Engineer's Report

Southeast Anderson Water Quality Improvement Project

Petitioned by the
City of Bloomington

Prepared for the
Nine Mile Creek Watershed District

January 2009

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Executive Summary

Overview

The City of Bloomington has petitioned the Nine Mile Creek Watershed District to undertake a project for improving the water quality of Southeast Anderson Lake. The Southeast Anderson Lake Water Quality Improvement Project is a necessary, feasible part of the overall Water Management Plan of the Nine Mile Creek Watershed District (NMCWD) and recommended in the Southeast, Southwest, and Northwest Anderson Lake Use Attainability Analysis (UAA).

The following is a summary of the work completed and the conclusions reached. The recommended treatment options will allow Southeast Anderson Lake to attain water quality levels that will meet the NMCWD water quality goal and state water quality standards.

Goals and Standards

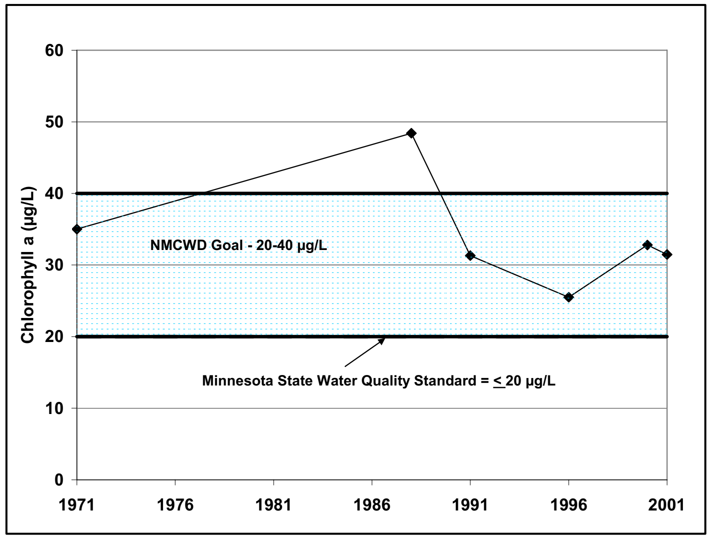
During the summer, recreational use of lakes is greatest, and at the same time algal blooms and diminished transparency are most common. Algal blooms and diminished water transparency in Southeast Anderson Lake each summer hampers recreational use of the lake. The NMCWD established a water quality goal to reduce algal blooms and increase water transparency in Southeast Anderson Lake to the extent necessary to support the recreational uses of the lake. The NMCWD goal is to achieve and maintain a summer average Carlson's Trophic State Index measure of between 50 and 60. The Index expresses the lake's nutrient, algae, and water transparency data on a scale from 1 to 100, with increasing numbers indicating increasing water quality degradation. The NMCWD goal is to attain a water quality near the middle of the scale. Numeric water quality standards for Minnesota Lakes, adopted by the Minnesota Pollution Control Citizen's Board on December 18, 2007, and approved by the U.S. Environmental Protection Agency on June 16, 2008, are within the water quality range of the NMCWD goal.

Southeast Anderson Lake Water Quality Problems: Wet, Dry, and Normal Climatic Conditions

The water quality of a lake provides an indication of how a lake functions, and a standardized lake rating system is often used to classify the ecological conditions of a lake. Three measures are used to determine a lake's health: phosphorus concentrations—food for small aquatic plants (algae), chlorophyll *a* concentrations—a measurement of the quantity of algae in the lake, and water clarity as measured by a Secchi disc lowered into the water until it is no longer visible to the eye.

Observed and predicted in-lake water quality conditions for Southeast Anderson Lake under wet, dry, and normal summertime conditions were calculated. Water-quality records dating back to 1971, when the records began were analyzed. These records indicate few changes in the lake's poor water quality over the last 30 years, which strongly suggest action is needed to help the lake return to a healthy state.

For example, summer average total phosphorus concentrations failed to meet the state standard during 1971, 1988, and 2000 and failed to meet the District goal during 2000. Summer average chlorophyll *a* concentrations failed to meet the state standard during all years of data collection. Summer average Secchi Disc water transparency failed to meet both the District goal and state standard during 1988, 1991, and 2000.



Chlorophyll *a* concentrations failed to meet the state standard during all years of data collection.

Currently, Southeast Anderson Lake's ecosystem is dominated by blue-green algae and Curlyleaf pondweed. It was determined that dry weather conditions produce the greatest impact on the water quality in Southeast Anderson Lake. The lake's problematic plant, Curlyleaf pondweed, grows even in dry years, when there is less water volume to dilute the phosphorus created when the plant decays. In addition, the lake's sediments add additional phosphorus to the lake during dry years, when there is less water volume to dilute it. Even during the best conditions, the lake fails to meet the standards set by the State of Minnesota and the NMCWD goals set by the Use Attainability Analysis prescribed by the 1996 Nine Mile Creek Watershed District *Water Management Plan*.

Invasive Species Lead To Phosphorous Loading and Unhealthy Amounts of Algae

Plant surveys conducted in 1996, 2000, and 2001 showed dense growths of pondweed, small stands of waterlily, and smaller patches of cattails and bulrushes in Southeast Anderson Lake. The surveys also showed large amounts of Curlyleaf pondweed, an invasive species that replaces native species. Although aquatic plants are a vital part of a lake's ecosystem, a dense non-native community of

Curlyleaf pondweed can impair a lake's recreational use, water quality, and fish habitat. Small fish hide in the weeds, making it difficult for larger fish, such as bass, to locate and prey upon the small fish they need for food. As such, Curlyleaf pondweed can hinder gamefish growth.

A dense growth of Curlyleaf pondweed in mid-June

The plant's own lifecycle increases the lake's phosphorus concentration. Pondweed seeds—known as turions—germinate in autumn. By May the plants are well-established, making it difficult for native plants to compete effectively. In mid-June, the dense mass of pondweed dies, and its decay releases a burst of phosphorus into the lakes system.

Excess phosphorus loads as seen in Southeast Anderson Lake stimulates blue-green algal growth. Southeast Anderson Lake's algal community is dominated by blue-green algae, which are generally inedible for fish, waterfowl, and most zooplankton. In fact, blue-green algae are toxic to animals (including dogs and people) in large amounts. These algae float at the lake surface in expansive, bright-green blooms. They can interfere with recreational uses of the lake such as boating and fishing. The warm growing conditions during July and August are particularly favorable to blue-greens, and blue-greens have a competitive advantage over the other algal species during this time.

It is recommended that the environment in which blue-green algae thrives be changed in order to allow moderate amounts of desirable algae, diatoms and green algae, to comprise the algae community of Southeast Anderson Lake. Algae or phytoplankton are the basis of the lake's food web. These small aquatic plants are naturally present in all lakes, where they derive energy from sunlight (through photosynthesis) and from dissolved nutrients, including phosphorus, found in lake water. They provide food for several types of animals, including zooplankton, which are in turn eaten by fish. While all lakes need algae, excess algae as well as large amounts of blue-green algae degrade a lake's water quality and create problems.

Because the water quality of Southeast Anderson Lake has been degraded by phosphorus from Curlyleaf pondweed, it is recommended to control/eliminate the Curlyleaf pondweed, thus reducing the phosphorous levels, thereby reducing the amount of algae, including blue-green algae.

Lake Sediments Load Phosphorus and Fuel Algal Blooms

Some of the phosphorus added to a lake flows out of the lake's outlet, but much of the phosphorus added to a lake is stored in the lake's sediments. When the lake's bottom waters become stagnant and lose oxygen, the sediment changes from a phosphorus storage unit to a massive phosphorus pumping system. The lake's sediment pumps phosphorus back into the lake where it can once again fuel algal blooms and degrade the lake's water quality. This cycle continues until oxygen is added to the water which breaks this cycle. The stagnant bottom waters of Southeast Anderson Lake annually load phosphorus into the lake each summer, degrading the lake's water quality and fueling algal blooms. It is recommended that measures be implemented to reduce the amount of phosphorus added to the lake from its sediments. This reduction will reduce the amount of algae in the lake, including blue-green algae and improve the lake's water quality.

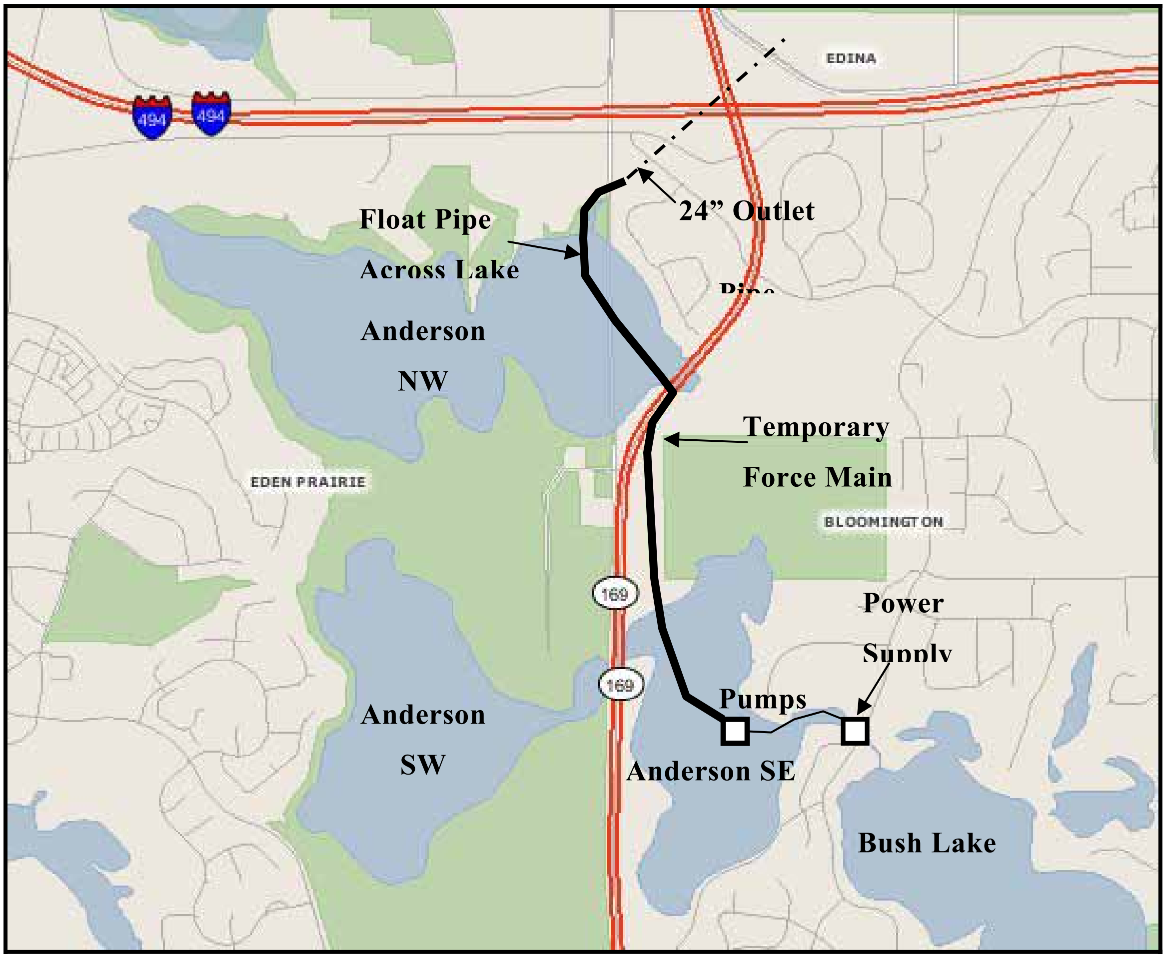
This lake sediment core contains phosphorus that is pumped back into the lake when the bottom waters lose oxygen.

Potential Treatment Method

A drawdown of the lake and allowing the lake-bed to freeze over the winter is one way to control non-native aquatic vegetation, such as Curlyleaf pondweed, and internal phosphorus release from the sediment. However, all riparian landowners must sign a drawdown approval document in order for a drawdown to occur. Two drawdown options of Southeast Anderson Lake were evaluated.

Option 1: Drawing the lake down by pumping water from the lake's center through a force main to the existing Northwest Anderson Lake outlet pipe. This option was estimated to cost approximately $343,000 to $393,300 (Figure EX-1).

Option 2: Drawing down the lake by a gravity outlet installed on the lake's northern side. This option would be more expensive and was estimated to cost approximately $1,109,200 (Figure EX-2).



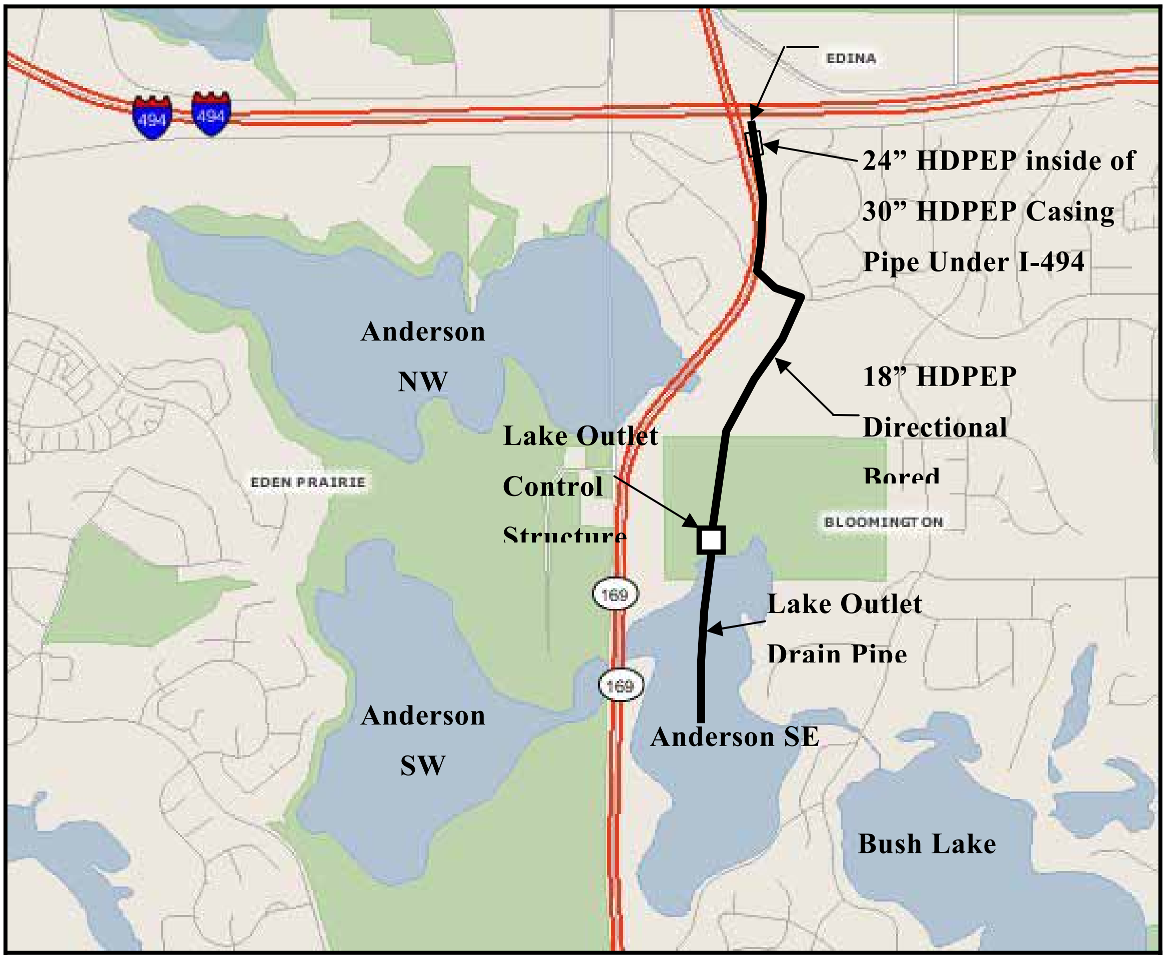
Option #1 Anderson Lakes SE Draw Down; Pumping to Lake Outlet Pipe

Approximately 5580' of force main, restricted to 24" RCP outlet pipe, power supply from existing Bush Lake by-pass pumping station.

Need to pump out 470 Ac/Ft (153,139,536 gallons)

At 3,000 gpm (6.7 cfs), (~36 days)

Figure EX-1 Anderson Lake Southeast Proposed Drawdown—Option #1



4,050 feet of directional bored 18” & 24” HDPEP and 1,400 feet 18” HDPEP lake drain and control structure.

To drain lake approx. 470 Ac/Ft would take 48 days.

Figure EX-2 Anderson Lake Southeast Proposed Gravity System—Option #2

Recommended Treatment Option: Herbicide and Alum Treatments

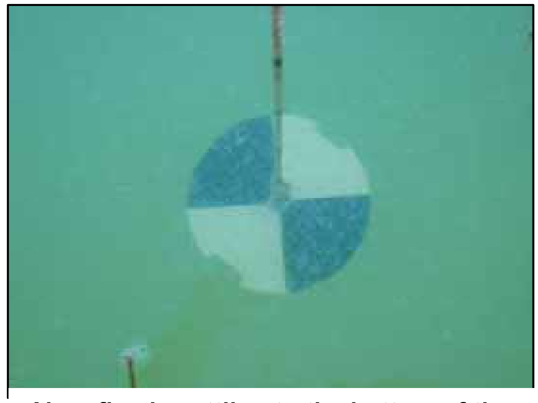
A herbicide treatment of Curlyleaf pondweed and alum treatments of the lake's sediment is equally effective in improving the water quality of Southeast Anderson Lake. This option is recommended since it does not require the approval of all riparian property owners. A two-stage treatment of Southeast Anderson Lake is recommended. First treating the Curlyleaf pondweed with Endothall, a herbicide formulated to kill Curlyleaf pondweed is recommended. Applying Endothall early in the spring will remove the Curlyleaf pondweed when native plants are seasonally suppressed. Herbicide treatment of Curlyleaf pondweed consists of four annual spring herbicide treatments in late April or early May, prior to the growth period for native species. The estimated cost of the Curlyleaf pondweed management program is $125,000 for the four annual treatments.

This lake is being treated with herbicide during spring

After the completion of the Curlyleaf treatment, the lake would be treated with alum in order to decrease the internal phosphorus load by approximately 80 percent. The water clarity improves because alum is heavy enough to settle to the bottom of the lake. After the alum comes to rest on the lake sediment, it binds to phosphorus found in the sediment in effect, inactivating it to prevent the phosphorus from going back into the water.

Alum treatment of Bryant Lake in 2008

Over time, the effectiveness of the alum layer bound to the lake's sediment diminishes as a new layer of sediment forms over it, and phosphorus from this new layer of sediment is again pumped into the lake's bottom waters. Alum treatment is normally reapplied at approximately 10-year intervals.



Alum floc is settling to the bottom of the lake where it binds the phosphorus found in sediment, preventing it from going back into the lake.

Permits and Monitoring Required for Herbicide and Alum Treatments

Permits/approvals for the recommended improvements will be required by the City of Bloomington, the Minnesota Department of Natural Resources, the Minnesota Pollution Control Agency, and the Nine Mile Creek Watershed District.

An aquatic plant management control permit must be obtained from the Minnesota Department of Natural Resources (MDNR) in order to treat the lake with herbicide. A letter of variance must be obtained from the MDNR, with riparian owners asked to sign a permission form. Should any residents not grant permission, the water from the property boundary to 150 feet lakeward would not be treated with the herbicide. The remainder of the lake would receive treatment. An estimated cost to attain a letter of variance, treatment permit, and letters of permission is $7,000.

The MDNR's treatment permit would require monitoring to determine treatment effectiveness. The monitoring would evaluate the coverage of Curlyleaf pondweed and native plants in the lake before and after treatment. The MDNR requires collection of turion samples in early fall, typically October, to determine the potential for new Curlyleaf pondweed growth the next year. The MDNR also requires herbicide residue monitoring for 21 ays after treatment. The monitoring will confirm that sufficient herbicide was applied to control Curlyleaf pondweed. Because Endothall is expected to degrade into carbon dioxide and water within 21 days after treatment, monitoring confirms that the herbicide is degrading on schedule for the native plants to grow.

The permit also requires monitoring data be analyzed and reported annually to the MDNR. The analysis and report determine the degree of Curlyleaf pondweed control and confirm the positive or neutral effect of the herbicide treatment on the native plant community. The prevalence of Curlyleaf pondweed and native plants will be evaluated in order to reveal the response of the native plant community to the treatment. Turion numbers would be evaluated to confirm their decrease, and the herbicide residual monitoring data would be analyzed to confirm that it is working and causing no harm to the native plant community. The estimated cost to complete the monitoring program, including aquatic plant, biomass, turion, and herbicide residue, is $184,000.

Sediment monitoring is needed to determine the alum dose required to attain the 80 percent reduction of phosphorus loading from the lake's sediment. Sediment monitoring is also needed to evaluate the success of the alum treatment. We estimate the cost of sediment monitoring and in-lake alum treatment of Southeast Anderson Lake is $178,000.

Combined Endothall and Alum Treatment Plans and Costs

Endothall and alum treatments would be combined to improve the water quality of Southeast Anderson Lake such that the NMCWD goal is attained. Below is the expected sequence of management activities for the 6-year period of project implementation.

Years 1-4 Herbicide (endothall) treatment; aquatic plant and herbicide residue monitoring;

Year 5-6 Alum treatment; post treatment sediment and water quality monitoring, spot treatment of herbicide, if needed, to attain Curlyleaf pondweed control goal

Water quality monitoring would occur for 1 year prior to treatment, during each of the two treatment years, and at 3-year intervals for 10 years after treatment. The data will indicate the treatment effectiveness and determine the longevity of the treatment.

The total estimated cost of the recommended improvements described in this Engineer's Report and shown in Table EX-1 is $554,000.

Table EX-1 Estimated Cost of Combined Endothall and Alum Treatment

Treatment Type	Task	Cost
Endothall Treatment	Letter of Variance From MDNR	$2,000
	Treatment Permits From MDNR & Permission Letter From Riparian Owners	$5,000
	Endothall Treatment (4 Annual Treatments)	$125,000
	Monitoring, Analysis, and Reporting Cost Estimate – Aquatic Plant, Biomass, Turion, and Herbicide Residue (4 Yrs)	$184,000
	Endothall Treatment Subtotal*	**$316,000**
Alum Treatment	Sediment Monitoring and In-Lake Alum Treatment (2 Yrs)	$178,000
	Water Quality Monitoring (6 Years)	$60,000
	Alum Treatment Subtotal*	**$238,000**
	Total*	**$554,000**

* Estimates include contingencies (10%) and engineering & administration (30%)

Engineer's Report
Southeast Anderson Water Quality Improvement Project

Nine Mile Creek Watershed District:
Basic Water Management Project

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Appendix B Anderson Lakes UAA Report (*Executive Summary only*)

Appendix C 1996, 2000, and 2001 Aquatic Plant Survey Data

Appendix D Affected Property Owners

1.0 Introduction

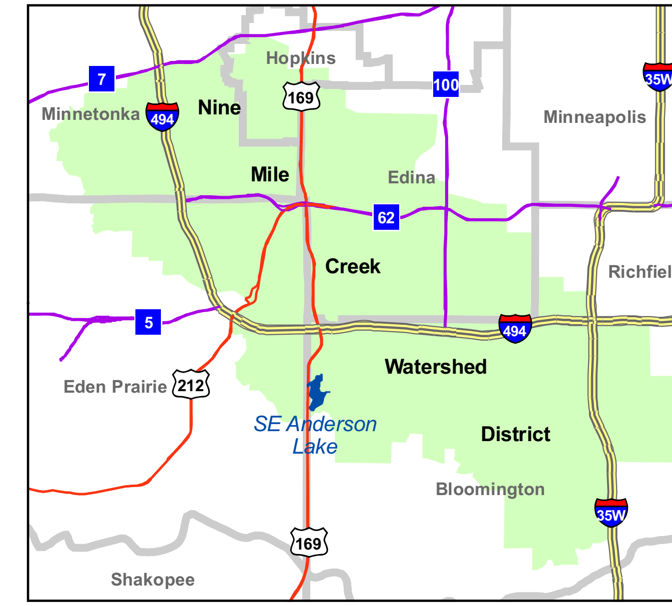
This report summarizes the proposed actions for improving the water quality of Southeast Anderson Lake.

