficial for agricultural use. It is possible that the lake sediments could be spread on local farm fields. Additional chemical testing of the lake sediments would be required to evaluate the disposal options.

Some of the problems associated with dredging include the disturbance of the benthic (lake bottom) community and the disturbance of both fishery nesting and refuge areas. Many of the residing aquatic organisms will be physically removed or smothered by the settling sediments in areas adjacent to the dredging operation. However, these problems are short-term, and the continued improvement of dredging equipment and dredging methods has helped to minimize these adverse impacts. The physical removal of lake sediments is often referred to as the “ultimate face-lift”. Overall, the costs for dredging are high, but the benefits are long-term, as long as control measures are implemented to minimize the amount of sediment entering the lake. Sources of sediment and nonpoint source pollution within the watershed should be addressed in order to reduce the likelihood and frequency of future dredging projects.

In terms of estimated costs, it is typically less costly (on a cubic yard basis) to dredge the entire lake rather than designing, permitting, and dredging multiple separate areas. The total cost for dredging all of Silver Lake is approximately $2.7 million (2013 cost estimate), including engineering design and permitting costs. If spot dredging of multiple areas is desired, all of the areas to be dredged should be included as one project for permitting purposes. The estimated cost for a 30,000 cubic yard spot dredging project is $1.1 million. If at all possible, the channel should also be dredged as per the 2010 Preliminary Feasibility Study.

5.2.3 Alum Addition

Aluminum sulfate (alum) and sodium aluminate are the most prevalent compounds used in sediment phosphorus inactivation treatments. The alum combines with the phosphorus in the lake water, settles to the bottom of the lake, and “seals” the bottom sediments. Once the sediments are "sealed," phosphorus cannot be released and resuspended during anoxic lake conditions. The objective is to reduce the amount of phosphorus available in the lake for algal growth.

A number of chemicals have been used for lake phosphorus inactivation, including aluminum, calcium and iron. The application of aluminum salts has been the most effective method, in terms of long-term effectiveness. Alum controls the release of phosphorus from sediments through the formation of aluminum hydroxide (Al(OH)3) floc. Aluminum hydroxide forms complexes, chelates and insoluble precipitates with phosphorus. These aluminum complexes and polymers are inert to redox changes in the sediments and effectively trap inorganic and particulate phosphorus from the water column. In lakes with a well-buffered pH, alum is used alone. The addition of sodium aluminate is used to buffer waters that have a low pH and/or buffering capacity. In either case, the treatment is often referred to by the generic term "Alum Treatment."

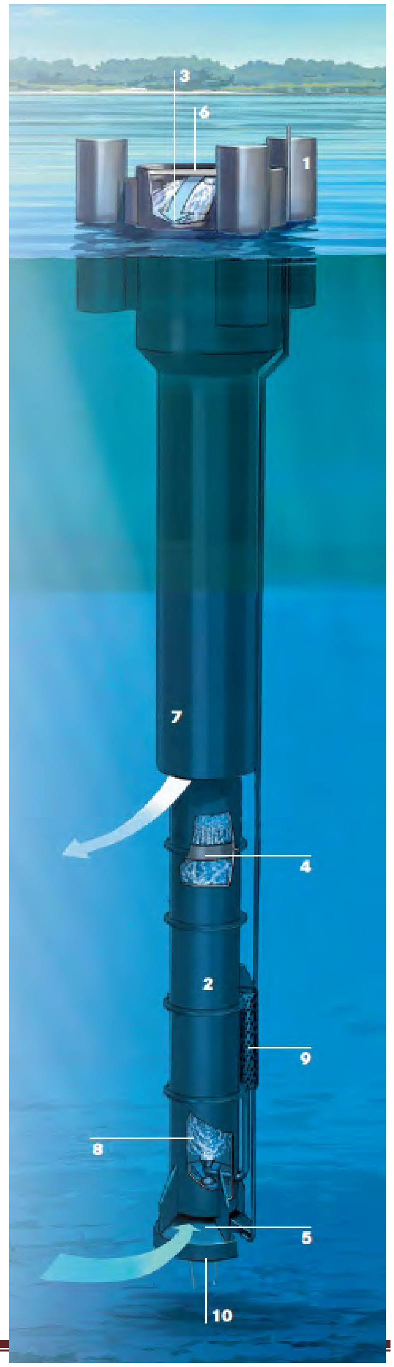
Two methods of alum treatment are available and commonly practiced where warranted: continuous alum treatment and batch alum treatment.

The continuous alum treatment method (also known as alum injection) involves a flow-weighted alum dosing system designed to fit inside a storm sewer manhole or at an inlet stream. Continuous alum treatment is typically used in unstratified lakes with short retention times to remove nutrients and sediments from the incoming waters at or near the lake inlets. Since Silver Lake is a highly stratified lake with a relatively long detention time, continuous alum treatment is not recommended.

Batch alum treatment involves adding a large batch of alum at a given time to bind phosphorus in a lake. Alum is added to the water column to precipitate suspended phosphorus, or directly to the hypolimnion to inhibit phosphorus release from the sediments, or both. This method typically helps to improve water quality in the lake immediately and over a long time period as long as additional phosphorus inputs to the lake are minimized prior to treatment. Batch alum treatment is generally used in lakes that exhibit long retention times with little flushing, such as Silver Lake. This method should be used only when phosphorus loads to the lake (via stormwater or other point or nonpoint sources) are addressed and minimized. Over the past 20 years, phosphorus loads to Silver Lake have been reduced; however, phosphorus loads still need to be lowered to achieve a target in-lake phosphorus level of 0.020 mg/L. A batch alum treatment in Silver Lake would lower the water column phosphorus level, and seal the sediments in the bottom of the lake so that phosphorus is not released during anoxic conditions. This would ultimately reduce to phosphorus level in the lake after the lake is mixed in the fall and may help to minimize or alleviate fall algal blooms in the lake. Based on bid prices for an alum treatment for Spring Lake in Minnesota that will be completed during the fall of 2013, the estimated cost for a batch alum treatment for Silver Lake would be approximately $750,000. Although this option would precipitate phosphorus from the water column and then seal the sediments so that they do not release phosphorus during anoxic conditions, this option would not address the anoxic conditions in the bottom lake water. An alum treatment feasibility study, including jar testing, would be needed prior to the design of an alum treatment program for Silver Lake to determine the quantities of chemicals that would be needed for a successful treatment.

5.2.4 Lake Aeration

Aeration has been widely used as a restoration measure for lakes and ponds where summer hypolimnetic oxygen depletion and/or winter-kill are of major concern. Aeration can be divided into two categories: those methods which destratify the lake water column and circulate the entire lake, and those methods which aerate the hypolimnion (deep water layer) without destratifying the lake. Both methods are based on the principle that if the dissolved oxygen concentration in a lake is increased, additional fish habitat will be provided and the release of phosphorus, manganese, and iron from the sediments that can occur under anoxic (low dissolved oxygen) conditions will be decreased or eliminated.



Since Silver Lake is a relatively deep lake, hypolimnetic aeration would be more appropriate than whole lake aeration. Hypolimnetic aerators work by adding oxygen to the hypolimnetic (bottom lake) water in a closed chamber and circulating the aerated water back into the hypolimnion. Hypolimnetic aeration will maintain temperature differences in the top and bottom waters and will not destratify the lake, which helps to preserve the natural lake ecosystem.

Since the primary area of treatment is the sediment-water interface, the primary intake of the hypolimnetic aerator should be located three to four feet from the lake bottom. Water is lifted up from the bottom to the surface where it is oxygenated and then pushed back down to the bottom and released. At the lower end of the unit, atmospheric air is inserted into the water by an ejector (#8). A mixture of water and oxygen is forced upwards in the upstream pipe. At the end of the upstream pipe the mixture flows into the degassing chamber (#3). Residual gases are separated from the oxygenated water. The gas escapes into the atmosphere, the oxygenated water flows back through the downstream pipe. The outlet provides a laminar flow and a horizontal outflow into the hypolimnion (#7). The units would be anchored with large concrete anchors. Individual parts of a typical hypolimnetic aerator are shown to the right:

Individual parts

1. Floating tanks
2. Upstream pipe (Telescope)

3. Degassing chamber
4. Mixing device
5. Suction fence
6. Covering fence
7. Downstream pipe
8. Oxygen input
9. Submersible pump with ejector
10. Main ballast tanks

Before hypolimnetic aeration is selected as a restoration alternative, additional pre-design activities must occur. The volume of the hypolimnion would need to be determined so that the aerators could be properly sized and the costs could be more accurately determined. The larger the volume of water that needs to be aerated, the higher the costs will be. The cost of a hypolimnetic aeration system for Silver Lake could range from
$400,000 to $1.5 million. These costs do not include power line installation or system operation and maintenance.

5.2.5 Zebra Mussels

Unfortunately, very few control options exist for zebra mussels. Zebra mussels reproduce rapidly via tiny veligers that are nearly impossible to detect and prevent from colonization. Prevention can be accomplished by diligent washing and sterilization of boats entering a lake, but prevention options in large water bodies with multiple inlets and access points is difficult. Once zebra mussels are present, they can only be managed, not eradicated fully using any existing technologies (USGS, 2014). Management options include the following:

- Biological control using a bacterium (Pseudomonas fluorescens), via a commercial product known as Zequanox®. This is not known to be terribly effective.

