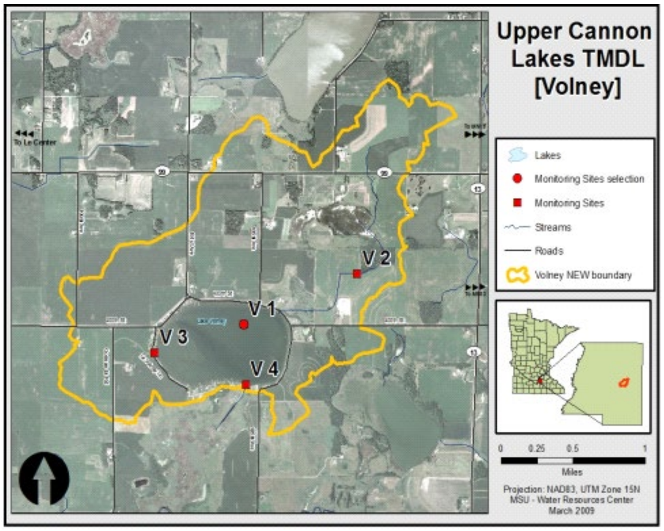
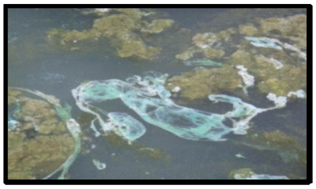
Upper Cannon Lakes
Excess Nutrients Total Maximum Daily Load:
Lake Volney







July 2014

Prepared by:

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TMDL Summary Table

<table>
<tr><th>EPA/MPCA Required Elements</th><th colspan="3">Summary</th><th>TMDL Page #</th></tr>
<tr><td>Location</td><td colspan="3">Lake Volney is a deep lake (22.7 feet average; 65 feet maximum) located in the east-central portion of Le Sueur County, Minnesota. At 277 acres, Lake Volney represents one of the smaller lake systems found within the Cannon River watershed. The Lake Volney is in the Cannon River Watershed which represents a major tributary to the Mississippi River.</td><td>14-15</td></tr>
<tr><td>303(d) Listing Information</td><td colspan="3">Lake Volney (40003300)
Affected designated use: Aquatic Recreation
Pollutant or Stressor: Nutrient/Eutrophication
Target start/completion date: 2005/2011
Original Listing year: 2002</td><td>26</td></tr>
<tr><td rowspan="6">Applicable Water Quality Standards/ Numeric Targets</td><td colspan="3">North Central Hardwood Forest Deep-Lake Eutrophication Standards (surface-layer, June-September means):</td><td rowspan="6">26</td></tr>
<tr><td><i>Parameter</i></td><td><i>Value</i></td><td><i>Units</i></td></tr>
<tr><td>Total Phosphorus</td><td>40</td><td>µg/L</td></tr>
<tr><td>Chlorophyll-<i>a</i></td><td>14</td><td>µg/L</td></tr>
<tr><td>Secchi Depth</td><td>1.4</td><td>m</td></tr>
<tr><td colspan="3">The numeric target for Total Phosphorus is 36 ug/L, reflecting a 10% Margin of Safety in concentration terms.</td></tr>
<tr><td rowspan="2">Loading Capacity</td><td></td><td>kg/yr</td><td>kg/day</td><td rowspan="2">40-41</td></tr>
<tr><td>Phosphorus Load</td><td>324.7</td><td>0.889</td></tr>
<tr><td rowspan="4">TMDL Allocations</td><td></td><td>kg/yr</td><td>kg/day</td><td rowspan="4">43-49</td></tr>
<tr><td>Wasteload Allocation</td><td>0.6</td><td>0.002</td></tr>
<tr><td>Load Allocation</td><td>324.1</td><td>0.887</td></tr>
<tr><td colspan="3">Reserve Capacity zero.</td></tr>
</table>

TMDL Summary Table, continued		
Margin of Safety	The MOS was set at 10%, and used to develop the TMDL value. The 10% value was modeled through a standard value adjusted to 36 µg/L (40 µg/L less 10%).	49
Seasonal Variation/Critical Condition	MPCA's eutrophication standard is compared to the growing season (June through September) average.	55
Reasonable Assurance	· Availability of reliable means of addressing pollutant loads (i.e. best management practices); · A means of prioritizing and focusing management; · Development of a strategy for implementation; · Availability of funding to execute projects; · A system of tracking progress and monitoring water quality response; · Interested and engaged Lake Association	56-58
Monitoring	The Minnesota Pollution Control Agency began a four-year Intensive Watershed Monitoring program in the Cannon River drainage in 2011. This is part of a 10-year cycle of monitoring, assessment, analysis, modeling, planning, and implementation that will be on-going throughout the State of Minnesota now and in the future. Additional monitoring programs involving state and local partnerships will also be developed.	59
Implementation	A general list of implementation activities has been included within the TMDL. A more detailed implementation plan will be included in the Cannon River Watershed Report by 2016.	53-54
Public Participation	This report includes a list of all meetings and events related to public and technical team involvement with the TMDL.	60-61

Executive Summary

In 2002, the Minnesota Pollution Control Agency (MPCA) listed Lake Volney as impaired for aquatic recreation due to excess nutrients under section 303(d) of the Clean Water Act. Excessive phosphorus loading is the main cause of the impairment. The goals of the Lake Volney Excess Nutrients Total Maximum Daily Load (TMDL) study are to describe the nature and extent of the lake's phosphorus impairment and determine source load allocations that consider major sources. Resources are currently being allocated to the Cannon River watershed (the major watershed that Volney lies in) to complete a comprehensive assessment, conduct stressor identification focused on biological impairments, construct a watershed model and complete additional TMDLs as necessary. These components of MPCA's watershed approach, particularly the modeling, will allow for simulation of various management scenarios aimed at pollutant load reductions.

The Lake Volney watershed is at the western headwaters of the Cannon River watershed and covers 2,017 acres within the North-Central Hardwood Forest ecoregion. With an average depth of 22.7 feet and a maximum depth of 65 feet, deep lake standards for its ecoregion apply. It is located in Le Sueur County and is dominated by agricultural land use. At 277 acres, Lake Volney represents one of the smaller lake systems found within the Cannon River watershed.

This lake has been the subject of many investigations. The first known comprehensive study of water quality on Lake Volney occurred through MPCA's Lake Assessment Program in 1986. The study results found average total phosphorus concentrations of 160 µg/L and also estimated that 90% of the phosphorus entering the lake was being retained. A Clean Water Partnership Diagnostic and Feasibility study followed by a successful implementation project was also completed on Lake Volney that spanned the period of 1995-2008. Summer mean total phosphorus concentrations improved from an average of 170 micrograms/liter (µg/L) in 1995 to 105 µg/L in 2002 to 87 µg/L in 2005 in response to several implementation activities within the watershed.

The focus and primary intent of this project is to better characterize phosphorus levels, probable sources, and estimate reductions required to meet the TMDL water quality goal. Watershed wide phosphorus loading was estimated to assess the magnitude of nonpoint and point sources and establish a cause-effect linkage of loading sources and subsequent in-lake phosphorus concentrations.

Samples were collected for the TMDL study between April and October 2009 and 2010 (note that only June-September results were used for TMDL calculation). Four monitoring stations were located throughout the watershed and lake. The resulting data illustrates a declining trend in water quality through the season due to watershed and internal phosphorus loading. The current total phosphorus load to Lake Volney is 807.6 kg/yr. A reduced total phosphorus load of 324.7 kg/yr would be required to reach the water quality goal of 36 µg/l; the goal includes a 10 percent margin of safety. For some years, a reduction from watershed sources of up to about 482.9 kg/yr or 60 percent would be required to meet this goal. Over time, reductions in external loading should lead to reductions in internal loading.

ACKNOWLEDGEMENTS

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Abbreviations and Acronyms

BMP	Best Management Practice
CWA	Clean Water Act
cfs	Cubic Feet per Second
CLP	Curly-leaf Pondweed
EPA	Environmental Protection Agency
FWMC	Flow weighted mean concentration
GIS	Geographic Information Systems
LA	Load Allocation
MDNR	Minnesota Department of Natural Resources
MOS	Margin of Safety
MPCA	Minnesota Pollution Control Agency
NCHF	North Central Hardwood Forest (eco-region)
NO_2+NO_3	Nitrite + Nitrate Nitrogen
NPDES	National Pollutant Discharge Elimination System
PO_4	Ortho-phosphorus
ppm	Part per million
QA/QC	Quality Assurance/Quality Control
QAPP	Quality Assurance Protection Plan
RC	Reserve Capacity
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Sediment
mg/L	Milligrams per liter
µg/L	Micrograms per liter
UCL	Upper Cannon Lakes
WLA	Waste Load Allocation
WRC	Water Resources Center (Minnesota State University, Mankato)

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Section 1.0 Background Information

1.1 Site Description

Lake Volney, located in Le Sueur County Minnesota is a small lake at only 277 acres; however, Lake Volney has a maximum depth of 65 feet and a mean depth of 22.7 feet making it one of the deepest lakes in southern Minnesota. Lake Volney is situated in a watershed that is comprised of moderate to steeply sloping hills that have been cleared primarily for agricultural purposes. The total acreage within the Lake Volney watershed is 2,017 acres; most of the watershed is dominated by agricultural land use. The watershed to lake ratio for Lake Volney is 7:1 (Table 1.1 A.). The stratification of this lake is highly beneficial to the water quality of this basin because a large percentage of the phosphorus load is retained within the hypolimnion (bottom layer of lake during stratification) during a majority of the open water season. The combination of a small watershed-to lake ratio and the thermal stratification of Lake Volney give this waterbody a better than average chance for restoration.

Fifty-four percent of Lake Volney has a depth greater than 15 feet; therefore, approximately 46% of the surface area is within the littoral zone (less than 15 feet deep) that is capable of supporting plant growth. Although curly-leaf pondweed (CLP) has been found in Lake Volney, the growth of this species has not become problematic. Moderately dense stands of CLP were found in a small percentage of the lake in 2009. The sediment within Lake Volney has been found to be non-conducive to supporting extremely dense stands of CLP (Pers. Comm. Steve McComas of Blue Water Science, 2008). The overall macrophyte community found in Lake Volney is extremely limited, with a total of three species found during the point intercept surveys conducted in 2009. The absence of macrophytes within Lake Volney may partially explain the high frequency by which algae blooms occur. The ample supply of nutrients in coordination with an absence of shading from macrophytes allows for algae to grow relatively uninhibited.

Table 1.1 A. Examples of surface area to watershed area ratios for Cannon River watershed lakes and reservoirs.

Lake Name	Lake or Reservoir *	Cannon River Flowage?	Surface Area** (acres)	Watershed Area*** (acres)	Ratio
Hunt (66-0047-00)	Lake	No	174	639	3.6
French (66-0038-00)	Lake	No	879	4,400	5.0
Shields (66-0055-00)	Lake	Yes	932	7,053	7.5
Rice (66-0048-00)	Reservoir	Yes	314	12,839	40.8
Volney (40-0003-00)	Lake	No	277	2,017	7.3

* Determined by presence or absence of artificial control structure at outlet.
**From draft 2012 303(d) lakes shapefile.
***Delineated by Cannon River Watershed Partnership at request of Rice County in 2002.

1.2 Purpose

Lake Volney (40003300) was listed on the 303(d) impaired waters list in 2002 for aquatic recreation based on nutrient/eutrophication. The target start and completion dates were set at 2005 and 2011, respectively. The goal of this Total Maximum Daily Load analysis was to quantify the nutrient reduction that will be required to meet the water quality standards established for lakes in the North Central Hardwood Forest (NCHF) eco-region. Furthermore, this study identified the largest sources of nutrients (phosphorus) to Lake Volney and complements existing studies to provide reduction strategies for source areas in accordance with section 303(d) of the Clean Water Act.

1.3 History

Prior to the 1980's, Lake Volney was considered a favorite swimming location of many residents in Le Sueur County. However, due to the increased severity and frequency of algal blooms, use of the public beach has decreased. The number of people fishing, boating, and enjoying other forms of aquatic recreation on Lake Volney has also dropped significantly over the last 20 years in response to the algal blooms which seem to now plague the lake (Schuler, 1997).

Members of the Lake Volney Lake Association filed several complaints with the MPCA during the summer of 1985. This led MPCA to conduct the first comprehensive study of the water quality present in Lake Volney during the summer of 1986. Results from this 1986 study documented TP concentrations of 160 µg/L; placing Lake Volney at the 92nd percentile in a sample of 1,028 Minnesota lakes (Wilson, 1987). Lake Volney was listed as impaired for aquatic recreation in 2002; excess nutrients/eutrophication was the defined stressor. Lake Volney is in the NCHF ecoregion and is a deep lake, and therefore needs to meet standard of 40 µg/L.

Prior restoration efforts on Lake Volney have focused on the large ditch system exiting a large wetland complex located in the northeastern corner of the watershed since it has historically been the dominant source of nutrients to Lake Volney. Elevated TP concentrations were again observed in water quality samples taken from this ditch system in 2009 and 2010. The Minnesota Pollution Control Agency (MPCA) conducted a comprehensive survey of the wetland in the summer of 2010, results from this survey indicate that the wetland is severely degraded and may be acting as a source of nutrients to the lake (Appendix A).

In 2009 and 2010, most recreational use consisted of angling and boating with swimming being restricted by algae blooms for several weeks during the summer. Documentation of a severe blue-green algae bloom consisting mostly of (*Aphanizomenon sp.* and *Microsystis sp.*) occurred in the summer of 2009, and to a lesser, but still significant, degree in 2010. Warning signs were posted on the public beach and at the boat launch on 7/23/2009 that advised potential users of the risk incurred by swimming in the lake at this time. In 2009, there were two reported cases where children experienced rashes, while 1 child experienced a fever after swimming in Lake Volney. Additionally, a dog was reported to be near death after playing fetch in the water during the summer of 2009. Additional information regarding the sampling of blue-green algae following the protocol designed by the MPCA (Pers. Comm. Steve Heiskary) can be seen in Appendix B.

Water quality samples collected from the 1990's through the 2000's have consistently documented high levels of nutrients and a low Secchi disk transparency. As a result of these observations, the Carlson Trophic Status Index (TSI) was used to score Lake Volney to determine the level of eutrophication that exists within the basin based on water quality samples taken in 1993 and again in 2007.

TSI values for Lake Volney indicate that eutrophic conditions have persisted on Lake Volney for the past 15 years. Members of the community want to see Lake Volney restored to the lake it once was. Efforts in 2009 by the County's Environmental Services department to restore the public beach on the southern shore of Lake Volney represent the vision the community has and the beginning stages of returning Lake Volney to a more recreationally usable state.

1.4 Landscape and Setting

The Lake Volney watershed is located in the central portion of Le Sueur County in south Central Minnesota. Lake Volney is part of the Cannon River watershed, which is part of the Lower Mississippi River Basin in Minnesota (Figure 2.1 A.).

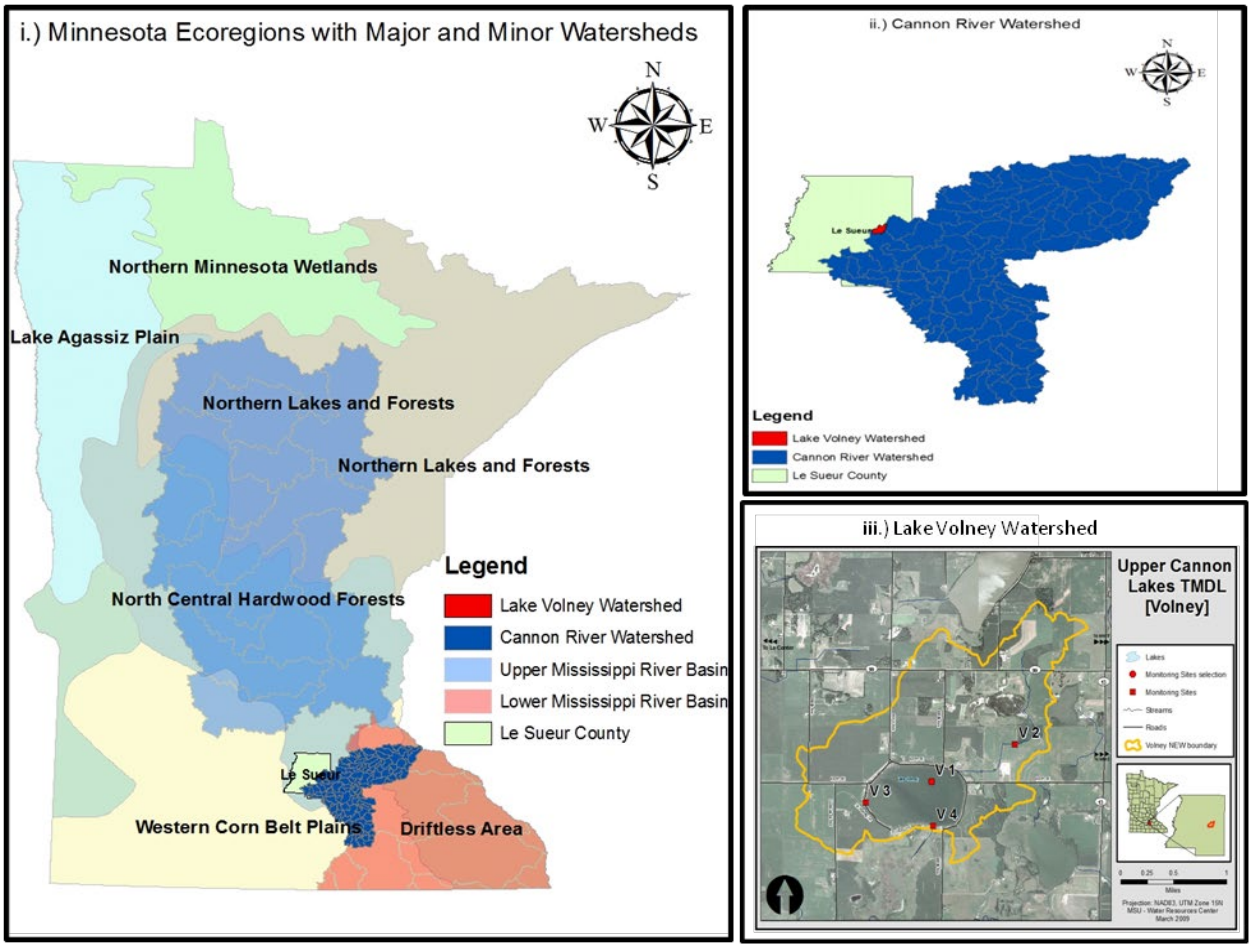

Figure 1.4 A: Geographical location of: (i) the Lower Mississippi River Basin within the EPA developed Minnesota Level III and IV Ecoregions, (ii) the Cannon River Watershed with catchment segmentation (note Lake Volney watershed in red) and (iii) location of the Lake Volney watershed delineated by yellow line.

Minnesota is divided into seven ecoregions based on vegetation, soil type, geology, and climate. Lake Volney is located in the North Central Hardwood Forest ecoregion; however the watershed is located close to the border of the Western Cornbelt ecoregion. Land use within the watershed features characteristics common to both ecoregions (Figure 1.4 A). All land use data is based on the 2009 NASS land use statistics, which is the most current version available during the creation of the TMDL.

Lake Volney's watershed is 2,017 acres. Cultivated land use practices account for 52% of the total watershed area represented mostly by corn and soybean (Figure 1.4 B; Table 1.4.). Housing subdivisions, permanent and seasonal cabins are found along the north, west, and southern shores; the county park and beach is located near the lake outlet on the southern shoreline. The landscape is rolling to steeply sloped with interspersed poorly drained swales and sloughs (Schuler, 1997). Historically, much of the watershed was covered with hardwoods; a vast majority of these hardwoods have been cleared for agricultural land use upon settlement (Schuler, 1997).

The Lake Volney watershed can be further subdivided into subwatersheds based upon the hydrology of the landscape (Figure 1.4 C.). These subwatersheds were calculated using the ARCSWAT watershed delineation tool and 10 meter DEM clipped to the Lake Volney watershed boundary. A comparison of nutrient inflows from each of the different subwatersheds is useful because it provides a method for identifying areas of the watershed that contribute a disproportionate amount of nutrients. Each of the two monitored inflow locations has a defined sub watershed (V2 was in subwatershed 3 and V3 was in subwatershed 9); these two sub watersheds were chosen for the current study because historically they have contributed the greatest amount of flow and nutrients to Lake Volney (Figures 1.4 C and 1.5 A). Discharge from the largest ditch system draining the north eastern portion of the watershed and passing through monitoring location V2 has historically contributed a majority of the TP entering into Lake Volney. Discharge from a small ditch system located in the western portion of the watershed and passing through monitoring location V3 has historically contributed a majority of the nitrogen load to Lake Volney. Additional sub watersheds exist within the Lake Volney watershed and periodically contribute flow. An attempt was made to collect grab samples from these subwatersheds when flow was present; however, loading from these sites have not historically contributed a large proportion of the overall nutrient load and this project did not calculate loads at these other locations.

Table 1.4. Lake Volney Watershed land use.