It is prepared in accordance with Section 103D.711 of the Minnesota Watershed Act under the direction of the Board of Managers of the Nine Mile Creek Watershed District, upon petition by the City of Bloomington (see Appendix A).

2.0 Background Information

The Nine Mile Creek Watershed District (NMCWD) was established by the Minnesota Water Resources Board in 1959 and consists of land that drains to Nine Mile Creek. The District encompasses approximately 50 square miles in southern Hennepin County and it includes portions of the cities of Bloomington, Edina, Hopkins, Minnetonka, and Richfield (see Figure 1). Nine Mile Creek flows approximately 15 miles from its headwater, where it crosses County Road No. 3 in Hopkins, to its mouth at the Minnesota River. The South Fork of Nine Mile Creek, joining the main creek in Bloomington just south of Interstate Highway 494, is approximately 8.5 miles long. Stormwater management within the urbanizing Nine Mile Creek watershed was guided initially by the District's *Overall Plan* dated March 1961. That plan was revised by the Watershed District in April 1973, as prescribed by the Minnesota Water Resources Board. The 1973 revised *Overall Plan* guided development in the District until it was further revised in May 1996 and again in March 2007 (*Water Management Plan)*, in accordance with the Metropolitan Surface Water Management Act and Watershed Law: Minnesota Statutes Chapters 103B and 103D, respectively.

The water quality improvement projects recommended in this Engineer's Report for Southeast Anderson Lakes (Figure 1) are the outcome of Use Attainability Analyses (UAAs) prescribed by the 1996 Nine Mile Creek Watershed District *Water Management Plan* (Plan), and completed during 2003 through 2005.



General Project Location

N

Feet
0 250 500 1,000

Meters
0 100 200 400

Figure 1

ENGINEER'S REPORT ON THE
SOUTHEAST ANDERSON LAKE
WATER QUALITY INPROVEMENT
PROJECT LOCATION MAP
Nine Mile Creek Watershed District
Eden Pairie, Minnesota

3.0 Description of Southeast Anderson Lake and Its Watershed

The UAA for the Anderson Lakes was completed to provide the scientific foundation for lake-specific management plans that will preserve existing- or achieve potential-beneficial uses for the three lakes. The UAA is a structured, scientific assessment of the factors affecting attainment of a beneficial use for both current and ultimate watershed development conditions. "Use Attainment" refers to achievement of water conditions suitable to support lake-specific beneficial uses such as swimming, fishing, aesthetic viewing, and wildlife habitat, among others, as designated in the 1996 *Management Plan*.

The characteristics of Southeast Anderson Lake and its watershed were evaluated in the Anderson Lakes' UAA. Details from this analysis follow.

3.1 Southeast Anderson Lake

Southeast Anderson Lake is located in the western portion of Bloomington and has a water surface of approximately 81 acres, a maximum depth of approximately 9 feet, and a mean depth of 4.7 feet at a water surface elevation of 839.0. At this elevation the lake volume is approximately 470 acre-feet. Southeast Anderson Lake is relatively shallow and has a large littoral area, thus causing it to be prone to frequent wind-driven mixing of the lake's shallow and deep waters during the summer. One would therefore expect Southeast Anderson Lake to be polymictic (mixing many times per year) as opposed to lakes with deep, steep-sided basins that are usually dimictic (mixing only twice per year).

3.2 Watershed Characteristics

Southeast Anderson Lake receives runoff from its watershed and from the infrequent pumping of water from Bush Lake (the pumped outlet from Bush Lake became operational in 2000 and only pumps when the water surface elevation in Bush Lake exceeds 834.0, which has not occurred since 2001). Water leaves the northwest corner of Southeast Anderson Lake by flowing through a 48-inch culvert under US Highway 169 to Southwest Anderson Lake.

Southeast Anderson Lake's 194-acre immediate watershed, including the lake's surface area of 81 acres, is primarily in the City of Bloomington. US Highway 169 is located along the western portion of the lake's watershed. The lake's immediate watershed does not include the area that first drains to Bush Lake and is pumped to Southeast Anderson Lake.

Three primary types of land uses dominate the immediate watershed of Southeast Anderson Lake. Thirty-nine percent of the watershed is in a "natural" state, and vegetated with naturally-occurring or cultivated trees, shrubs, or grasses. Fourteen percent of the land is devoted to low-density residential-use while 6 percent of the watershed is considered to be highway use. The remaining 41 percent is open water (the lake's surface area). The relatively high proportion of land still in natural condition is significant. These "natural" lands include significant park areas.

Because much of the Southeast Anderson Lake immediate watershed is currently in a natural state, the lake currently is benefiting from these areas' low impervious fraction and consequent low phosphorus loading.

The immediate watershed of Southeast Anderson Lake was analyzed with respect to probable future land use patterns by examination of the City of Bloomington ultimate land use map. Future land use is not expected to vary from present use. As a result the watershed is considered fully-developed.

4.0 Description of Water Quality Goal

4.1 Nine Mile Creek Watershed District Goals

The water quality goal for Southeast Anderson Lakes is a Level II classification as is specified in the approved *Nine Mile Creek District Water Management Plan* (March 2007). This level fully supports water-based recreational activities, including sailboating, canoeing, hiking and picnicking, among others. The specific District goal is to achieve and maintain a summer average Carlson's Trophic State Index (Secchi disc basis, TSI_{SD}) between 50 and 60. This index score is calculated from the interrelationships between summer Secchi disc transparencies and epilimnetic concentrations of chlorophyll *a* and total phosphorus. (The index results in scoring generally between zero and one hundred; lower score being indicative of better water quality). This TSI_{SD} score corresponds to summer average Secchi disc transparencies between 1.0 and 2.0 meters, total phosphorus concentrations between 45 and 75 µg/L, and chlorophyll a concentrations between 20 and 40 µg/L. These goals are listed in Table 1 along with the water quality goals of other resource management agencies that have an interest in the condition of Southeast Anderson Lake.

4.2 State of Minnesota Water Quality Standard

All Minnesota lakes, including Southeast Anderson, are required to comply with water quality standards. The primary rule for state wide water quality standards is Minnesota Rule Chapter 7050 (the 7050 rule). Included in this rule are:

- A classification system of beneficial uses for both surface and ground waters
- Numeric and narrative water quality standards
- Nondegradation provisions
- Other provisions related to the protection of Minnesota's water resources from pollution.

Until recently, the water quality standard for Southeast Anderson Lake was narrative, stating that lakes shall not be degraded and there shall be no material increase in algae and no impairment of aquatic biota and fish. However, numeric water quality standards for Minnesota Lakes were adopted by the Minnesota Pollution Control Citizens' Board on December 18, 2007 and approved by the U.S. Environmental Protection Agency on June 16, 2008. Hence, prior to the revision of the 7050 rule to include numeric lake standards, NMCWD did not have guidance from state rule regarding numeric goals for lake management. However, the NMCWD goals for Southeast Anderson Lake, which are a range of water quality conditions, include the specific numeric water quality standards now added to the 7050 rule

(See Table 1). Attainment of the following water quality will both attain the NMCWD water quality goal for Southeast Anderson Lake and attain the state water quality standards for the lake:

- Total Phosphorus ≤60 µg/L
- Chlorophyll *a* ≤20 µg/L
- Secchi Disc ≥1.0 m

Table 1 Lake Management—Water Quality, Recreational and Ecological Use Classifications of, and Management Philosophies for Southeast Anderson Lake Referencing Carlson's' Trophic State Index (TSI) Values (Secchi Disc Transparency Basis)

	Water Quality Condition (TSI_{SD})[1]			Lake Classification, by Regulatory Agency					
Lake	**"Current" (Most recent NMCWD data)**	**Expected Ranges, Ultimate Watershed Land Use With BMPs**	**Expected Ranges, Ultimate Watershed Land Use[2] Without BMPs**	**District Water Quality Goal[3]**	**MPCA* Swimmable Use Class (Reflects 7050 Rule for Shallow Lakes and 2008 Sec. 303(d.) Impaired Waters Listing Guidance)**	**Metro Council Priority Waters Class**	**Municipal Use[4]**	**MDNR* Ecological Class[5]**	**District Management Strategy**
Southeast Anderson	Year of Record = 2001 [TP] = 54 µg/L [Chla] = 31.5 µg/L S.D. = 1.0 m ***TSI_{SD} = 60***	[TP] = 34-52 µg/L [Chla] = 23-30 µg/L S.D. = 1.0-1.7 m ***TSI_{SD} = 52-59***	[TP] = 47-71 µg/L [Chla] = 28-38 µg/L S.D. = 0.7-1.2 m ***TSI_{SD} = 58-65***	II Partial body-contact recreational 75≥ [TP] >45 µg/L 40≥ [Chla] >20 µg/L 1.0≤ S.D. <2.0 m ***60≥ TSI_{SD} >50***	Shallow Lakes Criteria [TP] ≤60 µg/L [Chla] ≤20 µg/L S.D. ≥1.0 m ***TSI_{SD} ≤60***	3 Single-use recreational Period of Record = Not Monitored	Fish	44 Primary Fish Species: BLB, BG, BC ***TSI_{SD} = 61***	Protect

5.0 Description of Lake Water Quality

The water quality of a lake provides an indication of how a lake functions. A standardized lake rating system is often used to classify the ecological conditions of a lake. The rating system uses phosphorus, chlorophyll *a,* and Secchi disc transparency values to classify a lake into four categories: Oligotrophic (clear, low productivity lakes with excellent water quality), Mesotrophic (intermediate productivity lakes with good water quality), Eutrophic (high productivity lakes with poor water quality), and Hypereutrophic (extremely productive lakes with poor water quality).

Summer is the period of greatest interest to lake managers and the period of time in which the rating system is generally used to classify lakes. It is during the summer (June, July, and August) that recreational-use is greatest, and it is during these times that algal blooms and diminished transparency are most common. For these reasons, the following water quality discussion is focused on summer water quality in Southeast Anderson Lake.

This section summarizes observed and predicted in-lake water quality conditions for Southeast Anderson Lake under various climatological conditions, ranging from wet to dry. Because Southeast Anderson Lake is considered fully developed, these predicted water quality conditions are equally applicable for current and ultimate watershed land use conditions. Details of the analyses conducted to prepare these summaries and graphics are contained in the executive summary of the Anderson Lakes UAA report, which appears in Appendix B to this Engineer's Report.

5.1 Observed Lake Water Quality

Water quality data have been periodically collected from Southeast Anderson Lake during the period 1971 through 2001. Although the data indicate water quality improvement may have occurred during the period 1971 through 1988, not enough data were collected during this period to complete a statistical analysis, termed a trend analysis, of these data. A trend analysis of the data collected from 1988 through 2001 indicates the lake's water quality was stable during this period. Because no significant change occurred, the analysis results indicate the lake's water quality has neither improved nor degraded since 1988. It therefore appears that the lake's current water quality problems have been ongoing for at least 30 years.

An evaluation of data collected from Southeast Anderson Lake during 2001 confirms the perception that the lake currently notes problematic water quality. The 2001 epilimnetic summer averages for total phosphorus, chlorophyll *a*, and Secchi disc water transparency were 54 µg/L, 31 µg/L, and

1.0 meters, respectively (See Figure 2). These 2001 summer averages place the lake in the eutrophic category. This characterization means that by comparison to other lakes, Southeast Anderson Lake is extremely rich in algal nutrients, susceptible to dense algal blooms, and exhibits low water clarity. The 2001 summer average chlorophyll *a* concentration (31 μg/L) exceeded the lake's water quality standard found in the 7050 rule ($\leq$20 μg/L) due to dense algal blooms.

The lake's water quality problems have been ongoing since data collection began during 1971 (See Figures 3 through 5). An evaluation of data collected since 1971 indicates:

- Summer average total phosphorus concentrations failed to meet the state standard during 1971, 1988, and 2000 and failed to meet the District goal during 2000

- Summer average chlorophyll a concentrations failed to meet the state standard during all years of data collection

- Summer average Secchi Disc water transparency failed to meet both the District goal and state standard during 1988, 1991, and 2000

5.2 Modeled Lake Water Quality

Water quality simulations using the P8 and in-lake models indicate that dry weather conditions will produce the greatest strain upon water quality in Southeast Anderson Lake (see Table 2). This occurs despite the higher total load of phosphorus to the lake during wet weather (Table 3). Wetter weather results in larger volumes of relatively less concentrated water passing through the lake, so that in-lake phosphorus concentrations remain low. Despite the diminished phosphorus loading under dry conditions, the lake's flushing rate and volume is also diminished, so the in-lake phosphorus concentrations become elevated. In addition, the internal release of phosphorus appears to be the greatest under dry conditions (see Table 4).

Selection of the various climatic conditions was based on the summer precipitation totals (see Table 3). The surface runoff analysis using the P8 water quality model included estimating the watershed loadings for the preceding year to assess the lake's spring phosphorus concentration prior to the various summer climatic conditions. The 16 month total phosphorus load to Southeast Anderson Lake is greatest for model calibration conditions because of the variability in the precipitation patterns and intensities between the various climatic conditions analyzed and the variable nature of the internal phosphorus loads from sediment phosphorus release and Curlyleaf pondweed die-back.

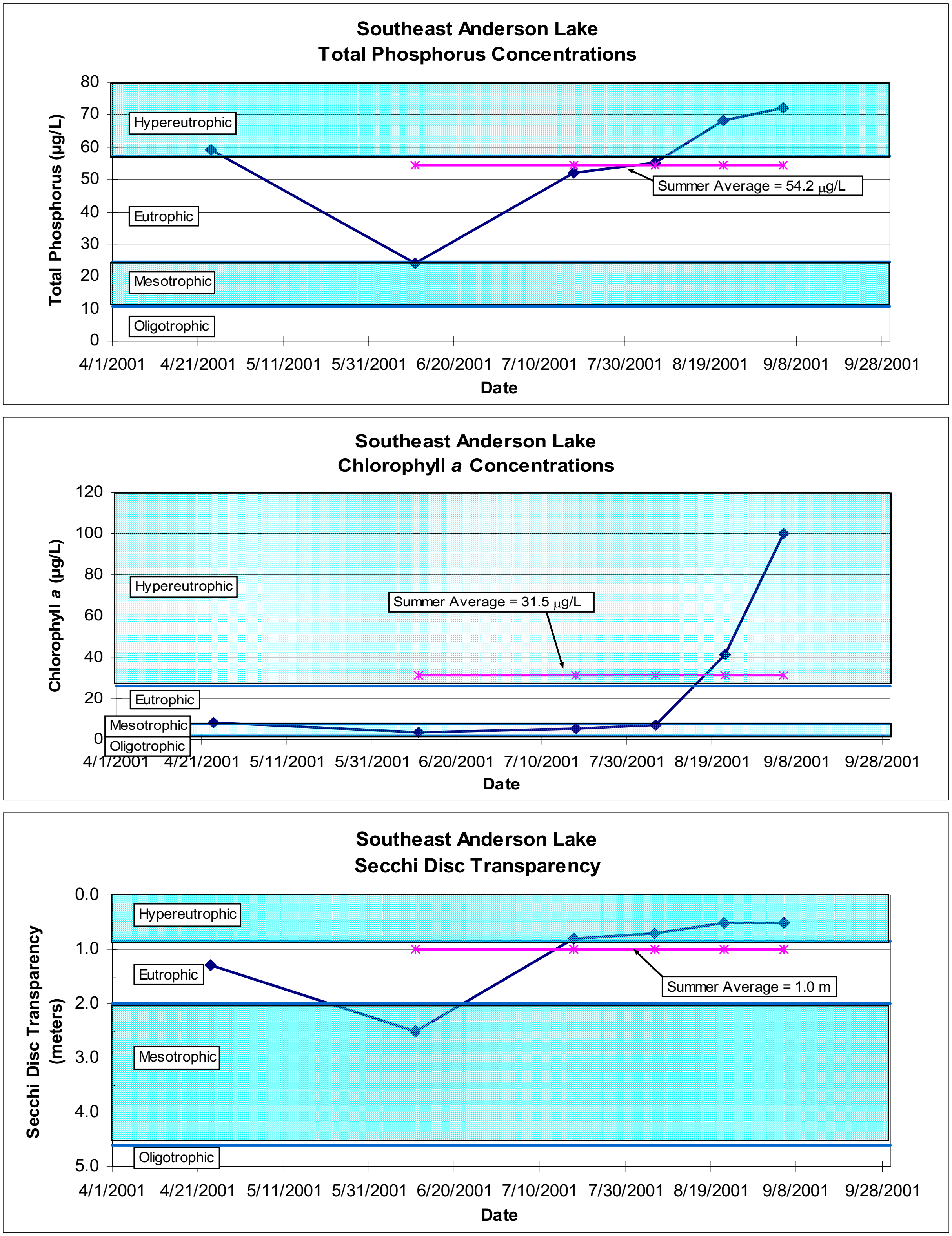


Figure 2 Seasonal Changes in Concentrations of Total Phosphorus, Chlorophyll a, and Secchi Disc Transparency in Southeast Anderson Lake For 2001

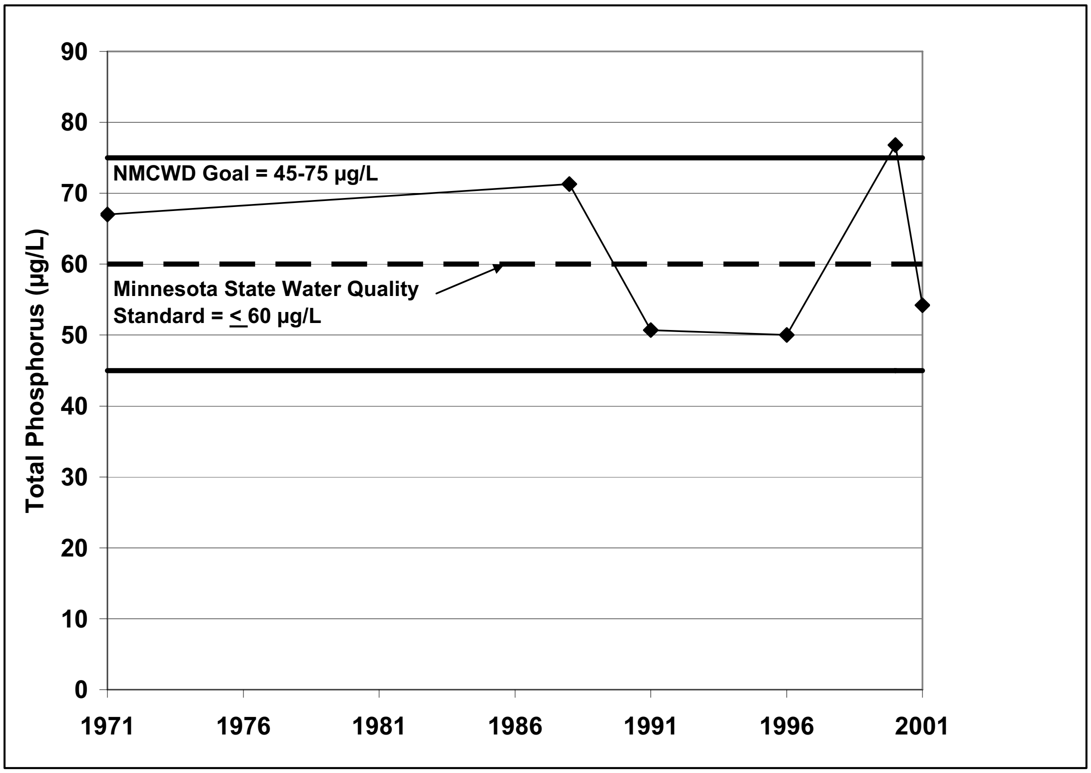


Figure 3 1971-2001 Southeast Anderson Average Summer Total Phosphorus Concentrations