- Physical scraping, pressure washing, filtration, or dessication. This option is difficult and can be costly.

- Oxidizing chemical control treatments such as hypochlorite reaction, chloramine, chlorine dioxide, bromine, ozone, potassium, permanganate, and sodium chlorite, in addition to chemical molluscicides. Chemical treatment options can be hazardous to the native ecosystem and should be used with caution and the appropriate permits (USGS, 2014).

For Silver Lake, we recommend prevention to the greatest extent possible. Where zebra mussels are present on water intakes, they should be scraped or pressure washed as best as possible. In extreme circumstances, chemical treatment may be necessary.

6.0 Conclusion and Recommendations

6.1 Conclusions

Based on background research, lake water quality data, and detailed watershed investigations, the following conclusions can be made about Silver Lake and its watershed:

1. In 2010 a TMDL Study was performed for the Silver Lake Watershed. Based on the TMDL report, total phosphorus must be reduced by 2,124.4 lbs/yr, or 59 percent, to meet water quality goals.

2. More than two-thirds of the watershed area consists of agricultural land uses. Forested land makes up approximately 22 percent of the watershed and is located in patches throughout the watershed and along some of the stream corridors. Developed land makes up a total of approximately seven percent of the watershed area and is primarily located along the eastern and western shores of the lake. Stormwater runoff from agricultural land is the major source of sediments and nutrients entering Silver Lake.

3. Silver Lake is meso-eutrophic based on in-lake total phosphorus concentrations, chlorophyll *a* concentrations, and Secchi disk transparency readings.

4. During 2012, blue-green algae populations in Silver Lake were moderate in the summer months and consisted mainly of *Anaebena.* Blue-green algae populations increased significantly in September. Based on DEC CSLAP data open water microsystin levels are low in Silver Lake; however, concentrations of microcystin levels in shoreline blooms are very high with an average concentration of 257.7 ug/L over the past several years.

5. Macrophytes in Silver Lake are excessive and include the non-native plant Eurasian milfoil and the native plant tape grass.

6. Based on dissolved oxygen and temperature profiles measured in 1990 through 2009, bottom waters in Silver Lake are anoxic, or devoid of oxygen, for most of the summer season. This lack of oxygen means that fish are unable to survive in the cooler bottom waters of the lake. Also, when bottom waters are devoid of oxygen, phosphorus, manganese, and iron are released from the bottom sediments. The phosphorus becomes an additional source of food for more algae growth, especially when the lake mixes in the fall.

7. Calcium concentrations in Silver Lake are high which makes the lake highly susceptible to zebra mussels. Zebra mussels have been in the lake since about 2006.

8. The Silver Lake Commission and the Wyoming County Soil and Water Conservation District have been working together with farmers in the watershed to develop Nutrient Management Plans and implement agricultural BMPs. Good progress has been made, but

additional work is necessary to reduce phosphorus loads to the lake in accordance with the 2010 TMDL.

6.2 Recommendations

The following recommendations are provided to help improve the water quality in Silver Lake. Both in-lake and watershed management options are discussed.

In-Lake Restoration Recommendations

The following recommendations are provided to help improve the water quality in Silver Lake. Both in-lake and watershed management options are discussed.

In-Lake Restoration Recommendations

1. The excessive macrophytes, namely Eurasian milfoil, in Silver Lake should be controlled either by the herbicide Renovate or by weed harvesting.

2. Spot dredging in the northern and southern ends of Silver Lake should be considered. Not only would dredging remove nutrient rich sediments from the lake, it would also remove macrophytes (milfoil) from the lake. A dredging feasibility study should be conducted to determine the exact areas for dredging, the chemical makeup of the sediments, and potential areas for sediment disposal. In addition, the outlet channel should be dredged as outlined in the 2010 Dredging Feasibility Study.

3. A large volume of bottom water in Silver Lake is anoxic. Hypolimnetic aeration of Silver Lake should be considered as it would increase the dissolved oxygen concentration in the bottom waters of the lake while maintaining the cool temperature of the bottom water. This will improve and expand habitat for a cold water fishery and will also keep phosphorus, manganese, and iron from being released into the water column.

4. A batch alum treatment should be considered for Silver Lake to reduce the phosphorus concentration in the lake water and to seal the bottom sediments. A batch alum treatment may last for 10 years or more and has an immediate impact on the water quality of the lake. Since a batch alum treatment does not do anything to increase the dissolved oxygen in the bottom lake water, the combination of an alum treatment with hypolimnetic aeration would be an ideal solution for Silver Lake.

5. Although the zebra mussels in the lake cannot be completely eradicated, control measures such as chlorination, filtration and mechanical scraping at the potable water intake structure can be implemented to reduce the impact of the mussels on the intake structure.

Watershed Restoration Recommendations

1. The implementation of agricultural BMPs should continue throughout the watershed. The Wyoming County Soil and Water Conservation District should continue to work with farmers to help reduce nutrient and sediment loads to Silver Lake. Increasing riparian buffers along streams that flow through agricultural lands should be a priority. The Silver Lake Commission should be a strong advocate to encourage farmers and the Conservation District to work on priority projects. The 2014 Farm Bill was recently passed and the Agricultural Conservation Easement Program (ACEP) received a funding increase of $1.2 billion. Since the new Farm Bill contains money for farmers to install and maintain conservation areas along streams that run through their farm fields, farmers should be encouraged to take advantage of these programs. Better stream buffers have the greatest potential the reduce sediment and pollutant loadings to Silver Lake.

2. Severely eroded streambanks in the Silver Lake watershed should be stabilized and restored using bioengineering streambank restoration methods. Although the TMDL does not include streambank erosion as a source of phosphorus to Silver Lake, there have been many studies that indicate that streambank erosion is a significant source of both sediments and nutrients. The SLA, the SLC, and the Wyoming County Soil and Water Conservation District should work with property owners to stabilize eroded streambanks and shorelines throughout the watershed. Grant or loan money may be available from the Clean Water State Revolving Fund to help finance stormwater management projects, including streambank erosion protection projects.

3. Stormwater runoff from any new development in the watershed should be properly controlled and stormwater management measures should be designed, constructed, and maintained in accordance with all current NYS DEC regulations. The Silver Lake Commission should ensure the lead agency that reviews and new development plans in the watershed makes sure that all stormwater management regulations are followed.

4. Homeowners around the lake and in other residential areas in the watershed should be educated about not using phosphorus rich fertilizers on their lawns. Lawn fertilizers can runoff yards and be a significant source of nutrients to lakes.

5. Stormwater runoff controls should be installed throughout the watershed, and especially around the lake, at individual residences. Homeowners should be encouraged to install rain barrels and rain gardens. Rain barrels collect stormwater runoff from rooftops. The stored water can be used to water flower and vegetable gardens when it is not raining. During larger rain events, discharges from rain barrels should be directed to a grassed area where the stormwater can be infiltrated into the ground rather than running directly into the swales and the lake. Rain barrels can be purchased on homeowners can make their own rain barrel.

Rain gardens can be installed by individual homeowners to treat stormwater runoff from their rooftop and driveways. Rain gardens can be an aesthetically pleasing way for homeowners to combine stormwater management and landscaping on their properties. Stormwater is directed to the rain garden where it infiltrates into the soil, providing water and nutrients for the plants. Excess stormwater is stored in this area and can continue to be used by the plants days after a rain event.

6. Shoreline buffers around Silver Lake are lacking in some areas where homeowners mow their lawns right down to the water's edge. A 5 foot minimum no-mow buffer along the shoreline should be maintained. Shoreline plantings and low bushes can be an aesthetically pleasing option that will help filter stormwater runoff and provide excellent wildlife habitat around the lake.

7. Homeowners should be encouraged to wash cars and trucks on grassy areas, if possible, or use commercial car washes. This practice will reduce the amount of phosphorus and detergent that runs into Silver Lake and its tributaries.

8. Dirt and gravel roads in the Silver Lake watershed are a significant source of sediments and nutrients that can enter Silver Lake. Dirt and gravel roads should be properly maintained to minimize sediment and nutrient transport.

7.0 References

The Cadmus Group, Inc. (2010). *Total Maximum Daily Load (TMDL) for Phosphorus in Silver Lake*. Report to US EPA and NYS DEC.

Clark Patterson Lee. (2010). *Preliminary feasibility study for the Village of Perry Silver Lake Outlet Sediment Removal Project*. Perry, NY.

F. X. Browne, Inc. (1991). *Phase I Diagnostic-Feasibility Study of Silver Lake, NY*. Report submitted to Silver Lake Watershed Commission.

Klein, Bethany. (2009). *Silver Lake Monitoring Report 2008-2009*. Wyoming County Soil and Water Conservation District, Warsaw, NY.

New York State DEC. (1996). *CSLAP 1996 Lake Water Quality Summary: Silver Lake*. Report to Silver Lake Association and Silver Lake Commission.