Land use Classification	Total Acreage	Percent of Total
Corn	297.57	14.79
Soybean	704.40	35.02
Sweet Corn	29.45	1.46
Alfalfa	6.97	0.35
Other Hays	1.55	0.08
Dry Beans	0.77	0.04
Peas	0.77	0.04
Pasture/Grass	51.14	2.54
Open Water (Lake)	277	12.98
Developed/Open Space	155.76	7.74
Developed/Low Intensity	30.22	1.50
Barren	3.10	0.15
Deciduous Forest	87.57	4.35
Evergreen Forest	0.77	0.04
Shrubland	0.77	0.04
Grassland-Herbaceous	41.07	2.04
Pasture/Hay	259.60	12.90
Woody Wetlands	13.17	0.65
Herbaceous Wetlands	65.87	3.27
Totals	**2017.67**	**100.00**

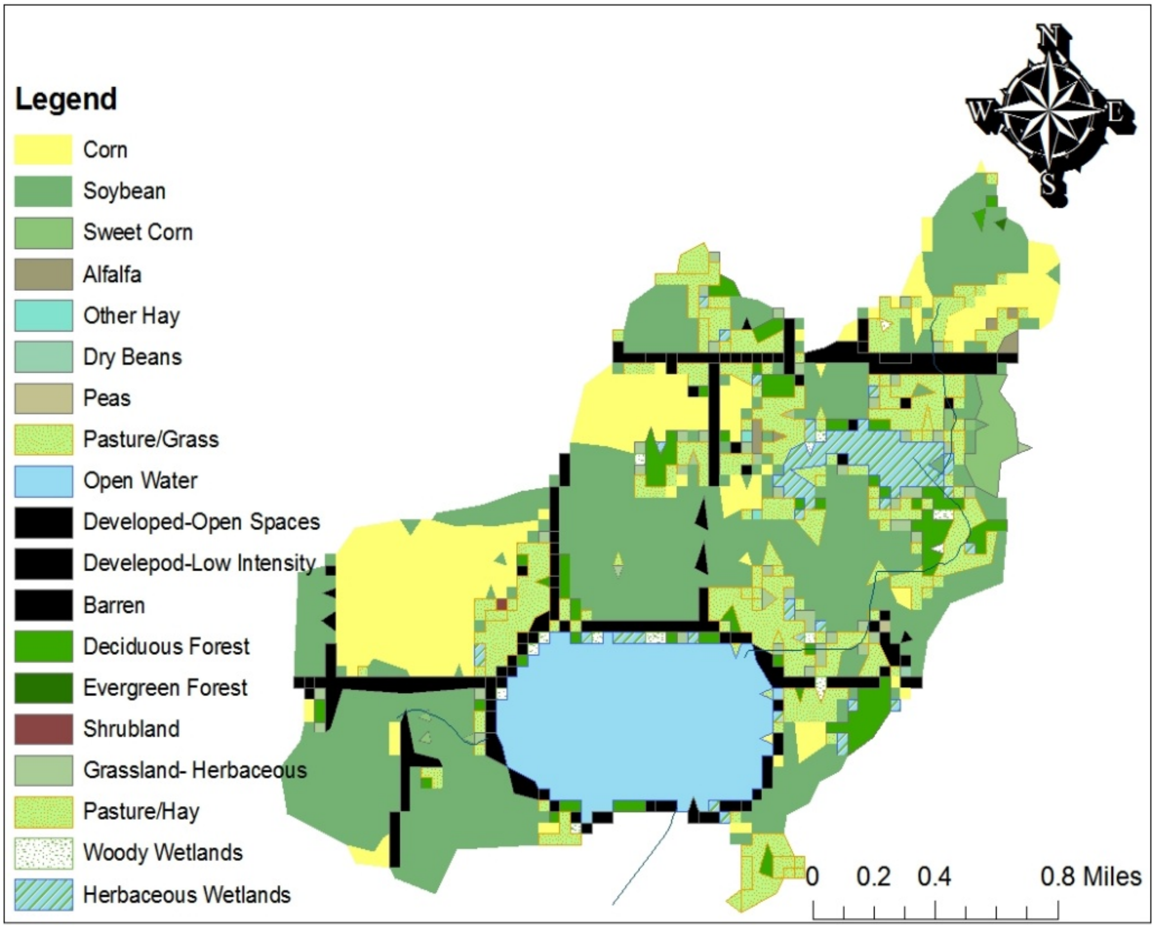

Figure 1.4 B. Land use in the Lake Volney watershed (2009 NASS).

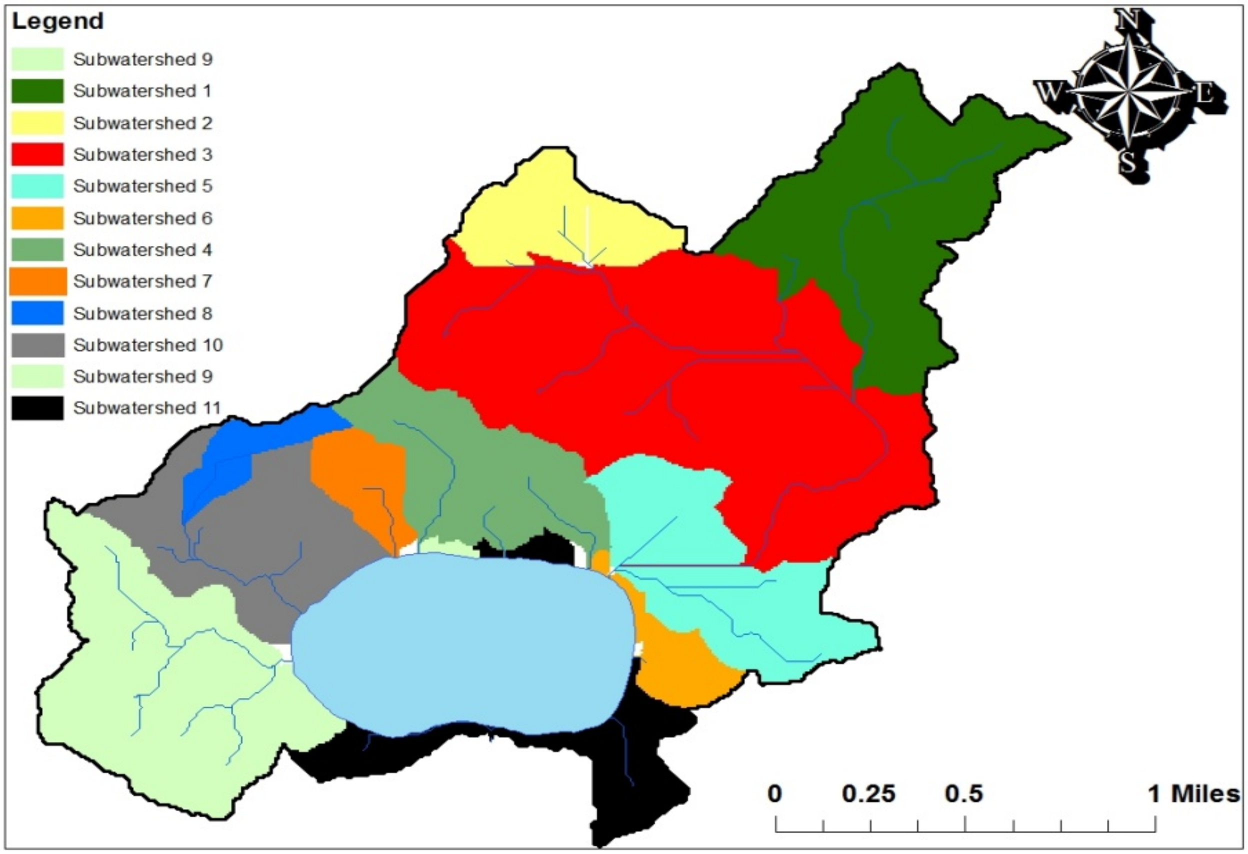

Figure 1.4 C. Lake Volney sub-watersheds.

1.5 Lake Volney Hydrology

Lake Volney receives a majority of its total volume from the large ditch system that passes through monitoring location V2 on the north eastern side of Lake Volney (Figure 1.5 A). Discharge from this ditch system represented 78% of the total flow volume entering Lake Volney during the 1995 monitoring season (Schuler, 1997). Flow passing through monitoring location V3 comprised 13.8% of the total flow volume entering Lake Volney during the 1995 monitoring season. Together these sites comprised close to 92% of the total calculated flow volume entering Lake Volney during the 1995 study; therefore, these locations were chosen as the main sampling points for the TMDL study. Based on data collected during the 2009 and 2010 sampling seasons, flow from V2 was again the dominant surface water inflow site within the watershed. Flow passing through V2 represented 35.5% of the total flow by volume entering Lake Volney during this study; V3 contributed 12.9% of the total flow by volume to Lake Volney. The remaining 51.6% of the flow volume to Lake Volney was derived from immediate watershed contributions not monitored during this study.

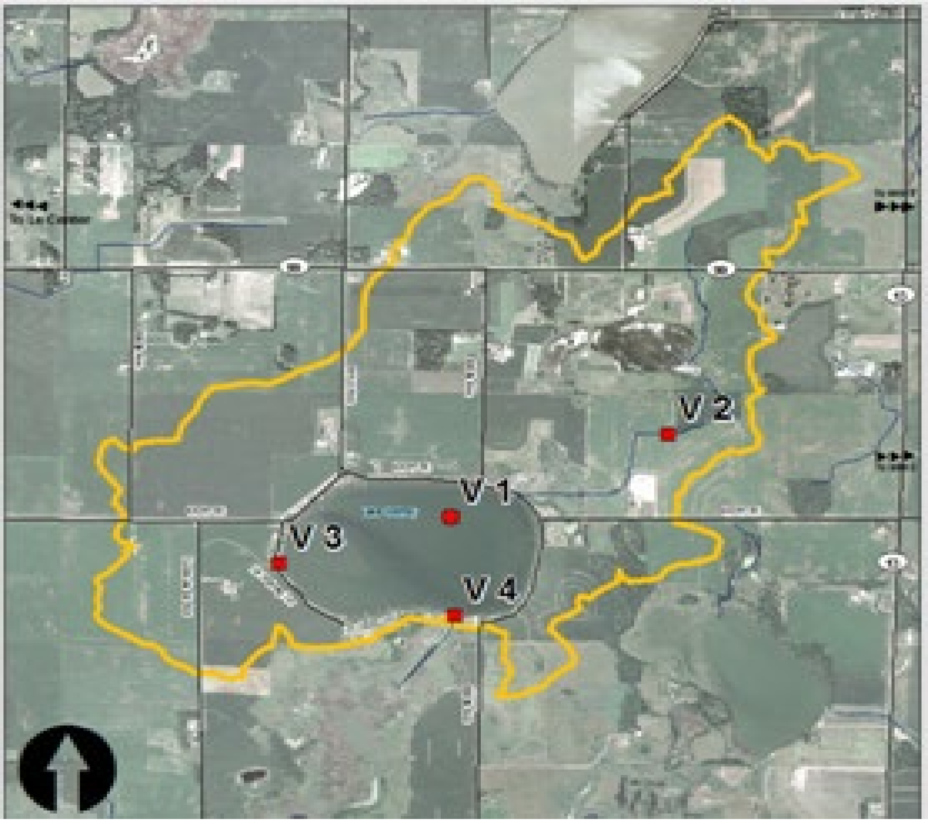

Figure 1.5 A. Location of water quality monitoring stations (V1-V4) in the Lake Volney Watershed.

1.6 Geography

Lake Volney is located in the eastern portion of Le Sueur County, which contains several lakes and small streams that influence the downstream water quality of the Cannon River. The surrounding surficial geographic landscape was formed during the period of glaciation that began nearly 2 million years ago and ended about 10,000 years ago (Le Sueur County, 1994). During this time, the Des Moines lobe of the Late Wisconsin Glaciations deposited yellowish gray, calcareous, medium textured material across all of Le Sueur County (Le Sueur County, 1994). Lake Volney was mostly likely formed from an ice block deposited in glacial till (Wilson, 1987). In the central portion of the county where Lake Volney is located, the landscape consists mostly of upland habitat with some rolling hills separated by swales and drainage ways (Le Sueur County, 1994). Much of the soil in Le Sueur County is poorly drained; therefore a large proportion of farmland is artificially drained with tile lines (Le Sueur County, 1994).

1.7 Soils

A total of eleven different soil associations are found within the Lake Volney watershed; (Figure 1.7 A). Four of these soil associations are more common than others within the watershed. Kilkenny clay loams can be found on slopes from 2-18 percent; however a majority of this soil type is found on slopes between 6 and 12 percent. This soil association is often found in areas where erosion has occurred within the watershed. Lerdal clay loams are found on portions of the watershed with slopes from 2- 12 percent; these soils are typically found on upland habitats that are currently being cultivated. Mazaska clay loams are also found on the upland habitats within the watershed and are almost extensively used for agriculture. The fourth major soil association found within the watershed is Caron Muck/Palms soils/ponded soils and represents areas where wetlands are currently found or where historical wetlands have been located. A large proportion of these wetlands have been drained for agricultural purposes, therefore extensive tile drainage exists within these areas. Dassel loams are found around the eastern and western shoreline of Lake Volney and consist of a fine sandy material. Dundas soils are typically black and poorly drained, and here are only found in one location in the watershed (Anoka County SWCD Soil Directory).

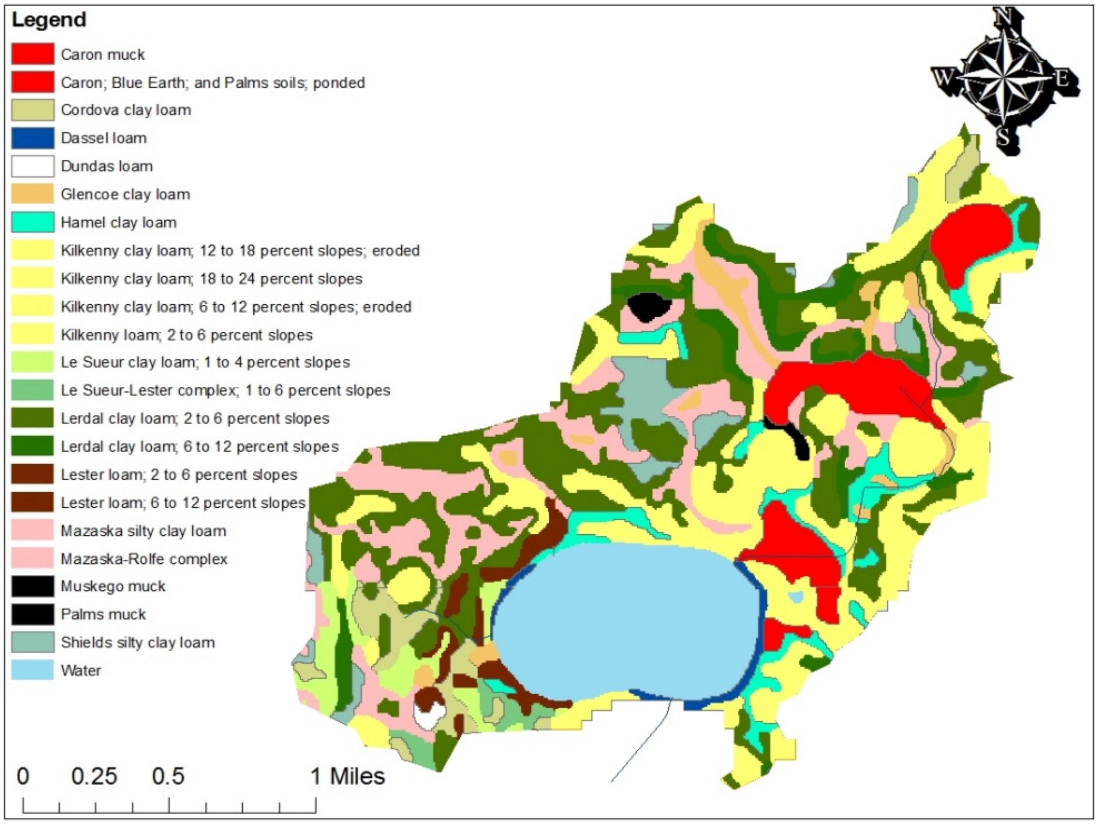

Figure 1.7 A. Soil map for the Lake Volney Watershed.

1.8 Climate

1.8 A. Temperature:

Climatological data was taken daily at St. Peter located in Le Sueur County, Minnesota over the course of 30 years from 1971 to 2000 by the United States Department of Agriculture Natural Resources Conservation Service (USDA NRCS, 2010). Results from this data depict an average daily maximum temperature of 56.0^{o}F and an average daily minimum temperature of 34.5^{o}F.

On average, January is the coldest month of year, and July is the warmest (Table 1.8 A; USDA NRCS, 2010). The total number of growing degree days in the 30 year time frame for southern Minnesota crops was averaged at 4,648 days with a threshold of 40ºF.

1.8 B. Precipitation:

Between 1971 and 2000, there was an average of 29.67 inches of precipitation per year in Le Sueur County, Minnesota (USDA NRCS, 2010). There is also an average of 29.6 inches of snow falling per year with at least 1 inch of snow being present on the ground an average of 41 days per year (USDA NRCS, 2010). There will usually be at least one inch of snow that falls per month between November and April. On average, there will be 52 days throughout the year where at least 0.1 inches of precipitation will fall (USDA NRCS, 2010). June has historically been the wettest in terms of the average amount of precipitation, with February historically having the lowest levels of precipitation (USDA NRCS, 2010). The majority of precipitation falls between May and August (Table 1.8 A; USDA NRCS, 2010). A TR 525 rain gauge equipped with a tipping bucket located near the Jefferson-German Chain of Lakes (approximately 15 miles south of Lake Volney) in Cleveland, MN was used to determine the amount of precipitation that had fallen within the watershed in 2009 and 2010. A similar device was placed in the Lake Volney watershed; however, this device failed to record accurate precipitation data. Precipitation data collected by the rain gauge includes results from the dry 2009 monitoring season and the wet 2010 monitoring season. Rainfall total during the 2009 monitoring season (4/3-11/1/2009) was 18.14 inches; rainfall total for the 2010 monitoring season (3/16-11/5/2010) was 27.55 inches. Rainfall totals during the 1993 sampling season (April-September) was 35.9 inches; indicative of the very wet conditions that existed during this study (Le Sueur County, 1994). The average rainfall from the 2009 and 2010 monitoring seasons was 22.85 inches; 13 inches less than the amount of rainfall that occurred in 1993. The large difference in the amount of precipitation that fell within the watershed in 1993 vs. 2009/10 suggests that results from the 1993 study may depict a much different nutrient load from the watershed in comparison to results observed in this study.

Table 1.8 A. Average daily maximum/minimum temperatures and average precipitation for Le Sueur County, Minnesota 1971-2000 (USDA Natural Resources Conservation Service). Precipitation data observed during the 2009/10 monitoring seasons represents rainfall totals from a very dry 2009 year and a wet 2010 year.

	Average Temperature		**Precipitation**		
Month	**Maximum (˚F)**	**Minimum (˚F)**	**Average (inches)**	**2009 (inches)**	**2010 (inches)**
January	23.1	3.0	0.89	--	--
February	29.5	9.9	0.53	--	--
March	42.1	22.4	1.89	--	--
April	58.1	34.6	2.29	1.57	1.54
May	71.7	47.1	3.55	1.23	2.41
June	80.3	56.7	4.89	3.01	5.91
July	83.8	61.3	3.94	1.84	5.38
August	81.2	59.0	4.12	5.25	3.22
September	73.2	49.0	2.76	0.46	7.88
October	60.8	37.0	2.22	4.78	1.15
November	41.1	24.1	1.70	--	--
December	27.5	9.7	0.89	--	--
Annual *avg.* / Total	***56.0***	***34.5***	**29.67**	**--**	**--**
Apr-Oct Total	**--**	**--**	**23.77**	**18.14**	**27.49**

1.9 Biological Monitoring

1.9 A. Fishery survey and analysis:

Lake Volney was last surveyed by the MNDNR in 2008; results from this survey indicate the walleye population has remained stable since the 2006 survey (MNDNR, 2011). Walleye caught in gill nets ranged in size from 16 to 22 inches (MNDNR, 2011). Black crappies were the most abundant fish surveyed in trap nets, and were also commonly sampled in gill nets (MNDNR, 2011). Yellow perch represented a majority of the fish sampled in gill nets. Blue gill abundance was 21.33 fish per trap net; the number of blue gills caught in trap nets is in line with the average for lakes with characteristics similar to Lake Volney (MNDNR, 2011). Common carp are extremely abundant in Lake Volney and were sampled at sizes ranging from 27 to 37 inches during the 2008 survey. A commercial fishing operation removed 10,000 pounds of common carp and buffalo in July of 2009 and 40,000 pounds of carp in November, 2009 (Figure 1.9 A).

Figure 1.9 A. Commercial fishing operations on Lake Volney in July, 2009.

The lack of emergent, submergent, and floating leaf vegetation on Lake Volney may limit the potential for this system to support game species such as northern pike, largemouth bass, and bluegill. Overall, a majority of the shoreline on Lake Volney has been developed; a portion of the eastern shoreline contains some natural vegetation. The restoration of natural shoreline vegetation and the enhancement of the existing submergent macrophyte community would likely be beneficial to the fishery and water quality in general.

1.9 B. Plant Survey and Analysis:

Staff from the Water Resource Center in coordination with the Minnesota Pollution Control Agency used a point-intercept sampling technique to provide a representative survey of the aquatic plant community on Lake Volney. Lake Volney was sampled twice in 2009; the first survey was completed on May 12th, when CLP is typically most abundant. The second survey was completed on August 11th when native species are typically most abundant. Overall, the aquatic plant community of Lake Volney is extremely limited. The deep morphometry and composition of sediment found in Lake Volney prohibits extensive macrophyte growth. Results from both aquatic plant surveys illustrate the lack of macrophyte growth within this basin (Appendix D).

1.10 Recreational Use

In the 1960's and 70's Lake Volney's county park was the popular swimming place for Le Sueur County. Many people living in the towns of Montgomery and Le Center, and Le Sueur went to the County Park and beach. There was a large public building, a concession stand, and a large dock with a large raft in deeper water. Students from Montgomery were transported by bus for swimming lessons. The lake was reported to be extremely clear at that time. After the 1970's, the lake quality declined and so did the amount of people recreating.