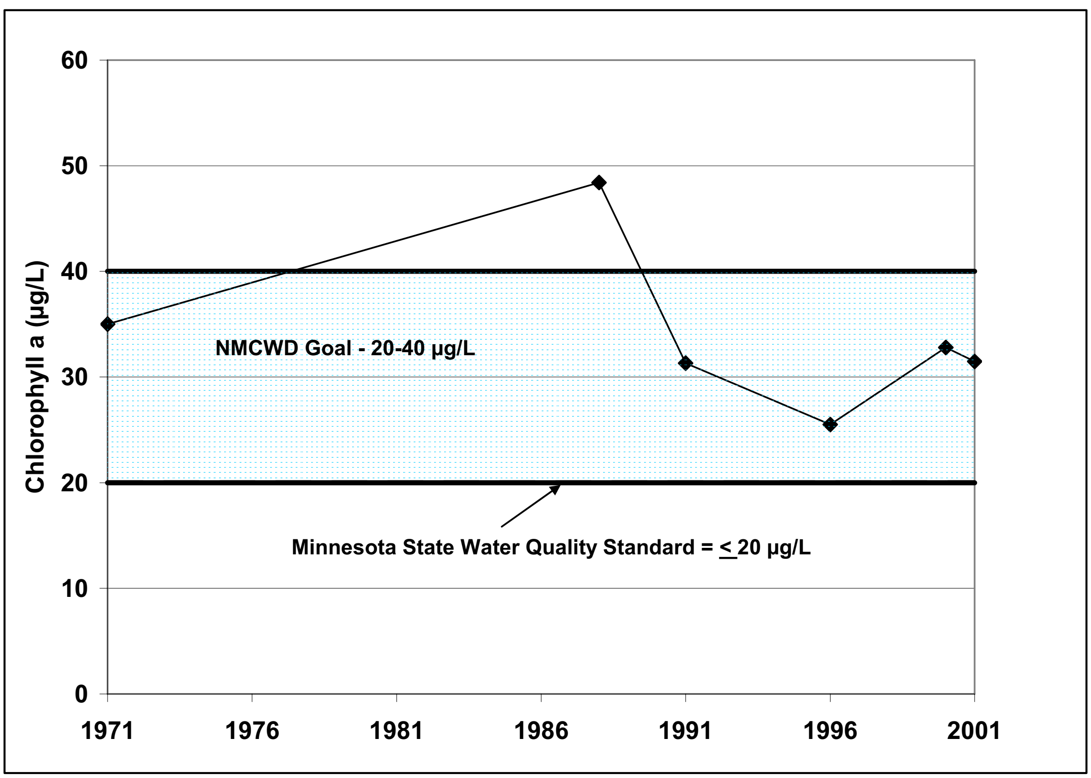


Figure 4 1971-2001 Southeast Anderson Average Summer Chlorophyll Concentrations

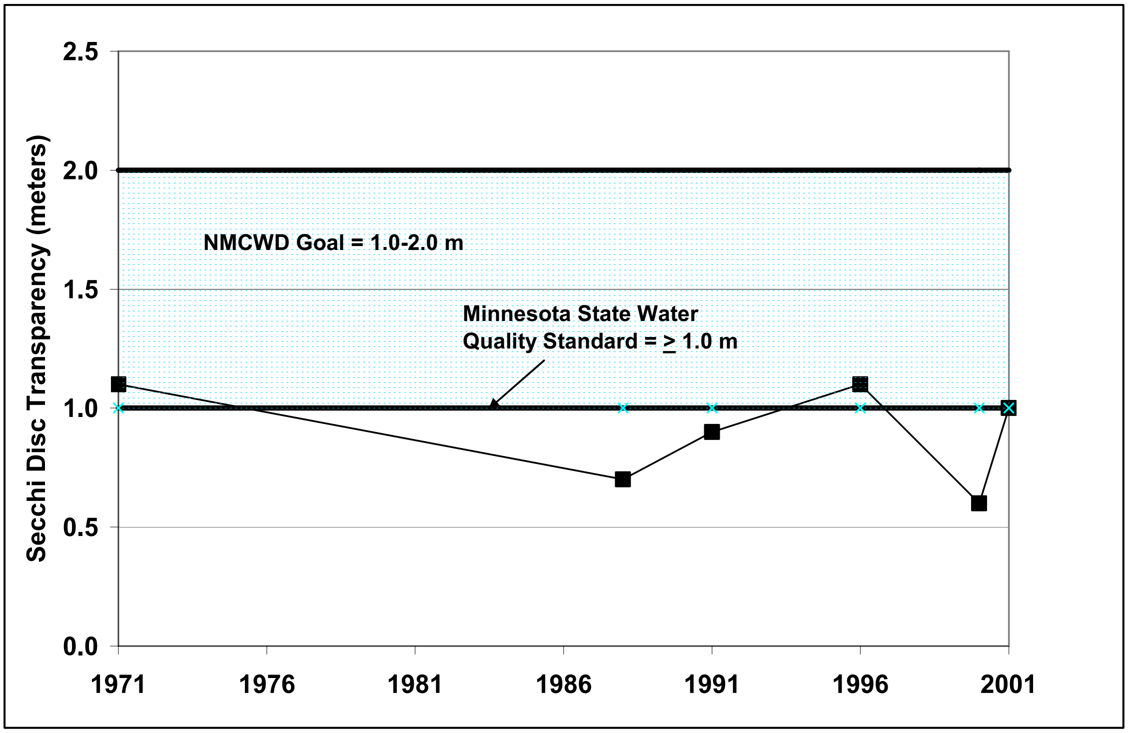


Figure 5 1971-2001 Southeast Anderson Average Summer Secchi Disc Transparency

Table 2 Southeast Anderson Lake Modeled Total Phosphorus and Chlorophyll a Concentrations, Secchi Disc Transparency, and TSI_{SD} for Varying Climatic Conditions Analyzed With a Normal Water Level at Elevation 839.0

	Summer Average			
Climatic Condition	**Total Phosphorus (µg/L)**	**Chlorophyll *a*(µg/L)**	**Secchi Disc (meters)**	**TSI_{SD}**
Dry Climatic Condition (1987-1988)*	71.9	38.3	0.7	65
Wet Climatic Condition (2001-2002)	54.9	31.3	1.0	60
Model Calibration Condition (2000-2001)	51.4	29.9	1.0	59
Average Climatic Condition (1994-1995)	46.5	27.8	1.2	58

*The May 1, 1987 through April 30, 1988 precipitation total excludes the 10-inch 1987 superstorm because of the rarity of this event.

Table 3 Southeast Anderson Lake Modeled Total Phosphorus Loading for Varying Climatic Conditions

Climatic Condition (inches of precipitation)	May 1_x through April 30_{x+1} Precipitation (inches)	May 1_{x+1} through September 30_{x+1} Precipitation (inches)	16 Month Modeled Total Phosphorus Load for Existing/Future Land Use (lbs)
Wet Climatic Condition (2001-2002)	25.66	27.36	133
Model Calibration Condition (2000-2001)	29.18	21.9	141
Average Climatic Condition (1994-1995)	28.26	15.33	92
Dry Climatic Condition (1987-88)*	24.86	10.17	106

*The May 1, 1987 through April 30, 1988 precipitation total excludes the 10-inch 1987 superstorm because of the rarity of this event.

Table 4 Southeast Anderson Lake Model Estimated Sediment Total Phosphorus Release Load for Varying Climatic Conditions

Climatic Condition (inches of precipitation)	Sediment Total Phosphorus Release Load (lbs)
Wet (2001-02)	9
Model Calibration (2000-01)	18
Average (1994-95)	0
Dry (1987-88)*	22

*The May 1, 1987 through April 30, 1988 precipitation total excludes the 10-inch 1987 superstorm because of the rarity of this event.

6.0 Description of Aquatic Communities

In addition to the physical and chemical indices of lake water quality, an evaluation of the lake's aquatic communities provides valuable information as to the health of the lake. An assessment of the current situation with respect to the lake's phytoplankton and aquatic plants communities is given in the following sections.

6.1 Phytoplankton

The phytoplankton community in Southeast Anderson Lake forms the base of the lake's food web and affects recreational-use of the lake. Phytoplankton, also called algae, are small aquatic plants naturally present in all lakes. They derive energy from sunlight (through photosynthesis) and from dissolved nutrients found in lake water. They provide food for several types of animals, including zooplankton, which are in turn eaten by fish.

An inadequate phytoplankton population limits the lake's zooplankton population and can, thereby, limit the fish production in a lake. Conversely, excess phytoplankton can alter the structure of the zooplankton community and interfere with sight-based fish predation, thereby also having an adverse effect on the lake's fishery. In addition, excess phytoplankton reduces water clarity; reduced water clarity can in itself make recreational-usage of a lake less desirable.

Southeast Anderson phytoplankton data confirm the problematic water quality conditions of the lake discussed in the previous section of this report (Section 5.0 Description of Lake Water Quality). Blue-green algae have dominated the lake's algal community during the 1988 through 2001 period for which data exist (See Figure 6). Blue-green algae are considered a nuisance algae because they:

- are generally inedible for fish, waterfowl, and most zooplankters;
- float at the lake surface in expansive algal blooms;
- may be toxic to animals when occurring in large blooms;
- can interfere with recreational uses of the lake

Excess phosphorus loads such as those seen in Southeast Anderson Lake stimulate blue-green algal growth. The warm growing conditions during July and August are particularly favorable to blue-greens, and blue-greens have a competitive advantage over the other algal species during this time.

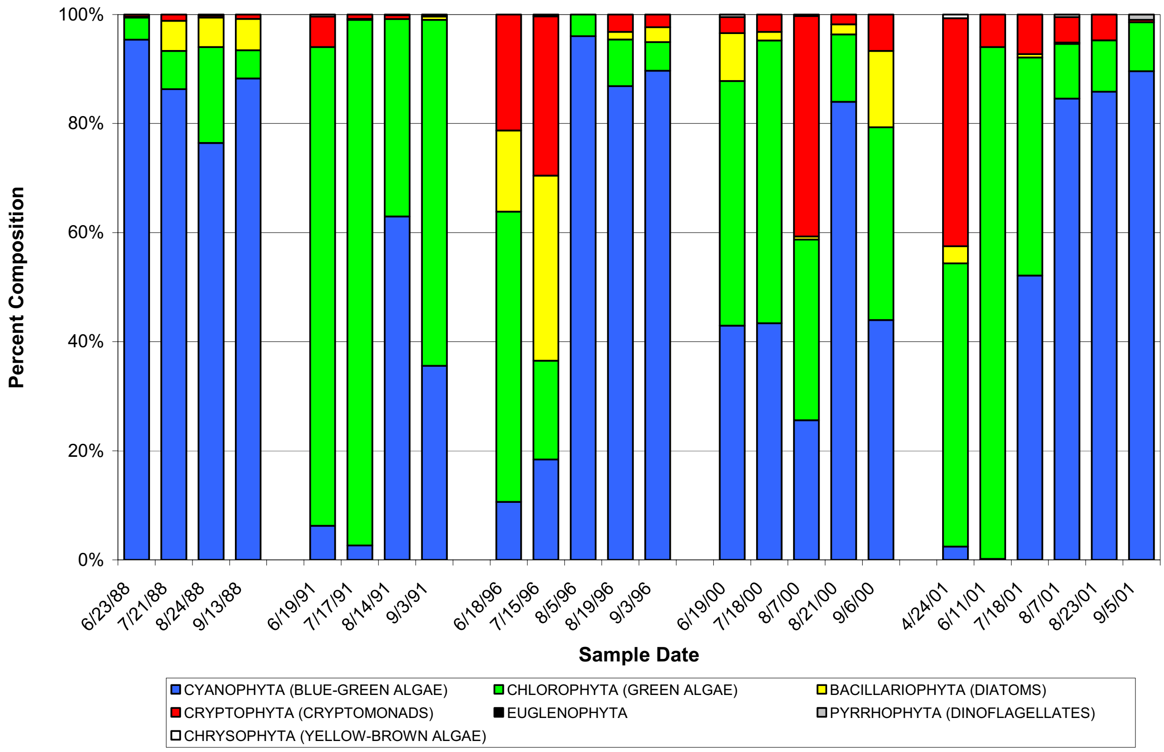


Figure 6 Southeast Anderson Lake Phytoplankton Data Summary by Division (Percent Composition)

Phytoplankton levels in 1988 through 2001 have varied from year to year with the highest phytoplankton levels occurring in 1991 (See Figure 7). The phytoplankton data confirm the presence of nuisance algal blooms and indicate that blue-green algae are the primary cause of these blooms.

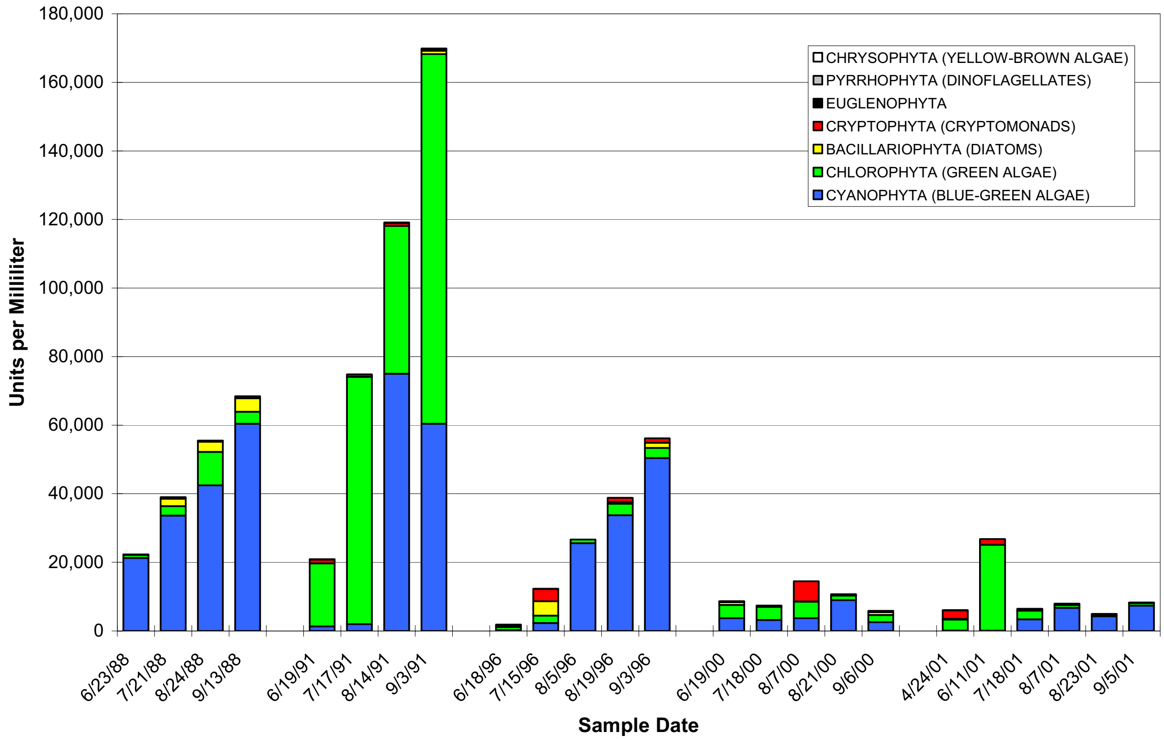


Figure 7 Southeast Anderson Lake Phytoplankton Data Summary by Division

6.2 Aquatic Plants

Aquatic plants—macrophytes—are a natural and integral part of most lake communities, providing valuable refuge, habitat and forage for many animal species. The lake's aquatic plants, generally located in the shallow areas near the shoreline of the lake:

- Provide habitat for fish, insects, and small invertebrates
- Provide food for waterfowl, fish, and wildlife
- Produce oxygen
- Provide spawning areas for fish in early-spring/provide cover for early-life stages of fish
- Help stabilize marshy borders and protect shorelines from wave erosion
- Provide nesting sites for waterfowl and marsh birds

A healthy native plant community contributes to the overall health of the lake. However, a dense non-native plant community creates problems for a lake which include recreational use, water quality, and fisheries habitat problems.

Aquatic plant surveys of Southeast Anderson Lake during 1996, 2000, and 2001 show the lake has historically shown dense pondweed growths with small stands of waterlily, and smaller patches of cattail and bulrush (See Appendix C). The lake consistently has shown dense growths of the non-native pondweed, Curlyleaf pondweed. This pondweed frequently replaces native species in lakes and exhibits a dense growth that may interfere with the recreational use of a lake. A dense growth also creates a convenient refuge for small fish, making it difficult for larger fish, such as bass, to locate and prey upon the small fish they need for food. As such, Curlyleaf pondweed can hinder gamefish production. Furthermore, the mid-season die-off that is a natural part of the life cycle of Curlyleaf pondweed can contribute (through plant matter decay) to increases in the lake's late-summer epilimnetic phosphorus concentration. This non-native species is thus often held partially responsible for late-summer algal blooms.

Because Curlyleaf pondweed decomposition was identified as a potentially significant source of internal loading, the total phosphorus mass contributed to the water column of Southeast Anderson Lake by the die-off of Curlyleaf pondweed was estimated. The contribution of phosphorus to the water column by pondweed is a two step process with die-off followed by decomposition and then release of phosphorus. James et al. 2001 estimated that this is a non-linear process with most of the phosphorus release occurring within 30 days of die-off. Because all of the pondweed does not die-off at the same time, a mathematical model was used to estimate die-off then phosphorus release. It was assumed that phosphorus input from pondweed die-off begins in mid-June of each year. The estimated total phosphorus load to Southeast Anderson Lake from Curlyleaf pondweed is shown in Table 5.

Table 5 Southeast Anderson Lake Modeled Curlyleaf Pondweed Total Phosphorus Loading for Varying Climatic Conditions

Climatic Condition (inches of precipitation)	Curlyleaf Pondweed Total Phosphorus Load (lbs)
Wet (2001-02)	37
Model Calibration (2000-01)	38
Average (1994-95)	38
Dry (1987-88)*	28

*The May 1, 1987 through April 30, 1988 precipitation total excludes the 10-inch 1987 superstorm because of the rarity of this event.

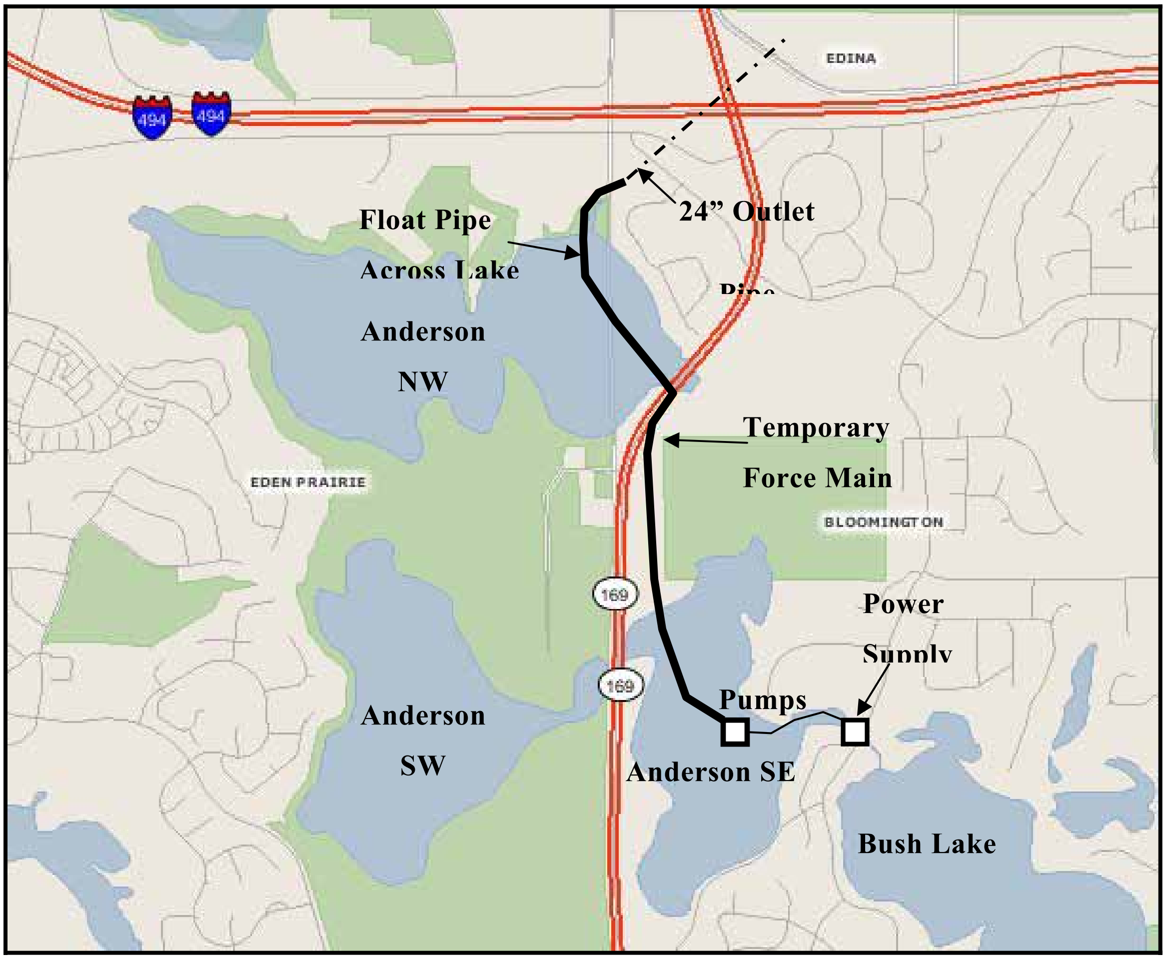
7.0 Proposed Improvement Plan

The UAA executive summaries contained in the Appendices of this Engineer's Report include a management recommendation to control purple loosestrife if it begins to dominate the lake's emergent plant community. This management recommendation would be undertaken separately, by either the City or the Watershed District, outside the work covered by this report. The Southeast Anderson Lake Water Quality Improvement Project includes the control of internal loading from Curlyleaf pondweed and lake sediments to improve the lake's water quality.

7.1 Drawdown to Manage Internal Loading From Curlyleaf Pondweed and Lake Sediments

A lake level draw down and winter freeze were considered as a management approach to control non-native aquatic vegetation, such as Curlyleaf pondweed, and internal phosphorus release from the sediment. However, it should be noted that all riparian landowners must sign a drawdown approval document in order for a drawdown to occur. Southeast Anderson riparian landowners are shown in Appendix D.

Two Southeast Anderson Lake drawdown options were evaluated. Option 1, shown in Figure 8, would draw the lake down by pumping water from the lake's center through a 5,580 foot temporary force main to existing Northwest Anderson Lake outlet pipe. The power supply from the Bush Lake by-pass pumping station outlet would be used to supply power to the pumps. The force main would convey water along the bottom of Southeast Anderson Lake from the lake's center to the lake's northwest shoreline and would then convey water along and immediately east of Highway 169 from Southeast Anderson Lake to Northwest Anderson Lake. Finally, the pipe would convey the water to the Northwest Anderson lake outlet pipe. An existing storm sewer drainage system would then convey the water to Nine Mile Creek. The drawdown would involve pumping 470 acre feet (153,139,536 gallons) at a rate of 3,000 gallons per minute (6.7 cubic feet per second) or 4,320,000 gallons per day over a 36 day period. Drawdown using Option 1 is estimated to cost approximately $343,000 to $393,300 depending upon whether Xcel Energy chooses an east side or south side location for the power drop (See Table 6).



Option #1 Anderson Lakes SE Draw Down; Pumping to Lake Outlet Pipe

Approximately 5580' of force main, restricted to 24" RCP outlet pipe, power supply from existing Bush Lake by-pass pumping station.