New York State DEC. (1997). *CSLAP 1997 Lake Water Quality Summary: Silver Lake*. Report to Silver Lake Association and Silver Lake Commission.

New York State DEC. (2006). *CSLAP 2006 Lake Water Quality Summary: Silver Lake*. Report to Silver Lake Association and Silver Lake Commission.

New York State DEC. (2007). *CSLAP 2007 Lake Water Quality Summary: Silver Lake*. Report to Silver Lake Association and Silver Lake Commission.

New York State DEC. (2008). *CSLAP 2008 Lake Water Quality Summary: Silver Lake*. Report to Silver Lake Association and Silver Lake Commission.

New York State DEC. (2009). *CSLAP 2009 Lake Water Quality Summary: Silver Lake*. Report to Silver Lake Association and Silver Lake Commission.

New York State DEC. (2010). *CSLAP 2010 Lake Water Quality Summary: Silver Lake*. Report to Silver Lake Association and Silver Lake Commission.

New York State DEC. (2011). *CSLAP 2011 Lake Water Quality Summary: Silver Lake*. Report to Silver Lake Association and Silver Lake Commission.

New York State DEC. (2012). *CSLAP 2012 Lake Water Quality Summary: Silver Lake*. Report to Silver Lake Association and Silver Lake Commission.

US Geological Survey. (2014). *Dreissena polymorpha*. Retrieved August 14, 2014, from USGS Nonindigenous Aquatic Species Database: http://nas.er.usgs.gov/queries/FactSheet.aspx?speciesID=5

US Geological Survey. (2013). Zebra mussels. Retrieved August 14, 2014, from National Atlas of the United States website: http://www.nationalatlas.gov/articles/biology/a_zm.html

Wickham, Jessica and McKurth, Gregory. (1998). Silver Lake Monitoring Data Analysis and Recommendations. Available from the Wyoming County Soil and Water Conservation District, Warsaw, NY.

Wyoming County Soil and Water Conservation District. (2012). CD with data spreadsheets and reports.

Appendix A

Glossary of Lake and Watershed Management Terms

Acid neutralizing capacity (ANC): the equivalent capacity of a solution to neutralize strong acids. The components of ANC include weak bases (carbonate species, dissociated organic acids, alumino-hydroxides, borates, and silicates) and strong bases (primarily, OH-). In the National Surface Water Survey, as well as in most other recent studies of acid-base chemistry of surface waters, ANC was measured by the Gran titration procedure.

Acidic deposition: transfer of acids and acidifying compounds from the atmosphere to terrestrial and aquatic environments via rain, snow, sleet, hail, cloud droplets, particles, and gas exchange.

Adsorption: The adhesion of one substance to the surface of another: clays, for example, can adsorb phosphorus and organic molecules

Aerobic: Describes life or processes that require the presence of molecular oxygen.

Algae: Small aquatic plants that occur as single cells, colonies, or filaments. Planktonic algae float freely in the open water. Filamentous algae form long threads and are often seen as mats on the surface in shallow areas of the lake.

Alkalinity: (see *acid neutralizing capacity*).

Anaerobic: Describes processes that occur in the absence of molecular oxygen.

Anoxia: A condition of no oxygen in the water. Often occurs near the bottom of fertile stratified lakes in the summer and under ice in late winter.

Anoxic: "Without oxygen." (see *anoxia*).

Baseflow: The portion of stream flow that is not due to stormwater runoff, and is supported by groundwater seepage into a channel.

Bathymetric map: A map showing the bottom contours and depth of a lake; can be used to calculate lake volume.

Benthic: Macroscopic (seen without aid of a microscope) organisms living in and on the bottom sediments of lakes and streams. Originally, the term meant the lake bottom, but it is now applied almost uniformly to the animals associated with the substrate. Also referred to as *benthos*.

Biochemical oxygen demand (BOD): The rate of oxygen consumption by organisms during the decomposition (respiration) of organic matter, expressed as grams oxygen per cubic meter of water per hour.

Biomass: The weight of biological matter. Standing crop is the amount of biomass (e.g., fish or algae) in a body of water at a given time. Often measured in terms of grams per square meter of surface.

Biota: All plant and animal species occurring in a specified area.

Bioretention: A water quality practice that utilizes landscaping and soils to treat urban stormwater runoff.

BMP (Best Management Practice): Systems, activities, and structures that human beings can construct or practice to prevent nonpoint source pollution.

Channel: A natural stream that conveys water; a ditch or channel excavated for the flow of water.

Chemical oxygen demand (COD): Non-biological uptake of molecular oxygen by organic and inorganic compounds in water.

Chlorophyll: A green pigment in algae and other green plants that is essential for the conversion of sunlight, carbon dioxide and water to sugar (photosynthesis).

Chlorophyll a: A type of chlorophyll present in all types of algae, sometimes in direct proportion to the biomass of algae.

Cluster development: Placement of housing and other buildings of a development in groups to provide larger areas of open space

Consumers: Animals that cannot produce their own food through photosynthesis and must consume plants or animals for energy (see *producers*).

Decomposition: The transformation of organic molecules (e.g., sugar) to inorganic molecules (e.g., carbon dioxide and water) through biological and non-biological processes.

Density flows: A flow of water of one density (determined by temperature or salinity) over or under water of another density (e.g. flow of cold river water under warm reservoir surface water).

Design Storm: A rainfall event of specified size and return frequency (e.g., a storm that occurs only once every 2 years) that is used to calculate the runoff volume and peak discharge rate to a BMP.

Detention: The temporary storage of storm runoff in a stormwater practice with the goal of controlling peak discharge rates and providing gravity settling of pollutants.

Detritus: Non-living dissolved and particulate organic material from the metabolic activities and deaths of terrestrial and aquatic organisms.

Drainage basin: Land area from which water flows into a stream or lake (see *watershed*).

Drainage lakes: Lakes having a defined surface inlet and outlet.

Dredging: The process of removing sediments from the bottom of a lake or reservoir with a large power shovel. Also known as lake deepening.

Ecology: Scientific study of relationships between organisms and their environment: also defined as the study of the structure and function of nature.

Ecosystem: A system of interrelated organisms and their physical-chemical environment. In limnology, the ecosystem is usually considered to include the lake and its watershed.

Effluent: Liquid wastes from sewage treatment, septic systems or industrial sources that are released to a surface water.

Environment: Collectively, the surrounding conditions, influences and living and inert matter that affect a particular organism or biological community.

Epilimnion: Uppermost, warmest, well-mixed layer of a lake during summertime thermal stratification. The epilimnion extends from the surface to the thermocline.

Erosion: Breakdown and movement of land surface which is often intensified by human disturbances.

Eutrophic: From Greek for well-nourished; describes a lake of high photosynthetic activity and low transparency.

Eutrophication: The process of physical, chemical, and biological changes associated with nutrients, organic matter, silt enrichment, and sedimentation of a lake or reservoir. If the process is accelerated by man-made influences it is termed cultural eutrophication.

Fall overturn: The autumn mixing, top to bottom, of lake water caused by cooling and wind-derived energy.

Fecal coliform test: Most common test for the presence of fecal material from warm-blooded animals. Fecal coliforms are measured because of convenience; they are not necessarily harmful but indicate the potential presence of other disease-causing organisms.

Floodplain: Land adjacent to lakes or rivers that is covered as water levels rise and overflow the normal water channels.

Flushing rate: The rate at which water enters and leaves a lake relative to lake volume, usually expressed as time needed to replace the lake volume with inflowing water.

Flux: The rate at which a measurable amount of a material flows past a designated point in a given amount of time.

Food chain: The general progression of feeding levels from primary producers, to herbivores, to planktivores, to the larger predators.

Food web: The complex of feeding interactions existing among the lake's organisms.

Forage fish: Fish, including a variety of panfish and minnows, that are prey for game fish.

Groundwater: Water found beneath the soil surface; saturates the stratum at which it is located; often connected to lakes.

Hard water: Water with relatively high levels of dissolved minerals such as calcium, iron, and magnesium.

Hydrographic map: A map showing the location of areas or objects within a lake.

Hydrologic cycle: The circular flow or cycling of water from the atmosphere to the earth (precipitation) and back to the atmosphere (evaporation and plant transpiration). Runoff, surface water, groundwater, and water infiltrated in soils are all part of the hydrologic cycle.

Hypolimnion: Lower, cooler layer of a lake during summertime thermal stratification.

Hypoxia: A condition of low oxygen in the water (< 2.0 mg/L). Often occurs near the bottom of fertile stratified lakes in the summer and under ice in late winter.

Impervious Surface: Material which resists or blocks the passage of water.

Infiltration: The penetration of water through the ground surface into subsurface soil. The infiltration rate is expressed in terms of inches per hour. Infiltration rates will be slower when the soil is dense (e.g., clays) and faster when the soil is loosely compacted (e.g., sands). Can also refer to seepage of groundwater into sewer pipes through cracks and joints.

Internal nutrient cycling: Transformation of nutrients such as nitrogen or phosphorus from biological to inorganic forms through decomposition in a lake. Also refers to the release of sediment-bound nutrients into the overlying water that typically occurs within the anoxic hypolimnion of stratified, mesotrophic and eutrophic lakes.