Since the public beach was restored in 2009, this facility has been used more consistently by lakeshore owners and members of the county throughout the open water season. Lake Volney occasionally became very busy during the summer months of this study, with multiple user groups present. The use of the public beach and the presence of a large number of user groups throughout the monitoring season suggest that Lake Volney is an important recreational destination for many families in the surrounding community for both swimming and fishing.

Section 2.0 Applicable Water Quality Standards and Water Quality Numeric Targets

2.1 Applicable Minnesota Water Quality Standards

Impaired waters are listed and reported to the citizens of Minnesota and to the EPA in the 305(b) report and the 303(d) list, named after relevant sections of the Clean Water Act. Assessment of waters for the 305(b) report identifies candidates for listing on the 303(d) list of impaired waters. The purpose of the 303(d) list is to identify impaired water bodies for which a plan will be developed to remedy the pollution problem(s) (the TMDL).

The basis for assessing Minnesota lakes for impairment due to eutrophication includes the narrative water quality standard and assessment factors in Minnesota Rules 7050.0150. The MPCA has completed extensive planning and research efforts to develop quantitative lake eutrophication standards for lakes in different ecoregions of Minnesota that would result in achievement of the goals described by the narrative water quality standards. Lakes were ranked and categorized by common characteristics, such as depth/lake morphometry, lake ecology, geographic setting, and reference lake conditions. Because of regional diversity in lake and watershed characteristics, it was felt that a single total phosphorus value could not be adopted as a statewide criterion for lake protection in Minnesota (Heiskary and Wilson, 1988). By using the eco-region derived data, natural lake loading is taken into account, and lakes are assessed based on natural landscape settings, local land use, and loading typical of the region.

Lake Volney (ID#40003300) is a deep lake located in the North Central Hardwood Forest (NCHF) ecoregion, therefore, the standards set forth for deep lakes in NCHF were applied (Table 2.1 A). The impaired affected use is aquatic recreation for excess nutrients causing eutrophication. To be listed as impaired by the MPCA, the monitoring data must show that the standards for both total phosphorus (the causal factor) and either chlorophyll a or Secchi disc depth (the response factors) are not met (MPCA, 2007). Target start for the TMDL was 2008 and target completion date was 2011, with an original listing year of 2002.

Table 2.1 A. MPCA deep lake standards for total phosphorus, chlorophyll-a and secchi disc (NCHF ecoregion).

	NCHF Deep
TP (µg/L)	40
Chl-a (µg/L)	14
Secchi (meters)	1.4

Source: Minnesota Rule 7050.0222 Subp. 4. Class 2B Waters

For this TMDL, the water quality target concentration was different than the lake standard. This was to account for an explicit 10% Margin of Safety (MOS). Therefore, total phosphorus standards were set at 10% below actual standards for the NCHF ecoregion (Table 2.1 B).

Table 2.1 B. Total phosphorus goals for Lake Volney and the actual NCHF ecoregion standard.

	TP (μg/L) actual	TP (μg/L) minus 10%
NCHF Deep	40	36

The primary water classification that this TMDL addresses are water bodies classified 2B. Class 2 is concerned with aquatic life and recreation, and subclass B refers to cool/warm water fisheries with the water body not protected as a drinking water source.

Section 3.0 Water Quality data

3.1 Data collection

Monitoring was completed through the TMDL study to collect current water quality data, as well as additional data to be used for the BATHTUB modeling application. While data was collected beyond the growing season (June through September), only those data collected within the growing season were used in BATHTUB and subsequently, TMDL development. This time period was chosen because it corresponds to the eutrophication criteria, it spans the months in which the lakes are most used by the public, and the months during which water quality is the most likely to suffer due to excessive nutrients leading to nuisance levels of algal growth (the critical condition).

Many previous projects collected additional water quality data, (1986 MPCA Lake Assessment Program, 1995 Diagnostic and Feasibility Study; Le Sueur County). While many of these studies have investigated similar problems (such as sediment and nutrient loading), these reports were unfortunately completed more than 10 years ago which is outside the data requirement window of the TMDL process. However, many of these studies were valuable to refer to during the current TMDL study, and can help provide a framework to investigate how the lake has changed over time.

Water quality was monitored at two inlet sites and the lake outlet site during 2009 and 2010 from March to October (Table 3.1 A). While data was collected for the entire open water season, only June-September results were used in the FLUX and BATHTUB calculations. For more detailed results on inlet/outlet water quality, refer to Appendix D.

Table 3.1 A. Water quality data summation for 2009/10 monitoring season at inlet and outlet sites on Lake Volney.

	Average TP (µg/L)	**Max TP (µg/L)**	**Min TP (µg/L)**
2009			
Inlet Site V2	500	2310	180
Inlet Site V3	310	870	110
Outlet Site V4	180	380	90
2010			
Inlet Site V2	550	1510	50
Inlet Site V3	210	1770	90
Outlet Site V4	110	290	30

3.2 Flux Results

FLUX, a computer program designed by the U.S. Army Corps of Engineer Waterways Experimental Station, was used to calculated values for flow rate, estimated nutrient and sediment loading, and flow weighted mean concentrations (FWMC) from each TMDL monitored inflow site during the TMDL study (Table 3.2 B). FLUX is used to estimate the load of nutrients or other water quality constituents passing a location over a given period of time. The FWMC data (Table 3.2 A) is calculated by dividing the total constituent load by the total flow volume. This provides an overall average concentration for each constituent during the monitoring period.

Measured inlet loads compared to outlet loads indicate the amount of TP accumulating within the lake each season. This is especially apparent in 2010 where the TP load of V2 and V3 was 1051 kg/yr and the TP load leaving at the V4 outlet location was 397 kg/yr (Table 3.2 B).

Table 3.2 A. Complete FLUX results for Lake Volney monitored inflows and outflow.

TMDL Site ID	Year	2009	2010	Mean (Input to BATHTUB)
V2	Monitoring Period	3/24-11/5	3/17-11/1	
	Flow Rate (hm^3/yr)	0.313	1.297	0.805
	TSS FWMC (µg/L)	13,776	61,425	52,161
	TSS Load (kg/y)	4,312	79,668	41,990
	NO_3–$N0_2$ FWMC (µg/L)	2,697	3,854	3,629
	NO_3–$N0_2$ Load (kg/y)	844	4,999	2,922
	TP FWMC (µg/L)	381	637	587
	TP Load (kg/y)	119	826	473
	PO4 FWMC (µg/L)	NA	280	280
	PO4 Load (kg/y)	NA	363	363
	PO4/TP	NA	44%	44%
TMDL Site ID	**Year**	**2009**	**2010**	**Mean (Input to BATHTUB)**
V3	Monitoring Period*	3/24-11/5	3/17-11/1	
	Flow Rate (hm^3/yr)	0.070	0.382	0.226
	TSS FWMC (µg/L)	18,481	51,856	46,699
	TSS Load (kg/y)	1,290	19,809	10,550
	NO_3–$N0_2$ FWMC (µg/L)	13,592	9,524	10,152
	NO_3–$N0_2$ Load (kg/y)	949	3,638	2,293
	TP FWMC (µg/L)	287	589	542
	TP Load (kg/y)	20.0	225	122.5
	PO4 FWMC (µg/L)	NA	330	330
	PO4 Load (kg/y)	NA	126	126
	PO4/TP	NA	56%	56%
TMDL Site ID	**Year**	**2009**	**2010**	**Mean (Input to BATHTUB)**
V4 (Outlet)	Monitoring Period*	3/24-11/5	3/17-11/1	
	Flow Rate (hm^3/yr)	0.273	2.920	1.596
	TSS FWMC (µg/L)	3,480	11,422	10,743
	TSS Load (kg/y)	950	33,354	17,151
	NO_3–$N0_2$ FWMC (µg/L)	311	860	813
	NO_3–$N0_2$ Load (kg/y)	85	2,511	1,298
	TP FWMC (µg/L)	232	136	144
	TP Load (kg/y)	63	397	230
	PO4 FWMC (µg/L)	NA	48	48
	PO4 Load (kg/y)	NA	139	139
	PO4/TP	NA	35%	35%

Table 3.2 B. Total Phosphorus FLUX results for Lake Volney monitored inflows and outflow.

	TP FWMC (µg/L)	TP Load (kg/y)
2009		
Inlet V2	381	119
Inlet V3	287	20
Outlet V4	232	63
2010		
Inlet V2	637	826
Inlet V3	589	225
Outlet V4	136	397

3.3 In-lake Sampling Results

3.3 A. In-Lake Sampling Summary:

In-lake samples were taken at the deepest point found within Lake Volney per EPA protocol. The deepest point was then saved on a GPS; each sampling round that followed was conducted at the saved GPS location.

The early and late season data collected was not included in this report because it does not impact the TMDL calculations: water quality samples taken prior to or after the growing season (June-September); vertical profiles (1 meter intervals) for temperature, pH, conductivity, and dissolved oxygen using a multi-parameter probe; hypolimnion samples taken with a Van Dorn sampler when a thermocline was detected.

3.3 B. Seasonality:

Nutrient loading can potentially vary greatly due to seasonal influences. Based on data collected within Lake Volney, in-lake TP concentrations were consistently above the NCHF class 2B ecoregion standard except during a brief period between June 30th and August 25th 2010.

In 2009 and 2010, Lake Volney was thermally stratified during the entire summer season (June-September). A release of phosphorus from sediments was likely occurring as dissolved oxygen concentrations approached zero within the hypolimnion. Stratification was weakest at the beginning of the season, indicated by hypolimnion TP concentration being not significantly greater than the TP concentration found in surface.

A general trend observed in 2009 and 2010 in Lake Volney is that TP concentrations often start out highest early in the season and decrease as the season progresses before increasing again at the end of the sampling season. This trend has been observed in prior studies of Lake Volney

(Schuler, 1997). Although nutrient loading from the watershed has historically increased as the season progresses, TP concentrations within the epilimnion have historically decreased as the season progresses. The strong thermal stratification present during the summer may account for the decrease in TP concentrations sampled at the surface as a greater proportion of the TP coming in from the watershed is likely being retained within the hypolimnion during the summer when thermal stratification is strongest (Schuler, 1997).

3.3 C. Water Quality Results (June-September):

Total Phosphorus (Surface)

In both 2009 (Figure 3.3 C.1.) and 2010 (Figure 3.3 C.2.), lower TP values were bracketed by high TP values early and late in the season. The mean TP concentration for the summer seasons of 2009 and 2010 combined was 63 µg/L.

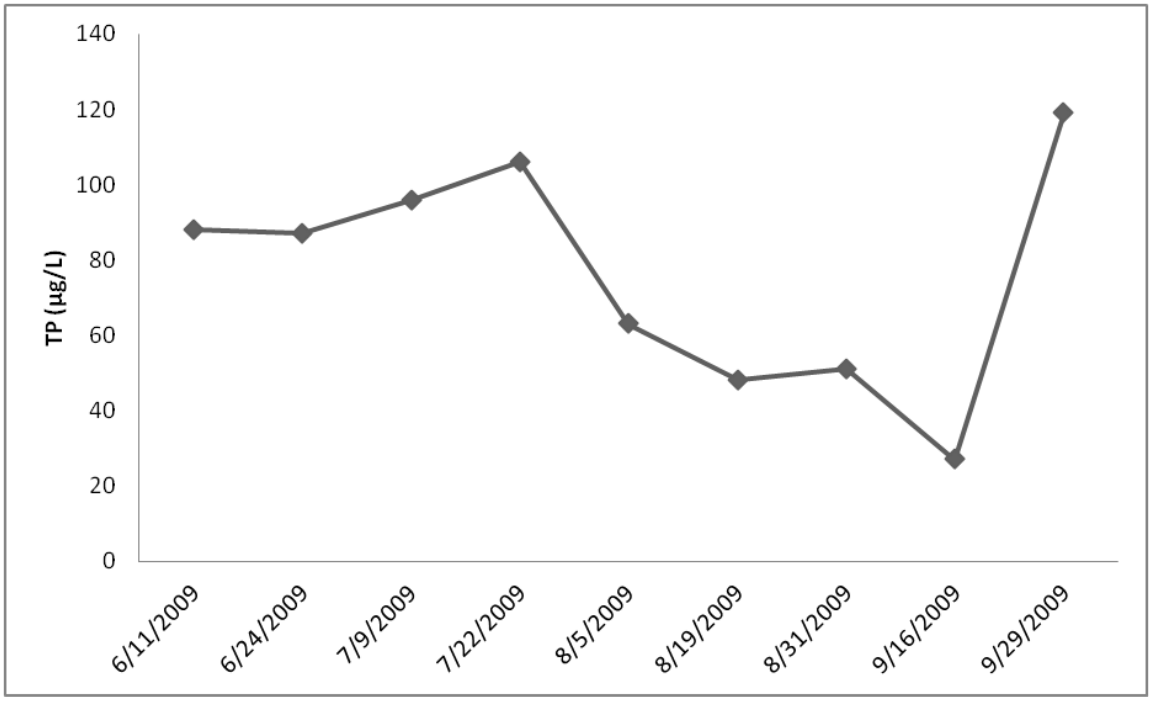

Figure 3.3 C.1. Lake Volney TP concentrations during the 2009 season. The deep lake NCHF ecoregion standard is 40 µg/L.

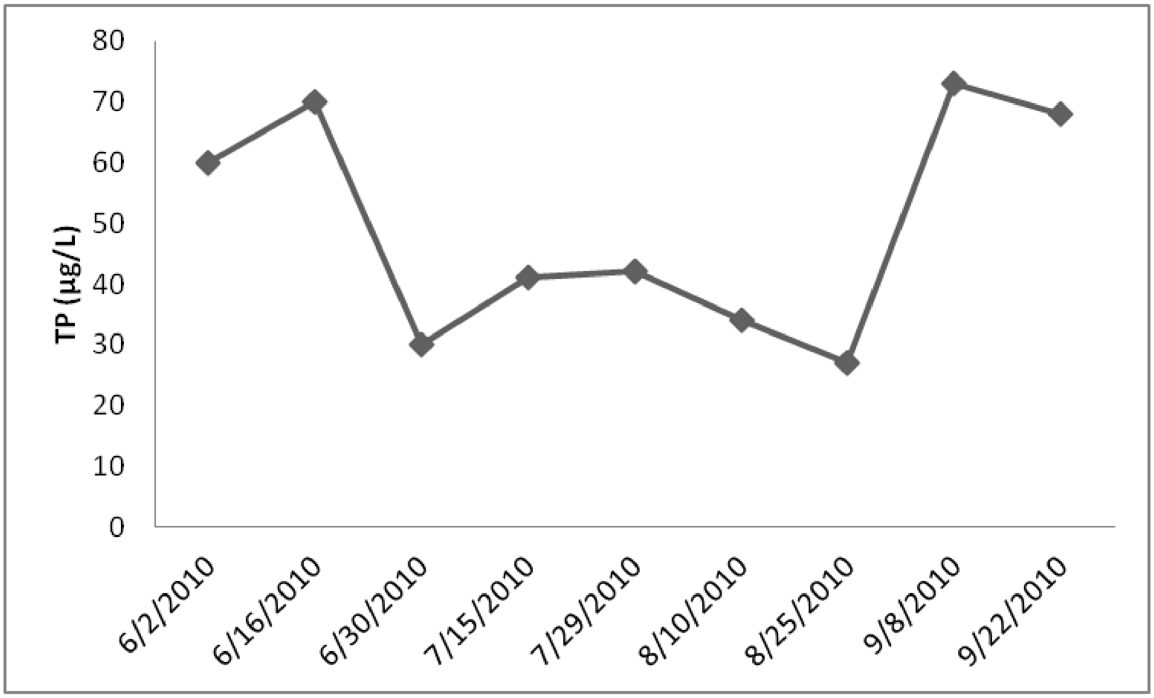

Figure 3.3 C.2. Lake Volney TP concentrations during the 2010 season. The deep lake NCHF ecoregion standard is 40 µg/L.

Chlorophyll-a

The mean chlorophyll-a (chl-a) concentration for the summer season of 2009 was 20 µg/L. (Figure 3.3 C.5.). In 2010, the mean chl-a concentration was 11 µg/L (Figure 3.3 C.6.). The mean chl-a value over the 2009 and 2010 summer seasons combined was 16 µg/L. An aphanizomen bloom was documented in early July both years; however, the bloom was more severe in 2009 than in 2010.

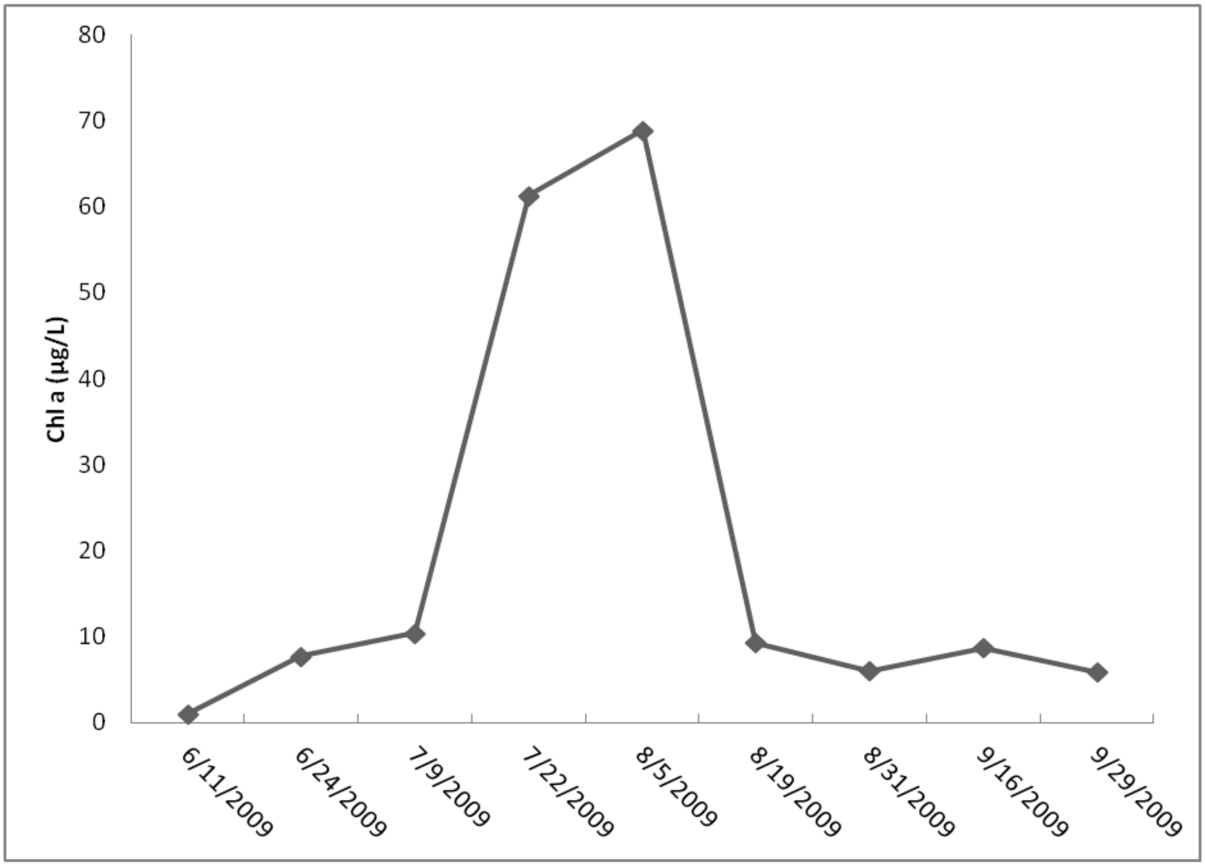

Figure 3.3 C.5. Lake Volney chl-a concentrations during the 2009 sampling season. The deep lake NCHF ecoregion standard is 14 µg/L.