Need to pump out 470 Ac/Ft (153,139,536 gallons)

At 3,000 gpm (6.7 cfs), (~36 days)

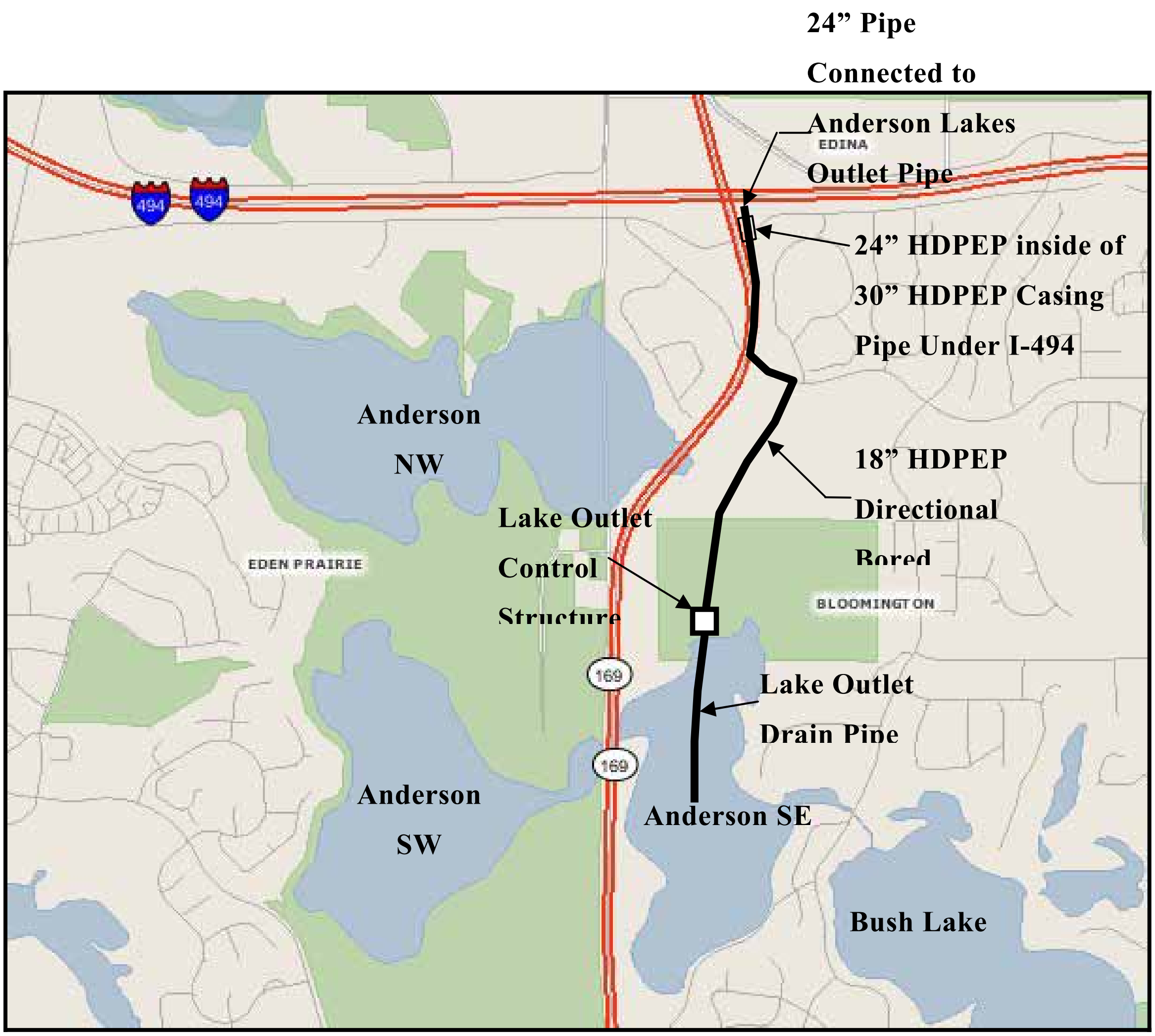
Anderson Lake Southeast
Proposed Draw Down
Option # 1

Figure 8 Anderson Lake Southeast Proposed Draw Down Option #1

Table 6 Estimated Cost for Southeast Anderson Lake Drawdown: Option 1

Item Description	Unit	Amount	Unit Cost	Total Cost
Mobilization and Demobilization	Each	1	$11,700	$11,700
Access	L.S.	1	$15,000	$15,000
Electrical Costs (Pole, Panel, Electrical Feed, Electrician)	L.S.	1	$12,000	$12,000
12" HDPEP Discharge Pipe	L.F.	5,580	$21	$117,200
Connect Discharge to Existing Pipe	L.S.	1	$2,500	$2,500
Lake Pumping	L.S.	1	$65,000	$65,000
Mn/DOT Permit	L.S.	1	$5,000	$5,000
Erosion Control	L.S.	1	$2,000	$2,000
Restoration	L.S.	1	$3,500	$3,500
Subtotal				$233,900
Contingencies (10%)				$23,400
Engineering & Administration (30%)				$70,200
Xcel Power Drop (East Side Power Drop - South Side Power Drop)				$15,500-65,800
Total With East Side Xcel Power Drop - Total With South Side Xcel Power Drop				$343,000-$393,300

Option 2, shown in Figure 9, would draw down the lake by a gravity outlet installed on the lake's north side. The lake outlet drain pipe would convey water along the bottom of Southeast Anderson Lake from the lake's deepest location to the lake outlet control structure on the north side of the lake (1,400 feet of 18-inch HDPEP lake drain). The water would then be conveyed north by an 18-inch HDPE pipe (directional drilled) through the city of Bloomington property, under the I-494 ramp (24-inch HDPEP inside of 30 inch HDPEP casing pipe), and connecting to the existing MnDOT storm sewer. The total length of directional bored 18-inch and 24-inch HDPEP would be 4,050 feet. Finally, the water would be conveyed to Nine Mile Creek. Option 2 is estimated to cost approximately $1,109,200 (See Table 7).



4,050 feet of directional bored 18" & 24" HDPEP and 1,400 feet 18" HDPEP lake drain and control structure.

To drain lake approx. 470 Ac/Ft would take 48 days.

Anderson Lake Southeast
Proposed Gravity System
Option # 2

Figure 9 Anderson Lake Southeast Proposed Drawdown: Option 2

Table 7 Estimated Cost for Southeast Anderson Lake Drawdown: Option 2

Item Description	Unit	Amount	Unit Cost	Total Cost
Mobilization and Demobilization	Each	1	$45,000	$45,000
Access Road, Clear and Grub	L.S.	1	$7,000	$7,000
18" HDPEP Directional Bored	L.F.	3,800	$90	$342,000
24" HDPEP Pipe (Under 494 Ramp)	L.F.	250	$185	$46,300
30" HDPEP Casing Pipe (Under 494 Ramp)	L.F.	250	$420	$105,000
18" HDPEP Lake Drain Pipe	L.F.	1,400	$110	$154,000
48" Diameter Standard Manhole	Each	12	$2,400	$28,800
Casting Assembly (Manhole)	Each	12	$519	$6,200
Spot Dig Utilities	Each	18	$350	$6,300
Remove and Replace Trench Pavement	S.Y.	156	$56	$8,700
RC Lake Outlet Control Structure	L.S.	1	$12,000	$12,000
Mn/DOT Permit	L.S.	1	$15,000	$15,000
Erosion Control	L.S.	1	$4,500	$4,500
Restoration	L.S.	1	$11,500	$11,500
Subtotal				$792,300
Contingencies (10%)				$79,200
Engineering and Administration (30%)				$237,700
Total				$1,109,200

7.2 Herbicide Treatment of Curlyleaf Pondweed

In addition to drawdown, Curlyleaf pondweed can be managed by treatment with herbicide. This option is less expensive than drawdown and, hence, is the recommended management approach for Southeast Anderson Lake. Herbicide treatment of Curlyleaf pondweed consists of annual spring herbicide treatment until this species is removed from Southeast Anderson Lake. Treatment would occur in late-April or early-May when the water temperature is approximately 55 to 60º F. Assuming normal plant growth conditions, treatment would be completed by the second week of May. Curlyleaf pondweed would be treated with the herbicide endothall at a dose of approximately

1 mg/L. To remove this species from the lake, treatment would need to continue annually until Curlyleaf pondweed and viable turions are eliminated. Treatment would be expected to continue for four years, although some spot treatments could occur after this period to attain the project goal. The estimated cost of the Curlyleaf pondweed management program is $124,600 (See Table 8).

Table 8 Cost Estimate – Endothall Treatments in Southeast Anderson Lake to Control Curlyleaf Pondweed

Item	Unit	Estimated Quantity	Unit Price*	Extension Per Year*	Extension 4 Years*
Mobilization (10%)	L.S.	1	$2,405	$2,400	$9,600
Endothall Application	Ac.	74	$325	$24,100	$96,400
Subtotal				$26,500	$106,000
Contingencies (10%)				$2,700	$10,600
Engineering & Administration (30%) (One Time Cost)				$8,000	$8,000
Total				$37,200	$124,600

*2008 dollars

7.2.1 Treatment Permit

An aquatic plant management control permit must be obtained from the Minnesota Department of Natural Resources (MDNR) prior to herbicide treatment of Southeast Anderson Lake. In addition, since more than 15 percent of the lake would be treated with herbicide, a letter of variance must be obtained from the MDNR. To maximize the effectiveness of the treatment, riparian owners would be asked to sign a permission form granting NMCWD permission to treat the area from the property boundary to 150 feet out. Should any residents not choose to sign the permission form, the area from property boundary to 150 feet out would not be treated for these residents, but the rest of the lake would receive treatment.

The estimated cost to attain a letter of variance, treatment permit, and letters of permission to treat within 150 feet of riparian property boundaries is $6,500 (See Table 9).

Table 9 Cost Estimate – Obtain MDNR Treatment Permit and Letter of Variance and Letters of Permission to Treat Within 150 Feet of Riparian Property Boundaries

Item	Unit	Estimated Quantity	Unit Price*	Extension Per Year*	Extension 4 Years*
Obtain Letter of Variance	L.S.	1	$500	$500	$2,000
Obtain Permit For Endothall Application	L.S	1	$1,000	$1,000	$4,000
Obtain Permission Letters From Riparian Owners	L.S	1	$500	$500	$500
Total				$2,000	$6,500

*2008 dollars

The treatment permit would require monitoring to determine treatment effectiveness. Monitoring details are discussed in the following sections.

7.2.2 Aquatic Plant Monitoring

The MDNR requires a pretreatment aquatic plant survey be conducted after the water temperature reaches 48 degrees Fahrenheit. The primary purpose of the pre-treatment survey would be to determine Curlyleaf pondweed (CLP) coverage prior to treatment. The survey would also determine native species present at the time of treatment. Two post treatment surveys would also be required to determine treatment effectiveness and treatment effects on the native plant community. Post treatment surveys would occur during June and August.

Point- intercept sampling methodology would be used for the pre-treatment and post treatment surveys. This method requires the creation of a regular grid of sample points over an orthorectified map or aerial photo of the lake. Each sample point would be numbered and downloaded into a GPS unit to allow for navigation to each sample point in the field. The MDNR would create the sample grid to use for the survey and provide it as an electronic file to NMCWD. These sample points would be used for each sample date. The number of sample points and sampling grid spacing varies depending upon the size of the lake. In general, a minimum 125 sample points would be located in the littoral zone of the lake (i.e., shallow area of the lake where plants grow) and the maximum distance between adjacent points in the sample grid would be 300 feet. At each of these points, water depth would be measured with an electronic depth finder for depths greater than 8 feet, or depth stick for depths less than 8 feet. All plant taxa retrieved on a plant rake sampler or observed within one square meter of sample site would be recorded. The plant rake sampler would be constructed from a double-headed garden rake tied onto the end of a rope at least 25 feet long or attached to a 16-foot pole. Taxa of samples recovered on the rake or observed in the water would be identified to species level if possible. At each sample point the sample point number, the sample depth, the plant taxa observed, and the estimated abundance of each taxon would be recorded. The abundance of each species would be estimated using the following ranking system (See Figure 10):

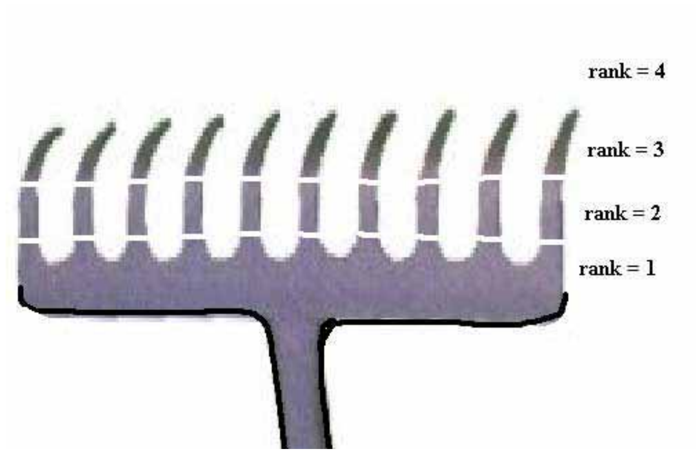


Figure 10 Abundance Ranking

- Rank 1 = < 1/3 of the rake head,
- Rank 2 = > 1/3 and < 2/3 of the rake head,
- Rank 3 = Plants filling >2/3 of the rake head,
- Rank 4 = Plants over the top of the rake

Surveyors would not have to sample in depths that are more than one inter-point distance deeper than the deepest vegetation, but they would sample at least one interval deeper than where vegetation was found.

A voucher specimen of each taxon identified would be collected, pressed and labeled with a standard herbarium label.

The following data would be reported to the MDNR:

- Frequency of occurrence of each species found in the survey and the combined frequency of: native submersed aquatic plants, all submersed aquatic plants, and all species found. Frequency of occurrence is calculated as the number of points in which a taxon (or combined taxa) occurred divided by the total number of points sampled (sample points that were deeper than the maximum depth where plants were found are excluded).

- Average number of submersed native species at each sample point and the standard error
- Average number of all submersed species at each sample point and the standard error
- Observed maximum depth of vegetation growth.

7.2.3. Biomass Monitoring

The MDNR requires, collection of biomass samples from 35 sample locations, during each sample event, to determine treatment effectiveness and the effect of treatment on the native plant community. Sample locations in the pre-treatment survey would be limited to locations containing CLP. The purpose of limiting pre-treatment sample locations to locations containing CLP would be to insure that the data adequately show treatment effectiveness. Biomass samples collected during the two post-treatment surveys would be collected from the same sample locations sampled during the pre-treatment survey. The pre-treatment and post treatment data would be compared to determine the reduction in CLP biomass and the increase in native plant biomass following treatment.

Samples would be collected using a rake attached to a pole. At each sample point, the rake would be lowered from the boat perpendicular to the bottom and then raised up to the water surface while slowly being twisted in a clockwise direction. Plant species from each sample would be separated into species and oven-dried to a constant weight.

7.2.4. Turion Monitoring

The MDNR also requires, collection of turion samples from 35 sample locations in October to determine the potential for new CLP growth during the subsequent year. Sample stations would be the 35 biomass sample stations. Samples would be processed and the number of turions at each sample location would be determined.

7.2.5 Herbicide Residue Monitoring

Herbicide residue monitoring, as required by the MDNR, would determine herbicide concentration in the water column during a 21 day period after treatment. For management of Curlyleaf pondweed, a 48 hour contact time of Endothall at a concentration of 1.0 mg/L would be required for effective treatment. Herbicide residue monitoring at one and two days after treatment would measure herbicide concentration in the water column and determine whether the required contact time had been attained. Herbicide residue monitoring would also show the degradation rate of the herbicide. Knowing the degradation rate of the herbicide would be necessary to verify that the herbicide degraded prior to the growth of native vegetation and, hence, did not adversely impact the lake’s native community. Endothall is expected to degrade into carbon dioxide and water within 21 days after treatment.

Herbicide residue samples would be collected from 2 locations within Southeast Anderson Lake. The stations would be located near the middle of the lake, and near the outflow. Samples would be collected at 1, 2, 7, 14, and 21 days after treatment. Sample collection would be at mid-depth.

7.2.6 Analysis and Reporting

Monitoring data would be analyzed and reported annually to the MDNR. The analysis and report would determine the degree of Curlyleaf pondweed control attained and confirm the positive or neutral effect of the herbicide treatment on the native plant community. The analysis would include the preparation of maps showing Curlyleaf pondweed coverage prior to and following each herbicide treatment. Analysis of the native plant community would include both an analysis of individual species and a community wide analysis. Specific analyses to be performed include frequency of occurrence and density (low, average, high) of individual species, diversity of the plant community, floristic quality index of the plant community (would determine the average quality of the plants comprising the community), percent open area, and percent similarity of the plant communities between sample events within each year and between years. Plant biomass would be compared between sample events to evaluate the decline in Curlyleaf pondweed and to evaluate the response of the native plant community to the treatment. Turion numbers would be evaluated to confirm an anticipated decrease in turions from the treatments. Herbicide residual monitoring data would be analyzed to confirm the correct application of the herbicide and to evaluate the herbicide degradation rate to confirm that the herbicide caused no harm to the native plant community. The data analysis and report would be submitted to the Minnesota DNR annually to confirm compliance with permit requirements.

7.2.7 Monitoring Cost Estimate

The estimated cost to complete the monitoring program, including aquatic plant, biomass, turion, and herbicide residue, is $183,700 (See Table 10). The aquatic plant monitoring cost assumes the MDNR would require an aquatic plant survey of 150 sample points and biomass and turion sampling at 35 sample points. If the MDNR would require either more or fewer sample points, the cost would change accordingly.

Table 10 Monitoring, Analysis, and Reporting Cost Estimate – Aquatic Plant, Biomass, Turion, and Herbicide Residue

Item	Unit	Estimated Quantity	Unit Price*	Extension Per Year*	Extension 4 Years*
Aquatic Plant Monitoring	L.S.	1	$22,500	$22,500	$90,000
Biomass Monitoring	L.S	1	$4,000	$4,000	$16,000
Turion Monitoring	L.S	1	$1,300	$1,300	$5,200
Herbicide Residue Monitoring	L.S.	1	$5,000	$5,000	$20,000
Subtotal				$32,800	$131,200
Contingencies (10%)				$3,300	$13,100
Engineering and Administration (30%)				$9,800	$39,400
Total				$45,900	$183,700

*2008 dollars

7.3 In-Lake Alum Treatment

Control of phosphorus loading from sediments is necessary to improve the water quality of Southeast Anderson Lake and attain the lake's water quality goal. Alum treatment of the lake is expected to diminish the extent of the internal loading, and result in significant long-term declines in summer average total phosphorus values. This assumes that application of alum to the lake sediments would decrease the internal phosphorus load by 80 percent (*Effectiveness and Longevity of Phosphorus Inactivation with Alum*, Welch and Cook, 1999).

In-lake alum treatment of the lake is expected to provide both a temporary and a long-term improvement in the water quality of the lake. The temporary benefit (lasting from 1 to 2 years) results from the alum's ability to remove phosphorus from the water column. The phosphorus removal inhibits algal growth by depriving the algae of phosphorus, a required nutrient. Additionally, temporary improvements in water clarity result from the "cleansing" of the water column that occurs as the alum floc settles and removes suspended particulate matter. Long-term benefits to the lake are expected to result from the alum's ability to bind phosphorus after the alum comes to rest on the lake sediment surface, thus preventing transfer of sediment-bound phosphorus back to the water column (i.e., preventing internal loading).

Over time, the effectiveness of the thin alum blanket on the sediment surface diminishes. Estimates of the effective duration of a single alum treatment in preventing sediment phosphorus release vary from 7 to 10 years. This effective duration can be affected by several factors, including homogeneity of treatment, wind-driven mixing and sediment resuspension, macrophyte decay, and changes in the sediment-water chemical exchange dynamics that may result from the treatment itself. Despite the uncertainties, it is reasonable to assume that for Southeast Anderson Lake, the alum treatment would be conducted at approximately 10-year intervals. If necessary, the treatment interval could be adjusted based on the results of ongoing water quality monitoring.

Following an alum treatment of Southeast Anderson Lake literature data suggest the internal summer phosphorus load could be reduced by about 80 percent. This estimated reduction in internal phosphorus release would reduce the total loading to the lake up to 17 percent (see Table 11).

Table 11 Southeast Anderson Lake Total Phosphorus Loading Reduction for Future Development with In-Lake Alum Treatment

Climatic Condition (inches of precipitation)	16 Month Modeled Total Phosphorus Load (lbs)	16 Month Modeled Total Phosphorus Load with In-Lake Alum Treatment (lbs)	Percent Decrease (%)
Wet (2001-02)	133	125	6
Model Calibration (2000-01)	142	127	10
Average (1994-95)	92	92	0
Dry (1987-88)*	106	88	17

*The May 1, 1987 through April 30, 1988 precipitation total excludes the 10-inch 1987 superstorm because of the rarity of this event.

7.3.1 Sediment Monitoring

Sediment monitoring is needed to determine the alum dose required to attain the 80 percent reduction of phosphorus loading from the lake's sediment. The monitoring would occur during the design phase of the water quality improvement project. Monitoring details are outlined in the following paragraphs.

Sediment cores would be collected from Southeast Anderson Lake at locations representative of varying water column depths and spatial locations. The surficial sediment of each core (approximately the top 30 cm – 12 inches) will be sliced at 2-cm (3/4 inch) depth intervals and each section would be analyzed for water content (H_20%), loss on ignition (LOI), mobile phosphorus, and organic phosphorus. The deeper samples would be used to estimate the background concentrations for the different phosphorus fractions and would be used to determine the excess phosphorus present in the surface sediment. The above analyses would be used to model the lake wide distribution of sediment phosphorus and then calculate the alum dose required to attain an 80 percent reduction in phosphorus loading from the lake's sediment.

Sediment monitoring is also needed to evaluate the success of the alum treatment Post-treatment sediment cores would be collected from the same sample locations used to determine the alum dose for the treatment. The surficial sediment of each core would be sliced at 2 cm depth intervals and each section would be analyzed for mobile phosphorus, organic phosphorus, and alum bound phosphorus. The location of the alum layer would also be determined. If the layer is below the sediment's surface, the distance from the surface would be measured.

7.3.1 Cost Estimate – Sediment Monitoring and In-Lake Alum Treatment

Because the in-lake alum treatment cost is dependent upon alum dose, the cost of the Southeast Anderson Lake alum treatment will not be known until sediment monitoring has been completed in the project's design phase. Sediment monitoring is needed to determine the alum dose required to attain the 80 percent reduction of phosphorus loading from the lake's sediment. A cost estimate of the lake's alum treatment, however, is provided based upon the average cost of in-lake alum treatments of other area lakes. The cost estimate assumes an alum dose of approximately 1,100 gallons per acre applied in two treatments (i.e., 550 gallons per acre for each treatment). The cost estimate assumes three sediment monitoring events—pre-treatment and after each treatment. As shown in Table 12, the estimated cost of sediment monitoring and in-lake alum treatment of Southeast Anderson Lake is $177,800.

Table 12 Cost Estimate – Sediment Monitoring and In-Lake Alum Treatment

Item	Unit	Estimated Quantity	Unit Price*	Extension Per Year*	Extension All Years*
Mobilization (15%)	L.S.	1	$14,000	$14,000	$14,000
Alum Application (One Time Cost)	Ac.	74	$1,220	$88,000	$88,000
Subtotal					$102,000
Dosing Determination, Analytical	L.S.	1	$10,000	$10,000	$10,000
Post Treatment Sediment Analyses	L.S.	2	$7,500	$7,500	$15,000
Subtotal					$127,000
Contingencies (10%)					$12,700
Engineering & Administration (30%) (one-time cost)					$38,100
Total					$177,800

*2008 dollars

7.4 Combine Endothall and Alum Treatments

Endothall and alum treatments would be combined to improve the water quality of Southeast Anderson Lake such that the NMCWD goal is attained. Below is the expected sequence of management activities for the six year period of project implementation.

Years 1-4 Herbicide (endothall) treatment; aquatic plant and herbicide residue monitoring;

Year 5-6 Alum treatment; post treatment sediment and water quality monitoring, spot treatment of herbicide, if needed, to attain CLP control goal

Water quality monitoring would occur for one year prior to treatment, during each of the two treatment years, and at 3 year intervals for 10 years after treatment. The data will indicate the treatment effectiveness and determine the longevity of the treatment.

7.5 Cost Estimate

The estimated cost of the recommended improvements described in this Engineer's Report and shown in Figure 1 is $552,600. Cost details are presented in Table 13.

Table 13 Cost Estimate – Endothall and In-Lake Alum Treatments in Southeast Anderson Lake, Including Permitting, and Monitoring Costs

Treatment Type	Task	Cost
Endothall Treatment	Letter of Variance From MDNR	$2,000
	Treatment Permits From MDNR & Permission Letter From Riparian Owners	$4,500
	Endothall Treatment (4 Annual Treatments)	$124,600
	Monitoring, Analysis, and Reporting Cost Estimate – Aquatic Plant, Biomass, Turion, and Herbicide Residue (4 Yrs)	$183,700
Endothall Treatment Subtotal*		**$314,800**
Alum Treatment	Sediment Monitoring and In-Lake Alum Treatment (2 Yrs)	$177,800
	Water Quality Monitoring (6 Years)	$60,000
Alum Treatment Subtotal*		**$237,800**
Total*		**$552,600**

* Estimates include contingencies (10%) and engineering & administration (30%).

The estimated water quality improvement benefits to result from the combined endothall and alum treatments are shown in Figures 11 through 14.

7.6 Permits

Permits for the recommended improvements will be required by the City of Bloomington, the Minnesota Department of Natural Resources, the Minnesota Pollution Control Agency, and the Nine Mile Creek Watershed District.

7.7 Affected Property Owners

Owners of the properties potentially affected by the recommended improvements are listed in Appendix D.

8.0 Impacts Caused by the Project

No long-term adverse impacts to natural resources are expected to result from implementation of the recommended improvements.