Lake: A considerable inland body of standing water, either naturally formed or manmade.

Lake district: A special purpose unit of government with authority to manage a lake(s) and with financial powers to raise funds through mill levy, user charge, special assessment, bonding, and borrowing. May or may not have police power to inspect septic systems, regulate surface water use, or zone land.

Lake management: The practice of keeping lake quality in a state such that attainable uses can be achieved and maintained.

Lake protection: The act of preventing degradation or deterioration of attainable lake uses.

Lake restoration: The act of bringing a lake back to its attainable uses.

Lentic: Relating to standing water (versus lotic, running water).

Limnologist: One who studies limnology.

Limnology: Scientific study of fresh water, especially the history, geology, biology, physics, and chemistry of lakes. Also termed freshwater ecology.

Littoral zone: That portion of a waterbody extending from the shoreline lakeward to the greatest depth occupied by rooted plants.

Loading: The total amount of material (sediment, nutrients, oxygen-demanding material) brought into the lake by inflowing streams, runoff, direct discharge through pipes, groundwater, the air, and other sources over a specific period of time (often annually).

Macroinvertebrates: Aquatic insects, worms, clams, snails, and other animals visible without the aid of a microscope, that may be associated with or live on substrates such as sediments and macrophytes. They supply a major portion of fish diets and consume detritus and algae.

Macrophytes: Rooted and floating aquatic plants, commonly referred to as waterweeds. These plants may flower and bear seed. Some forms, such as duckweed and coontail (*Ceratophyllum*), are free-floating forms without roots in the sediment.

Mandatory property owners association: Organization of property owners in a subdivision or development with membership and annual fee required by covenants on the property deed. The association will often enforce deed restrictions on members' property and may have common facilities such as bathhouse, clubhouse, golf course, etc.

Marginal zone: Area where land and water meet at the perimeter of a lake. Includes plant species, insects and animals that thrive in this narrow, specialized ecological system.

Mesotrophic: Describes a lake of moderate plant productivity and transparency; a trophic state between oligotrophic and eutrophic.

Metalimnion: Layer of rapid temperature and density change in a thermally stratified lake. Resistance to mixing is high in this region.

Morphometry: Relating to a lake's physical structure (e.g., depth, shoreline length).

National Pollutant Discharge Elimination System (NPDES): Federal operating permits issued by EPA to industrial and municipal facilities to help them comply with the Clean Water Act.

Nonpoint Source (NPS) Pollution: Pollution that cannot be traced to a specific origin, but seems to flow from many different sources. NPS pollutants are generally carried off the land by stormwater or snowmelt runoff.

Nutrient: An element or chemical essential to life, such as carbon, oxygen, nitrogen, and phosphorus.

Nutrient budget: Quantitative assessment of nutrients (e.g., nitrogen or phosphorus) moving into, being retained in, and moving out of an ecosystem; commonly constructed for phosphorus because of its tendency to control lake trophic state.

Nutrient cycling: The flow of nutrients from one component of an ecosystem to another, as when macrophytes die and release nutrients that become available to algae (organic to inorganic phase and return).

Oligotrophic: "Poorly nourished," from the Greek. Describes a lake of low plant productivity and high transparency.

Ooze: Lake bottom accumulation of inorganic sediments and the partially decomposed remains of algae, weeds, fish, and aquatic insects. Sometimes called muck (see *sediment*).

Ordinary high water mark: Physical demarcation line, indicating the highest point that water level reaches and maintains for some time. Line is visible on rocks, or shoreline, and by the location of certain types of vegetation.

Organic matter: Molecules manufactured by plants and animals and containing linked carbon atoms and elements such as hydrogen, oxygen, nitrogen, sulfur, and phosphorus.

Paleolimnology: The study of the fossil record within lake sediments.

Pathogen: A microorganism capable of producing disease. They are of great concern to human health relative to drinking water and swimming beaches.

Pelagic zone: This is the open area of a lake, from the edge of the littoral zone to the center of the lake.

Perched: A condition where the lake water is isolated from the groundwater table by impermeable material such as clay.

pH: A measure of the concentration of hydrogen ions of a substance, which ranges from very acid (pH = 1) to very alkaline (pH = 14). pH 7 is neutral and most lake waters range between 6 and 9. pH values less than 6 are considered acidic, and most life forms can not survive at pH of 4.0 or lower.

Photic zone: The lighted region of a lake where photosynthesis takes place. Extends down to a depth where plant growth and respiration are balanced by the amount of light available.

Phytoplankton: Microscopic algae and microbes that float freely in open water of lakes and oceans.

Plankton: Microscopic plants, microbes and animals floating or swimming freely about in lakes and oceans.

Point Source (PS) Pollution: Pollution discharged into water bodies from specific, identifiable pipes or points, such as an industrial facility or municipal sewage treatment plant.

Primary productivity: The rate at which algae and macrophytes fix or convert light, water and carbon dioxide to sugar in plant cells (through photosynthesis). Commonly measured as milligrams of carbon per square meter per hour.

Primary producers: Green plants that manufacture their own food through photosynthesis.

Reservoir: A manmade lake where water is collected and kept in quantity for a variety of uses, including flood control, water supply, recreation and hydroelectric power.

Residence time: Commonly called the hydraulic residence time -- the amount of time required to completely replace the lake's current volume of water with an equal volume of new water.

Respiration: Process by which organic matter is oxidized by organisms, including plants, animals, and bacteria. The process releases energy, carbon dioxide, and water.

Retention: The amount of precipitation on a drainage area that does not escape as runoff. The difference between total precipitation and total runoff.

Retrofit: The installation of a new stormwater practice or the improvement of an existing one in a previously developed area.

Riparian: Pertaining to the land area immediately adjacent to a lake, river, reservoir, or other water body.

Riparian Forest Buffer: The area from the streambank in the floodplain to, and including, an area of trees, shrubs, and herbaceous vegetation located upslope from the body of water.

Runoff: That portion of precipitation that flows over the land carrying with it nutrient and pollutants until it ultimately reaches streams, rivers, lakes, or other water bodies.

Sand Filter: A stormwater BMP in which the first flush of runoff is diverted into a self-contained bed of sand. The runoff is then strained through the sand, collected in underground pipes and returned back to the stream or channel. Can also be used to treat wastewater.

Scour: Concentrated erosive action of flowing water in streams that removes material from the bed and banks.

Secchi depth: A measure of transparency of water obtained by lowering a black and white, or all white, disk (Secchi disk, 20 cm in diameter) into water until it is no longer visible. Measured in units of meters or feet.

Sediment: Bottom material in a lake that has been deposited after the formation of a lake basin. It originates from remains of aquatic organisms, chemical precipitation of dissolved minerals, and erosion of surrounding lands (see *ooze* and *detritus*).

Sedimentation: The process of soil and silt settling and building up on the bottom of a creek, river, lake, or wetland.

Seepage lakes: Lakes having either an inlet or outlet (but not both) and generally obtaining their water from groundwater and rain or snow.

Septic System: A conventional on-lot wastewater system where household wastewater is transported via a septic tank to a drain field (leach field) where it is treated by the soil.

Soil retention capacity: The ability of a given soil type to adsorb substances such as phosphorus, thus retarding their movement to the water.

Stakeholder: Any agency, organization, or individual that is involved in or affected by the decisions made in the development of a watershed plan.

Storm Drain (or Storm Sewer System): Above- and below-ground structures for transporting stormwater to streams or outfalls for flood control purposes.

Stormflow: The portion of stream flow that is due to stormwater runoff.

Stormwater Management: Programs designed to maintain or return the quality and quantity of stormwater runoff to pre-development levels.

Stormwater Runoff: Excess precipitation that is not retained by vegetation, surface depressions, or infiltration, and thereby collects on the surface and drains into a surface water body.

Stormwater Wetland: A shallow, constructed pool that captures stormwater and allows for the growth of characteristic wetland vegetation. Also known as a "constructed wetland."

Stratification: Layering of water caused by differences in water density. Thermal stratification is typical of most deep lakes during summer. Chemical stratification can also occur.

Streambank Stabilization: Methods of securing the structural integrity of earthen stream channel banks with structural supports to prevent bank slumping and undercutting of riparian trees, and overall erosion prevention. Techniques include the use of willow stakes, imbricated riprap, or brush bundles.

Swimmers itch: A rash caused by penetration into the skin of the immature stage (cercaria) of a flatworm (not easily controlled due to complex life cycle). A shower or alcohol rubdown should minimize penetration.

Thermal stratification: Lake stratification caused by temperature-created differences in water density.

Thermocline: A horizontal plane across a lake at the depth of the most rapid vertical change in temperature and density in a stratified lake (see *metalimnion*.).

Topographic map: A map showing the elevation of the landscape at specified contour intervals. Can be used to delineate the watershed.

Total Suspended Solids: The total amount of particulate matter that is suspended in the water column.

Trophic state: The degree of eutrophication of a lake. Transparency, chlorophyll a levels, phosphorus concentrations, amount of macrophytes, and quantity of dissolved oxygen in the hypolimnion can be used to assess state.

US EPA: United States Environmental Protection Agency (see Environmental Protection Agency).