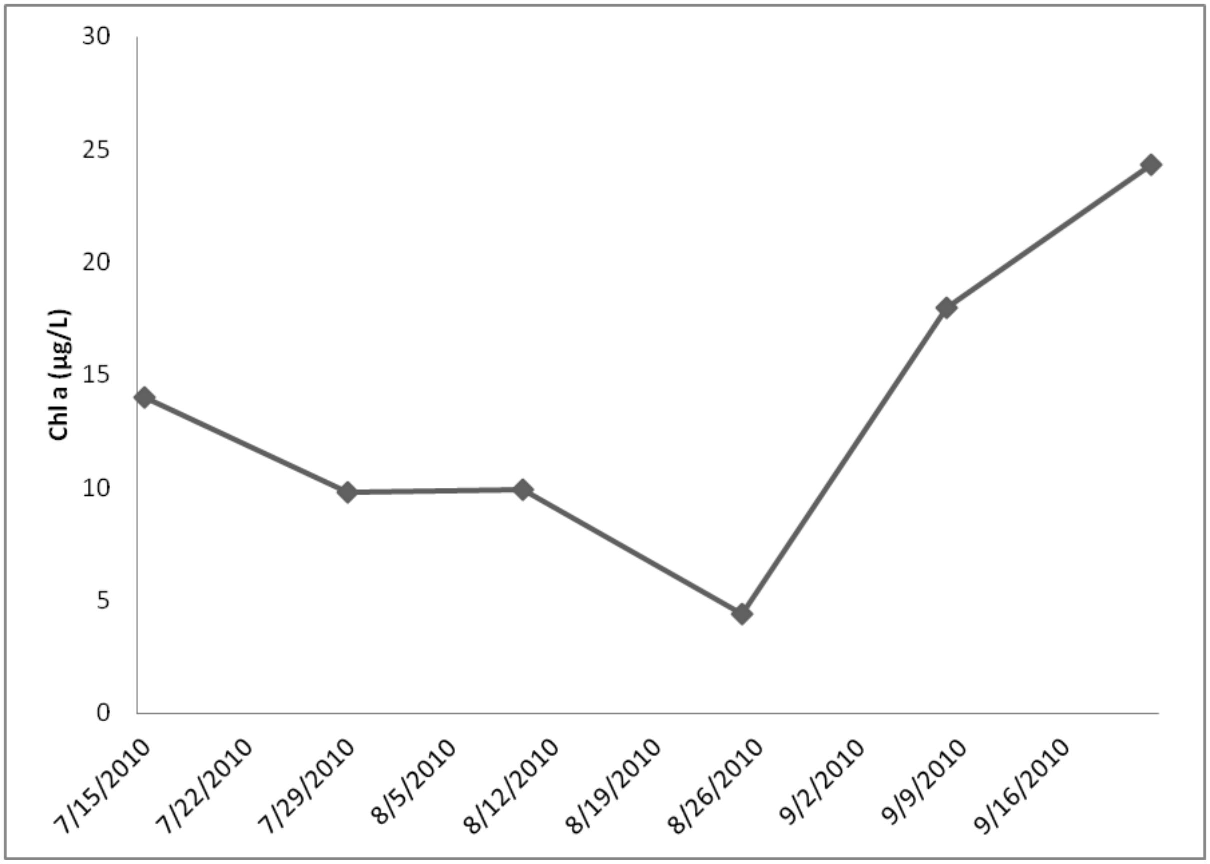

Figure 3.3 C.6. Lake Volney chl-a concentrations during the 2010 sampling season. The deep lake NCHF ecoregion standard is 14 µg/L.

Secchi disk transparency
The mean secchi disk reading for 2009 was 3.9 m. During the 2009 summer season, the secchi disk transparency exceeded (was better than) the NCHF eco region standard during all but one sampling event. The poorest water clarity occurred on August 5th, 2009; indicative of the blue-green algae (aphanizomenon) bloom occurring during this time (Figure 3.3 C.7). The mean secchi disk reading for 2010 was 2.7 m (Figure 3.3 C.8). The mean secchi disk value over the 2009 and 2010 summer seasons combined was 3.3 m.

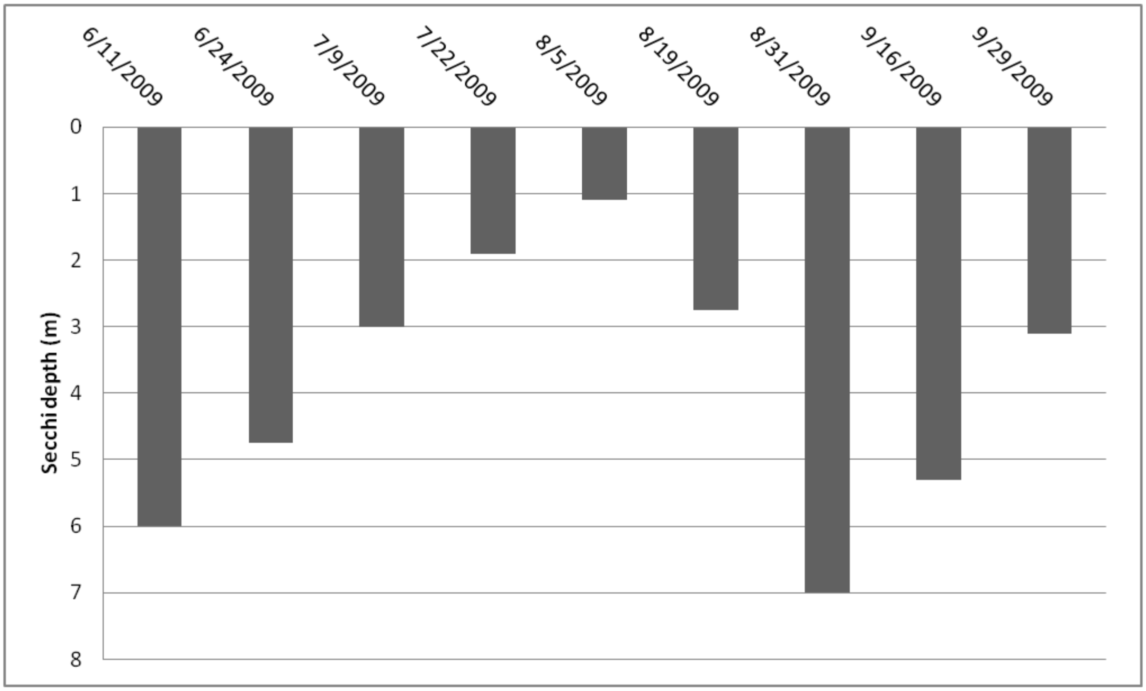

Figure 3.3 C.7. Lake Volney secchi disk transparency during the 2009 sampling season. The deep lake NCHF ecoregion standard is 1.4 m.

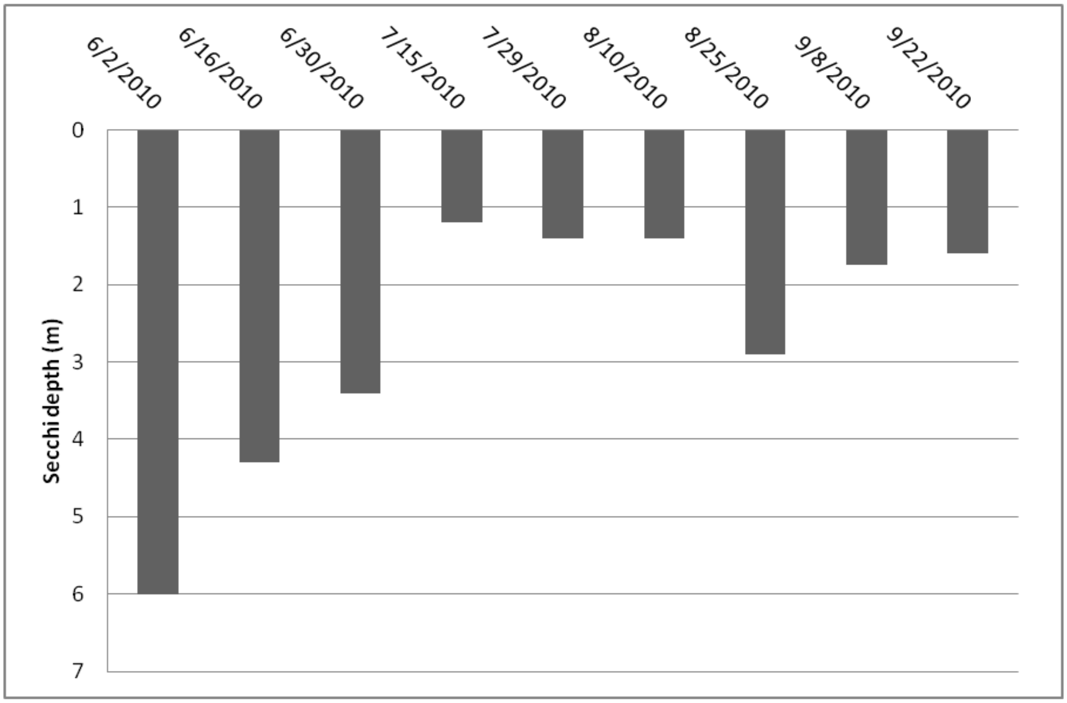

Figure 3.3 C.8. Lake Volney secchi disk during the 2010 sampling season. The deep lake NCHF ecoregion standard is 1.4 m.

Section 4.0 Modeling and Analysis

4.1 Watershed Data Analysis/Methods

For the purposes of this TMDL, two models were used (MINLEAP and BATHTUB) to analyze the various factors impacting Lake Volney. In order to accurately use the models, the interaction and influence of the areas contributing waters to Lake Volney also needed to be investigated, and loading data needed to be calculated.

In order to do this, the following watersheds were used: TMDL inflow site V2 watershed, TMDL inflow site V3 watershed, and the Lake Volney Watershed area.

As discussed in the “Lake TMDL Protocol and Submittal Requirements” developed by the MPCA, two models were used to evaluate the data. These models examine the existing data, and help determine if additional data analysis was required. Starting with a “Level I Assessment”, Lake Volney was evaluated using the MINLEAP model (Appendix E). Based on the results, additional assessments were also necessary using additional models. Descriptions of the models are below, as well as initial data results.

4.2 BATHTUB Model and Results

BATHTUB is a lake water quality model developed by William Walker under contract with the US Army Corp of Engineers. BATHTUB has been widely used to model lake nutrient balances within a steady-state, spatially segmented hydraulic network by calculating advective and diffusive transport, and nutrient sedimentation dynamics within the system.

BATHTUB predicts eutrophication-related water quality conditions (expressed in terms of total phosphorus concentration and other parameters) using empirical relationships previously developed and tested, some for reservoir applications (Walker 1985) and others for natural lakes (e.g., Canfield-Bachmann (1981) lake model, incorporated into BATHTUB as an option).

Phosphorus and water inflows calculated with FLUX for V2 and V3 were input to the Volney BATHTUB model (2009 and 2010 averages from Table 3.1 A.). The combined V2-V3 drainage area is 54% of the lake’s total watershed, not including the lake itself. The remainder of Lake Volney’s watershed (the “direct” or “local” watershed) was assigned a water contribution that balanced the measured outflow (station V4), with evaporation from the lake and direct precipitation on the lake estimated to be equal. The mean TP concentration for runoff from the direct watershed was assumed to be the same as the overall flow-weighted mean for the monitored subwatersheds, 320 µg/L.

The initial results from the BATHTUB model for Lake Volney predicted TP concentrations very close to the observed values. A precise match was achieved (Table 4.2 A) by specifying a calibration factor for phosphorus sedimentation that differed only slightly from unity (1.069).

Table 4.2 A. Lake Volney BATHTUB results for current conditions.

	Predicted	Observed
Total Phosphorus (µg/L)	62.8	62.8

Note: Phosphorus sedimentation rate was adjusted by Calibration Factor = 1.069 to match the observed value.

The corresponding phosphorus mass balance (Table 4.2 B) includes an overall phosphorus load of 807.6 kg/yr.

Table 4.2 B. Lake Volney mass balance for current conditions.

	Phosphorus Load		TP as Flow-weighted Mean	P Export
Component	**(kg/yr)**	**(%Total)**	**(µg/L)**	**(kg/km^2/yr)**
Inflow V2 (monitored)	472.6	59%	587	144.5
Inflow V3 (monitored)	122.4	15%	542	105.5
Lake Volney Direct	178.9	22%	320	48.0
Atmospheric Load	33.6	4%	30	30.0
Total Inputs / *means*	**807.6**	**100%**	***299***	***87.0***
Surface Outflow	99.8	12%	63	10.8
Retention	707.8	88%	--	--
Total Outputs	**807.6**	**100%**	--	--

The phosphorus loading capacity of Lake Volney was determined by requiring an in-lake TP concentration of 36 µg/L (the water quality standard of 40 µg/L, minus a 10% margin of safety). See Table 4.2 C.

Table 4.2 C. Lake Volney TMDL BATHTUB predictions.

	Predicted	Goal	Standard
Total Phosphorus (µg/L)	36.0	36.0	40.0

Note: To meet the phosphorus goal, all runoff Total P concentrations were reduced to 183 µg/L.

The loading capacity was found to be 324.7 kg/yr, which was achieved in the TMDL model scenario by reducing the TP concentration to 183 µg/L for all watershed runoff (Table 4.2 D.).

Table 4.2 D. Lake Volney TMDL mass balance.

Component	Phosphorus Load (kg/yr)	Phosphorus Load (%Total)	Total P (µg/L)	P Export (kg/km^2/yr)
Inflow V2	147.4	45%	183	45
Inflow V3	41.4	13%	183	36
Lake Volney Direct	102.3	32%	183	27
Atmospheric Load	33.6	10%	30	30
Total Inputs / *means*	**324.7**	**100%**	***120***	***35***
Surface Outflow	57.2	18%	36	6
Retention	267.4	82%	--	--
Total Outputs	**324.7**	**100%**	--	--

The loading capacity equivalent in terms of average daily loading – i.e., the TMDL – is 0.889 kg/day. This is simply the modeled annual loading capacity divided by the average number of days in a year (365.25 days/yr).

4.3 Lake Volney Hydrologic Balance

The mean total flow rate at the monitored outflow location (V4) based on all stage and velocity data recorded during the 2009 and 2010 monitoring seasons was 1.59 hm^3/yr (Table 4.3). BATHTUB used all monitoring data collected from V2 and V3, and estimated inflow rates from various non-point sources based on land use practices within the watershed. The runoff depth used in the BATHTUB model to estimate contributions from nonpoint sources was adjusted such that the tributary inflow rate combined with monitored inflow rates from monitoring locations V2 and V3 produced an outflow rate equal to the outflow rate observed at the outlet monitoring site (V4) during the 2009 and 2010 field season.

For the three sub watersheds here, runoff values were 9.7 (V2) and 7.7 (V3) inches/yr, based on measured flows, and 5.9 inches/yr, estimated as above, for the Direct Watershed.

Table 4.3. Lake Volney water balance.

Component	Area km^2	Flow hm^3/yr	Runoff m/yr
Inflow V2 (monitored)	3.27	0.805	0.246
Inflow V3 (monitored)	1.16	0.226	0.195
Lake Volney Direct Watershed	3.73	0.559	0.150
Precipitation	1.12	1.110	0.990
Total Inflow	**9.28**	**2.700**	**0.291**
Surface Outflow	9.28	1.590	0.171
Evaporation	1.12	1.110	0.990

4.4 Existing TP Loading Sources to Lake Volney

Based on data collected during the TMDL, the largest source of TP to Lake Volney was the monitored inflows. Unmonitored sources also contributed almost one quarter of the load (figure 4.4 A.).

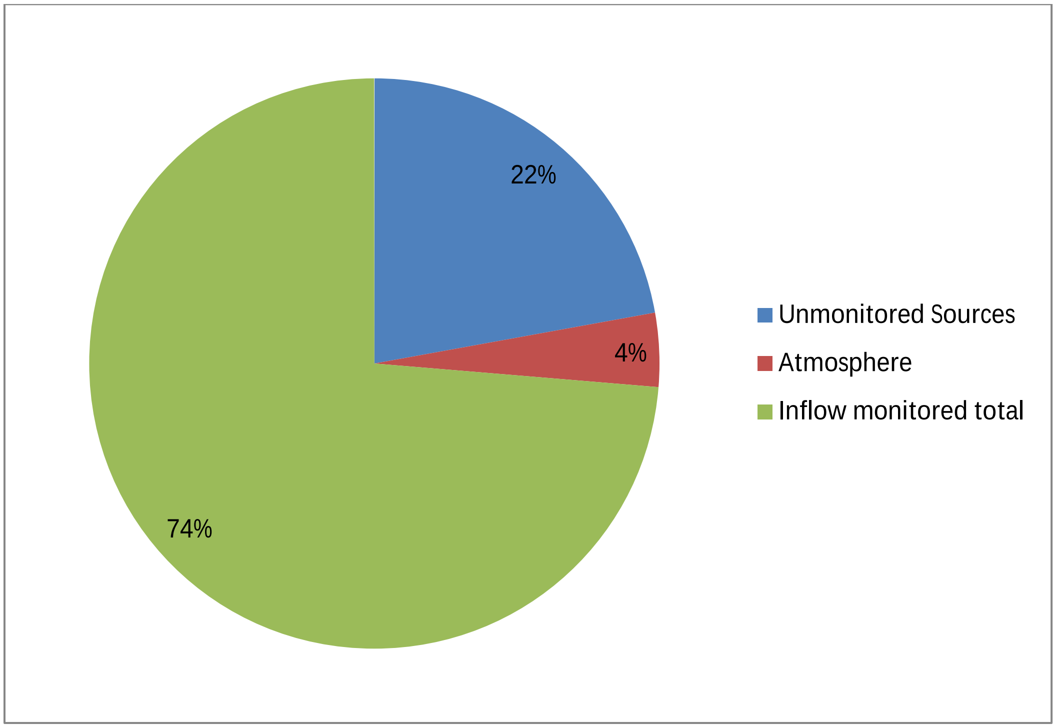

Figure 4.4 A. Contributions of TP by source to Lake Volney.

Section 5.0 TMDL Allocation

The TMDL process establishes the allowable loading of pollutants for a waterbody based on the point and nonpoint pollution sources, natural background conditions, and in-stream water quality conditions. In general terms, the process can be described by the following equation:

TMDL = LC = ∑WLA + ∑LA + MOS

Where:

LC = loading capacity, or the maximum amount of loading a water body can receive without violating water quality standards;

WLA = Waste load allocation, or the portion of the TMDL allocated to existing or future point sources;

LA = Load allocation, or the amount of the TMDL allocated to existing or future nonpoint sources;

MOS = margin of safety, or an accounting of uncertainty about the relationship between pollutant loads and the receiving water quality;

Within the WLA, LA, and MOS, there are additional categories and values taken into account.

5.1 WLA allocation

The waste load allocation is the sum of all the permitted discharges within the watershed of an impaired reach. All permitted sources are designed to not exceed the nutrient (TP) standard due to permit limits, but must be considered when calculating total loading within a system.

The WLA includes three subcategories: municipalities subject to MS4 NPDES permit requirements; Wastewater Treatment and Industrial; non-MS4 waste water treatment facilities, and Construction and Industrial Stormwater (NPDES).

Municipalities subject to MS4 NPDES permit requirements:

The development of urban areas have led to drainage alteration with impervious surfaces and varying volumes of storm water being delivered to area streams and rivers. Municipalities of a certain size or density, or located in a sensitive area are subject to Municipal Separate Storm Sewer Systems (MS4) rules (Minnesota Rules, Chapter 7090), which limits the amount of discharge from storm water within the area. These MS4 values are calculated for the TMDL by reviewing the developed area within the impaired reach watershed, and adding 5% to the value (to account for future growth). Lake Volney and its surrounding watershed are not considered a part of a MS4 community and therefore have no WLA loading under the MS4 category.

Municipal and industrial wastewater treatment facilities:

No wastewater treatment facilities, either municipal or industrial, are located in the JGC watershed, so there is no loading under this category.

Feedlots

A review of all MPCA permit records for the Lake Volney watershed over a 10 year period revealed a few permitted feedlots (Figure 5.1 A.). The NPDES permits for feedlots allow no nutrient discharges to occur.

Construction stormwater runoff

A permit is required for any construction activities disturbing: one acre or more of soil; less than one acre of soil if that activity is part of a “larger common plan of development or sale” that is greater than one acre; or less than one acre of soil, but the MPCA determines that the activity poses a risk to water resources. A Construction Stormwater runoff WLA is needed in case of future construction. Based on tracking of construction activity by the MPCA’s Construction Stormwater Program in a number of Minnesota counties, a generally appropriate estimate of the WLA for construction stormwater is 0.1% of the TMDL watershed load. This estimate was adopted for the Lake Volney TMDL.

Industrial stormwater runoff

There would appear to be little, if any, industrial activity in the JGC watershed at present. But again, to provide for possible future industrial stormwater, a WLA is included in the TMDL. For simplicity, and in line with a number of EPA-approved Minnesota TMDLs, the same estimate used for construction stormwater, 0.1% of the TMDL watershed load, was adopted for the Industrial Stormwater runoff WLA as well.

For the purposes of the TMDL, the WLA includes the following:

∑WLA = NPDES Permitted values (0.00) + Construction stormwater (0.104%)

Figure 5.1. A. Active permitted feedlots within the Lake Volney watershed.

5.2 Load allocation

The load allocation (LA) is the portion of the total loading capacity assigned to nonpoint and natural background sources of nutrient loading. These sources include the atmospheric loading and nearly all of the loading from watershed runoff. The only portion of the watershed runoff not included in the LA is the small loading set aside for regulated stormwater runoff from construction and industrial sites.

5.2 A. Natural Background:

Natural Background is not given a separate allocation; rather it will be part of the discussion of goals. For this report, it is included in the LA without differentiation.

5.2 B. TMDL Monitored Inflows:

The two monitored inflow sites and grab sample locations investigated in this study have been monitored during several projects in the past including a Lake Assessment Program conducted in 1987, a 1992 water quality study conducted by the MPCA in response to concerns from residents, and an intensive Phase I Diagnostic and Feasibility study conducted in 1995. The loading data applied in this study was developed through the use of FLUX software and data collected during the 2009 and 2010 monitoring seasons. This program calculated loading based on recorded flow and sample data. Data was reviewed from prior studies however only flow and sample data recorded during the 2009 and 2010 sampling seasons was used in this model. The flow and sample data from prior studies were not used for the models, but were used as a means of comparison to see how Lake Volney reacts to varying levels of precipitation. The most intensive study conducted on Lake Volney prior to the current TMDL study was the 1995 Phase I Diagnostic and Feasibility study. Rainfall during the 1995 sampling season was estimated at 25.79 inches, slightly less than the 27.55 inches that fell in 2010 but significantly greater than the 18.14 inches of rainfall that occurred during the extremely dry 2009 monitoring season.