Expected benefits of completing the petitioned project are summarized in Figures 11 through 14. The result of the petitioned project will be improved lake water quality to the point where it consistently meets its goal and state water quality standards under wet, average, dry, and calibration climatic conditions.

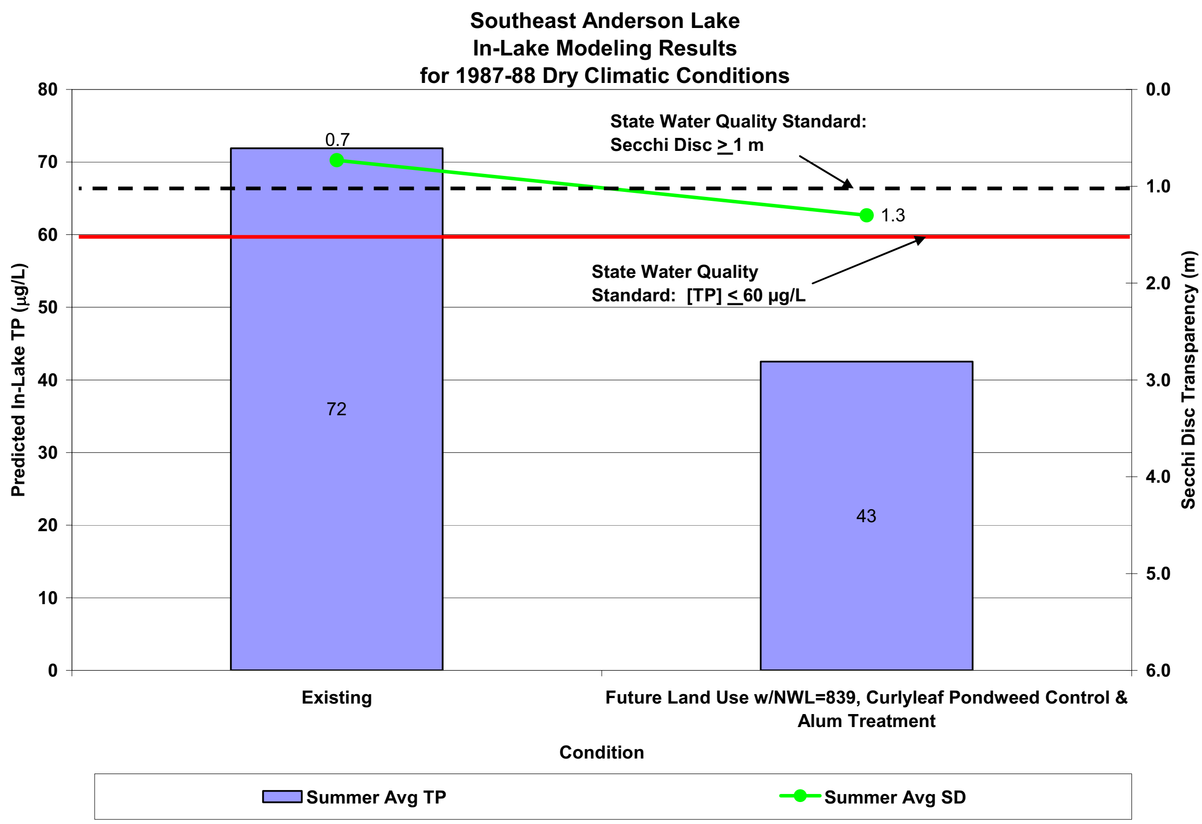


Figure 11 Modeled Southeast Anderson Water Quality Improvements From Curlyleaf Pondweed Control and Alum Treatment Under Dry Climatic Conditions

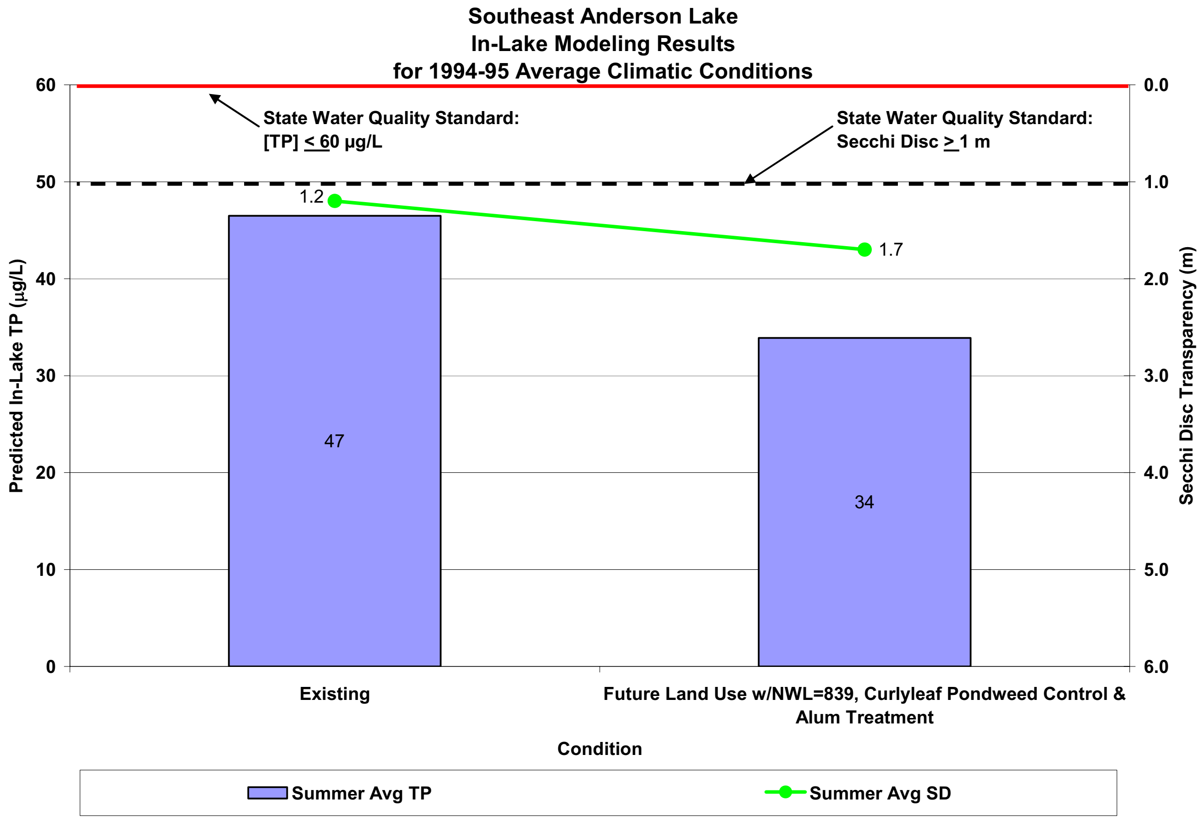


Figure 12 Modeled Southeast Anderson Water Quality Improvements From Curlyleaf Pondweed Control and Alum Treatment Under Average Climatic Conditions

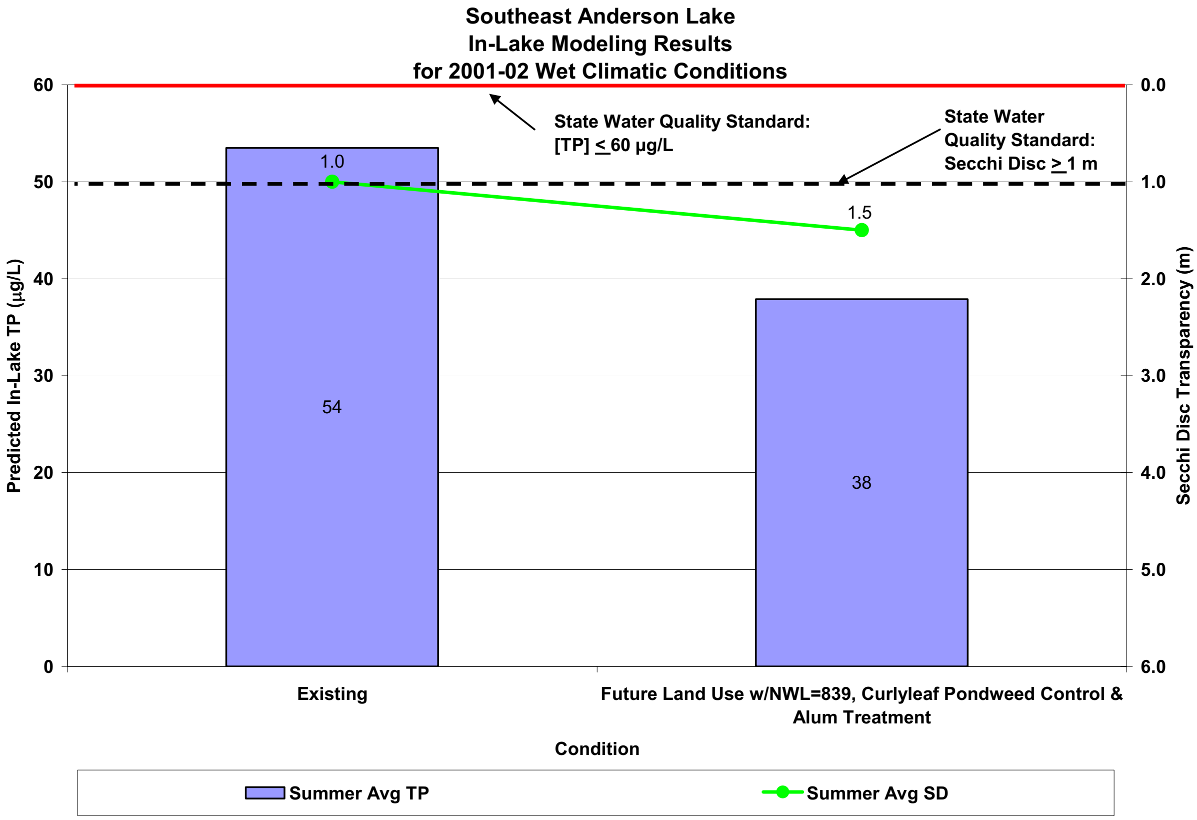


Figure 13 Modeled Southeast Anderson Water Quality Improvements From Curlyleaf Pondweed Control and Alum Treatment Under Wet Climatic Conditions

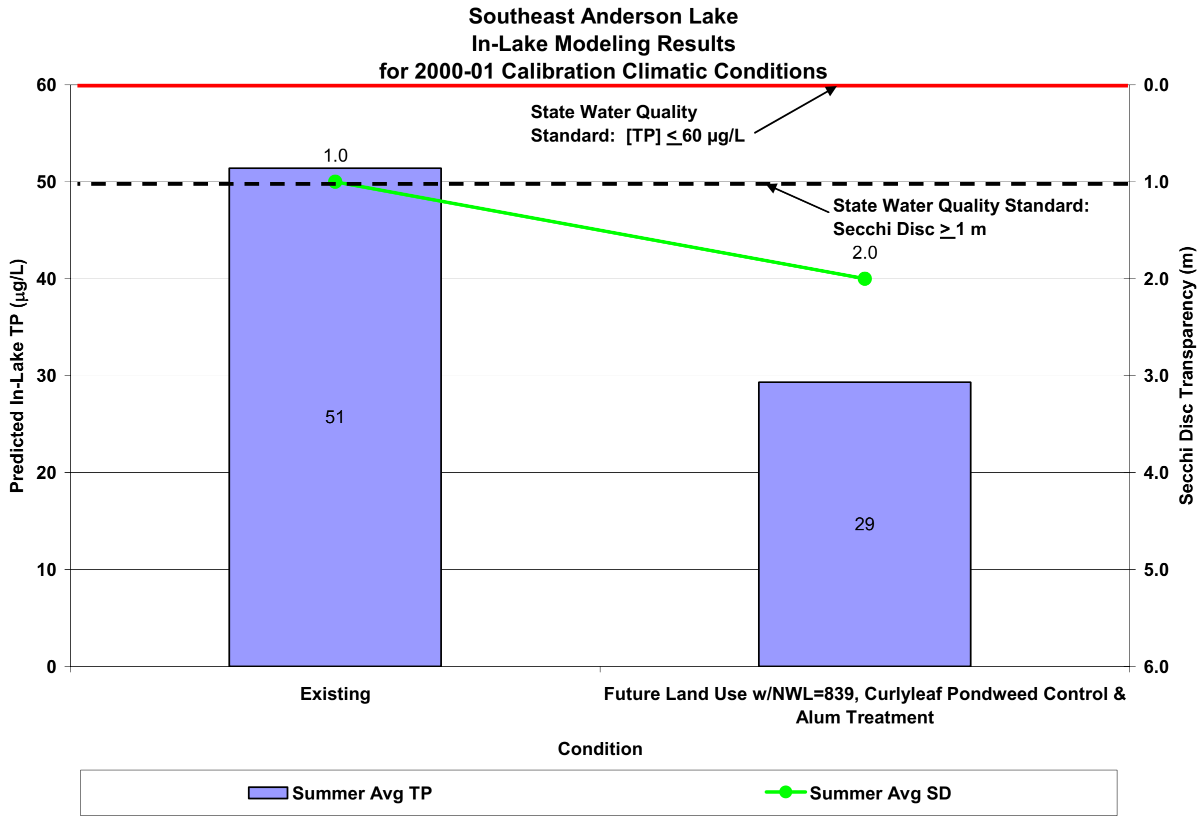


Figure 14 Modeled Southeast Anderson Water Quality Improvements From Curlyleaf Pondweed Control and Alum Treatment Under Calibration Climatic Conditions

9.0 Recommendation

The Southeast Anderson Lake Water Quality Improvement Project is a necessary and feasible part of the Overall Water Management Plan of the Nine Mile Creek Watershed District. The city of Bloomington has petitioned the Nine Mile Creek Watershed District to undertake this work on a cooperative basis with the City (see Appendix A). Because the project meets the water quality management goals of the District, it is recommended that the herbicide and whole lake alum treatments be implemented as is generally described in this Engineer's Report.

Appendix A

Petition of the City of Bloomington to the NMCWD for a Basic Water Management Project and Accompanying City Council Resolution

CITY OF
BLOOMINGTON
MINNESOTA

March 13, 2008

Kevin Bigalke
District Administrator
Nine Mile Creek Watershed District
7710 Computer Avenue
Suite 135
Edina, MN 55435

RE: Petition for Basic Water Management Project

Dear Mr. Bigalke,

Enclosed please find a petition to undertake a basic water management project to improve the water quality of SE Anderson Lake.

The Bloomington City Council passed a resolution on March 3, 2008 authorizing signature of the petition. The City has recognized the need for water quality improvements to SE Anderson Lake to maintain existing identified uses and goals and as a benefit to the Eden Prairie Lakes Project.

The City asks that the Board of Managers consider this petition at their next available regular meeting. If you have any questions or need any additional information, please contact me at 952-563-4557 or Scott Anderson at 952-563-4867. Thank you.

Sincerely,

Bryan Gruidl
Engineering Division

PUBLIC WORKS DEPARTMENT
1700 WEST 98TH STREET, BLOOMINGTON MN 55431-2501
PH 952-563-4581 FAX 952-563-4868 TTY 952-563-8740

PETITION OF THE CITY OF BLOOMINGTON TO THE NINE MILE CREEK WATERSHED DISTRICT TO UNDERTAKE A BASIC WATER QUALITY MANAGEMENT PROJECT TO IMPROVE THE WATER QUALITY SOUTHEAST ANDERSON LAKE

I. AUTHORITY

This petition, submitted by the City of Bloomington pursuant to the provisions of the Minnesota Statutes Sections 103D.605, 103D.705, and 103D.905 requests the Nine Mile Creek Watershed District (District) to undertake a water quality management project to improve water quality in Southeast Anderson Lake.

II. PURPOSE

The public benefits and objectives of improving the water quality of Southeast Anderson Lake include enhancement of the diversity and quality of the aquatic vegetation in the lake, improvement of the habitat for wildlife surrounding and using the lake, and preservation of existing public recreational opportunities.

On Southeast Anderson Lake, the project would include control of Curlyleaf pondweed as well as other identified non-native invasive vegetative species. Other in-lake or watershed management approaches identified in the 2003 Use Attainability Analysis, or otherwise, for the purposes of improving lake water quality and/or meeting District water quality and recreational use goals would be included.

III. GENERAL DESCRIPTION OF WORK PROPOSED AND PURPOSES

The proposed work at Southeast Anderson Lake includes the engineering and construction of all appurtences necessary to control Curlyleaf pondweed in the lake to reduce summer in-lake total phosphorus concentrations and improve water quality.

Other in-lake or watershed management best management practices as identified in the UAA or in an Engineer's Report or feasibility study resulting in improvements to water quality should also be considered. The purpose or goal of all work is to improve water quality to meet the District identified classification for the lake and to ultimately support the water quantity, water quality, aquatic communities, recreational use, and wildlife goals for Southeast Anderson Lake.

IV. JURISDICTION OF THE LANDS OVER WHICH THE IMPROVEMENTS ARE LOCATED

Southeast Anderson Lake is wholly located within the City of Bloomington. The majority of the lakeshore is owned by the City of Bloomington with approximately 20 residential parcels on the lake

V. DESCRIPTION OF THE PART OF THE DISTRICT AFFECTED

The area to be served is entirely comprised of District lands tributary to Southeast and Southwest, Northeast Anderson Lakes, and ultimately Nine Mile Creek. The area immediately surrounding Southeast Anderson Lake is a mix of parkland, residential, and highway uses.

VI. NEED AND NECESSITY FOR THE PROPOSED IMPROVEMENT

Petitioner recognizes the need for water quality improvements to Southeast Anderson Lake to maintain existing identified uses and goals for the lake as well being consistent with the preservation of flood control. The Petitioner recognizes the necessity of recreational assets within Bloomington and the value of Southeast Anderson Lake and Nine Mile Creek. The project is necessary to address hydrological impacts from urban development of the tributary drainage area, to enhance the ecology of the lake and overall creek system, and improve the quality of the existing recreational opportunities.

VII. THE PROPOSED IMPROVEMENTS WILL INCREASE FUNCTIONALITY, ENHANCE RECREATION, AND PROMOTE PUBLIC WELFARE.

Petitioner proposes that these improvements be based upon its intention to increase functionality, enhance recreation, and promote public welfare. Improvements to Southeast Anderson Lake identified in the UAA will reduce in-lake nutrient concentrations resulting in better water quality and enhanced lake ecology more capable of supporting existing identified uses.

VIII. FINANCING OF THE PROPOSED IMPROVEMENT

The project is of common benefit to the District and is subject to Minnesota Statutes Section 103D.905, Subdivision 3, providing for the financing of the basic water management features.

IX. ABANDONMENT OF PROJECT

The Petitioner hereby states that it will pay all costs and expenses which may be incurred should the project be dismissed, no contract for the construction is let, or the project petition is withdrawn by the City of Bloomington.

Dated: March 4, 2008

CITY OF BLOOMINGTON

By ______________________
Acting Mayor

By ______________________
City Manager

Appendix B

Anderson Lakes UAA (Executive Summary Only)

Executive Summary

Overview

This report describes the results of the Use Attainability Analysis (UAA) for Southeast, Southwest, and Northwest Anderson Lakes in Bloomington and Eden Prairie, MN. The UAA provides the scientific foundation for a lake-specific best management plan that will permit maintenance of, or attainment of, intended beneficial uses of Southeast, Southwest, and Northwest Anderson Lakes. The UAA is a scientific assessment of a water body's physical, chemical, and biological condition. This study includes both a water quality assessment and prescription of protective and/or remedial measures for Southeast, Southwest, and Northwest Anderson Lakes and their watersheds. The conclusions and recommendations are based on historical water quality data, the results of an intensive lake water quality monitoring in 2000-01, and computer simulations of land use impacts on water quality in Southeast, Southwest, and Northwest Anderson Lake using watershed and lake models calibrated to the 2001 data set. In addition, best management practices (BMPs) were evaluated to compare their relative effect on total phosphorus concentrations and Secchi disc transparencies (i.e., water clarity). Management options were then assessed to determine attainment or non-attainment with the lake's beneficial uses.

Water Quality Goals

Nine Mile Creek Watershed District Water Quality Goals

The approved *Nine Mile Creek Watershed District Water Management Plan* (Barr, 1996) preliminarily assessed ultimate watershed water quality for Southeast, Southwest, and Northwest Anderson Lakes and articulated five specific goals for the lake. These goals address water quantity, water quality, aquatic communities, recreational-use, and wildlife. Where possible, the Nine Mile Creek Watershed District (NMCWD) goals were quantified by using the standardized lake rating system termed the Carlson's Trophic State Index (TSI). This index considers the lake's total phosphorus, chlorophyll *a*, and Secchi disc transparencies to assign a water quality index number reflecting the lake's general fertility level. The rating system results in index values between 0 and 100, with the index value increasing with increased lake fertility. Total phosphorus, chlorophyll *a*, and Secchi disc transparency are key water quality indicators for the following reasons.

- Phosphorus generally controls the growth of algae in lake systems. Of all the substances needed for biological growth, phosphorus is typically the limiting nutrient.

- Chlorophyll *a* is the main photosynthetic pigment in algae. Therefore, the amount of chlorophyll *a* in the water indicates the abundance of algae present in the lake.
- Secchi disc transparency is a measure of water clarity, and is inversely related to the abundance of algae. Water clarity typically determines recreational-use impairment.

All three of the parameters can be used to determine a TSI. However, water transparency is typically used to develop the TSI_{SD} (trophic state index based on Secchi disc transparency) because people's perceptions of water clarity are often directly related to recreational-use impairment. The TSI rating system results in the placement of a lake with medium fertility in the mesotrophic trophic status category. Water quality trophic status categories include oligotrophic (i.e., excellent water quality), mesotrophic (i.e., good water quality), eutrophic (i.e., poor water quality), and hypereutrophic (i.e., very poor water quality). Water quality characteristics of lakes in the various trophic status categories are listed below with their respective TSI ranges:

1. **Oligotrophic –** [$20 \leq TSI_{SD} \leq 38$] clear, low productive lakes, with total phosphorus concentrations less than or equal to 10 mg/L, chlorophyll *a* concentrations of less than or equal to 2 mg/L, and Secchi disc transparencies greater than or equal to 4.6 meters (15 feet).

2. **Mesotrophic –** [$38 \leq TSI_{SD} \leq 50$] intermediately productive lakes, with total phosphorus concentrations between 10 and 25 mg/L, chlorophyll *a* concentrations between 2 and 8 mg/L, and Secchi disc transparencies between 2 and 4.6 meters (6 to 15 feet).

3. **Eutrophic –** [$50 \leq TSI_{SD} \leq 62$] high productive lakes relative to a neutral level, with 25 to 57 mg/L total phosphorus, chlorophyll *a* concentrations between 8 and 26 mg/L, and Secchi disc measurements between 0.85 and 2 meters (2.7 to 6 feet).

4. **Hypereutrophic –** [$62 \leq TSI_{SD} \leq 80$] extremely productive lakes which are highly eutrophic and unstable (i.e., their water quality can fluctuate on daily and seasonal basis, experience periodic anoxia and fish kills, possibly produce toxic substances, etc.) with total phosphorus concentrations greater than 57 mg/L, chlorophyll *a* concentrations of greater than 26 mg/L, and Secchi disc transparencies less than 0.85 meters (2.7 feet).