Voluntary lake property owners association: Organization of property owners in an area around a lake that members join at their option.

Water column: Water in the lake between the interface with the atmosphere at the surface and the interface with the sediment layer at the bottom. Idea derives from vertical series of measurements (oxygen, temperature, phosphorus) used to characterize lake water.

Water table: The upper surface of groundwater; below this point, the soil is saturated with water.

Watershed: A drainage area or basin in which all land and water areas drain or flow toward a central collector such as a stream, river, or lake at a lower elevation.

Wetland: Land on which water covers the soil or is present either at or near the surface of the soil or within the root zone, all year or for varying periods of time during the year, including during the growing season. Wetlands are identified by determining the nature of soil development and the types of plant and animal communities living in the soil and on its surface. Human-made wetlands include constructed stormwater wetlands designed to treat stormwater runoff, and artificial wetlands created to comply with mitigation requirements.

Zooplankton: Microscopic animals that float or swim freely in lake water, graze on detritus particles, bacteria, and algae, and may be consumed by fish.

Appendix B

2012 Silver Lake Water Quality Data

Silver Lake
2012 Water Quality Data
FXB Project No. NY1211-02

Date	Sample Depth (m)	pH (mg/L)	NO3 (mg/L)	NH4 (mg/L)	TDN (mg/L)	TP (mg/L)	CHL a (ug/L)	SD (m)	TN:TP
5/31/2012	1.5	7.440	0.540	0.054		0.016	3.400	5.800	
6/15/2012	1.5	7.510	0.460	0.045	0.939	0.018	2.800	4.600	114.133
6/25/2012	1.5	7.590	0.350	0.020	0.797	0.021	4.800	3.650	85.532
7/19/2012	1.5	8.000	0.005	0.023	0.588	0.030	5.100	2.300	43.120
8/1/2012	1.5	8.230	0.005	0.005	0.489	0.027	3.900	2.200	39.986
8/19/2012	1.5	7.930	0.005	0.005	0.503	0.029	7.100	3.550	38.424
8/30/2012	1.5	7.590	0.005	0.028	0.470	0.021	6.000	3.100	50.143
9/13/2012	1.5	8.040	0.005	0.036	0.610	0.045	8.800	2.300	29.625
Min		7.440	0.005	0.005	0.470	0.016	2.800	2.200	29.625
Max		8.230	0.540	0.054	0.939	0.045	8.800	5.800	114.133
Average		7.791	0.172	0.027	0.628	0.026	5.238	3.438	57.280

Date	Sample Depth (m)	NO3 (mg/L)	NH4 (mg/L)	TP (mg/L)	Fe (mg/L)	Mn (mg/L)
5/31/2012	10.0	0.160	0.160	0.027	0.03	0.38
7/19/2012	10.0				0.49	1.95
8/1/2012	10.0		1.300	0.425		
8/19/2012	9.5		0.000		0.49	2.81
8/30/2012	10.0		2.400	0.928		
9/13/2012	10.0				0.60	2.51
Min		0.160	0.000	0.027	0.030	0.380
Max		0.160	2.400	0.928	0.600	2.810
Average		0.160	0.965	0.460	0.403	1.913

Appendix C

2012 Silver Lake Phytoplankton Data

PHYTOPLANKTON DENSITY (CELLS/ML)

TAXON	Silver 07/19/12	Silver 08/01/12	Silver 08/19/12	Silver 08/30/12	Silver 09/13/12
BACILLARIOPHYTA					
Centric Diatoms					
Aulacoseira	239	171	2356	167	62
Stephanodiscus	0	0	15	0	0
Araphid Pennate Diatoms					
Asterionella	68	0	616	3691	108
Fragilaria/related taxa	599	1265	955	518	92
Synedra	0	0	15	0	0
Monoraphid Pennate Diatoms					
Biraphid Pennate Diatoms					
Cymbella/related taxa	0	0	15	0	0
CHLOROPHYTA					
Flagellated Chlorophytes					
Coccoid/Colonial Chlorophytes					
Ankistrodesmus	0	0	15	0	0
Crucigenia	205	821	0	0	0
Elakatothrix	34	34	0	67	0
Oocystis	68	616	62	134	0
Schroederia	17	17	15	0	46
Sphaerocystis	342	479	0	0	0
Filamentous Chlorophytes					
Desmids					
Closterium	0	0	15	0	0
Staurastrum	17	0	0	0	0
CHRYSOPHYTA					
Flagellated Classic Chrysophytes					
Non-Motile Classic Chrysophytes					

PHYTOPLANKTON DENSITY (CELLS/ML)

TAXON	Silver 07/19/12	Silver 08/01/12	Silver 08/19/12	Silver 08/30/12	Silver 09/13/12
Haptophytes					
Tribophytes/Eustigmatophytes					
Raphidophytes					
CRYPTOPHYTA					
Cryptomonas	222	86	708	67	493
CYANOPHYTA					
Unicellular and Colonial Forms					
Aphanocapsa	1710	1026	0	0	0
Chroococcus	0	1505	0	0	0
Microcystis	513	171	616	1002	1232
Woronichinia	0	0	0	2004	4620
Other Coccoid Bluegreens	0	0	0	0	0
Filamentous Nitrogen Fixers					
Anabaena	513	684	770	3674	31878
Cylindrospermum	0	0	0	200	0
Filamentous Non-Nitrogen Fixers					
Plectonema	2565	3420	2772	0	0
EUGLENOPHYTA					
Trachelomonas	17	17	0	0	0
PYRRHOPHYTA					
Ceratium	0	0	0	17	185
DENSITY (CELLS/ML) SUMMARY					
BACILLARIOPHYTA	**906.3**	**1436.4**	**3973.2**	**4375.4**	**261.8**
Centric Diatoms	239.4	171	2371.6	167	61.6
Araphid Pennate Diatoms	666.9	1265.4	1586.2	4208.4	200.2
Monoraphid Pennate Diatoms	0	0	0	0	0
Biraphid Pennate Diatoms	0	0	15.4	0	0
CHLOROPHYTA	**684**	**1966.5**	**107.8**	**200.4**	**46.2**
Flagellated Chlorophytes	0	0	0	0	0
Coccoid/Colonial Chlorophytes	666.9	1966.5	92.4	200.4	46.2

PHYTOPLANKTON DENSITY (CELLS/ML)

TAXON	Silver 07/19/12	Silver 08/01/12	Silver 08/19/12	Silver 08/30/12	Silver 09/13/12
Filamentous Chlorophytes	0	0	0	0	0
Desmids	17.1	0	15.4	0	0
CHRYSOPHYTA	**0**	**0**	**0**	**0**	**0**
Flagellated Classic Chrysophytes	0	0	0	0	0
Non-Motile Classic Chrysophytes	0	0	0	0	0
Haptophytes	0	0	0	0	0
Tribophytes/Eustigmatophytes	0	0	0	0	0
Raphidophytes	0	0	0	0	0
CRYPTOPHYTA	**222.3**	**85.5**	**708.4**	**66.8**	**492.8**
CYANOPHYTA	**5301**	**6805.8**	**4158**	**6880.4**	**37730**
Unicellular and Colonial Forms	2223	2701.8	616	3006	5852
Filamentous Nitrogen Fixers	513	684	770	3874.4	31878
Filamentous Non-Nitrogen Fixers	2565	3420	2772	0	0
EUGLENOPHYTA	**17.1**	**17.1**	**0**	**0**	**0**
PYRRHOPHYTA	**0**	**0**	**0**	**16.7**	**184.8**
TOTAL	**7130.7**	**10311.3**	**8947.4**	**11539.7**	**38715.6**
CELL DIVERSITY	**0.84**	**0.89**	**0.80**	**0.71**	**0.28**
CELL EVENNESS	**0.71**	**0.77**	**0.69**	**0.68**	**0.30**
NUMBER OF TAXA					
BACILLARIOPHYTA	**3**	**2**	**6**	**3**	**3**
Centric Diatoms	1	1	2	1	1
Araphid Pennate Diatoms	2	1	3	2	2
Monoraphid Pennate Diatoms	0	0	0	0	0
Biraphid Pennate Diatoms	0	0	1	0	0
CHLOROPHYTA	**6**	**5**	**4**	**2**	**1**
Flagellated Chlorophytes	0	0	0	0	0
Coccoid/Colonial Chlorophytes	5	5	3	2	1
Filamentous Chlorophytes	0	0	0	0	0
Desmids	1	0	1	0	0
CHRYSOPHYTA	**0**	**0**	**0**	**0**	**0**
Flagellated Classic Chrysophytes	0	0	0	0	0
Non-Motile Classic Chrysophytes	0	0	0	0	0
Haptophytes	0	0	0	0	0
Tribophytes/Eustigmatophytes	0	0	0	0	0
Raphidophytes	0	0	0	0	0
CRYPTOPHYTA	**1**	**1**	**1**	**1**	**1**
CYANOPHYTA	**4**	**5**	**3**	**4**	**3**
Unicellular and Colonial Forms	2	3	1	2	2
Filamentous Nitrogen Fixers	1	1	1	2	1

PHYTOPLANKTON DENSITY (CELLS/ML)