5.2 Bi. V2 (Large Ditch System Draining Northeast Section of Watershed):

For the purposes of the TMDL, V2 is listed as a monitored inflow within the models. Loading values for V2 accounted for 59% of the total load coming into Lake Volney in the initial BATHTUB model before internal loading was accounted for. This value may under represent the normal contribution from this site, as loading from this site was significantly reduced during the extremely dry 2009 monitoring season. In 2009, a portion of this ditch system was periodically stagnant; furthermore, sections of the stream briefly dried out leaving a series of non-flowing puddles. However, this site is extremely flashy and can contribute a large amount of nutrients in a short amount time, often responding quickly to large rain events. In 2010, flow from this location was present throughout the entire monitoring season and had the potential to contribute a large amount of nutrients especially during/following storm events. The stream at TMDL site V2 rose 1.84 feet in 48 hours following a large storm event on September 22nd and 23rd. Historically, flow from this location had been the predominant source of nutrients to Lake Volney. Loading passing through this ditch system accounted for 61.7% of the subwatershed TP load entering Lake Volney during the 1995 monitoring season. Prior discussions of BMP's within the V2 watershed have focused on restoring the large wetland complex located upstream of V2 and/or restoring some additional wetlands downstream of the large wetland complex that would serve as settling basins for nutrients and TSS.

5.2 Bii. V3 (Large Ditch System Draining Western Portion of Watershed):

For the purposes of the TMDL, V3 is listed as a monitored inflow within the models. Loading values for V3 accounted for 15% of the total load coming into Lake Volney in the initial BATHTUB model before internal loading was accounted for. In 2009, flow from this site was continuous despite minimal rainfall. This may indicate that a large proportion of the water is derived from tiles lines located within the watershed. The TSS load from this site was often minimal, and transparency tube measurements from this location often exceeded 60 cm. Nitrate and Nitrite ($NO^2 + NO^3$) concentrations were extremely high at V3 during the 2009 and 2010 sampling seasons. Nitrates move faster through the soil in comparison with phosphorus; therefore, it is possible that a majority of this nitrogen is derived from nitrogen mobilized from the fertilizers applied to agricultural soils that subsequently move through the soil layers and into the network of underground tile drainage present within this watershed. Historically, V3 has been the predominant source of nitrogen to Lake Volney. TMDL inflow site V3 had the highest mean $NO^2 + NO^3$ concentration in 2009 and 2010, however inflow site V2 contributed the greatest amount of $NO^2 + NO^3$ to Lake Volney.

5.2 C. Internal Loading:

The Bathtub model did not indicate the need for specifying internal load.

5.2 D. Urban and residential sources:

Untreated stormwater runoff is potentially a large contributor of nutrients to Lake Volney. A large amount of storm water can transport materials such as sediment, fertilizers, vehicle fluids/chemicals, leaves and grass clippings. A large number of culverts and storm systems directly enter Lake Volney (Figure 5.2). Many of these culverts transport materials that enter into the lake system, break down, and release additional nutrients. Since the developed areas within the Lake Volney watershed are not part of a MS4 community, they do not have MS4 requirements regarding stormwater discharges. The stormwater loading was calculated using the area of total developed spaces, and multiplying them times the runoff coefficients (ranging from .5 to 1.25 kg/ha) and recorded climatic data. For example, the Lake Volney watershed has approximately 89 ha of urban land use practices; this includes all roads, houses, and any other impervious surfaces within the watershed. Multiplying the mean phosphorus runoff coefficient for urban land uses of 1 kg/ha by 89 ha yields 89 kg of TP derived from urban sources within the watershed. This value was accounted for in the BATHTUB model.

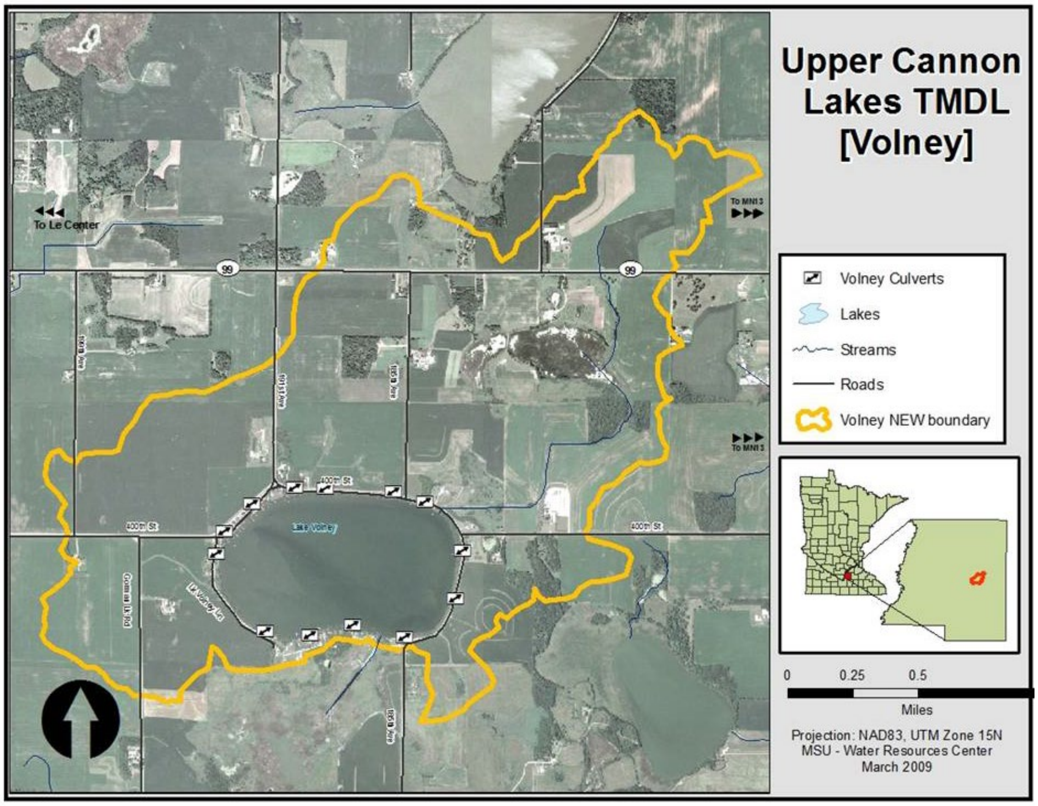

Figure 5.2. Location of culverts/stormwater lines entering into Lake Volney.

5.2 E. Failing SSTS:

Failing Subsurface Sewer Treatment Systems (SSTS), or failing septic systems and/or “straight pipe systems” (systems without proper holding/discharge areas) around Lake Volney are another source of nutrients. The nutrient source from leeching of septage (partially treated sewage), may be considerable even under low flow conditions, because it provides nutrients in the form of OP, a pollutant type that is more readily available for uptake and use by algae. Pro-active implementation and rule enforcement within Le Sueur County’s department of environmental services has significantly reduced the number of failing or straight pipe SSTS within the watershed. It is likely that nutrient input from septic systems is minimal relative to other sources contributing to Lake Volney at this time, but should not be ruled out. Continued implementation at the county level will further reduce this potential nutrient input, as this will be a targeted source within the implementation plan. Pollutant contributions from septic systems were not measured in the TMDL monitoring; therefore, were not accounted for directly in the TMDL nutrient budget.

5.2 F. Atmospheric Loading:

Additional loading to the lake system can result from trace levels of phosphorus carried by precipitation. This type of phosphorus can enter the lake via direct input (rain falling on the lake surface) or transported via overland from stormwater flow.

The additional levels of phosphorus carried through the overland flow or stormwater from the precipitation are difficult to quantify, but best efforts have been made to calculate the loading based on runoff coefficients found in literature. The levels of atmospheric deposition vary based on the quantities of rainfall and climate conditions in an area, considering both wet and dry deposition rates. These levels are discussed in the MPCA report, "Detailed Assessment of Phosphorus Sources to Minnesota Watersheds" (Barr Engineering, 2004).

For the purposes of this TMDL, the rate is estimated to be 0.3 kg/ha/year. Based on the calculated deposition rates, atmospheric loading is a small portion of the overall nutrient load, and potentially insignificant when compared to the external and internal loading sources. It is also important to note that the value, even if small, is important to consider in the overall budget, especially when this loading source is not possible to control. Based on the estimated rate, the total loading value from atmospheric loading is 0.28 lbs/acre/year, or .0007 lbs/acre/day.

∑LA = nonpoint sources as listed above. No specific allocations for each area.

5.3 Margin of Safety (MOS)

The third component, MOS, is the allocation that accounts for uncertainty within the calculation methods, sample data, or the allocations which will result in attainment of water quality standards. The Margin of Safety can either be explicit or implicit.

For the purposes of this TMDL, an explicit 10% MOS in terms of lake TP concentration was selected. The in-lake TP concentration goal, therefore, was 36 µg/L (40 minus 10%). A 10% MOS accounts for the uncertainty that the allocations set forth in this TMDL will result in Lake Volney meeting the required water quality standards. The uncertainties are a result of the presence of multiple non-monitored ephemeral streams, culverts and storm systems, and the potential capacity for internal loading via contributions from sediment during periods of anoxia. However, uncertainties were also minimized by comparing current data with historical water quality data, as well as through the calibration process used in the BATHTUB. Using up to date land-use statistics and accurately defining the watershed boundaries for the Lake Volney watershed further helped to minimize uncertainties; therefore, an excessive MOS was not necessary. Ultimately, incorporating an explicit standard into the BATHTUB model, and subsequently calibrating the model to match observed conditions helped to reduce uncertainty. Many TMDLs within Minnesota have used an explicit standard of 10%; this standard provides additional assurance that lakes will meet water quality standards by requiring the waterbodies to reach a more rigorous goal.

5.4 Reserve Capacity and Future Growth

Within the watershed and contributing areas, there are no NPDES permits (other than construction stormwater) pertaining to nutrient loading. The Lake Volney watershed is not considered to be an area of future development for businesses or industry; additionally, there are no wastewater treatment plants within the watershed. Therefore, any new businesses or industry requiring a NPDES permit for a nutrient discharge would be held under the WLA total limit any discharge to TMDL standards to be required to use a nutrient credit trading system to offset any discharge. The reserve capacity for this TMDL is zero. The MPCA, in agreement with the US EPA Region 5, have developed a streamlined process for wasteload allocations (WLAs) for new and expanding wastewater discharges to waterbodies with EPA approved TMDLs. This procedure will be used to update WLAs in approved TMDLs for new or expanding wastewater dischargers whose permitted effluent limits are sufficiently restrictive to ensure that the effluent concentrations will not exceed applicable water quality standards or surrogate measures. The process for modifying any and all WLAs after TMDL approval will be handled by the MPCA, with input and involvement of the US EPA, once a permit request or reissuance is submitted. The overall process will use the permitting public notice process to allow for the public and US EPA to comment on the changes and recommendations based on the proposed WLA modification(s). Once any comments or concerns are addressed, and the MPCA determines that new or expanded WWTF is consistent with the applicable water quality standards, the permit will be issued and any updates to the TMDL WLA(s) will be made.

5.5 Lake Volney TMDL Summary

The Lake Volney TMDL for total phosphorus is summarized in annual and daily increments to better illustrate the division between WLA and LA, with the LA comprising a majority of the allocation (Table 5.5).

Table 5.5. Total phosphorus wasteload, load allocation, and TMDL.

Load Component	Phosphorus Load (kg/yr)	Phosphorus Load (kg/day)
Wasteload Allocation	0.6	0.002
Load Allocation	324.1	0.887
TMDL	324.7	0.889

5.6 Necessary Reductions

It is helpful to look at TMDLs in terms of reductions necessary to meet the standards. Watershed runoff phosphorus loads need to be reduced 62% overall, with reductions varying from 43% to 69% for individual watershed portions. The same reduction percentages apply to average export and concentrations (Table 5.6). The runoff TMDLs are based on requiring the same runoff concentration (183 µg/L) for each watershed portion.

The atmospheric load is the only load that is not included in Table 5.6; all other loading, including the watershed load's WLA portion, are represented. Internal load is zero due to Canfield-Bachman model incorporating as implicit in BATHTUB.

Table 5.6. Watershed runoff phosphorus loads, exports, concentrations, and reductions.

	Watershed Portion			
Description	**Stream Inflow V2**	**Stream Inflow V3**	**Lake Direct**	**Total**
	Runoff phosphorus load (kg/yr)			
Existing	472.6	122.4	178.9	773.9
TMDL	147.4	41.4	102.3	291.1
Reduction	325.2	81.1	76.5	482.9
Reduction	69%	66%	43%	62%
	Watershed phosphorus export (kg/km^2-yr)			
Existing	145	106	48	95
TMDL	45	36	27	36
Reduction	99	70	21	59
Reduction	69%	66%	43%	62%
	Runoff TP concentration (µg/L)			
Existing	587	542	320	487
TMDL	183	183	183	183
Reduction	404	359	137	304
Reduction	69%	66%	43%	62%

Section 6.0 Implementation Strategy

Implementation of the Lake Volney TMDL will require significant reductions from non-point sources throughout the watershed. Assigning a predetermined reduction amount per implementation practice is not within the scope of this project. There is not enough research to determine the exact phosphorus reduction realized through implementation of individual BMPs. Rather, a list of potential tasks that could be completed in both agricultural and developed portions of the watershed is provided. Further stakeholder involvement is needed to determine how this TMDL aligns with other local plans (e.g. county water plans). Also, the Intensive Watershed Monitoring (IWM) was initiated in the Cannon River Watershed in 2011. The next few years of study in the Cannon River Watershed will allow for further cooperation between water resource professionals. It will also allow the use of adaptive management, which is an iterative implementation process that makes progress toward achieving water quality goals while using any new data and information to reduce uncertainty and adjust implementation activities.

Restoration options for lakes are numerous with varying rates of success. Consequently, each technology must be evaluated in light of our current understanding of physical and biological processes in that lake. Best estimate using professional judgment and review of other projects in similarly sized watersheds is a range from $1,000,000 to $3,000,000. This estimate will be refined as implementation plans and projects are developed. A list of potential activities by land use is listed below:

Potential Agricultural BMPs to promote:

1) Nutrient management plans
2) Crop residue management
3) Wetland restoration potential. One specific area in need of attention is the wetland to the NE of the lake. Land acquisition has been attempted in the past but this approach should not be abandoned.
4) Identification and targeting of highly erodible lands and promotion of appropriate BMPs
5) Identification of agricultural producers who are willing to implement water retention on their land.
6) Drainage considerations:
    a. Determination of potential to redirect drainage outlets through treatment ponds or through water retention basins before directly entering Lake Volney
    b. Implement drainage projects that improve/maintain water quality
7) Utilization of the Agricultural BMP Handbook for Minnesota (MDA, 2012)

Potential Developed Land BMPs to promote:

1) Identification of lakeshore property owners that are willing to implement stormwater BMPs on their property (rain gardens, rain barrels, etc.)
2) Determination of the potential to redirect culverts through treatment ponds or through rain gardens before directly entering Lake Volney.

3) Sewer system audits and upgrades as needed

Potential in-Lake Implementation Activities to promote:

1) Continuation of rough fish harvesting
2) Identification of areas in the littoral zone for re-establishment of native vegetation and implementation
3) Aquatic invasive species and non-native plant management

Section 7.0 Seasonal Variation and Critical Conditions

In Lake Volney, the highest chlorophyll-*a* values generally occur in July through September. This seasonal variation is taken into account in the TMDL goals by using the eutrophication standards, which are based on growing season averages. The eutrophication standards were set with seasonal variability in mind. The load reductions are designed so that the lakes will meet the water quality standards over the course of the growing season (June through September).

Critical conditions in Lake Volney occur during the growing season, which is when the lake is used for aquatic recreation. Similar to the manner in which the standards take into account seasonal variation, since the TMDL is based on growing season averages, the critical condition is covered by the TMDL.

Section 8.0 Reasonable Assurance

Reasonable assurance that the water quality of Lake Volney will be improved is formulated on the following points:

- Availability of reliable means of addressing pollutant loads (i.e. best management practices);
- A means of prioritizing and focusing management;
- Development of a strategy for implementation;
- Availability of funding to execute projects;
- A system of tracking progress and monitoring water quality response;
- Interested and engaged members in the Lake Association.

Accordingly, the following summary provides reasonable assurance that implementation will occur and result in phosphorus load reductions in the Lake Volney watershed.

- The BMPs outlined in the *Cannon River Watershed Management Strategy* have all been demonstrated to be effective in reducing transport of pollutants to surface water. The University of Minnesota Extension Service summarizes phosphorus management strategies: http://www.extension.umn.edu/nutrient-management/phosphorus-management/. This suite of practices is supported by the basic programs administered by the SWCDs and the NRCS. Local resource managers are well-trained in promoting, placing and installing these BMPs. Some watershed counties have shown significant levels of adoption of these practices. Thus, these BMPs constitute the standard means of addressing nonpoint source pollutant loads in the Lake Volney watershed.
- Various projects and tools provide means for identifying priority pollutant sources and focusing implementation work in the watershed:
    - Barr Engineering, Inc. Detailed Assessment of Phosphorus Sources to Minnesota Watersheds. 2004. http://www.pca.state.mn.us//////hot/legislature/reports/phosphorus-report.html
    - The State of Minnesota funded a shoreland mapping project to inventory land use in riparian areas in southeast Minnesota. The project is complete, and the results are available here: http://www.crwp.net/shoreland-mapping/. This information will be used in the implementation planning process to examine riparian land use in the Lake Volney watershed, and prioritize potential BMP installation.
    - Light Detection and Ranging (LIDAR) data are available for all of southeast Minnesota, and being increasingly used by local government units to examine landscapes, understand water flow and dynamics, and accordingly prioritize BMP targeting.
    - Intensive Watershed Monitoring (IWM) was initiated in the Cannon River Watershed in 2011. Inherent in its design is geographic prioritization and focus.

Encompassing site placement across the watershed will allow for a full examination of designated use support, which will be the foundation for subsequent steps, ultimately leading to focused management efforts.
  - In 2008 and again in 2012, the Lake Volney Lake Association commissioned A.W. Research Laboratory to perform an Environmental Assessment Overflight (EAO). The purpose of the EAO was to document existing environmental conditions at residences along the shoreline. Visible and hyperspectral images were taken with aircraft mounted and handheld cameras. The images were analyzed for environmental concerns. The lake association is planning to use the images in future planning and restoration efforts.
- The State of Minnesota (Clean Water Fund) funded development of a watershed management strategy for the Cannon River watershed. This pilot effort constitutes a foundational planning piece that supports and informs local government plans (e.g. local water plans). It was conceptualized and composed by the local watershed partnership (Cannon River Watershed Partnership), which includes a diverse cross-section of stakeholders. The document includes strategies and tools specific to the various landscapes in the watershed. It will be revised and maintained as further prioritization and understanding of pollutant dynamics are made available.
  - Lake Volney: Phosphorus Loading Reduction is called out as a Priority Management Zone in the strategy (Chapter 8-5)
- On November 4, 2008, Minnesota voters approved the Clean Water, Land & Legacy Amendment to the constitution to:
  - protect drinking water sources;
  - protect, enhance, and restore wetlands, prairies, forests, and fish, game, and wildlife habitat;
  - preserve arts and cultural heritage;
  - support parks and trails;
  - and protect, enhance, and restore lakes, rivers, streams, and groundwater.

  This is a secure funding mechanism with the explicit purpose of supporting water quality improvement projects.
- Monitoring components in the Cannon River watershed are diverse and constitute a sufficient means for focusing work, tracking progress and supporting adaptive management. One example is the Citizen Lake Monitoring performed on Lake Volney over the last three decades that has shown an increase in transparency (Figure 10).
- Le Sueur County Activities:

  - The Le Sueur County Local Water Plan: implementation of this plan is ongoing and supersedes other plans for Le Sueur County.

  (http://www.co.le-sueur.mn.us/environmentalservices/LeSueurCountyWaterPlan.pdf)
  - Establishment of a program for cost share on shoreland BMP projects

Further, preliminary results of MPCA trend analysis have documented decreasing total suspended solids and total phosphorus concentrations at the Cannon River Milestone site (S000-003). This provides reasonable assurance in that it suggests that long-term, enduring efforts to decrease erosion and nutrient loading to surface waters have the potential for positive impacts.

Section 9.0 Monitoring

The *Cannon River Watershed Management Strategy* (CRWP, 2011) includes a detailed monitoring plan that is applicable to Lake Volney. There is a long history of data that will allow comparison. A *Citizen Lake Monitoring Program* (CLMP) volunteer regularly monitors water clarity. The median transparency at this lake from 1981 to 2011 increased by 0.70 feet per decade. Given the variability over these years, this is strong evidence for a long-term trend. A plausible range for the long-term trend is between no trend and an increase of 1.68 feet per decade (Figure 10).

The implementation plan will provide further detail on an effectiveness monitoring plan that will discuss site locations, parameters, and frequency. Lake Volney and inlets both included in this TMDL document and otherwise, will be included. Focus will be on areas where significant phosphorus reduction strategies have been placed on the landscape.