The NMCWD's management strategy has been to "protect" the three Anderson Lakes. According to the *NMCWD Water Management Plan*, "protect" means "to avoid significant degradation from point and nonpoint pollution sources and from wetland alterations, in order to maintain existing beneficial uses, aquatic and wetland habitats, and the level of water quality necessary to protect these uses in receiving waters." The NMCWD goals for Southeast, Southwest, and Northwest Anderson Lake include the following:

The **Water Quantity Goal** for the three Anderson Lakes is to provide sufficient water storage of surface runoff during a regional flood, the critical 100-year frequency storm event. This goal is attainable with no action.

The **Water Quality Goal** for Southeast and Southwest Anderson Lakes is specified by the NMCWD and presented in the *NMCWD Water Management Plan*. The plan specifies a Category II classification Category. The specific NMCWD goal for Southeast and Southwest Anderson Lakes is to achieve and maintain a TSI_{SD} between 50 and 60. The plan specifies a Category III classification for Northwest Anderson Lakes. The specific NMCWD goal is to achieve and maintain a TSI_{SD} between 60 and 70. These goals, as established by and presented in the *NMCWD Water Management Plan*, are attainable, but only with the implementation of the BMPs described in this UAA.

The **Aquatic Communities Goal** for Southeast Anderson Lake is to achieve a water quality that fully supports the lake's fisheries-use classification determined by the MDNR as outlined in *An Ecological Classification of Minnesota Lakes with Associated Fish Communities* (Schupp, 1992) and achieve a balanced ecosystem. This includes a diverse growth of native aquatic macrophytes. Specifically, the goal for Southeast Anderson Lake is to achieve and maintain a $TSI_{SD} \simeq 61$ and a balanced fishery.

Since the MDNR did not specify the ecologic class for Northwest and Southwest Anderson Lakes there is no specific fisheries related TSI goal. However, like Southeast Anderson Lake, the NMCWD wants to achieve water quality that will result in a diverse native ecosystem.

The **Wildlife Goal** for each of the three Anderson Lakes is to protect existing beneficial wildlife uses. The wildlife goal can be achieved with no action, especially if the wetlands and natural land surrounding the lake remain intact.

Three Rivers Park District and City of Eden Prairie Goals

Both the Parks District and City of Eden Prairie have expressed a desire to manage Southwest and Northwest Anderson Lakes to improve the waterfowl nesting habitat and the overall wildlife use of the area. Neither organization wishes to promote recreational use of these two resources. The specific water quality criteria listed in the Three Rivers Park District's 1999 Water Quality Management Plan is to maintain a TSI < 77. The City did not provide any specific water quality criteria but have indicated that they agree with the Parks District's criteria. A TSI value of 77 translates into the following total phosphorus concentration, chlorophyll *a* concentration, and Secchi disc transparency.

- TSI < 77
- Total Phosphorus Concentration ≤ 156 μg/L
- Chlorophyll a concentration ≤ 113 μg/L
- Secchi disc transparency ≥ 0.3 meters

In addition to the water quality criteria listed above, the Parks District and City want to pursue lowering the normal water level (NWL) of Southwest and Northwest Anderson Lakes by 1.5 feet to Elevation 837.5. In order to lower the NWL in these water resources the Parks District or City would be required to get a permit from the MDNR.

City of Bloomington Goals

As part of the City of Bloomington's Surface Water Management Plan the City adopted the same management goals for Southeast Anderson Lake as outline to the NMCWD 1996 Water Management Plan.

Lake Characteristics

Historically the three Anderson Lakes were considered to be landlocked. In the early-1980's NMCWD installed an outlet structure at the northeast corner of Northwest Anderson Lake. This structure was designed to control the normal water Category (NWL) of the three lakes at Elevation 839.0. At this elevation the three lakes are interconnected. This original structure had a capacity of 2 cubic feet per second (cfs). Following the construction of US Highway 169, a new outlet structure with the same control elevation and a 10 cfs capacity was installed and became operational in the spring of 2000. With this structure installed the anticipated 100-year high water level (HWL) is estimated to be 841.0. In general, water is detained significantly by the lakes because of the limited outlet capacity. Therefore, the water levels in these lakes can fluctuate significantly and this fluctuation was incorporated into the lake water quality modeling process.

Southeast Anderson Lake receives runoff from its watershed and from the periodic pumping of water from Bush Lake (the pumped outlet from Bush Lake became operational in 2000 and starts pumping when the water surface elevation in Bush Lake exceeds 834.0). Water leaves the northwest corner of Southeast Anderson Lake by flowing through a 48-inch culvert under US Highway 169 to Southwest Anderson Lake. Southwest Anderson Lake is connected to Northwest Anderson Lake by a wetland area and small natural channel at the north end of the lake.

Southeast Anderson Lake

Southeast Anderson Lake is located in the western portion of Bloomington and has a water surface of approximately 81 acres, a maximum depth of approximately 9 feet, and a mean depth of 4.7 feet at a water surface elevation of 839.0. At this elevation the lake volume is approximately 470 acre-feet. Southeast Anderson Lake is relatively shallow and has a large littoral area, thus causing it to be prone to frequent wind-driven mixing of the lake's shallow and deep waters during the summer. One would therefore expect Southeast Anderson Lake to be polymictic (mixing many times per year) as opposed to lakes with deep, steep-sided basins that are usually dimictic (mixing only twice per year).

Southwest Anderson Lake

Southwest Anderson Lake has an open water surface area of approximately 110 acres (the open water area is variable, depending on the seasonally-varying coverage of the lake's cattail fringe), a maximum depth of approximately 8 feet, and a mean depth of approximately 4 feet. The lake volume is approximately 437 acre-feet. Southwest Anderson Lake is quite shallow, especially in comparison with its large surface area. Therefore, as is the case with Southeast Anderson Lake, Southwest Anderson Lake would be expected to be prone to frequent wind-driven mixing which is supported by the data gathered from Southwest Anderson Lake indicating that this lake is also polymictic. Because the lake is so shallow, aquatic plants can grow over the entire lake bed and a summer thermocline is not usually present.

Northwest Anderson Lake

Northwest Anderson Lake has an open water surface area of approximately 185 acres, a maximum depth of approximately 10 feet, and a mean depth of approximately 4 feet. The lake volume is approximately 732 acre-feet. Since Northwest Anderson Lake is quite shallow, especially in comparison with its large surface area, it would be expected to be prone to frequent wind-driven mixing, indicating that this lake is also polymictic.

The lake area, depth, and volume depend on the water level of the lake, which has been observed to vary between a high measurement of 840.7 feet MSL (1998) and a low measurement of 835.3 feet MSL (1978). The approximate water surface area, depth, and volume (given above) are as measured at the average water level of 839.0 feet MSL. The water level in the lake is controlled mainly by weather conditions (snowmelt, rainfall, and evaporation) and by the elevation of the outlet structure located at the northeast corner of Northwest Anderson Lake. Water balance modeling also indicates that the lake is influenced by groundwater inflows.

Water Quality Problem Assessment

Baseline Lake Water Quality Status

The Minnesota Lake Eutrophication Analysis Procedure (MnLEAP) is intended to be used as a screening tool for estimating lake conditions and for identifying "problem" lakes. In addition, MnLEAP modeling has been done in the past to identify Minnesota lakes which may be in better or worse condition than they "should be" based on their location, watershed area and lake basin morphometry (Heiskary and Wilson, 1990). MnLEAP predicts total phosphorus concentrations of approximately 39 µg/L, 59 µg/L, and 61 µg/L for Southeast, Southwest, and Northwest Anderson Lakes, respectively. The predicted phosphorus concentrations have a respective standard error of 15 µg/L, 19 µg/L, and 19 µg/L, which means that the NMCWD's water quality goals for total phosphorus are within the range of what is realistically attainable for each of the Anderson Lakes.

Vighi and Chiaudani (1985) developed another method to determine the phosphorus concentration in lakes that are not affected by anthropogenic (human) inputs. As a result, the phosphorus concentration in a lake resulting from natural, background phosphorus loadings can be calculated from information about the lake's mean depth and alkalinity or conductivity. Using the specific conductivity data or the long-term average alkalinity values for Southeast, Southwest, and Northwest Anderson Lakes (119, 104, and 117 mg/L as $CaCO_3$, respectively), the predicted phosphorus concentration from natural, background loadings should be 22-30 µg/L, 24-33 µg/L, and 25-34 µg/L, respectively. These predicted concentrations are significantly lower than the NMCWD's water quality goal for Southeast, Southwest, and Northwest Anderson Lakes total phosphorus concentrations and indicates that the NMCWD's goals are attainable, given the appropriate phosphorus loadings.

Southeast Anderson Lake Current (2001) Water Quality

Figure EX-1 summarizes the seasonal changes in concentration of total phosphorus and chlorophyll *a*, and Secchi disc transparencies for Southeast Anderson Lake during 2001. The data are shown compared to the trophic status categories. As Figure EX-1 illustrates, the epilimnetic (surface water, i.e., 0-2 meter depth) phosphorus concentration increased from the lake's steady-state spring concentration (24 mg/L) to the lake's summer average concentration (54 mg/L). The increase was due to additional phosphorus inputs from a combination of stormwater runoff, and internal sources. Chlorophyll *a* measurements (0 to 2 meters) during 2001, including the summer average concentration (31 mg/L), indicate nuisance algal blooms (greater than 20 mg/L chlorophyll *a*) likely occurred during 2001, resulting in recreational-use impairment. The 2001 Southeast Anderson Lake

Secchi disc measurements were primarily in the hypereutrophic (i.e., very poor water quality) category during the summer with June transparency placing the lake in the mesotrophic category. The summer average Secchi disc transparency (1.1 m) of the lake is considered highly eutrophic. The Secchi disc measurements ranged between 0.5 and 2.5 meters, with the best Secchi disc transparencies occurring during early-June, the same time periods when the total phosphorus and chlorophyll *a* concentrations were at their lowest. Therefore, the data indicate the lake's transparency is largely determined by algal abundance. During 2001, the average phosphorus concentration, chlorophyll *a* concentration, and Secchi disc transparency were low enough to maintain the NMCWD's Category II water quality designation.

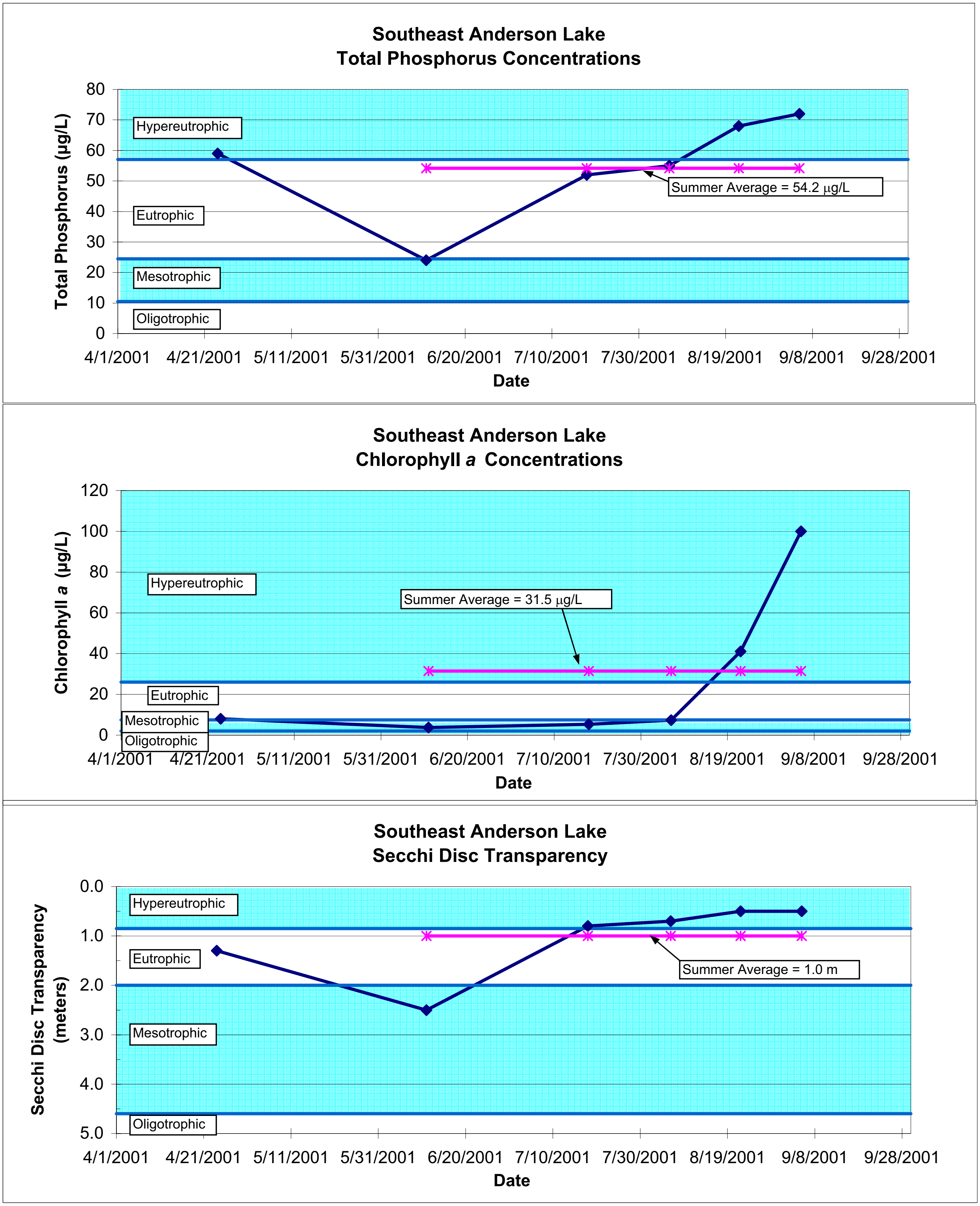


Figure EX-1

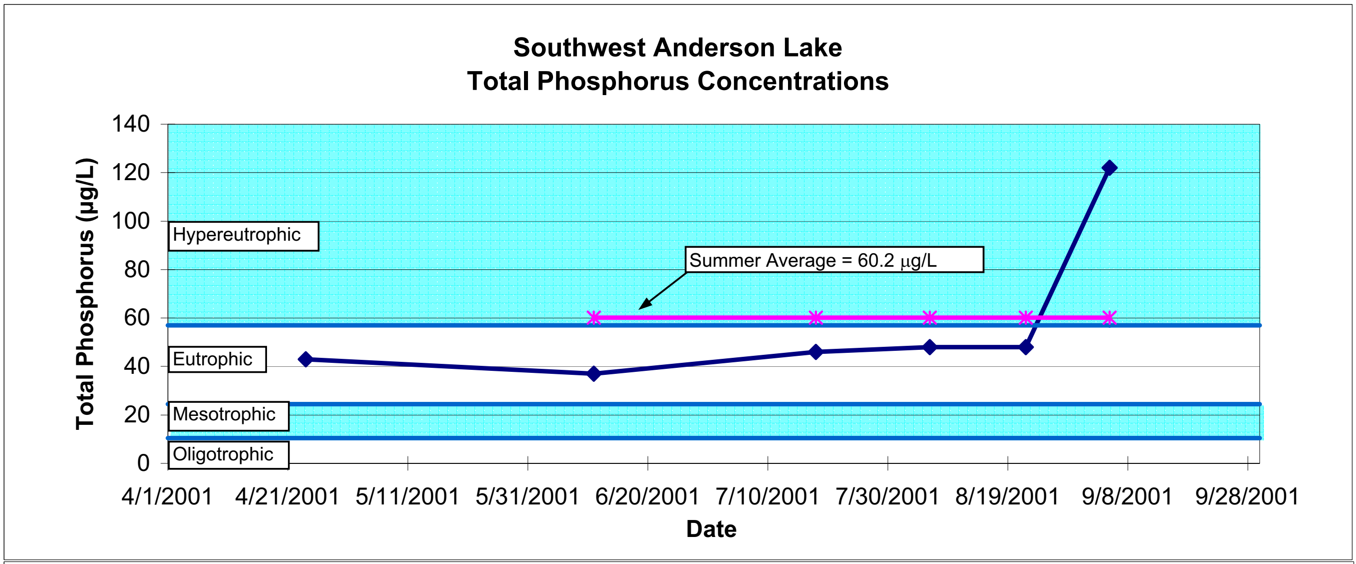
Southeast Anderson Lake 2001 Seasonal Changes in Concentration of Total Phosphorus and Chlorophyll *a* and Secchi Disc Transparencies

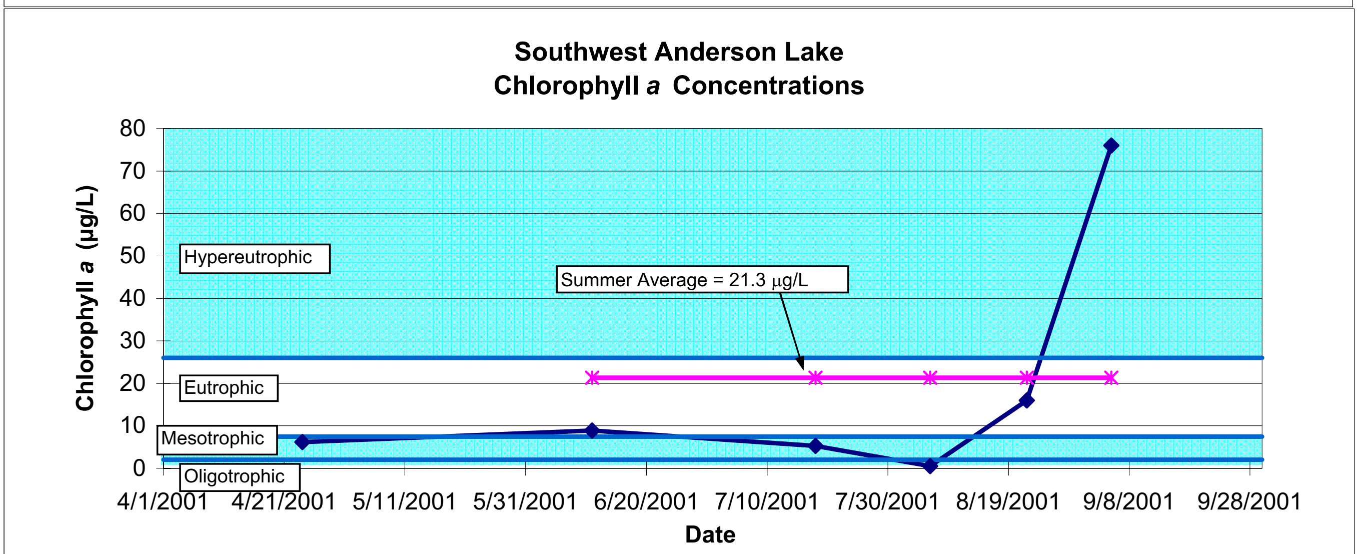
Southwest Anderson Lake Current (2001) Water Quality

Figure EX-2 summarizes the seasonal changes in concentration of total phosphorus and chlorophyll *a*, and Secchi disc transparencies for Southwest Anderson Lake during 2001. The data are shown compared to the trophic status categories. As Figure EX-2 illustrates, the epilimnetic (surface water, i.e., 0 to 2 meter depth) phosphorus concentration increased from the lake's steady-state spring concentration (~37 mg/L) to the lake's summer average concentration (60 mg/L). The increase was due to additional phosphorus inputs from a combination of stormwater runoff, and internal sources. Chlorophyll *a* measurements (0 to 2 meters) during 2001 were in the mesotrophic to hypereutrophic categories during the monitoring period. The summer average concentration (21 mg/L) indicates nuisance algal blooms (greater than 20 mg/L chlorophyll *a*) likely occurred during 2001 and would have resulted in recreational use impairment. The 2001 Southwest Anderson Lake Secchi disc measurements were primarily in the eutrophic category during the summer. Similar to Southeast Anderson Lake, Southwest Anderson Lake's summer average Secchi disc transparency (1.2 m) is considered highly eutrophic. The average phosphorus concentration, chlorophyll *a* concentration and Secchi disc transparency were low enough to maintain the NMCWD's Category II water quality designation.

Northwest Anderson Lake Current (2001) Water Quality

Current water quality in Northwest Anderson Lake is poor. The lake would be classified as a hypereutrophic (very high nutrient) water body for 2001. Summer total phosphorus concentrations were mostly within the range expected for hypereutrophic lake systems (Figure EX-3). The total phosphorus concentration increase steadily throughout the summer from the spring steady-state concentration (27 mg/L) to the early-fall concentration (147 mg/L). The increase was due to additional phosphorus inputs from a combination of stormwater runoff, and internal sources. Chlorophyll *a* concentrations during 2001 ranged from 9 µg/L to 110 µg/L. The summer average concentration for chlorophyll *a* of 48 µg/L was indicative of a hypereutrophic (very high nutrient) system (Figure EX-3) while the summer average Secchi disc transparency (0.8 m) of the lake is considered highly eutrophic. The summer average phosphorus concentration, chlorophyll *a* concentration and Secchi disc transparency were low enough to maintain the NMCWD's Category III water quality designation. However several individual samples fall short of goals established for a Category III lake.