TAXON	Silver 07/19/12	Silver 08/01/12	Silver 08/19/12	Silver 08/30/12	Silver 09/13/12
EUGLENOPHYTA	1	1	0	0	0
PYRRHOPHYTA	0	0	0	1	1
TOTAL	15	14	14	11	9

PHYTOPLANKTON BIOMASS (UG/L)					
	Silver	Silver	Silver	Silver	Silver
TAXON	**07/19/12**	**08/01/12**	**08/19/12**	**08/30/12**	**09/13/12**
BACILLARIOPHYTA					
Centric Diatoms					
Aulacoseira	71.8	51.3	706.9	50.1	18.5
Stephanodiscus	0.0	0.0	1.5	0.0	0.0
Araphid Pennate Diatoms					
Asterionella	13.7	0.0	123.2	738.1	21.6
Fragilaria/related taxa	179.6	379.6	286.4	155.3	27.7
Synedra	0.0	0.0	12.3	0.0	0.0
Monoraphid Pennate Diatoms					
Biraphid Pennate Diatoms					
Cymbella/related taxa	0.0	0.0	15.4	0.0	0.0
CHLOROPHYTA					
Flagellated Chlorophytes					
Coccoid/Colonial Chlorophytes					
Ankistrodesmus	0.0	0.0	1.5	0.0	0.0
Crucigenia	20.5	82.1	0.0	0.0	0.0
Elakatothrix	3.4	3.4	0.0	6.7	0.0
Oocystis	27.4	246.2	24.6	53.4	0.0
Schroederia	42.8	42.8	38.5	0.0	115.5
Sphaerocystis	68.4	95.8	0.0	0.0	0.0
Filamentous Chlorophytes					
Desmids					
Closterium	0.0	0.0	61.6	0.0	0.0
Staurastrum	13.7	0.0	0.0	0.0	0.0
CHRYSOPHYTA					
Flagellated Classic Chrysophytes					
Non-Motile Classic Chrysophytes					

PHYTOPLANKTON BIOMASS (UG/L)

TAXON	Silver 07/19/12	Silver 08/01/12	Silver 08/19/12	Silver 08/30/12	Silver 09/13/12
Tribophytes/Eustigmatophytes					
Raphidophytes					
CRYPTOPHYTA					
Cryptomonas	212.0	88.9	227.9	106.9	141.7
CYANOPHYTA					
Unicellular and Colonial Forms					
Aphanocapsa	17.1	10.3	0.0	0.0	0.0
Chroococcus	0.0	15.0	0.0	0.0	0.0
Microcystis	5.1	1.7	6.2	10.0	12.3
Woronichinia	0.0	0.0	0.0	20.0	46.2
Other Coccoid Bluegreens	0.0	0.0	0.0	0.0	0.0
Filamentous Nitrogen Fixers					
Anabaena	102.6	136.8	154.0	2388.1	6375.6
Cylindrospermum	0.0	0.0	0.0	2.0	0.0
Filamentous Non-Nitrogen Fixers					
Plectonema	513.0	684.0	554.4	0.0	0.0
EUGLENOPHYTA					
Trachelomonas	17.1	17.1	0.0	0.0	0.0
PYRRHOPHYTA					
Ceratium	0.0	0.0	0.0	290.6	3215.5
BIOMASS (UG/ML) SUMMARY					
BACILLARIOPHYTA	**265.1**	**430.9**	**1145.8**	**943.6**	**67.8**
Centric Diatoms	71.8	51.3	708.4	50.1	18.5
Araphid Pennate Diatoms	193.2	379.6	422.0	893.5	49.3
Monoraphid Pennate Diatoms	0.0	0.0	0.0	0.0	0.0
Biraphid Pennate Diatoms	0.0	0.0	15.4	0.0	0.0
CHLOROPHYTA	**176.1**	**470.3**	**126.3**	**60.1**	**115.5**
Flagellated Chlorophytes	0.0	0.0	0.0	0.0	0.0
Coccoid/Colonial Chlorophytes	162.5	470.3	64.7	60.1	115.5
Filamentous Chlorophytes	0.0	0.0	0.0	0.0	0.0
Desmids	13.7	0.0	61.6	0.0	0.0

PHYTOPLANKTON BIOMASS (UG/L)

TAXON	Silver 07/19/12	Silver 08/01/12	Silver 08/19/12	Silver 08/30/12	Silver 09/13/12
CHRYSOPHYTA	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Flagellated Classic Chrysophytes	0.0	0.0	0.0	0.0	0.0
Non-Motile Classic Chrysophytes	0.0	0.0	0.0	0.0	0.0
Haptophytes	0.0	0.0	0.0	0.0	0.0
Tribophytes/Eustigmatophytes	0.0	0.0	0.0	0.0	0.0
Raphidophytes	0.0	0.0	0.0	0.0	0.0
CRYPTOPHYTA	**212.0**	**88.9**	**227.9**	**106.9**	**141.7**
CYANOPHYTA	**637.8**	**847.8**	**714.6**	**2420.2**	**6434.1**
Unicellular and Colonial Forms	22.2	27.0	6.2	30.1	58.5
Filamentous Nitrogen Fixers	102.6	136.8	154.0	2390.1	6375.6
Filamentous Non-Nitrogen Fixers	513.0	684.0	554.4	0.0	0.0
EUGLENOPHYTA	**17.1**	**17.1**	**0.0**	**0.0**	**0.0**
PYRRHOPHYTA	**0.0**	**0.0**	**0.0**	**290.6**	**3215.5**
TOTAL	**1308.2**	**1855.0**	**2214.5**	**3821.3**	**9974.6**
BIOMASS DIVERSITY	**0.85**	**0.83**	**0.81**	**0.53**	**0.36**
BIOMASS EVENNESS	**0.72**	**0.72**	**0.71**	**0.51**	**0.38**

Appendix D

2012 Silver Lake Zooplankton Data

ZOOPLANKTON DENSITY (#/L)

TAXON	Silver 7/19/2012	Silver 8/1/2012	Silver 8/19/2012	Silver 8/30/2012	Silver 9/13/2012
PROTOZOA					
Ciliophora	0.0	0.0	0.0	0.0	0.0
Mastigophora	0.0	0.0	0.0	0.0	0.0
Sarcodina	0.0	0.0	0.0	0.0	0.0
ROTIFERA					
Asplanchna	2.5	0.0	0.0	0.0	0.0
Conochilus	2.5	2.5	38.2	1.2	0.0
Kellicottia	0.0	0.0	1.1	0.0	0.0
Keratella	0.0	1.2	3.2	1.2	0.0
Polyarthra	2.5	8.7	6.4	1.2	2.7
COPEPODA					
Copepoda-Cyclopoida					
Cyclops	1.2	0.0	1.1	0.0	1.3
Mesocyclops	11.2	0.0	2.1	1.2	4.0
Copepoda-Calanoida					
Diaptomus	7.4	0.0	8.5	1.2	4.0
Copepoda-Harpacticoida	0.0	0.0	0.0	0.0	0.0
Other Copepoda-Adults	0.0	0.0	0.0	0.0	0.0
Other Copepoda-Copepodites	0.0	0.0	0.0	0.0	0.0
Other Copepoda-Nauplii	5.0	3.7	5.3	1.2	12.0
CLADOCERA					
Chydorus	0.0	0.0	0.0	1.2	1.3
Daphnia galeata	5.0	0.0	3.2	3.7	2.7
Diaphanosoma	0.0	0.0	1.1	2.5	1.3
OTHER ZOOPLANKTON					

ZOOPLANKTON DENSITY (#/L)

TAXON	Silver 7/19/2012	Silver 8/1/2012	Silver 8/19/2012	Silver 8/30/2012	Silver 9/13/2012
DENSITY					
PROTOZOA	0.0	0.0	0.0	0.0	0.0
ROTIFERA	7.4	12.4	48.8	3.7	2.7
COPEPODA	24.8	3.7	17.0	3.7	21.3
CLADOCERA	5.0	0.0	4.2	7.4	5.3
OTHER ZOOPLANKTON	0.0	0.0	0.0	0.0	0.0
TOTAL ZOOPLANKTON	37.2	16.1	70.0	14.9	29.3
TAXONOMIC RICHNESS					
PROTOZOA	0	0	0	0	0
ROTIFERA	3	3	4	3	1
COPEPODA	4	1	4	3	4
CLADOCERA	1	0	2	3	3
OTHER ZOOPLANKTON	0	0	0	0	0
TOTAL ZOOPLANKTON	8	4	10	9	8
S-W DIVERSITY INDEX	0.81	0.50	0.68	0.91	0.77
EVENNESS INDEX	0.90	0.83	0.68	0.95	0.85
MEAN LENGTH (mm): ALL FORMS	0.55	0.15	0.28	0.64	0.49
MEAN LENGTH: CRUSTACEANS	0.65	0.30	0.68	0.82	0.53

ZOOPLANKTON BIOMASS (UG/L)