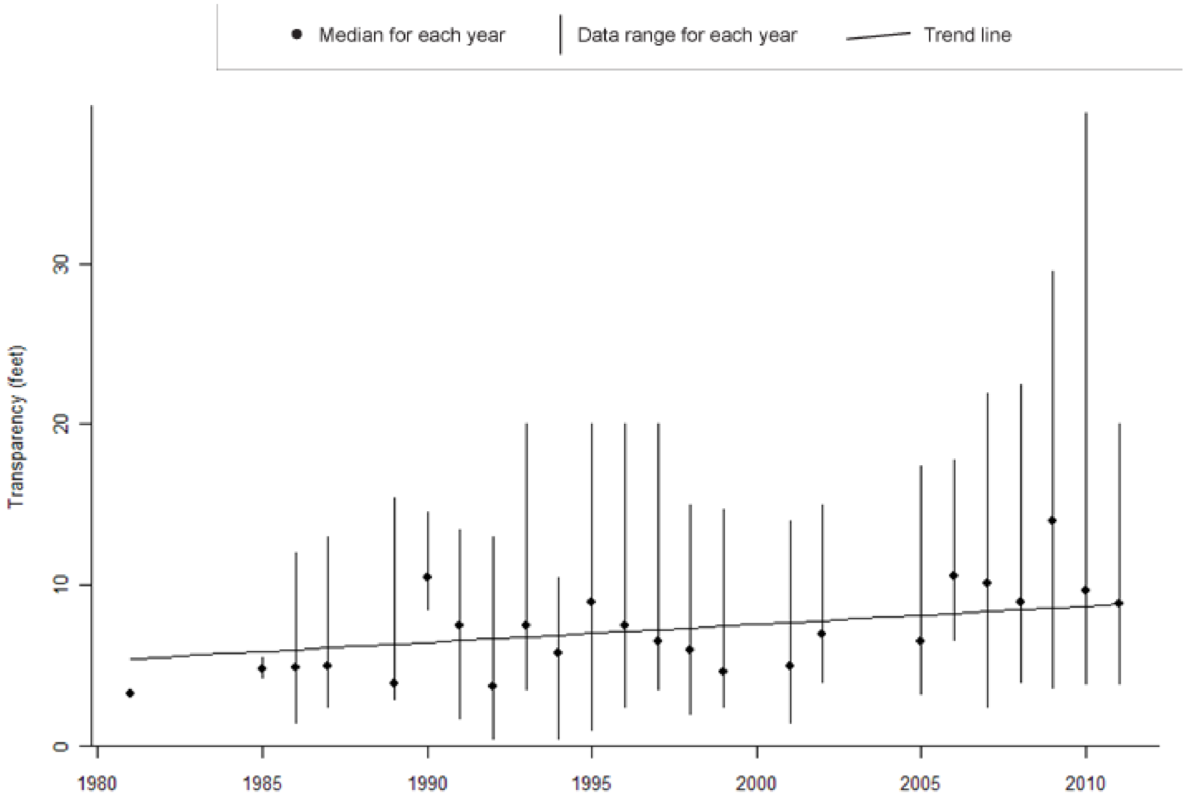

Figure 10. Record of Citizen Stream Monitoring data from Lake Volney from 1981-2011.

Section 10.0 Public Participation

Public participation and involvement are important in the successful design, review, and implementation of a TMDL study. For this reason, the UCL TMDL project worked closely with a broad array of county, state and citizen groups and organizations.

To address the broad interests involved in the project, the technical advisory team was created and was composed of various representatives of stakeholders groups to help ensure that all groups would remain up to date and able to raise concerns and/or opinions as necessary.

The Technical group included state, and local government employees, research groups and projects, and joint powers boards. Agencies on the mailing and contact lists included SWCD, MPCA, CRWP, BWSR, MSU, DNR, County Employees, and LVLA members.

Stakeholder and Advisory Meetings

- Organized & hosted public/stakeholder open house meeting on April 22nd, 2009. This meeting was held at St. Paul's Lutheran Church, which is in close proximity to Lake Volney. The overall objectives for the TMDL study were discussed at this time. A large number of stakeholders and concerned citizens voiced their opinion in regards to different aspects of the study. All of these opinions were documented and implemented into the overall project design.

- Stakeholder Meeting November 12th 2009: The WRC at MSU, Mankato in conjunction with the MPCA, and CRWP provided a PowerPoint presentation highlighting progress made to date. A majority of the presentation focused on water quality data collected during the 2009 season as well as results from the aquatic plant survey conducted in 2009. This information was presented by Katie Brosch Rassmussen and Joe Pallardy of the WRC at MSU, Mankato. Shaina Keseley of the MPCA provided additional data regarding the overall TMDL process. All questions and input from stakeholders were addressed accordingly at this time.

- Technical Committee Meeting June 17th 2010: The WRC at MSU, Mankato in coordination with the MPCA, Le Sueur County, and the CRWP held a technical meeting. A large amount of information was discussed at this time, including many historical and future implementation strategies. People from the previously mentioned groups were in attendance.

- Implementation Meeting April 20th, 2011: Joe Pallardy of the WRC at MSU, Mankato met with Hugh Valiant of the MNDNR and three of the property owners that own land that directly borders the wetland complex in the Lake Volney watershed to discuss potential wetland restoration options.

- Lake Association/Stakeholder Meeting May 21st, 2011: Shaina Keseley from the Minnesota Pollution Control Agency (MPCA) and Joe Pallardy of the WRC at MSU, Mankato presented a draft of the Lake Volney TMDL to the LVLA. Aaron Willis of the CRWP provided technical support and helped to arrange the meeting location. Members of the LVLA were given the chance to ask questions about the TMDL. The members of the LVLA were supportive of findings from the TMDL study.

Websites, Mailings, and Citations in Newsletters

- The CRWP website maintained updates on the progress of the TMDL study on their websites www.cwrp.net
- In May 2010, CRWP sent out a newsletter to Lake Volney property owners with information highlighting progress made on the TMDL study to date.
- The CRWP sent out a mailing to all stakeholders within the Lake Volney watershed informing stakeholders of the November 12th, 2009 meeting.
- The CRWP sent out a mailing to all stakeholders within the Lake Volney watershed informing stakeholders of the April 22nd, 2009 meeting.
- A press release was sent out to local newspapers informing area residents of the April 22nd, 2009 and November 12th, 2009 meeting.

Public Notice

This TMDL study was open for public comment from December 9, 2013 to January 9, 2014 and then again for an extended public comment period from February 17 to March 3, 2014. Four public comment letters were received and responded to.

Section 11.0 References

Anoka County. Soil Associations. Nessel-Dundas-Weber. 2011. http://www.anokanaturalresources.com/soil/index.htm

Barr Engineering Company. 2004. Detailed Assessment of Phosphorus Sources in Minnesota Watersheds. Prepared for Minnesota Pollution Control Agency. http://www.pca.state.mn.us/index.php/view-document.html?gid=3960

Canfield, D.E. Jr., and R. W. Bachman. Prediction of total phosphorus concentrations, chlorophyll *a*, and Secchi depths in natural and artificial lakes. Canadian Journal of Fisheries and Aquatic Science. 38: 414-423.

Cannon River Watershed Partnership, (2011). Cannon River Watershed Management Strategy. Prepared under contract of Minnesota Pollution Control Agency. http://crwp.net/about/watershed-strategy/

Heiskary, Steven A. and W. W. Walker, Jr.. 1988, Developing Phosphorus Criteria for Minnesota Lakes. Lake and Reservoir Management 4(1):1-9.

Le Sueur County. 1994. Jefferson-German Lake Complex Restoration Project. A Clean Water Partnership Project Part 1. Diagnostic-Feasibility Study.

Minnesota Department of Agriculture, Emmons and Olivier Resources, Inc. 2012. Agricultural BMP Handbook for Minnesota. (http://www.eorinc.com/documents/AG-BMPHandbookforMN_09_2012.pdf)

Minnesota Department of Natural Resources. 2011. The Minnesota Department of Natural Resources Web Site (online). Accessed 2011-2-14 at http://www.dnr.state.mn.us/lakefind/showreport.html?downum=40003300

Schuler, David. (1997). Lake Volney Diagnostic Study. Publication No.1 Planning and Zoning Administration, LeSueur County.

Walker Jr., William W. and R. H. Kennedy (1985). Simplified Techniques for Assessing Eutrophication-related Problems in Reservoirs. Environmental and Water Quality Operation Studies, Volume E-85-1.

Wilson, C. Bruce (1987). Lake Assessment Program: Lake Volney. MPCA. St. Paul, MN 26pp.

Wilson, C.B., and W. W. Walker, Development of Lake Assessment Methods Based Upon the Aquatic Ecoregion Concept. Lake and Reservoir Management 1989 5(2): 11-22.

Section 12.0 Appendices

Appendix A: MPCA Biological Monitoring Report for the Lake Volney Wetland

Biological Monitoring Report: Lake Volney Wetland
John Genet & Mark Gernes
February 2011

South Biological Monitoring Unit
Environmental Analysis and Outcomes Division
Minnesota Pollution Control Agency
St. Paul, MN 55155

Minnesota Pollution Control Agency

In the summer of 2010 Minnesota Pollution Control Agency (MPCA) staff biologists collected wetland plant, macroinvertebrate, and water chemistry data from a large wetland complex located in the northeastern corner of Lake Volney's watershed. Additionally, a Minnesota Routine Assessment Method (MnRAM version 3.0) was performed to evaluate the ecosystem services and societal values this wetland provides. The purpose of this monitoring was to characterize the biological condition of this wetland and gain a better understanding of this wetland's role in the watershed regarding nutrient retention and export.

Lake Volney Wetland

We call this wetland the "Lake Volney Wetland". According to the DNR's Public Waters Inventory, the Lake Volney wetland is unnamed and has a Division of Water's Lake ID of 40-0022-00. It is approximately 63 acres and is bisected by a field access road that splits the wetland into a smaller western basin and a larger eastern basin (connected via a culvert). Both basins are largely comprised of dense, emergent marsh vegetation with pockets of open water and submerged aquatic vegetation. Based on attempts to gain access to the interior portions of the Lake Volney wetland during field survey work it appears that the majority of the emergent vegetation in this wetland is dominated by a floating mat of cattails (*Typha* X *glauca* and *Typha angustifolia*) over a water column of varying depths.

Surface water enters the Lake Volney wetland via three inlets which are distributed along the North side of the wetland (Figure 10.1) as well as through several drain tiles (Schuler 1997). The landscape of this wetland's catchment area is largely agricultural; only inlet 3 drains an area that is primarily native vegetation. The outlet is located in the southeast corner of this wetland where surface water then flows approximately 1.5 km before entering Lake Volney.

MPCA Wetland Monitoring

MPCA staff visited Lake Volney wetland on June 21, 2010 to collect aquatic macroinvertebrate and water chemistry data. Aquatic macroinvertebrate samples were collected from locations A and B (Figure 10.1) with D-frame dip nets. The resulting data from these samples were used to calculate an index of biological integrity (IBI) score, an indicator used to assess the condition of the wetland. A macro-invertebrate IBI score (0 -100 range) was generated for each sample. Water chemistry samples were collected from locations A and B as well as from inlets 1-3. Water temperature, pH, specific conductance, and dissolved oxygen were also measured at these locations using a Hach meter (HQ40d18). Transparency was measured using a 100 cm transparency tube (T-tube).

On July 8, 2010 MPCA staff visited Lake Volney wetland to collect wetland plant and water chemistry data as well as perform a functional assessment of the wetland. The wetland plant community was characterized at locations A and B (Figure 10.1), recording the presence and estimated relative cover of species occurring within 10m x 10m sampling plots. This plant community data was used to calculate an IBI score (0-100 range) for each location. Water chemistry data was collected from the three inlets during this sampling visit. The MnRAM functional assessment that was conducted considered the entire wetland basin (western & eastern portions) during the evaluation.

Monitoring Results & Discussion

Macroinvertebrate IBI scores for Lake Volney Wetland were 45 and 38 for locations A and B, respectively. Compared to least-disturbed regional reference sites these scores are indicative of a poor

Figure 10.1. Aerial photograph (2008) of Lake Volney Wetland indicating the location of wetland sampling stations (A&B) and inlet water chemistry stations.

aquatic macroinvertebrate community. Based on the samples that were collected, the macroinvertebrate community of Lake Volney wetland can be described as having low overall taxa richness, very few sensitive taxa, and moderate densities of tolerant individuals. At both sampling locations, it was difficult to obtain 'clean' invert samples due to the thick layer of duckweed that covered the water surface (Figure 2). This inhibited field picking, a process used to separate macroinvertebrates from the detritus and vegetation that also gets collected while sweeping the dip net through the water column, and may have lowered the resulting IBI scores.

Plant IBI scores from the Lake Volney wetland were 25 and 9 in sampling locations A and B, respectively. Compared to data and IBI scores from least disturbed reference wetlands from this region of the state these scores indicate a wetland in poor condition based on the aquatic plant community. A total of 11 plant species were observed, and the five dominant species (*Typha X glauca*, *Typha angustifolia*, *Lemna minor*, *Ceratophyllum demersum* and *Phalaris arundinacae*) are generally considered to be tolerant of pollution and disturbance.

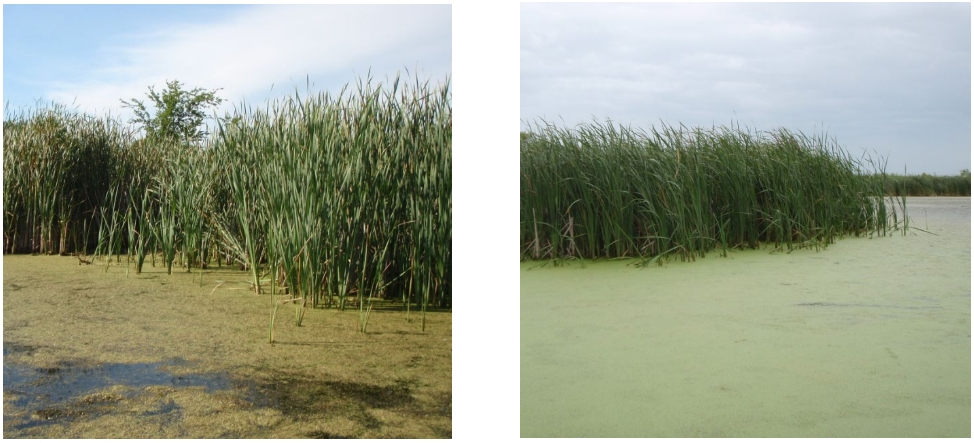

Figure 10.2. Macroinvertebrate sampling locations A (left) and B (right) within Lake Volney Wetland. Photos taken on June 21, 2010.

Water chemistry results from the two locations within Lake Volney Wetland and its three inlets are presented in Table 1. Similar to the biological indicators, some of the water chemistry parameters can be compared to the range of values obtained at least-disturbed reference sites occurring within the same ecoregion. At location A, transparency, nitrate+nitrite, and sulfate concentrations were within the range of values obtained at reference sites, while total phosphorus and total chloride were above this range. At location B transparency was the only parameter within the range of values obtained at reference sites, while total Kjeldahl nitrogen, nitrate+nitrite, total chloride, and total sulfate concentrations were all considered elevated. Total phosphorus concentrations at location B were considered intermediate, occurring above the 75th percentile of the reference site distribution of phosphorus concentrations.

Overall, there are indications that the aquatic macroinvertebrate and wetland plant communities are being impacted by elevated nutrient concentrations (relative to reference sites) entering this wetland from adjacent agricultural areas. Low dissolved oxygen concentrations, an overabundance of submerged aquatic and floating-leaved plant growth (*pers. obs.*), and high nitrate+nitrite concentrations all likely contribute to the low macroinvertebrate IBI scores observed within this wetland. Nutrient loading to the Lake Volney wetland has very likely adversely impacted the plant community at this wetland and promoted dominance by pollution tolerant species. Though no quantitative data are available on hydraulic loading to the wetland it is likely that water level fluctuations in this wetland are not in the normal range as evidenced by the formation of *Typha* mats within the wetland and free floating species (*Lemna minor* and *Ceratophyllum demersum*) dominating in the open water pockets.

According to MnRAM, Lake Volney wetland was rated high for the following functions: flood attenuation and protection of downstream water quality. Unfortunately, the MnRAM assessment tool is a qualitative estimate of functional capacity based on landscape setting and it doesn't take into consideration the possibility of a wetland exceeding its capacity to retain nutrients. Therefore, even though Lake Volney wetland is well positioned in the landscape to protect downstream water quality, the amount of nutrients and other pollutants entering this wetland over the years is likely to have accumulated to a point where this wetland is no longer able to sufficiently perform this function and may in fact be a source of nutrient loading downstream to Lake Volney. Previous studies in this watershed suggest that this may be the case (e.g., Schuler 1997). Maintenance of wetland water quality, characteristic hydrologic regime, characteristic wildlife habitat structure, and characteristic fish habitat functions were all rated as medium. The vegetative diversity/integrity function and the aesthetics/recreational value of this wetland were both rated as low.

Table 10.1 Water chemistry data from Lake Volney Wetland and three of its main surface water inlets.

Analyte	Sample	Wetland Sites		Inflow Sites		
	Date	Location A	Location B	Inlet 1	Inlet 2	Inlet 3
Water Temperature (°C)	6/21/2010	21.0	20.3	17.4	18.0	18.0
	7/8/2010	no data	no data	18.7	20.3	20.2
Transparency (cm)	6/21/2010	> 100	> 100	> 100	no data	no data
	7/8/2010	no data	no data	> 100	73.5	24.6
Color (PCU)	6/21/2010	80	70	no data	no data	no data
	7/8/2010	no data	no data	no data	60	50
Dissolved Oxygen (mg/L)	6/21/2010	1.86	0.26	0.61	5.62	3.66
	7/8/2010	no data	no data	0.70	5.60	6.49
pH	6/21/2010	6.85	7.22	7.21	7.63	7.29
	7/8/2010	no data	no data	7.14	7.54	7.00
Specific Conductance (*u* S/cm)	6/21/2010	683	842	903	935	891
	7/8/2010	no data	no data	929	913	877
Total Phosphorus (mg/L)	6/21/2010	1.08	0.237	0.252	0.128	0.626
	7/8/2010	no data	no data	0.366	0.159	0.395
Nitrate+Nitrite Nitrogen (mg/L)	6/21/2010	< 0.05	5.3	12	13	0.09
	7/8/2010	no data	no data	8.4	10	0.46
Total Kjeldahl Nitrogen (mg/L)	6/21/2010	2.35	3.12	2.32	2.34	1.06
	7/8/2010	no data	no data	1.63	1.21	1.06
Total Organic Carbon (mg/L)	6/21/2010	20	13	10	8.3	10
	7/8/2010	no data	no data	9.9	8.5	6.2
Total Chloride (mg/L)	6/21/2010	48.5	38.4	39	35.6	65.8
	7/8/2010	no data	no data	41	34.8	46.8
Total Sulfate (mg/L)	6/21/2010	2.54	49.9	56.1	56.9	13
	7/8/2010	no data	no data	58.3	52.8	22.5
Flow Observations	6/21/2010	n/a	n/a	no flow	minimal flow	no flow, intermittent
	7/8/2010	n/a	n/a	no flow		no flow, intermittent

The work by Schuler (1997) suggested that the Volney Lake wetland may be an important source of nutrient loading to Lake Volney. The findings from the 2010 field work we conducted support the assertion that this wetland has experienced and continues to experience significant nutrient loads. Interestingly, the photos in Figure 2, the grab sample chemistry findings from inlets 1, 3 & 2 as well as the invertebrate and plant community results all suggest the western 1/3 of the wetland to be under greater stress than the eastern 2/3. The June and July grab sample results suggest phosphorus concentrations to be greater in the western section compared with the eastern 2/3 of the wetland. Because quantitative flow data is not available it is not clear whether the mass load differs between inlet 1 and 2. However, because of the close proximity of inlet 2 to the wetland outlet, inputs to the majority of wetland could be expected to be lower due to hydraulic short circuiting from the inlet almost directly to the outlet. Thus the load retention time from inlet 2 would be expected to lower. In contrast, the load from inlet 1 would be expected to have a longer retention time due to the field road "berm" restricting flow through the wetland. It is not known when this field road was installed, but it appears to have been at least partially present in the early 1950's as evident on historic 1951 aerial photos available at http://www.dnr.state.mn.us/maps/landview.html . This historic photo further suggests that the current land use conditions within the Lake Volney wetland catchment to have been present for at least 60 years. Loading of sediment and nutrient into this wetland has been going on a long time which further substantiates a contention that the wetland has likely reached its' capacity as a nutrient (phosphorus) sink and without management intervention it can be expected to be a net exporter of phosphorus.

Continuous flow based nutrient inputs and outputs as well as detailed characterization of the internal phosphorus load coming from the wetland sediments would be needed to conclusively determine if the wetland is in fact a bioreactor nutrient pump as Schuler suggested in 1997. Flow based modeling of inlet (and outlet) loads and characterization of the wetland sediments was beyond the scope of our normal wetland work.

Appendix B: Lake Volney Vegetation Surveys

Introduction

Staff from MSU-Mankato's Water Resource Center in coordination with the Minnesota Pollution Control Agency used a point-intercept sampling technique to provide a representative sample of the aquatic plant community in Lake Volney. A 100*100 meter grid was created using a geographic information systems (GIS) process. Hawth's Analysis Tools for Arc GIS was used to outline the image of each lake basin; the 100*100 meter grid was then placed over the outlined image of each lake basin.

The point-intercept method allows researchers to sample a variety of points that include locations near shore and off shore while ensuring that the entire lake basin is included (Madsen, 1999). The point-intercept method is used by both the Wisconsin and Minnesota Department of Natural Resources because it provides a less subjective and statistically appropriate method of sampling across all lake types (Madsen, 1999). The grid points were then downloaded to a handheld GPS device. We used the Garmin E Trek Legend because of its capability to store waypoints, therefore being useful in the field to locate each GPS sampling location.

Methods

At each site, a sample was taken using a 3 m (10 ft.) double headed rake extended to the bottom of the water column and into the top layer of sediment. The depth and sediment type present was also recorded at each site. The person operating the "rake sampler" twisted the rake two times in the sediment in an attempt to grab any macrophytes at the present location. The rake sampler method is described as the best means of getting a representative sample at each locale (UWSP, 2008). At locations under 3 m (10 ft) it is recommended to use a pole sampling method. At locations over 3 m a double headed rake attached to the end of a rope was used (UWSP, 2008). At locations over 3 m, the rake was allowed to fall to the bottom of the lake and into the top layer of sediment, and then retrieved back to the surface. The size of the rake head is the same for both techniques, therefore, the area sampled was similar.