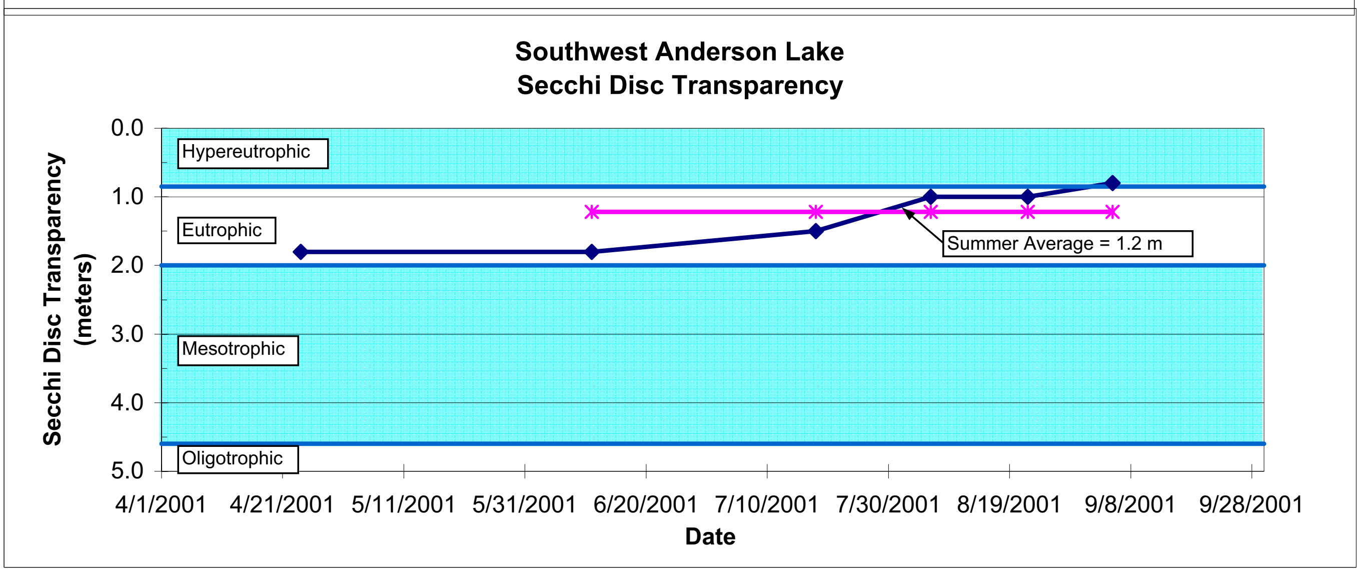
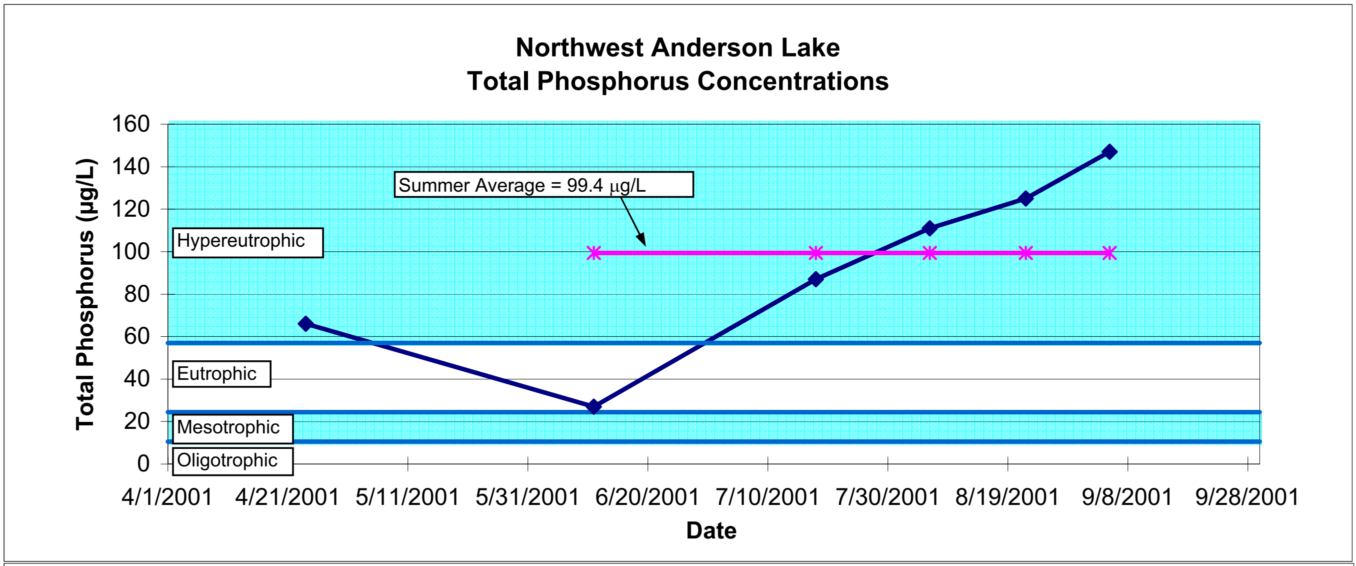
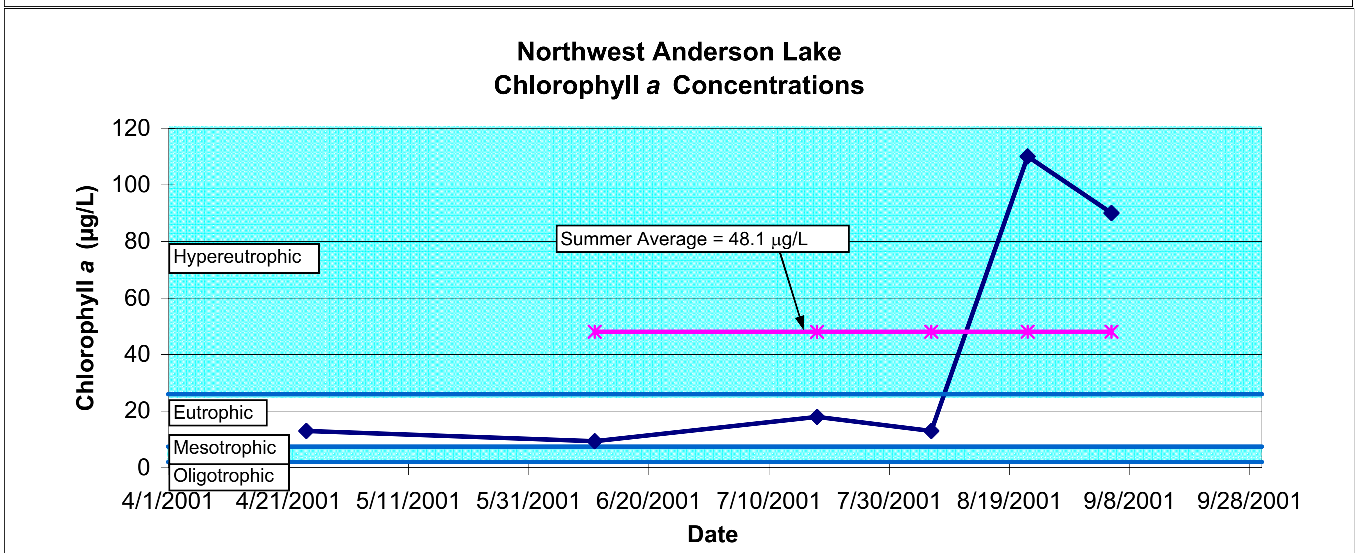


Figure EX-2

Southwest Anderson Lake 2001 Seasonal Changes in Concentration of Total Phosphorus and Chlorophyll *a* and Secchi Disc Transparencies





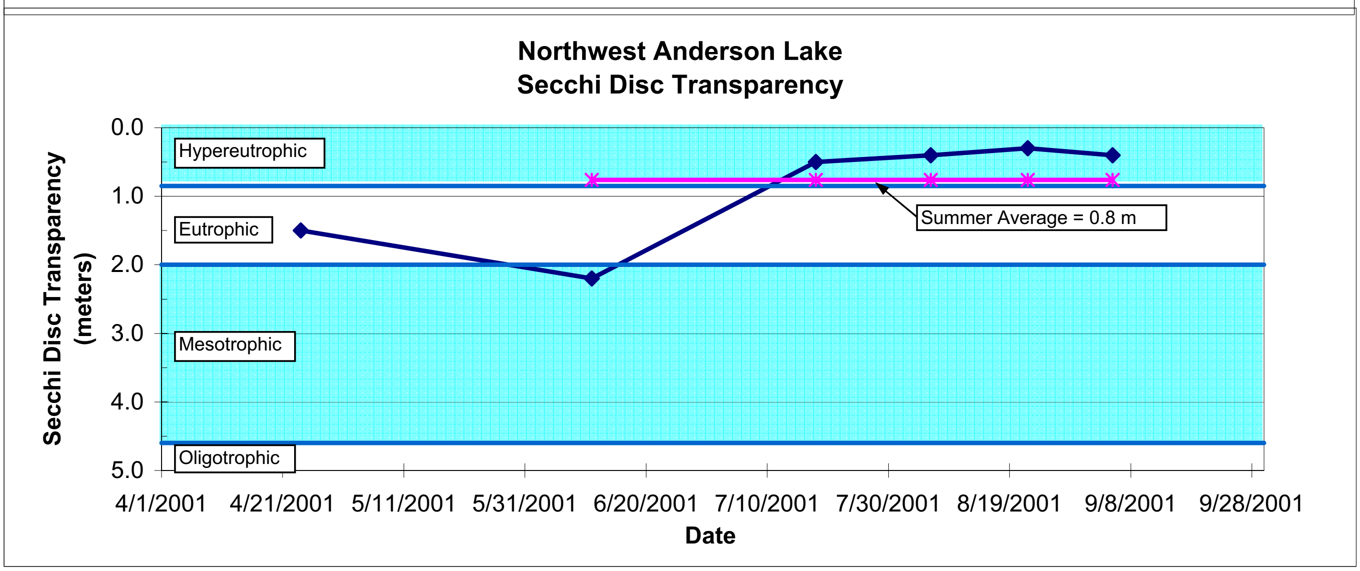


Figure EX-3

Northwest Anderson Lake 2001 Seasonal Changes in Concentration of Total Phosphorus and Chlorophyll *a* and Secchi Disc Transparencies

Trend Analyses

Trend analysis is a process by which changes in measured water quality indices can be evaluated as to their statistical significance; it is a way to determine whether apparent trends constitute a real decline or improvement in lake water quality. The trend analysis for Southeast, Southwest, and Northwest Anderson Lakes considers the historical trends for the three key water quality parameters: Total Phosphorus (TP), Chlorophyll a (Chl *a*), and Secchi disc transparency (SD). The analyses revealed that over the last 15 years there has been no statistically significant improvement or decline in the lakes' water quality.

Watershed Runoff Pollution

Historically, the three Anderson Lake watersheds were primarily comprised of basswood, sugar maple, and oak forests. There were also numerous wetlands located throughout the watershed. The terrain varies from gently to steeply rolling.

Southeast Anderson Lake

Southeast Anderson Lake's 194-acre watershed, including the lakes surface area of 81 acres, is primarily in the City of Bloomington. US Highway 169 is located along the western portion of the lake's watershed. Several types of land use exist within the immediate watershed of Southeast Anderson Lake. Based on analysis of 2000 aerial photographs, Southeast Anderson Lake's immediate watershed is dominated by three primary types of use (see Figure EX-4). Thirty-nine percent of the watershed is in a "natural" state, and vegetated with naturally-occurring or cultivated trees, shrubs, or grasses. Fourteen percent of the land is devoted to low-density residential-use while 6 percent of the watershed is considered to be highway use. The remaining 41 percent is open water (the lake's surface area). The relatively high proportion of land still in natural condition is significant. These "natural" lands include significant park areas.

The immediate watershed of Southeast Anderson Lake was analyzed with respect to probable future land use patterns by examination of the City of Bloomington ultimate land use map. Future land use is not expected to vary from present use (see Figure EX-5). As a result the watershed would be considered fully-developed.

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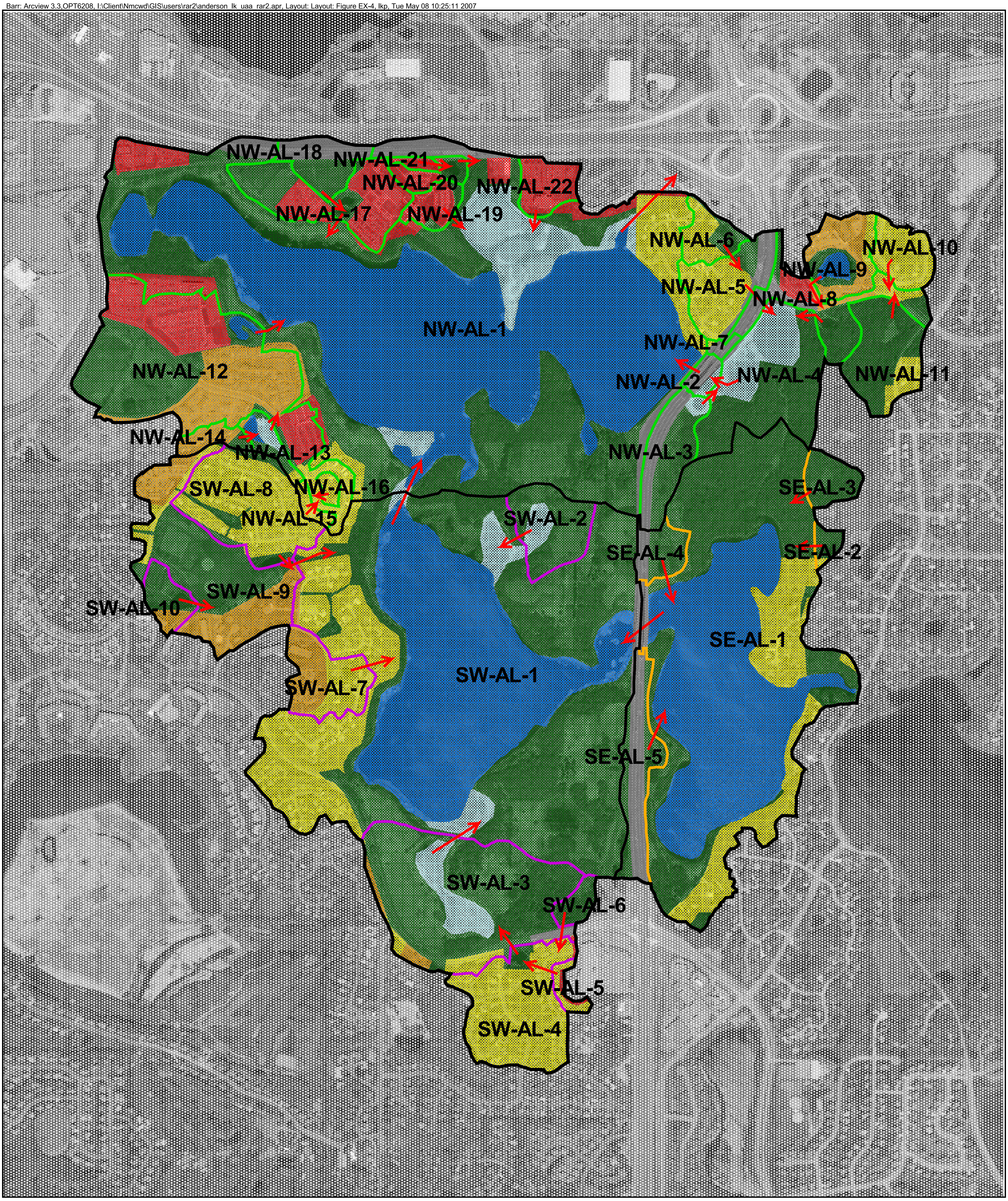


Legend

Anderson Lakes Watershed Boundary

Existing Subwatershed Boundries

- Northwest Anderson Lake
- Southwest Anderson Lake
- Southeast Anderson Lake
- Flow Arrows

Existing Land Use

- Natural/Park/Open
- Low Density Residential
- Medium Density Residential
- High Density Residential
- Highway
- Commercial
- Open Water
- Wetland

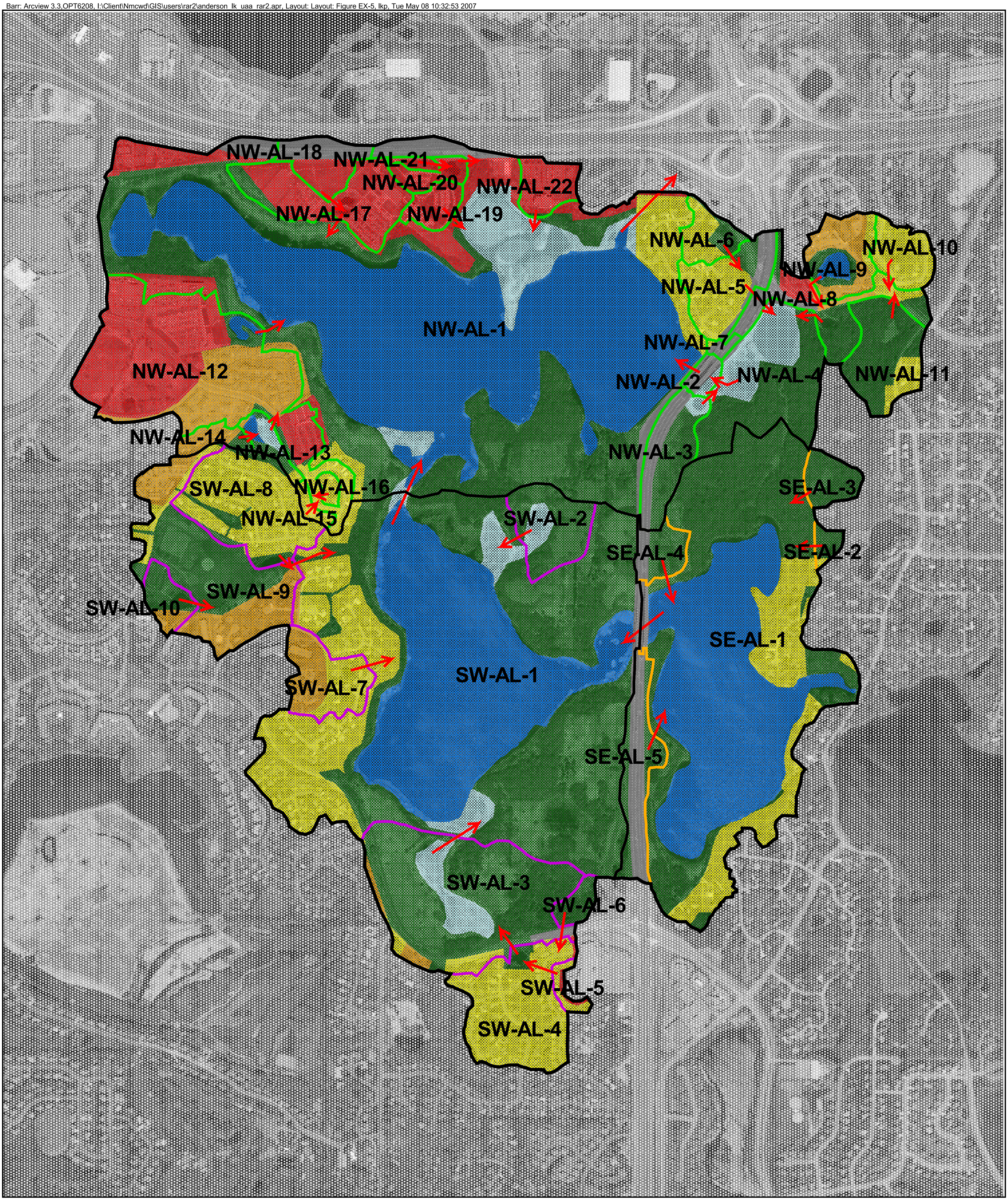
N W E S

500 0 500 1000 1500 Feet

200 0 200 400 600 Meters

Figure EX-4

Anderson Lakes UAA
Watersheds and Existing (2002) Land Use
Nine Mile Creek Watershed District



Legend

Anderson Lakes Watershed Boundary

Ultimate Subwatershed Boundries
- Northwest Anderson Lake
- Southwest Anderson Lake
- Southeast Anderson Lake
- Flow Arrows

Ultimate Land Use
- Natural/Park/Open
- Low Density Residential
- Medium Density Residential
- High Density Residential
- Highway
- Commercial
- Open Water
- Wetland

N W E S

500 0 500 1000 1500 Feet

200 0 200 400 600 Meters

Figure EX-5

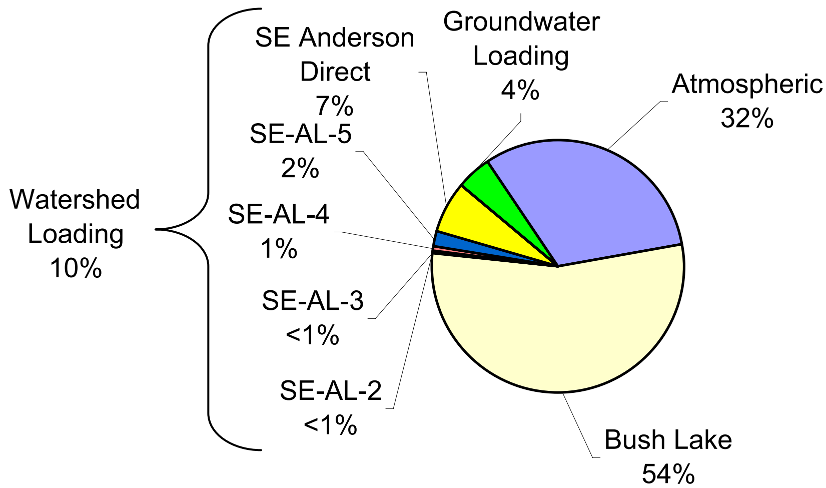
Anderson Lakes UAA
Watersheds and Ultimate Land Use
Nine Mile Creek Watershed District

For existing land use conditions on the Southeast Anderson Lake watershed, modeling simulations indicate a total phosphorus load from the watershed during 2001 of 32 lbs, and a watershed stormwater runoff volume of 59 acre-feet. The annual water and phosphorus loads are equivalent to 6.2 inches and 0.28 lb/acre, respectively (assuming a terrestrial area of 115 acres). The relatively large fraction of land remaining in natural condition in the Southeast Anderson Lake watershed helps to reduce average areal external phosphorus loads to the lake. Watershed analysis suggests that under existing conditions, the lake's direct watershed contributes the second largest amount, 21 percent, of the lake's annual phosphorus load while only contributing 7 percent of the annual water load (see Figure EX-6). Groundwater contributes roughly 4 percent of the lakes annual water budget while the internal release of phosphorus from the die-back of curlyleaf pondweed, a non-native aquatic plant, and bottom sediment contributed 42 percent of the annual phosphorus load in 2001.

Southwest Anderson Lake

The overall watershed of Southwest Anderson Lake includes the areas that drain to it after passing through other upstream water bodies, such as Bush Lake and Southeast Anderson Lake. However, the lake's immediate watershed (the area that does not first drain to an upstream lake) is approximately 453 acres. Based on 2000 Metropolitan Aerial photos, the 453-acre watershed includes about 98 acres for the lakes water surface. Therefore, the net immediate watershed, excluding lake water surface area, is approximately 355 acres. Since the Southwest Anderson Lake's immediate watershed is within the City of Eden Prairie, the City of Eden Prairie Guide Plan Map was consulted to verify land uses. The Southwest Anderson Lake watershed is nearing full-development. Figure EX-4 illustrates the urbanized watershed consists predominantly of natural/open space land use (43 percent). About 24 percent of the watershed is devoted to low-density residential-use. High-density residential, wetlands, and highway comprise 6, 4 and 1 percent of the watershed, respectively. There is a small percentage of the watershed (0.2 percent) that has been developed for commercial/office use near the intersection of US Highway 169 and Anderson Parkway. Future land use is not expected to vary from present use (see Figure EX-5).