TAXON	Silver 7/19/2012	Silver 8/1/2012	Silver 8/19/2012	Silver 8/30/2012	Silver 9/13/2012
PROTOZOA					
Ciliophora	0.0	0.0	0.0	0.0	0.0
Mastigophora	0.0	0.0	0.0	0.0	0.0
Sarcodina	0.0	0.0	0.0	0.0	0.0
ROTIFERA					
Asplanchna	2.5	0.0	0.0	0.0	0.0
Conochilus	0.1	0.1	1.5	0.0	0.0
Kellicottia	0.0	0.0	0.0	0.0	0.0
Keratella	0.0	0.1	0.3	0.1	0.0
Polyarthra	0.2	0.8	0.6	0.1	0.2
COPEPODA					
Copepoda-Cyclopoida					
Cyclops	3.0	0.0	2.6	0.0	3.2
Mesocyclops	14.0	0.0	2.7	1.6	5.0
Copepoda-Calanoida					
Diaptomus	3.6	0.0	4.1	0.6	1.9
Copepoda-Harpacticoida	0.0	0.0	0.0	0.0	0.0
Other Copepoda-Adults	0.0	0.0	0.0	0.0	0.0
Other Copepoda-Copepodites	0.0	0.0	0.0	0.0	0.0
Other Copepoda-Nauplii	13.1	9.9	14.0	3.3	31.7
CLADOCERA					
Chydorus	0.0	0.0	0.0	1.2	1.3
Daphnia galeata	53.8	0.0	39.9	46.6	28.9
Diaphanosoma	0.0	0.0	1.0	2.4	1.3
OTHER ZOOPLANKTON					

ZOOPLANKTON BIOMASS (UG/L)

TAXON	Silver 7/19/2012	Silver 8/1/2012	Silver 8/19/2012	Silver 8/30/2012	Silver 9/13/2012
SUMMARY STATISTICS					
BIOMASS					
PROTOZOA	0.0	0.0	0.0	0.0	0.0
ROTIFERA	2.8	1.0	2.4	0.3	0.2
COPEPODA	33.7	9.9	23.4	5.4	41.9
CLADOCERA	53.8	0.0	40.9	50.3	31.5
OTHER ZOOPLANKTON	0.0	0.0	0.0	0.0	0.0
TOTAL ZOOPLANKTON	90.3	10.9	66.7	56.0	73.6

Appendix E

Watershed Investigation Information

Areas of Specific Concern

Time Series: Fall 2009 Watershed: Silver Lake Site ID: Club Rd.
Updated: Summer 2012

Date: 10/27/2009 Location: Town of Castile Length of AOC: 650 ft
Date Revisited: 8/29/2012

Elevation at Start: 1427 ft Elevation at End: 1402 Change: 25 ft

Distance	Depth (Top Bank – Bottom Channel)
0 ft	Approx. 5.3 ft
100 ft	Approx. 5.3 ft
200 ft	Approx. 5.3 ft
300 ft	Approx. 5.3 ft
400 ft	Approx. 5.3 ft
500 ft	**Approx. 5.3 ft**
600 ft	**Approx. 5.3 ft**

Comments:

The area of concern begins at the West Lake Rd. culvert outlet beginning on Club Rd. At the outlet there is some rock rip rap, but the roadside sediment is very gravelly and unstable. This gravelly sediment continues the length of the area. There are three properties abutting the ditch and have driveway crossings. Some damage surrounding each driveway crossing can be seen. At the last property, erosion is taking place at the base of a telephone pole which could be a potential concern. The far bank of the channel, throughout the entire area, is bare with no vegetation present. There are also tree root being exposed.

From the bottom of the channel to the top of bank is approximately 5.3 ft; this is consistent throughout the whole area. The bank near the road has a very steep grade and extensive rilling can be seen in the gravel at the top of bank down the length of the slope.

Pictures:

Culvert outlet with rock rip rap. Deep rills can be seen in the left corner.

Looking downstream from the culvert outlet. Rock rip rap and deep rills can be seen in the roadside bank.

One the of the three driveway crossings (view from the inlet). Stabilization efforts can be seen, but have been ineffective.

View of the first driveway crossing outlet. Similarly, stabilization has been attempted. Erosion can be seen on both banks from the road and the driveway.

A view of the channel between the first and second properties. The second driveway crossing can be seen. Steep bank grade and rilling can be seen. The far bank, lacking vegetation, is also seen.

A view of the channel between the second and third properties. The telephone pole is becoming exposed, tree roots are visible. Both banks are experiencing severe erosion.

Part of the channel between the second and third properties. Water has cut into the far bank approximately 6 inches to 1 ft deep. The telephone pole is to the immediate right of the photo.

Time Series: Fall 2009 **Watershed:** Silver Lake **Site ID:** Private Dr. 1
Updated: Summer 2012

Date: 10/27/2009 **Location:** Town of Castile **Length of AOC:**650-750ft
Date Revisited: 8/29/2012

Elevation at Start: 1403 ft **Elevation at End:** 1370 ft

Distance	Depth (Top Bank - Bottom of Slope)	Est. Angle of Slope (degrees)
0 ft	**Depths varied, at some points the bottom of channel to top of bank was greater than 5.3 ft.**	**Angles varied. Several spots had near vertical slopes, other undercut the road.**
150 ft		
300 ft		
450 ft		
600 ft		
750 ft		

Comments:

This area of concern begins at a culvert outlet off of West Lake Rd at Private Dr. 1. There is a lot of brush and shrubs lining the whole area, but there are a few spots within the channel where the water has made other cuts, which signifies that it is stressed. There are also several places along the channel where the bank has been eroded to within 3 ft or less of the roadside. There is a point near the end of the ditch where the bank is under cutting the roadway. The bank cuts in approximately 26 inches from the top of bank. There is one property that is of concern at this site. The far bank of the channel is eroding the lawn, nearing a propane tank which is approximately 20 ft ± 10 ft from the bank. Several trees and shrubs have exposed roots due to erosion and plant debris has been washed in the stream.

It appears that there is evidence of stabilization attempts. Concrete slabs and other brick debris was used to stabilize certain spots, but are having little effect. A bridge exists as a golf cart crossing that may or may not be a concern due to eroding banks.

Pictures:

Golf Cart access bridge. Banks underneath appear to be eroding, which could create an unstable bridge.

Portion of the channel where the bank comes approximately 3ft from the roadway. Some concrete slabs can be seen; used to attempt stabilization.

Concrete slabs used to stabilize the bank (continued from above).

Bank erosion along the roadway.

Portion of the channel where the bank is less that 3 ft from the roadway.

More stabilization efforts. Concrete slabs and other cobbles used.

Bank cuts under the top approximately 26 inches.

Tree and shrub roots have been exposed due to bank erosion.

The channel is eroding the bank and lawn of property owner. Propane tank is approximately 20-30ft from bank.

Driveway crossing suffering from erosion. Rill can be seen on the sides of the drainage pipes and a concrete slab was placed along the far bank to help stabilize the bank.

Time Series: Fall 2009 **Watershed:** Silver Lake **Site ID:** Luther Rd.
Updated: Summer 2012

Date: 10/27/2009 **Location:** Town of Castile **Length of AOC:** 50 ft
Date Revisited: 8/29/2012

Distance	Depth (Top Bank - Bottom of Slope)	Est. Angle of Slope (degrees)
0 ft	**Depths varied, at some points the bottom of channel to top of bank was greater than 4.0 ft.**	**Angles varied.**
150 ft		
300 ft		
450 ft		
600 ft		
750 ft		

Comments:

In 2006, stabilization remediation was completed in the ditch along Luther Rd. Approximately 915 ft of road ditch was stabilized. Several different types of erosion control methods were used on the site including erosion control blankets, grade controls, rock rip rap, and hydroseeding. While these methods have been successful in controlling and minimizing sediment erosion, minor repair work is needed.

Along the area of concern, some erosion mats and grade controls are out of place or need replacing. At the corner of Silver Grove Rd. and Luther Rd., erosion of the inner bank has started to occur. The rock rip rap placed in the ditch has also experienced some wash out. Extending around the bend up Silver Grove, some minor bank erosion is visible.

Pictures:

Successful remediation of the ditch along Luther Rd.

The corner of Silver Grove and Luther Rd. Erosion of the inner bank can be seen as well as rock rip rap used to stabilize the bank.

Time Series: Summer 2012 **Watershed:** Silver Lake

Site ID: Sucker Brook at Route 20A and Suckerbrook Rd.

Date: 8/28/2012 **Location:** Town of Perry **Length of AOC:** 450 ft

Distance	Depth (Top Bank - Bottom of Slope)	Est. Angle of Slope (degrees)
0 ft	**Depths varied, at some points the bottom of channel to top of bank was greater than 4.0 ft.**	**Angles varied.**
150 ft		
300 ft		
450 ft		

Comments:

Along the area of concern, moderately eroded stream banks up to 4-5 feet high. Sediment deposition in the stream channel itself has caused stream flow to become disconnected in parts. There is evidence that debris piles have caused blockages in the stream channel itself and further exacerbated some of the erosion problems.

Pictures:

These pictures show evidence of disconnected flow areas and sediment deposition. The channels are undefined in parts and debris and log jams can be seen in the channel.