Each rake sample was then carefully lifted up through the water column and any plants that were attached to the rake were identified and recorded. Additionally, at each site the abundance of each species and the overall rake was rated on a 0-4 scale; 0 = no plants present, 1 = plants filling < 1/3 of the rake head, 2 = 1/3 < plants filling < 2/3 of the rake head, 3 = plants filling > 2/3 of the rake head, 4 = plants over the entire top of the rake (Crowell, 2006). The following two plant identification keys were used during each sampling round: Wetland Plants and Plant Communities of Minnesota and Wisconsin (Eggers and Reed, 1997) and Through the Looking Glass (Borman et al., 1997). This process was repeated at each of the intercept points until the grid was completed (Crowell, 2006).

Calculations of plant diversity

The calculation of species diversity used was the floristic quality index (FQI) and was chosen as the only necessary calculation needed in response to the extremely poor quality of species sampled. A FQI is useful for several reasons; the most applicable reason for this study is that the

FQI allows for a means of comparison between lakes (Swink and Wilhem, 1994; Rocchio, 2007). A FQI uses aspects of both conservation and rarity to allow for a representative calculation to be made that will help to determine how much disturbance a given lake might have experienced (Rocchio, 2007).

Every macrophyte in the state of Minnesota has been assigned a coefficient of conservatism value (c-value) ranging from 0 to 10. The c-value of all macrophytes sampled from a lake is used to determine the FQI for a given lake. Species with a c-value of 0 include species like CLP because this species is non-native and indicative of a highly disturbed environment. In comparison, a species like Oakes pondweed (*Potamogeton oakesainus*) has a c-value of 10 because this species is extremely rare and only found in undisturbed, pristine settings.

Floristic Quality Index (FQI)

$FQI = C * \sqrt{S}$

$\bar{C}$= Mean coefficient of conservatism value

S= Number of species in sample

Results from 5/12/2009 Point Intercept Survey

Anthropogenic changes to shoreline habitat and the introduction of CLP have resulted in a lake environment that is not capable of supporting a high level of floristic diversity. Curly-leaf pondweed and sago pondweed were the only two species of plants found in Lake Volney's basin. In addition to a low level of species diversity, only 18/113 (16%) of locations sampled on Lake Volney had any macrophytes present. Efforts to reestablish macrophytes within the Lake may provide a valuable means of combating the algal blooms that occur annually. The FQI score for May 12th survey conducted on Lake Volney is 2.12. Curly leaf pondweed was the most predominate species sampled during the May survey, and was found at all 18 of the locations that supported any type of macrophyte within Lake Volney (Figure 10.3).

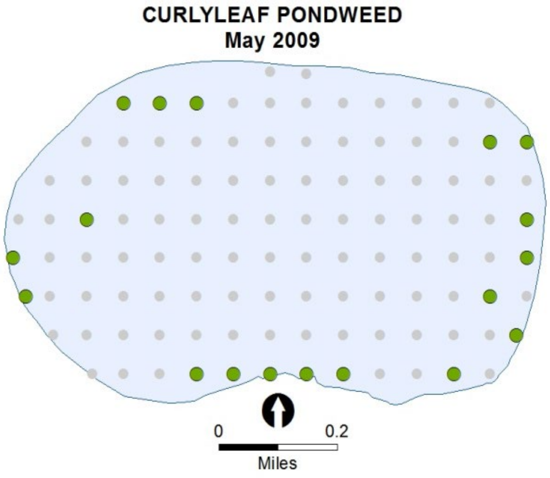

Figure 10.3. Curly-leaf pondweed distribution on Lake Volney, May 12th, 2009.

Results from 8/11/2009 Point Intercept Survey

Results from the second point intercept survey conducted on Lake Volney indicate that a majority of Lake Volney is not conducive to growing macrophytes for three reasons. First, Lake Volney is extremely deep compared to most other lakes within the North-Central Hardwood Forest Ecoregion, and therefore most plants cannot grow at these deeper depths (Figure 10.4). Secondly, according to Steve McComas of Blue-Water science, the sediment in Lake Volney is not conducive for macrophyte growth. A large majority of the sediment in Lake Volney is sandy and contains low levels of organic matter near shore where plants would be expected to grow. Thirdly, many of the lakeshore residents have removed emergent vegetation such as cattails, bulrushes, and reeds from their shoreline. Therefore, the near shore plant communities consist mainly of manicured lawns that lack species diversity. The overall FQI score for all macrophytes found during the August survey was 2.31.

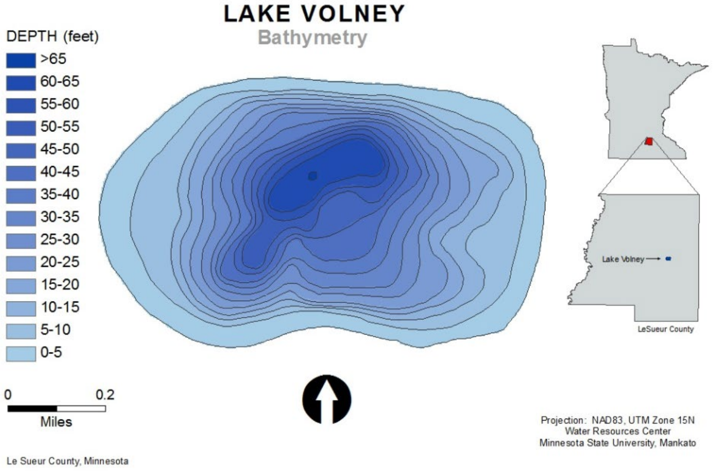

Figure 10.4. Bathymetric map of Lake Volney located in Le Sueur County, MN.

Appendix C: Blue-Green Algae Rapid Response Summary

Lake Volney – 7/23/2009
Le Sueur County, Minnesota

APHANIZOMENON (blue green) bloom

- 2 reported rashes in children (1 with a fever) after swimming and not showering
- 1 reported dog illness (near death), after playing fetch in the water

Two samples collected:

- Lake Volney: Sample #1 (mid-lake)
  14:30 DST on 7/23/09
    - 44° 22' 9.45"N, 93° 38'24.88" W
    - Dissolved oxygen: 14.05 mg/L
    - Temperature: 24.6° C
    - Specific Conductivity: 331.3 µS/cm
    - pH: 9.11
    - Secchi: 1.15 meters
- Lake Volney: Sample #2 (near dock)
  YSI sonde measurements from 7/22/09 at 10:00 DST
    - DO: 12.04 mg/L
    - Temp: 22.77° C
    - Specific Conductivity: 396 µS/cm
    - pH: 9.17
    - Secchi: 1.9 meters
    - Chlorophyll a – 61.3

Description of bloom:

An Aphanizomenon bloom was evident on Lake Volney from 7/8/09 to 8/1/09. The lake had an overall pea green hue when the sun was shining on the water; however the clarity of water was not exceedingly poor due to the type of bloom. Secchi readings were still greater than one meter. Aphanizomenon was seen throughout the entire water column, several small clumps of aphanizomenon (most less than one inch in diameter) were observed. On wind driven shores, the clumps were more dominant. Larger clumps have been seen near the boat landing

Appendix D: Inlet/Outlet Sampling Results for Lake Volney

Sampling Results Summary:

Water quality data was collected from two inflow sites (V2 and V3) and one outflow site (V4) during the 2009 and 2010 monitoring seasons (Figure 1). Additional grab samples were collected on 2-4 occasions at three additional inflow sites; however no flow data was recorded with this data.

All water quality samples were taken from the middle of each monitoring location where the thalweg (or channel) is deepest. Each monitoring location contained a reference point that is used to determine the measured stage. The measured stage is used to ensure that the stage read by the monitoring equipment (gauge height) was accurate. A difference of 0.03 between the two devices was maintained. Flow data and water quality samples were used to calculate mean weighted flows for nutrients entering Lake Volney. As samples were collected, a transparency tube reading, general weather, and general notes were recorded. Water quality samples were sent to Minnesota Valley Testing Laboratories (MVTL) for analysis.

Monitoring Location V2 Northeast Corner of Lake Volney:

Inflow site V2 is located on a ditch adjacent to a feedlot that is adjacent to 400th street near Le Center, MN. The ditch enters on the north east side of Lake Volney (Figure 1). In 2009 V2 was equipped with an ISCO 2150 area velocity flow module and sensor which use continuous wave Doppler technology to measure mean velocity. The sensor transmits a continuous ultrasonic wave, and then measures the frequency shift of returned echoes reflected by air bubbles or particles in the flow. Level or stage measurements are achieved by a differential pressure transducer. The equipment takes a reading every 3 minutes, averages the data, and compiles the stage and velocity data every 15 minutes. Stage and velocity data were stored on the module until the data was downloaded using Flowlink® software installed to a PC. In 2010, it was decided that V2 would be better equipped with an INW9805 submersible pressure transducer that was connected to a CR 1000 datalogger. The pressure transducer was used to measure the stage height. The equipment recorded a stage reading every 3 minutes, averaged the data, and compiled the stage data every 15 minutes. This data was then downloaded and stored on a PC using PC 200W software. Water quality samples were taken 22 times in 2009 and 36 times in 2010 with an emphasis placed upon sampling during or following storm events (Table 1). The 2009 sampling season began on 3/24 with the collection of grab samples and flow measurements; monitoring equipment was installed on 3/27. The 2009 monitoring season ended on 11/09 with the final grab sample collection and removal of equipment. The 2010 sampling season began on 3/17 with the installation of monitoring equipment and the collection of water quality grab samples. The 2010 season ended on 11/02 with the final grab sample collection and removal of equipment.

Site V7 is located near the intersection of 400th street and 185th avenue in Le Center, MN. It is the point where the ditch containing sample site V2 actually enters Lake Volney. The purpose of collecting grab samples at this location was to verify the presence/absence of a significant change in the mean concentration of nutrient parameters at monitoring location V2 verses at the point where this ditch system enters Lake Volney. Water quality samples taken on April 20th indicated that a significant difference was not present; therefore sampling downstream of V2 was decidedly unnecessary.

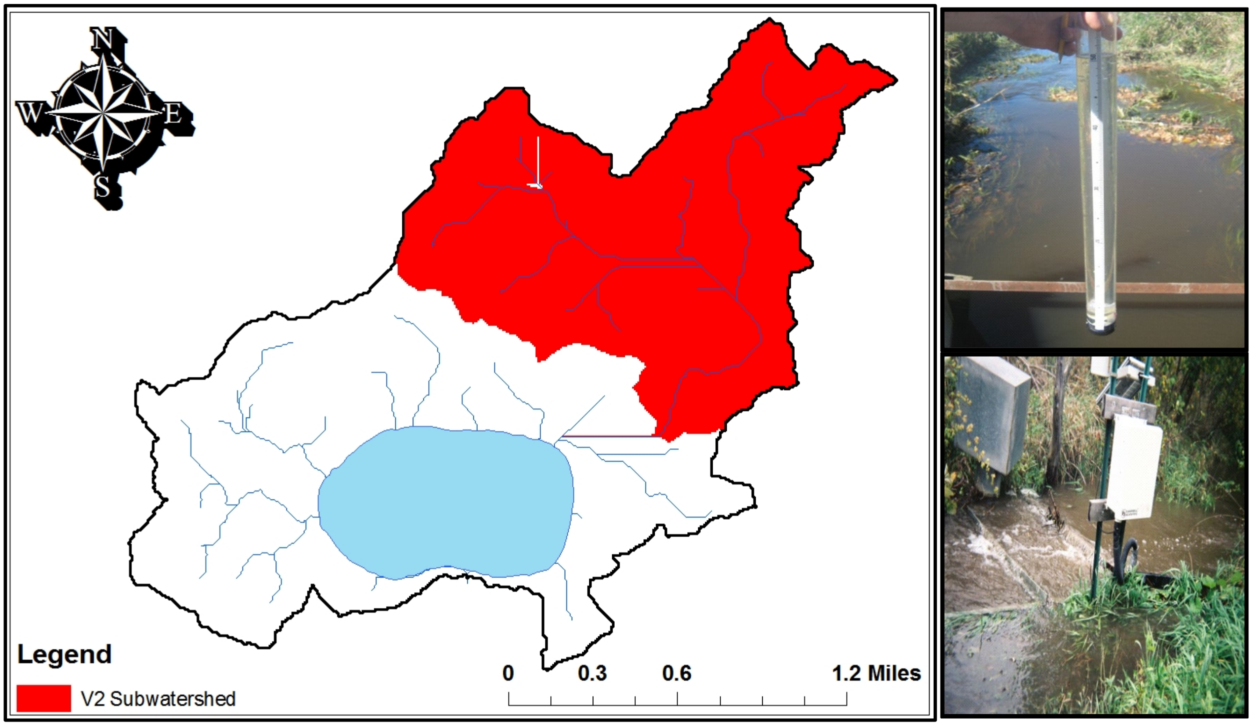

Figure 1. Monitoring location V2 sits on a ditch on the northeast corner of Lake Volney. Picture on top right shows a transparency tube reading during a routine sample and bottom right shows the site during a rain event, where the water level was so high that it topped over the flume.

Table 1. V2 water quality data summation for 2009/10 monitoring season.

2009	TP (mg/L)	NO_3–$N0_2$ (mg/L)	TSS (mg/L)	PO4 (mg/L)	% PO4	*T-Tube (cm)
Average	0.50	2.28	26.77	NA	NA	51.42
Max	2.31	7.92	386	NA	NA	60.00
Min	0.179	0.1	1	NA	NA	2.5
Number of samples taken	22	22	22	NA	NA	22
2010	**TP (mg/L)**	**NO_3–$N0_2$ (mg/L)**	**TSS (mg/L)**	**PO4 (mg/L)**	**% PO4**	***T-Tube (cm)**
Average	0.55	2.17	37.79	0.34	57.08	44.62
Max	1.51	10.70	478	.73	80.75	60.00
Min	0.05	6.09	2.00	0.05	19.76	3.80
Number of samples taken	36	36	36	26	26	36

* The actual T-Tube reading was often greater than 60 cm.

Monitoring Location V3 Western Shore Lake Volney:

TMDL inflow site V3 is located off of Lake Volney Lane, in Le Center Minnesota. The ditch at this location flows underneath Lake Volney Lane and into Lake Volney (Figure 2). In 2009 and 2010, V3 was equipped with an INW9805 submersible pressure transducer that was connected to a CR 1000 datalogger. The pressure transducer was used to measure the stage height. The equipment recorded a stage reading every 3 minutes, averaged the data, and compiled the stage data every 15 minutes. This data was then downloaded and stored on a PC using PC 200W software. Water quality samples were taken during 29 sampling events in 2009; a total of 31 samples were generated during these sampling events. Water quality samples were taken during 36 sampling events in 2010; a total of 37 samples were taken during this time (Table 2). The 2009 sampling season began on 3/24; however equipment was not officially installed at this site until 4/1. The last water quality sample was taken on 11/5; all equipment was removed at this time. The 2010 sampling season began on 3/12 with the installation of sampling equipment and ended on 11/1 when all equipment was removed.

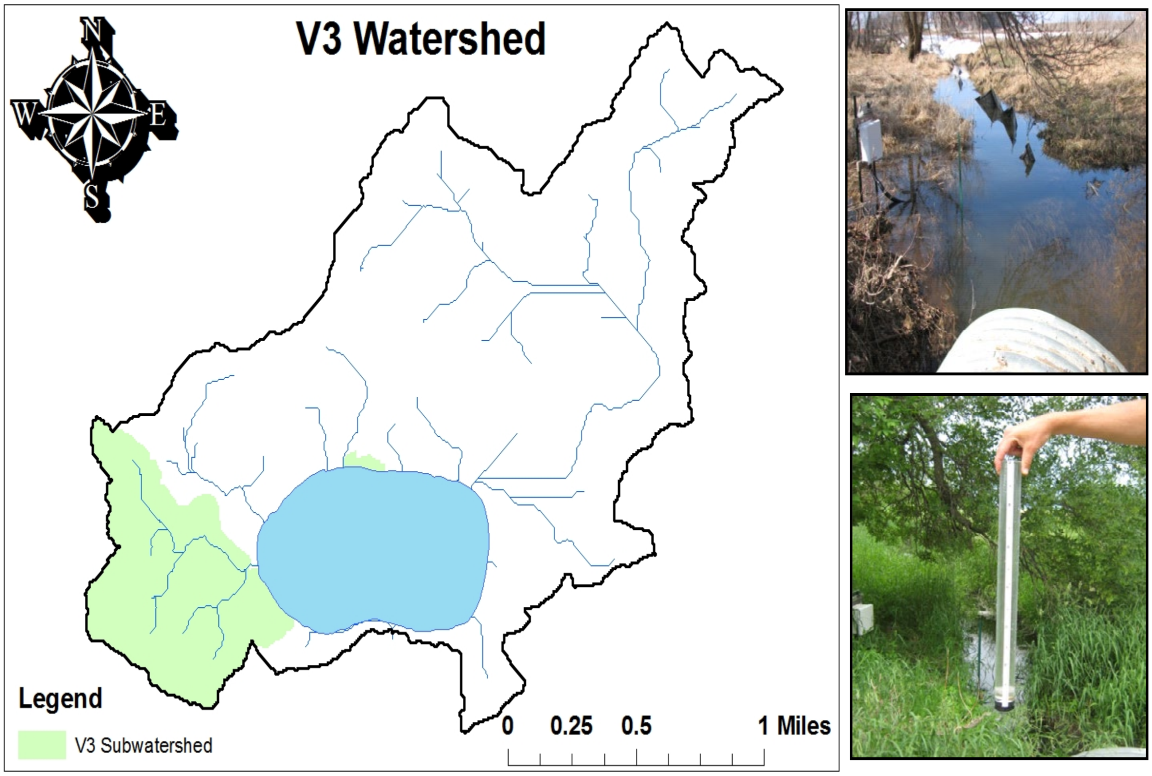

Figure 2. Monitoring location V3 on the west side of Lake Volney. Picture on top right shows sight just after snowmelt and bottom right shows site during routine sampling with correlating transparency tube.

Table 2. V3 water quality data summation for 2009/10 monitoring season.

2009	**TP (mg/L)**	**NO_3–$N0_2$ (mg/L)**	**TSS (mg/L)**	**PO4 (mg/L)**	**% PO4**	***T-Tube (cm)**
Average	0.31	14.26	27.65	NA	NA	48.3
Max	0.873	18.4	114	NA	NA	60
Min	0.109	6.59	3	NA	NA	5.4
Number of samples taken	27	27	27	NA	NA	27
2010	**TP (mg/L)**	**NO_3–$N0_2$ (mg/L)**	**TSS (mg/L)**	**PO4 (mg/L)**	**% PO4**	***T-Tube (cm)**
Average	0.21	14.50	11.97	0.15	78.28	55.26
Max	1.77	19.60	254.00	0.76	99.44	60
Min	0.089	3.11	1	0.077	42.9	2.5
Number of samples taken	37	37	37	26	26	37

* The actual secchi disk was often greater than 60 cm.

Monitoring Location V4 Outlet for Lake Volney:

The outflow site V4 was located off of Beach Lane that intersects 185th avenue in Le Center, MN on the southwest shoreline (Figure 3). The site was equipped with a single ISCO 2150 area velocity flow module and sensor in 2009, no rain gauge was present at this location. The 2150 Flow Module uses continuous wave Doppler technology to measure mean velocity. The sensor transmits a continuous ultrasonic wave, and then measures the frequency shift of returned echoes reflected by air bubbles or particles in the flow. Level or stage measurements are achieved by a differential pressure transducer. The equipment takes a reading every 3 minutes, averages the data, and compiles the stage and velocity data every 15 minutes. Stage and velocity data were stored on the module until the data was downloaded using Flowlink® software (Table 3). In 2010, Le Sueur County replaced both the monitored culvert and an adjacent collapsed culvert with two brand new culverts. Two ISCO 2150 area velocity sensors were used at this location in 2010, with both of the area velocity sensors installed on mounted plate boards that stretched the entire width of the culvert.

Figure 3. TMDL outflow monitoring site V4 is located on the southern shoreline of Lake Volney (indicated on map by arrow). Picture on top right shows site during routine sampling with correlating transparency tube and bottom right shows site after a rain event.

Table 3. V4 water quality data summation for 2009/10 monitoring season.

2009	**TP (mg/L)**	**NO_3 –$N0_2$ (mg/L)**	**TSS (mg/L)**	**PO4 (mg/L)**	**% PO4**	**T-Tube (cm)***
Average	0.18	0.24	5.46	NA	NA	58.34
Max	0.377	0.43	26	NA	NA	60
Min	0.09	0.1	1	NA	NA	45.4
Number of samples taken	13	13	13	NA	NA	13
2010	**TP (mg/L)**	**NO_3 –$N0_2$ (mg/L)**	**TSS (mg/L)**	**PO4 (mg/L)**	**% PO4**	**T-Tube (cm)***
Average	0.11	0.74	9.48	0.03	27.02	57.00
Max	0.29	3.26	37.00	0.08	59.84	60.00
Min	0.03	0.21	2.00	0.00	3.70	28.40
Number of samples taken	34	34	34	25	25	34

Appendix E: MINLEAP modeling results for Lake Volney

Developed by Bruce Wilson and Dr. William Walker Jr., the “Minnesota Lake Eutrophication Analysis Procedure” or MINLEAP, is a simple modeling method used to estimate loading levels and lake response based on specific lake data when compared to reference lakes within the same eco region.