Time Series: Summer 2012 **Watershed:** Silver Lake

Site ID: Unnamed Trib. to Sucker Brook at Soper and Adrian Rds

Date: 8/28/2012 **Location:** Town of Perry **Length of AOC:** 900 ft

Distance	**Depth (Top Bank - Bottom of Slope)**	**Est. Angle of Slope (degrees)**
0 ft	**Depths varied, at some points the bottom of channel to top of bank was greater than 3.0 ft.**	**Angles varied.**
150 ft		
300 ft		
450 ft		
600 ft		
750 ft		
900 ft		

Comments:

Along the area of concern, riparian buffers are deficient and runoff from agricultural fields likely runs off into the channel. Sediment deposition in the stream channel has partially filled some of the culverts. Deposition is silty in nature and very evident in the stream channels.

Pictures:

Silt and gravel deposition has partially filled culverts at the end of the stream channels.

A gravel bar can be seen at the center of the channel that is running dry due to the drought like conditions.

Deposition of silt just upstream of the roadway culvert is evident in these photos.

Time Series: Summer 2012 **Watershed:** Silver Lake

Site ID: Unnamed Trib. to Sucker Brook at driveway for 6725 Soper Road

Date: 8/29/2012 **Location:** Town of Perry **Length of AOC:** 250 ft

Distance	Depth (Top Bank - Bottom of Slope)	Est. Angle of Slope (degrees)
0 ft	**Depths varied, at some points the bottom of channel to top of bank was greater than 3.0 ft.**	**Angles varied.**
125 ft		
250 ft		

Comments:

Although stream channel was very dry during the site visit, 2-3 feet cut banks were visible with some undercutting and evidence of tree fall upstream and downstream of the driveway.

Pictures:

Undercut banks with exposed roots are visible on the outside bend of the stream.

Time Series: Summer 2012 **Watershed:** Silver Lake

Site ID: Unnamed Trib. to Sucker Brook at Bacon Rd (adjacent to 3271 Bacon Rd)

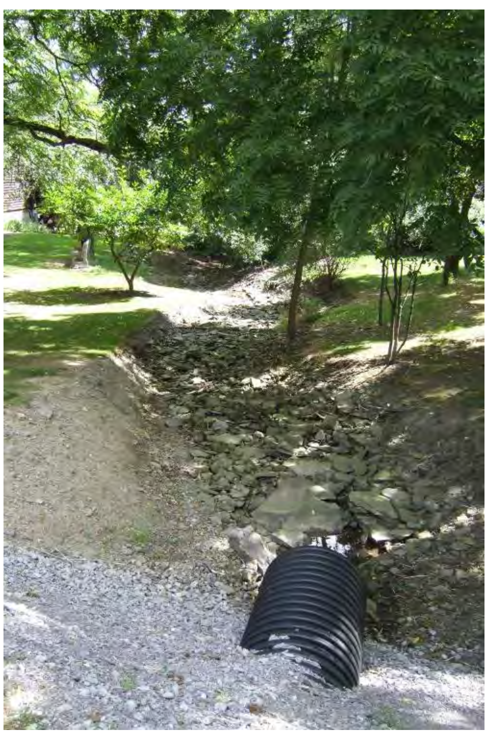
Date: 8/29/2012 **Location:** Town of Perry **Length of AOC:** 300 ft

Distance	Depth (Top Bank - Bottom of Slope)	Est. Angle of Slope (degrees)
0 ft	**Depths varied, at some points the bottom of channel to top of bank was greater than 3 ft (near culvert)**	**Angles varied.**
150 ft		
300 ft		

Comments:

Mowed lawn areas were adjacent to the top of the stream banks and areas of bare soils were evident on some of the side slopes. Recent repairs of the culvert and riprap stabilization of the channel bottom was also observed.

Pictures:



View of culvert and riprap stabilization looking downstream from Bacon Rd. Bare soils can be seen on the left bank and mowed grass is adjacent to top of banks on both sides.

Time Series: Summer 2012 **Watershed:** Silver Lake

Site ID: Unnamed Trib. to Sucker Brook between Bacon Rd and Suckerbrook Rd

Date: 8/29/2012 **Location:** Town of Perry **Length of AOC:** 750 ft

Distance	Depth (Top Bank - Bottom of Slope)	Est. Angle of Slope (degrees)
0 ft	15 ft	Angles varied.
150 ft	15 ft	
300 ft	20 ft	
450 ft	15 ft	
600 ft	10 ft	
750 ft	10 ft	

Comments:

This location has the most severe erosion of all sites observed in the watershed. Side slopes are very high and steep with very little vegetation. Row crops were observed at the top of the right bank with very little riparian buffer. Large trees were undercut and had exposed roots and may fall and cause obstructions during a large flooding event.

Pictures:

Undercut trees with exposed roots approximately 10 feet above stream channel and large fallen trees were observed here.

Steep side slopes with very little vegetation and exposed soils pose very high erosion potential.

15 feet high banks with exposed soils and trees with undercut and exposed roots pose a very high risk for severe erosion and tree falls.

Very steep and high side slopes on the right bank appears to have been caused by high flows and severe erosion.

Time Series: Summer 2012 **Watershed:** Silver Lake

Site ID: Suckerbrook and Silver Lake Inlet at Oatka Rd.

Date: 8/29/2012 **Location:** Town of Perry **Length of AOC:** 750 ft

Distance	Depth (Top Bank - Bottom of Slope)	Est. Angle of Slope (degrees)
0 ft	**Depths varied, at some points the bottom of channel to top of bank was greater than 4.0 ft.**	**Angles varied.**
150 ft		
300 ft		
450 ft		
600 ft		
750ft		

Comments:

Minor to moderate erosion with some undercut banks were observed in the inlet area. Areas of bare soil were also seen at entry points where canoes and other watercraft are usually dropped into the stream. Recently mowed grass up to edge of the stream was also observed during field reconnaissance. Algae bloom was evident along the entire area of concern and pointed to excess nutrient runoff.

Pictures:

View from Oatka Rd. looking north. Culverts can be seen in the foreground and algal blooms have turned the stream channel completely green.

View of Silver Lake inlet (dual 72" corrugated metal pipe culverts). Algal bloom can be clearly seen along entire length to culverts.

Minor erosion on far bank and algal blooms in the stream channel

Undercut banks around bends

Bare soils at access point to stream where canoes and watercraft are regularly placed into stream.

Moderate erosion (2-4' cut banks) around some bends were observed but appear to be stabilizing.

Time Series: Summer 2012 **Watershed:** Silver Lake

Site ID: Stormwater inlet by 4240 Fairview Road

Date: 8/29/2012 **Location:** Town of Castille **Length of AOC:** 50 ft

Comments:

Bare and exposed soils at toe of slope and adjacent to a storm drain that discharges into the lake. Erosion was evident on the gravel road.

Pictures:

Time Series: Summer 2012 **Watershed:** Silver Lake

Site ID: Stormwater inlet by 6793 N Hillcrest Dr

Date: 8/29/2012 **Location:** Town of Castille **Length of AOC:** 50 ft

Comments:

Minor to moderate erosion in and around stormwater inlet that discharges into Silver Lake. Efforts to stabilize with riprap do not appear to be working. Roadway regrading and stabilization may be necessary to alleviate this problem.

Pictures:

Time Series: Summer 2012 **Watershed:** Silver Lake

Site ID: Unnamed Trib. to Silver Lake at Lake Shore Dr. between East and West Springbrook Roads

Date: 8/29/2012 **Location:** Town of Castile **Length of AOC:** 600 ft

Distance	Depth (Top Bank - Bottom of Slope)	Est. Angle of Slope (degrees)
0 ft	Depths varied, at some points the bottom of channel to top of bank was greater than 5.0 ft.	Angles varied.
150 ft		
300 ft		
450 ft		
600 ft		

Comments:

Portions of the stream is diverted through buried culverts and may have been done recently as evidenced by existing soil piles and areas of disturbed soil. End sections of some culverts show evidence of gravel and sediment build up indicating mild to moderate erosion in the stream channel itself.

Pictures:

Soil stockpile showing recent construction activities with ditch repairs and installation of culverts

View of ditch along Lake Shore Dr with fallen sign that indicated ditch repair work

Culverts and end sections with minor erosion around buried culvert pipe

Bare soils showing recent construction activities likely associated with culvert and ditch repair work

Gravel and sediment in end section of culvert indicating moderate erosion in upstream channel.

Appendix F

Outlet Sediment Thickness Map

(Clark Patterson Lee 2010)

Sediment Depths Table			
Number	Minimum Depth	Maximum Depth	Color
1	0.00	2.00	
2	2.01	4.00	
3	4.01	6.00	
4	6.01	8.00	
5	8.01	10.00	
6	10.01	20.00	

APPROXIMATE SEDIMENT REMOVAL VOLUME: 20,000 CU.YDS.

APPROXIMATE VOLUME OF CLASS B MATERIAL: 14,500 CU.YDS.

APPROXIMATE VOLUME OF CLASS A MATERIAL: 5,500 CU.YDS.

Clark Patterson Lee
DESIGN PROFESSIONALS

SILVER LAKE OUTLET SEDIMENT REMOVAL PROJECT

SEPTEMBER 25, 2009

Scale: 1" =100'