This model is useful because it allows the comparison between the predicted phosphorus, chl-a and Secchi depths to the actual, observed data. This comparison allows a quick method of comparing what the lake should be at based on its location and reference lakes in the area, to actual loading levels based on the sample results. This information can be used to perform a cursory comparison and calculation based on the reductions necessary to meet the standards. Similarly, the model can be calibrated to calculate the necessary loading to predict the same values as the observed values. Using information such as inflow, mean lake depth, and residence time, MINLEAP will estimate in-lake TP, chl-a levels, and average Secchi depth.

Table A: Lake Volney MINLEAP model predictions using 2009 data.

Avg TP Inflow (µg/L)	**TP Load (kg/yr)**	**Phos Ret Coef**	**Lake Outflow (hm3/yr)**	**Res Time (years)**	**Areal Water Load (m/yr)**
172	191	0.83	1.1	7	0.99

Var	**Observed**	**Predicted**	**Std Err**	**Residual**	**T-test**
TP (µg/L)	95	29	12	0.51	2.76*
Chl-a (µg/L)	15.6	9.1	6.1	0.23	0.74
Secchi (m)	4.6	2.1	0.9	0.34	1.68

* Yellow highlighted sections indicate a significant difference between the predicted values for lakes in the NCHF and the observed value.

Based on the initial modeling run using only data from 2009, Lake Volney is predicted to have a lower TP and a lower chl-a value in comparison with other lakes found in the NCHF ecoregion. MINLEAP predicts that TP concentrations, chl-a concentrations, and Secchi disk readings should all be better than the NCHF standard (Table A). This was likely due to the small size of the Lake Volney watershed and the fact that the watershed to lake ratio is less than 10:1. MINLEAP uses average values for land use within a given ecoregion *i.e.,* NCHF, the mean depth of a given lake, and run off coefficients to predict what is likely entering the system. The mean depth of Lake Volney is much deeper than a large percentage of the lakes within the NCHF ecoregion; this affected the predicted reading. The observed TP concentration for Lake Volney was significantly higher than the predicted TP concentration; this indicates that the TP concentration present in Lake Volney is significantly higher than the mean TP concentration found in other lakes within the NCHF that have a similar watershed size and similar basin morphometry.

Table B: Lake Volney MINLEAP model predictions using 2010 data.

Avg. TP Inflow (µg/L)	TP Load (kg/yr)	Phos Ret Coef	Lake Outflow (hm3/yr)	Res Time (years)	Areal Water Load (m/yr)
172	191	0.83	1.1	7	0.99

Var	Observed	Predicted	Std Err	Residual	T-test
TP (µg/L)	81	29	12	0.44	2.39
Chl-a (µg/L)	17.5	9.1	6.1	0.29	0.9
Secchi (m)	3.3	2.1	0.9	0.19	0.93

* Yellow highlighted sections indicate a significant difference between the predicted values for lakes in the NCHF and the observed value.

Based on the initial modeling run using all data collected during the 2010 monitoring season, MINLEAP predicts that TP concentrations and chl-a concentrations should be less (better) than and secchi disk transparency readings greater (better) than the NCHF standard given the watershed size and morphometry of the Lake Volney basin. The observed mean TP concentration during the 2010 monitoring season was significantly worse than the predicted values for lakes with similar morphometry and watershed size (Table B).

Table C: Lake Volney MINLEAP model predictions using 2009 and 2010 data.

Avg TP Inflow (µg/L)	TP Load (kg/yr)	Phos Ret Coef	Lake Outflow (hm3/yr)	Res Time (years)	Areal Water Load (m/yr)
172	191	0.83	1.11	7	0.99

Var	Observed	Predicted	Std Err	Residual	T-test
TP (µg/L)	87	29	12	0.48	2.56
Chl-a (µg/L)	14.2	9.1	6.1	0.2	0.62
Secchi (m)	3.9	2.1	0.9	0.27	1.31

* Yellow highlighted sections indicate a significant difference between the predicted values for lakes in the NCHF and the observed value.

Based on the initial modeling run using all data collected during the 2009 and 2010 monitoring seasons, MINLEAP predicts that TP concentrations and chl-a concentrations should be less (better) than and secchi disk transparency readings greater (better) than the NCHF standard given the watershed size and morphometry of the Lake Volney basin. The observed mean TP concentration during the 2009 and 2010 monitoring seasons was significantly worse than the predicted values for lakes with similar morphometry and watershed size (Table C).

The MINLEAP model has been demonstrated to perform well in the Northern Lake/Forest and Northern Central Hardwood Forest areas. Data collected during the summer of 1985 was used to demonstrate MINLEAP's capacity to identify problems within a given lake by C. Bruce Wilson and William Walker, developers of the MINLEAP program; Lake Volney was used as a case study. Results from this analysis found that the mean TP and chl-a concentration observed within Lake Volney was significantly greater than values predicted by the MINLEAP model. As a result, Wilson and Walker concluded that Lake Volney was subjective to extensive nutrient loading (Wilson and Walker, 1989). Results from the MINLEAP model conducted using data from the 2009 and 2010 monitoring seasons found similar results. The mean TP concentration observed was significantly greater than predicted values in both 2009 and 2010. Based on these results, it can safely be concluded that Lake Volney is still subjective to extensive nutrient loading today.

Appendix F: BATHTUB case files, computed 8/30/2012

Volney for Existing Conditions:

Global Variables	Mean	CV
Averaging Period (yrs)	1	0.0
Precipitation (m)	0.99	0.0
Evaporation (m)	0.99	0.0
Storage Increase (m)	0	0.0

Atmos. Loads (kg/km^2-yr)	Mean	CV
Conserv. Substance	0	0.00
Total P	30	0.50
Total N	1000	0.50
Ortho P	15	0.50
Inorganic N	500	0.50

Model Options	Code	Description
Conservative Substance	0	NOT COMPUTED
Phosphorus Balance	8	CANF & BACH, LAKES
Nitrogen Balance	0	NOT COMPUTED
Chlorophyll-a	0	NOT COMPUTED
Secchi Depth	0	NOT COMPUTED
Dispersion	1	FISCHER-NUMERIC
Phosphorus Calibration	1	DECAY RATES
Nitrogen Calibration	1	DECAY RATES
Error Analysis	1	MODEL & DATA
Availability Factors	0	IGNORE
Mass-Balance Tables	1	USE ESTIMATED CONCS
Output Destination	2	EXCEL WORKSHEET

Segment Morphometry

		Outflow		Area	Depth	Length	Mixed Depth (m)		Hypol Depth		Non-Algal Turb (m^{-1})		Internal Loads (mg/m2-day) Conserv.		Total P		Total N
Seg	**Name**	**Segment**	**Group**	**km^2**	**m**	**km**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**	**Mean**
1	Volney	0	1	1.12097	6.918	1.51396	5.6	0.12	7	0	0.08	0	0	0	0	0	0

Segment Observed Water Quality

	Conserv		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**
1	0	0	62.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Segment Calibration Factors

	Dispersion Rate		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**
1	1	0	1.069	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0

Tributary Data

				Dr Area	Flow (hm^3/yr)		Conserv.		Total P (ppb)		Total N (ppb)		Ortho P (ppb)		Inorganic N (ppb)	
Trib	**Trib Name**	**Segment**	**Type**	**km^2**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**
1	TMDL Inflow V2	1	1	3.27	0.805	0	0	0	587	0	0	0	0	0	0	0
2	TMDL Inflow V3	1	1	1.16	0.226	0	0	0	542	0	0	0	0	0	0	0
3	Lake Volney Watershed	1	2	3.73	0	0	0	0	0	0	0	0	0	0	0	0

Tributary Non-Point Source Drainage Areas (km^2)

		Land Use Category--->							
Trib	**Trib Name**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1	TMDL Inflow V2	0	0	0	0	0	0	0	0
2	TMDL Inflow V3	0	0	0	0	0	0	0	0
3	Lake Volney Watershed	0.1885	2.22	0.3969	0.753	0.1687	0	0	0

Non-Point Source Export Coefficients

		Runoff (m/yr)		Conserv. Subs.		Total P (ppb)		Total N (ppb)	
Categ	**Land Use Name**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**	**Mean**	**CV**
1	Forest	0.15	0	0	0	92.31	0	0	0
2	Agriculture	0.15	0	0	0	307.69	0	0	0
3	Urban	0.15	0	0	0	769.23	0	0	0
4	Pasture/Grassland	0.15	0	0	0	230.77	0	0	0
5	Wetland	0.15	0	0	0	76.92	0	0	0
6	Open Water	0	0	0	0	0	0	0	0
7		0	0	0	0	0	0	0	0
8		0	0	0	0	0	0	0	0

Model Coefficients	**Mean**	**CV**
Dispersion Rate	1.000	0.70
Total Phosphorus	1.000	0.45
Total Nitrogen	1.000	0.55
Chl-a Model	1.000	0.26
Secchi Model	1.000	0.10
Organic N Model	1.000	0.12
TP-OP Model	1.000	0.15
HODv Model	1.000	0.15
MODv Model	1.000	0.22
Secchi/Chla Slope (m^2/mg)	0.025	0.00
Minimum Qs (m/yr)	0.100	0.00
Chl-a Flushing Term	1.000	0.00
Chl-a Temporal CV	0.620	0
Avail. Factor - Total P	0.330	0
Avail. Factor - Ortho P	1.930	0
Avail. Factor - Total N	0.590	0
Avail. Factor - Inorganic N	0.790	0

Overall Water & Nutrient Balances

Overall Water Balance **Averaging Period = 1.00 years**

Trb	Type	Seg	Name	Area km^2	Flow hm^3/yr	Variance (hm3/yr)^2	CV -	Runoff m/yr
1	1	1	TMDL Inflow V2	3.27	0.805	0.00E+00	0.00	0.246
2	1	1	TMDL Inflow V3	1.16	0.226	0.00E+00	0.00	0.195
3	2	1	Lake Volney Watershed	3.73	0.559	0.00E+00	0.00	0.150
PRECIPITATION				1.12	1.110	0.00E+00	0.00	0.990
TRIBUTARY INFLOW				4.43	1.031	0.00E+00	0.00	0.233
NONPOINT INFLOW				3.73	0.559	0.00E+00	0.00	0.150
***TOTAL INFLOW				9.28	2.700	0.00E+00	0.00	0.291
ADVECTIVE OUTFLOW				9.28	1.590	0.00E+00	0.00	0.171
***TOTAL OUTFLOW				9.28	1.590	0.00E+00	0.00	0.171
***EVAPORATION					1.110	0.00E+00	0.00	

Overall Mass Balance Based Upon **Predicted** **Outflow & Reservoir Concentrations**
Component: **TOTAL P**

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance (kg/yr)^2	%Total	CV	Conc mg/m^3	Export kg/km^2/yr
1	1	1	TMDL Inflow V2	472.6	58.5%	0.00E+00		0.00	587.1	144.5
2	1	1	TMDL Inflow V3	122.4	15.2%	0.00E+00		0.00	542.0	105.5
3	2	1	Lake Volney Watershed	178.9	22.2%	0.00E+00		0.00	320.0	48.0
PRECIPITATION				33.6	4.2%	2.83E+02	100.0%	0.50	30.3	30.0
TRIBUTARY INFLOW				595.0	73.7%	0.00E+00		0.00	577.2	134.3
NONPOINT INFLOW				178.9	22.2%	0.00E+00		0.00	320.0	48.0
***TOTAL INFLOW				807.6	100.0%	2.83E+02	100.0%	0.02	299.1	87.0
ADVECTIVE OUTFLOW				99.8	12.4%	1.47E+03		0.38	62.8	10.8
***TOTAL OUTFLOW				99.8	12.4%	1.47E+03		0.38	62.8	10.8
***RETENTION				707.8	87.6%	1.71E+03		0.06		

Overflow Rate (m/yr)	1.4	Nutrient Resid. Time (yrs)	0.6028
Hydraulic Resid. Time (yrs)	4.8774	Turnover Ratio	1.7
Reservoir Conc (mg/m3)	63	Retention Coef.	0.876

Volney for Modeled Conditions:

Global Variables	Mean	CV
Averaging Period (yrs)	1	0.0
Precipitation (m)	0.99	0.0
Evaporation (m)	0.99	0.0
Storage Increase (m)	0	0.0

Atmos. Loads (kg/km^2-yr)	Mean	CV
Conserv. Substance	0	0.00
Total P	30	0.50
Total N	1000	0.50
Ortho P	15	0.50
Inorganic N	500	0.50

Model Options	Code	Description
Conservative Substance	0	NOT COMPUTED
Phosphorus Balance	8	CANF & BACH, LAKES
Nitrogen Balance	0	NOT COMPUTED
Chlorophyll-a	0	NOT COMPUTED
Secchi Depth	0	NOT COMPUTED
Dispersion	1	FISCHER-NUMERIC
Phosphorus Calibration	1	DECAY RATES
Nitrogen Calibration	1	DECAY RATES
Error Analysis	1	MODEL & DATA
Availability Factors	0	IGNORE
Mass-Balance Tables	1	USE ESTIMATED CONCS
Output Destination	2	EXCEL WORKSHEET

Segment Morphometry

		Outflow		Area	Depth	Length	Mixed Depth (m)		Hypol Depth		Non-Algal Turb (m^{-1})		Internal Loads (mg/m2-day) Conserv.		Total P		Total N	
Seg	Name	Segment	Group	km^2	m	km	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	Volney	0	1	1.12097	6.918	1.51396	5.6	0.12	7	0	0.08	0	0	0	0	0	0	0

Segment Observed Water Quality

	Conserv		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	0	0	62.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Segment Calibration Factors

	Dispersion Rate		Total P (ppb)		Total N (ppb)		Chl-a (ppb)		Secchi (m)		Organic N (ppb)		TP - Ortho P (ppb)		HOD (ppb/day)		MOD (ppb/day)	
Seg	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	1	0	1.069	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0

Tributary Data

				Dr Area	Flow (hm^3/yr)		Conserv.		Total P (ppb)		Total N (ppb)		Ortho P (ppb)		Inorganic N (ppb)	
Trib	Trib Name	Segment	Type	km^2	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	TMDL Inflow V2	1	1	3.27	0.805	0	0	0	183.064	0	0	0	0	0	0	0
2	TMDL Inflow V3	1	1	1.16	0.2259	0	0	0	183.064	0	0	0	0	0	0	0
3	Lake Volney Watershed	1	2	3.73	0	0	0	0	0	0	0	0	0	0	0	0

Tributary Non-Point Source Drainage Areas (km^2)

		Land Use Category--->							
Trib	Trib Name	1	2	3	4	5	6	7	8
1	TMDL Inflow V2	0	0	0	0	0	0	0	0
2	TMDL Inflow V3	0	0	0	0	0	0	0	0
3	Lake Volney Watershed	0.1885	2.22	0.3969	0.753	0.1687	0	0	0

Non-Point Source Export Coefficients

		Runoff (m/yr)		Conserv. Subs.		Total P (ppb)		Total N (ppb)	
Categ	Land Use Name	Mean	CV	Mean	CV	Mean	CV	Mean	CV
1	Forest	0.15	0	0	0	52.815	0	0	0
2	Agriculture	0.15	0	0	0	176.043	0	0	0
3	Urban	0.15	0	0	0	440.111	0	0	0
4	Pasture/Grassland	0.15	0	0	0	132.034	0	0	0
5	Wetland	0.15	0	0	0	44.009	0	0	0
6	Open Water	0	0	0	0	0	0	0	0
7		0	0	0	0	0	0	0	0
8		0	0	0	0	0	0	0	0

Model Coefficients	Mean	CV
Dispersion Rate	1.000	0.70
Total Phosphorus	1.000	0.45
Total Nitrogen	1.000	0.55
Chl-a Model	1.000	0.26
Secchi Model	1.000	0.10
Organic N Model	1.000	0.12
TP-OP Model	1.000	0.15
HODv Model	1.000	0.15
MODv Model	1.000	0.22
Secchi/Chla Slope (m^2/mg)	0.025	0.00
Minimum Qs (m/yr)	0.100	0.00
Chl-a Flushing Term	1.000	0.00
Chl-a Temporal CV	0.620	0
Avail. Factor - Total P	0.330	0
Avail. Factor - Ortho P	1.930	0
Avail. Factor - Total N	0.590	0
Avail. Factor - Inorganic N	0.790	0

Overall Water & Nutrient Balances

Overall Water Balance **Averaging Period = 1.00 years**

Trb	Type	Seg	Name	Area km^2	Flow hm^3/yr	Variance (hm3/yr)^2	CV -	Runoff m/yr
1	1	1	TMDL Inflow V2	3.27	0.805	0.00E+00	0.00	0.246
2	1	1	TMDL Inflow V3	1.16	0.226	0.00E+00	0.00	0.195
3	2	1	Lake Volney Watershed	3.73	0.559	0.00E+00	0.00	0.150
PRECIPITATION				1.12	1.110	0.00E+00	0.00	0.990
TRIBUTARY INFLOW				4.43	1.031	0.00E+00	0.00	0.233
NONPOINT INFLOW				3.73	0.559	0.00E+00	0.00	0.150
***TOTAL INFLOW				9.28	2.700	0.00E+00	0.00	0.291
ADVECTIVE OUTFLOW				9.28	1.590	0.00E+00	0.00	0.171
***TOTAL OUTFLOW				9.28	1.590	0.00E+00	0.00	0.171
***EVAPORATION					1.110	0.00E+00	0.00	

Overall Mass Balance Based Upon **Predicted** **Outflow & Reservoir Concentrations**

Component: **TOTAL P**

Trb	Type	Seg	Name	Load kg/yr	%Total	Load Variance (kg/yr)^2	%Total	CV	Conc mg/m^3	Export kg/km^2/yr
1	1	1	TMDL Inflow V2	147.4	45.4%	0.00E+00		0.00	183.1	45.1
2	1	1	TMDL Inflow V3	41.4	12.7%	0.00E+00		0.00	183.1	35.7
3	2	1	Lake Volney Watershed	102.3	31.5%	0.00E+00		0.00	183.1	27.4
PRECIPITATION				33.6	10.4%	2.83E+02	100.0%	0.50	30.3	30.0
TRIBUTARY INFLOW				188.7	58.1%	0.00E+00		0.00	183.1	42.6
NONPOINT INFLOW				102.3	31.5%	0.00E+00		0.00	183.1	27.4
***TOTAL INFLOW				324.7	100.0%	2.83E+02	100.0%	0.05	120.3	35.0
ADVECTIVE OUTFLOW				57.2	17.6%	4.32E+02		0.36	36.0	6.2
***TOTAL OUTFLOW				57.2	17.6%	4.32E+02		0.36	36.0	6.2
***RETENTION				267.4	82.4%	6.53E+02		0.10		

Overflow Rate (m/yr)	1.4	Nutrient Resid. Time (yrs)	0.8599
Hydraulic Resid. Time (yrs)	4.8774	Turnover Ratio	1.2
Reservoir Conc (mg/m3)	36	Retention Coef.	0.824

Appendix G. Monitoring Parameters

A. Phosphorus (P):

Phosphorus data was collected via grab samples at inflow/out flow sites using sterile bottles supplied through Minnesota Valley Testing Laboratories, Inc. (MVTL). Lake samples were taken two meters below the water surface at a geo-located position using a two meter long integrated sampler. Additional in-lake samples were taken below the thermocline during periods of thermal stratification on three deepest lake basins (West Jefferson, East Jefferson, and German) using a Van Dorn sampler. The P samples were then delivered to MVTL in New Ulm and analyzed for both TP and OP concentrations (Table F.1).

B. Nitrogen(N):

Nitrogen data was collected very similarly to the P data; using grab samples at the inflow/outflow sites, in-lake water quality samples were not analyzed for their N content. The N samples were analyzed for nitrate-nitrite (Table F.1).

C. Chlorophyll-a (Chl-a) (with phaeophytin correction):

Chl-a data was also collected at the JGC sites using the below surface sample method. Chl-a was not sampled at the inflow/outflow sites. All samples were collected, and then temporarily stored in an opaque plastic or amber glass bottle to prevent any additional development or breakdown of the Chl-a within the sample (Table F.1).

D. Temperature, Dissolved Oxygen (DO), Specific Conductance (SCond), and pH:

Temperature, DO, SCond, and pH data were collected using a YSI 6820 V2 Data Sonde connected to a YSI 650 multiparameter handheld display unit. This unit was equipped with a 23 m (75 ft.) cable that allowed vertical profiles to be taken of the entire water column at 1 meter wed to equilibrate at each depth interval until a constant reading was achieved (Table F.1).

E. Secchi Depth:

The Secchi disk is a flat, circular object used to measure water transparency in oceans and lakes. The disc is divided into four evenly spaced sections alternating with colors of black and white. The disc is mounted on a pole or line, and lowered down in the water. The depth at which the pattern on the disk is no longer visible is taken as a measure of the transparency of the water. This measure is known as the Secchi depth and is related to water turbidity (Table 4.2).

Table F.1. Sample method information.

Analyte	Sample Quantity	Sample Container	Preservative	Holding Time	Analytical Method
Chlorophyll a	1 L	Amber glass	Cool to 4°C	4 H†	SM* 10200 H
Total Phosphorus	500 mL	Plastic	H_2SO_4 to pH <2, Cool to 4°C	28 D	EPA 365.1 Rev 2.0
Ortho-Phosphorus	500 mL	Plastic	Cool to 4°C	2 D	EPA 365.1 Rev 2.0
Nitrate + Nitrite	250 mL	Plastic	H_2SO_4 to pH <2, Cool to 4°C	28 D	EPA 353.2 Rev 2.0
Total Suspended Solids	500 mL	Plastic	Cool to 4°C	7 D	USGS I-3765-85

†May be stored on ice in the dark for up to 48 hrs. prior to analysis, otherwise, filter within 48 hrs. and store frozen at ≤ -20