Southeast Anderson Lake Annual Water Budget (603 ac-ft/yr)
Model Calibration Year (May 1, 2000 to April 30, 2001)
Using Existing Land Use



Southeast Anderson Lake Phosphorus Budget (129 lbs/yr)
Model Calibration Year (May 1, 2000 to April 30, 2001)
Using Existing Land Use

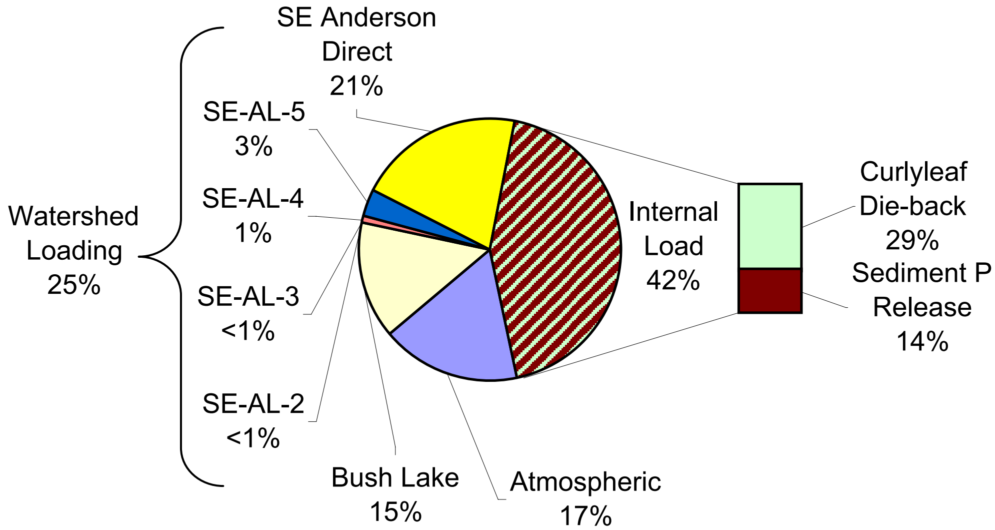


Figure EX-6
Southeast Anderson Lake Watershed
Phosphorus and Water Budgets

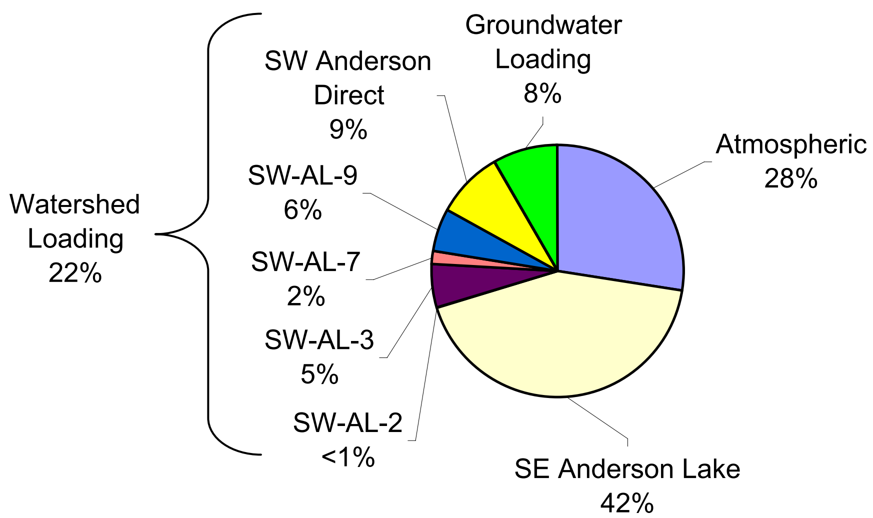
For existing land use conditions on the Southwest Anderson Lake watershed, modeling simulations indicate a total phosphorus load from the watershed during 2001 of 103 lbs, and a watershed stormwater runoff volume of 208 acre-feet. The water and phosphorus loads are equivalent to 7.1 inches and 0.29 lb/acre, respectively (assuming a immediate terrestrial area of 354 acres). Watershed analysis suggests that under existing conditions, the largest external loading source, 21 and 42 percent of the annual phosphorus and water budgets, respectively, to the lake appears to be from upstream Southeast Anderson Lake (see Figure EX-7). Atmospheric deposition directly on the lake surface and runoff from the lake's direct watershed contribute 10 and 17 percent of the lake's annual phosphorus budget. In addition to watershed and atmospheric loadings, model simulations indicate groundwater contributes roughly 8 percent of the lakes annual water budget. The internal release of phosphorus from the die-back of curlyleaf pondweed, a non-native aquatic plant, and bottom sediment contributed 33 percent of the annual phosphorus load in 2001.

Northwest Anderson Lake

Northwest Anderson Lake's watershed in located primarily in Eden Prairie with the eastern portion in the City of Bloomington. The watershed is located just south of where I-494 and US Highway 169 bisects the eastern portion of the watershed. Not counting the land area that drains to Northwest Anderson Lake indirectly, after the water passes through Southeast and Southwest Anderson Lakes; the watershed of Northwest Anderson Lake (its "immediate" watershed) is approximately 587 acres, including 179 acres for the lake surface area

Based on analysis of 2000 aerial photographs, Northwest Anderson Lake's immediate watershed is dominated by natural open space (see Figure EX-4). Thirty-three percent of the watershed is in a "natural" state, and vegetated with naturally-occurring or cultivated trees, shrubs, or grasses. Fifteen percent of the land is devoted to residential-use of various densities. Eleven percent is used for commercial uses. Future conversion of these natural areas to other highly impervious uses will place additional stress on Northwest Anderson Lake. Future land use is expected to vary from present use (see Figure EX-5). The three primary future land uses will be: Natural (26 percent); Residential (15 percent); and Commercial (18 percent).

Southwest Anderson Lake Annual Water Budget (978 ac-ft/yr)
Model Calibration Year (May 1, 2000 to April 30, 2001)
Using Existing Land Use



Southwest Anderson Lake Phosphorus Budget (288 lbs/yr)
Model Calibration Year (May 1, 2000 to April 30, 2001)
Using Existing Land Use

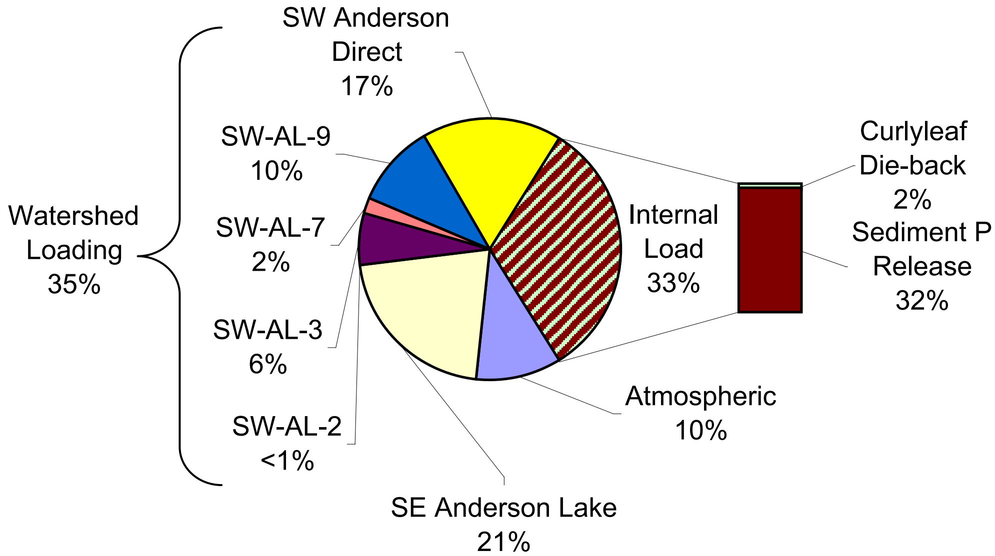
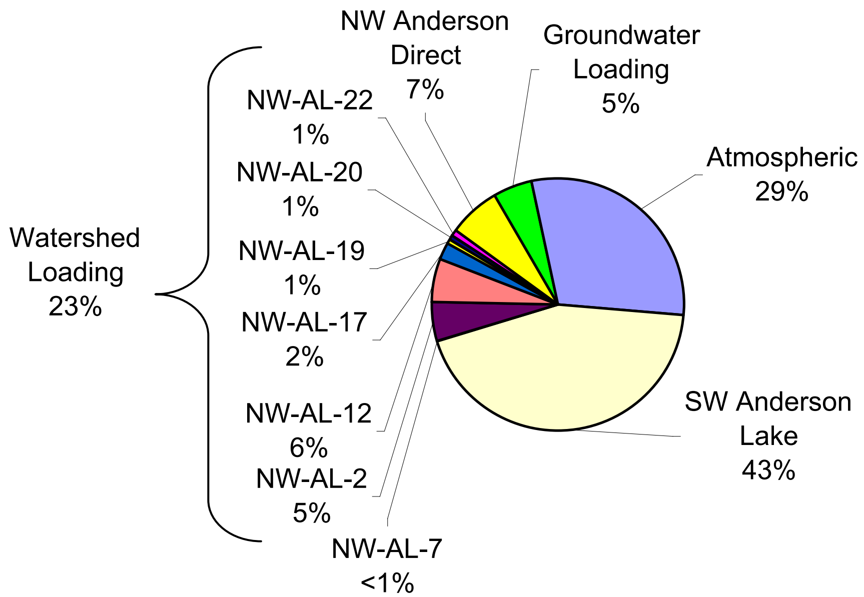


Figure EX-7
Southwest Anderson Lake Watershed
Phosphorus and Water Budgets

Computer simulations of runoff water quality, based on 2000-01 precipitation, indicate that the phosphorus yield from Northwest Anderson Lake's immediate watershed was about 0.37 lb/ac/year (157 pounds annually). The modeled water load from the lake's watershed during 2000-01 (338 acre-feet) is equivalent to 9.8 inches of runoff over the 415-acre watershed. Both the phosphorus and water areal yields are significantly higher than the other two Anderson Lakes because there is considerably more development with large areas of imperviousness in the Northwest Anderson Lake watershed. Northwest Anderson Lake's phosphorus budget for 2001 indicates approximately 22 percent of the lake's annual phosphorus load was from Southwest Anderson Lake (see Figure EX-8). Similar to Southwest Anderson Lake, the pumping from Bush Lake was the primary reason for the large loading from the upstream lake. Southwest Anderson Lake also contributes the largest portion of the annual water load 43 percent (see Figure EX-8). The fact that atmospheric deposition and direct precipitation comprise large percentages of the loading is the direct result of the lake's relatively large surface area in relation to the lake's immediate watershed size. Figure EX-8 also shows that 29 percent of the annual phosphorus and 23 percent of the annual water budget is associated with watershed runoff. In addition to watershed and atmospheric loadings, model simulations indicate groundwater contributes roughly 5 percent of the lakes annual water budget while internal phosphorus release contributes about 39 percent of the lakes annual phosphorus budget.

Northwest Anderson Lake Annual Water Budget (1,576 ac-ft/yr)
Model Calibration Year (May 1, 2000 to April 30, 2001)
Using Existing Land Use



Northwest Anderson Lake Phosphorus Budget (527 lbs/yr)
Model Calibration Year (May 1, 2000 to April 30, 2001)
Using Existing Land Use

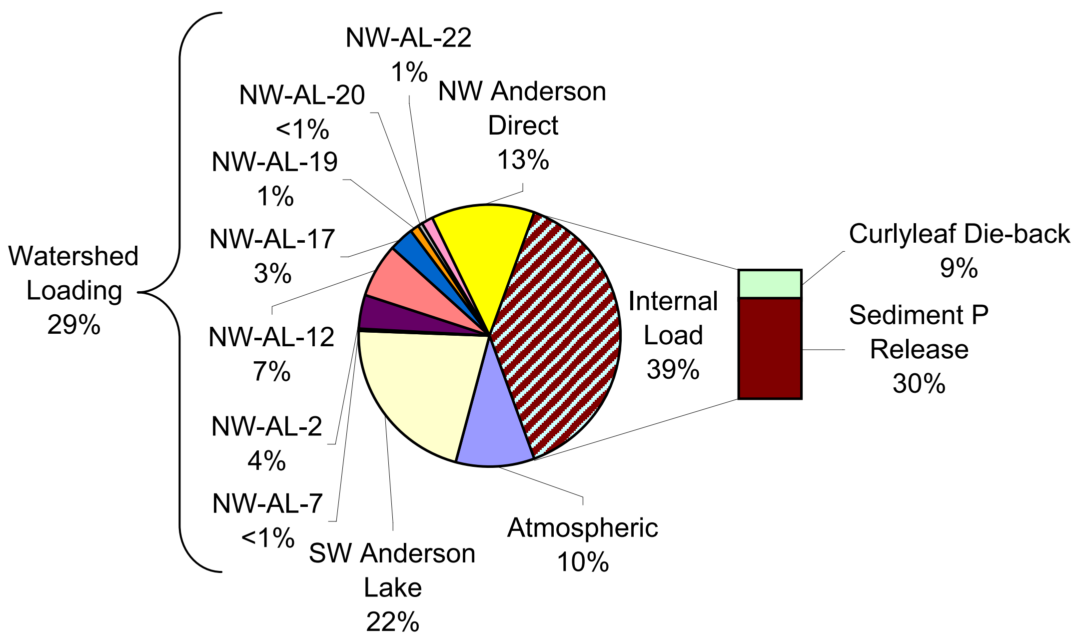


Figure EX-8
Northwest Anderson Lake Watershed
Phosphorus and Water Budgets

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Aquatic Weeds

Macrophyte (i.e., lake weed) surveys were conducted during June and August 2000 and 2001. The current macrophyte communities in Southeast, Southwest, and Northwest Anderson Lake are diverse and healthy. However, a couple of non-native species (purple loosestrife and curlyleaf pondweed) were sampled during either the June or August surveys. Abundant growths of purple loosestrife (*Lythrum salicaria*), a non-native noxious emergent weed species which produces brilliant purple flowers and large quantities of persistent seeds, was identified sporadically spaced along the shorelines of Southeast and Northwest Anderson Lakes. It out-competes native plants, such as cattail, and can eventually replace the native species, thereby interfering with the wildlife use of the lake.

Curlyleaf pondweed (*Potamogeton crispus*) is a non-native submerged aquatic species. Light-to-heavy-density growths were observed in the Southeast and Northwest Anderson Lakes during the June 2001 survey. The June 2000 survey also identified curlyleaf pondweed in various densities in all three Anderson Lakes. By the August surveys the curlyleaf pondweed had undergone its natural mid-season die-off. This mid-season die-back contributes (through plant matter decay) to the lake's summer surface water total phosphorus concentration and, therefore, supplies nutrients for algal growth. Curlyleaf pondweed can also replace native submerged macrophyte species and interfere with recreational use of the lake.

Ecosystem and Fisheries

The most recent fisheries reports for Southeast, Southwest, and Northwest Anderson Lake, conducted in 1993, 1962, and 1962, respectively, indicates a low abundance of planktivorous fish species (sunfish, etc.). The reports also suggest the lakes may be subject to winterkills. Since there is no public access on any of the lakes the MDNR will not stock fish in the lakes.

Recently collected phytoplankton and zooplankton data (2000 and 2001) suggest the communities are healthy and in balance with each other. Continued balance of the lake's ecosystem may be enhanced under ultimate watershed land use conditions by reducing phosphorus loads to the lake.

Recommended Lake and Watershed Management Practices

Aquatic Weed Management

Macrophyte surveys should continue on these lakes to monitor the growths of undesirable non-native species. If purple loosestrife (Lythrum salicaria) starts dominating the emergent macrophyte community, some mitigation measures, such as chemical or biological treatment, may be needed. Chemical treatment of the curlyleaf pondweed (*Potamogeton crispus*) is needed to reduce the internal phosphorus load when it dies back in mid to late-June. The resultant decline in native species would reduce the available habitat for wildlife, invertebrates and other food organisms for small fish. A typical macrophyte survey costs approximately $2,000 per lake.

Watershed Management

Model simulations indicated that upgrading existing ponds to NURP criteria and adding two additional water quality ponds (see Figure EX-9) will not achieve the NMCWD's goals during the various climatic conditions examined for this UAA (see Figures EX-10, EX-11a & b, and EX-12a & b). Therefore, no watershed BMPs are recommended as part of this UAA. However, the NMCWD should still require developers to provide appropriately-sized (in accordance with existing NURP-criteria) detention ponds for urbanizing subwatersheds, and that the ponds are sized appropriately for the ultimate land-use conditions.

Comparing Figures EX-11a with EX-11b and EX-12a with EX-12b the impacts of lowering the NWL of Southwest and Northwest Anderson Lakes can be assessed. This comparison indicates that the lake water quality will generally be worse under the lower NWL scenarios. However, only the dry climatic conditions will likely result in TSI_{SD} values that fails to achieve the District's goals.

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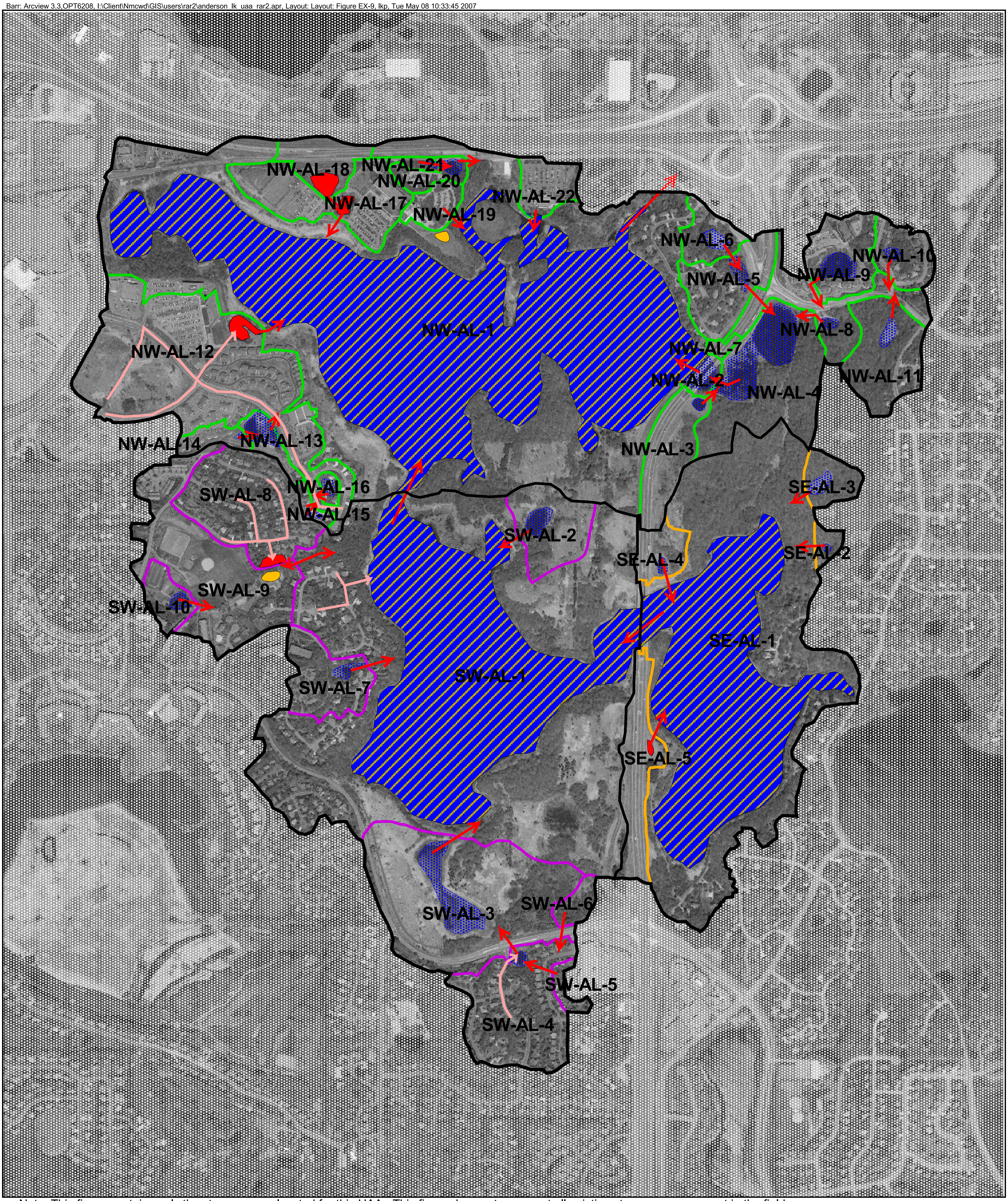


Note: This figure contains only the storm sewers located for this UAA. This figure does not represent all existing storm sewers present in the field.

Legend

- Anderson Lakes Watershed Boundary
- Water Bodies

Existing Subwatershed Boundries

- Northwest Anderson Lake
- Southwest Anderson Lake
- Southeast Anderson Lake
- Existing Storm Sewers
- Flow Arrows

Proposed BMP's

- Add Pond
- Endothal Treatment and In-Lake Alum plus Lime Treatment
- Upgrade Pond

N W E S

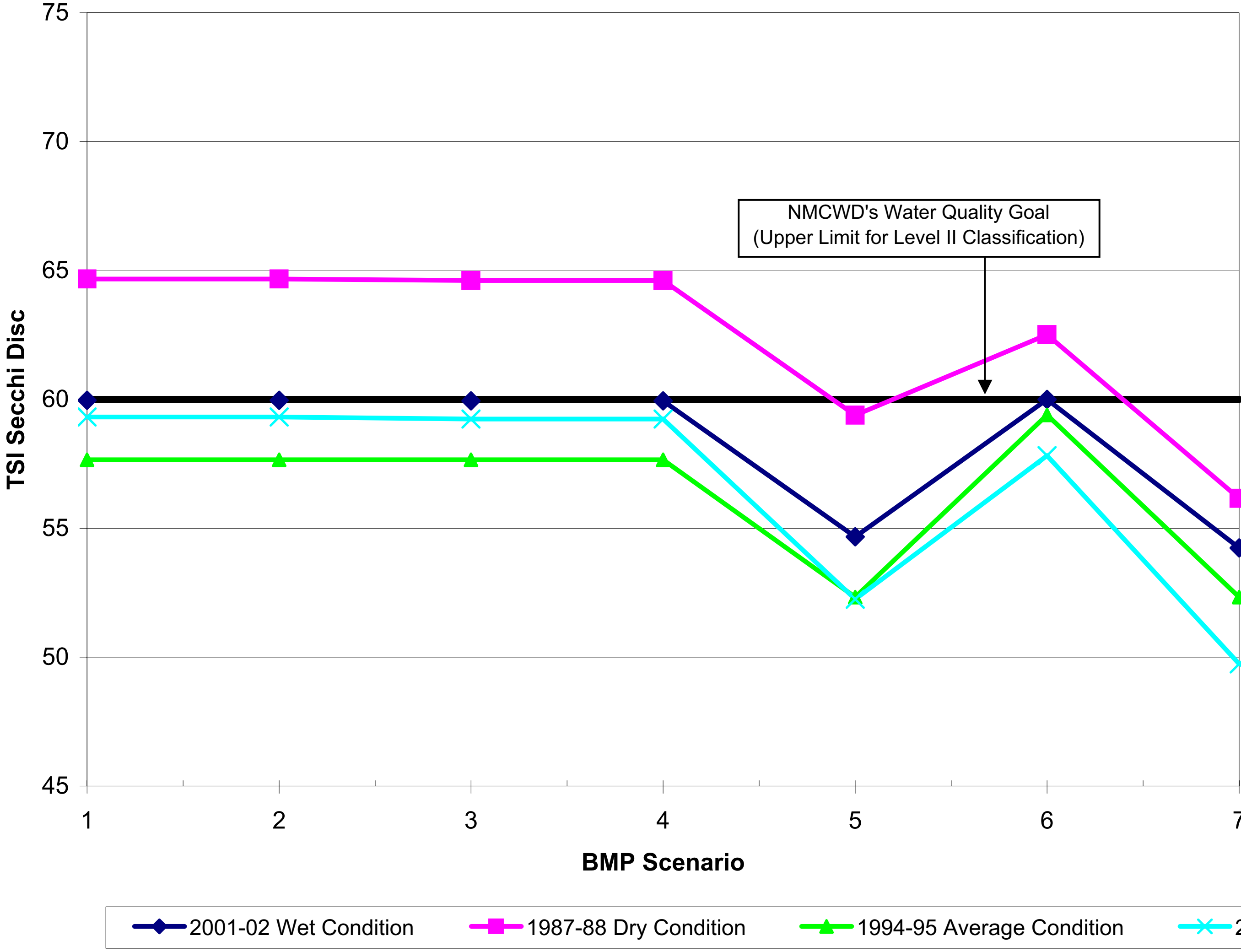
500 0 500 1000 1500 Feet

200 0 200 400 600 Meters

Figure EX-9

Anderson Lakes UAA
Watersheds and Existing Storm Sewers
Nine Mile Creek Watershed District

Figure EX-10
Southeast Anderson Lake: Estimated TSI_{SD} Following BMP Implementation with the Normal Water Level at Elevation 839.0



BMP Legend:
1 Existing Land Use: No Action
2 Future Land Use: No Action by NMCWD
3 Future Land Use: Upgrade Selected Existings Ponds to Meet MPCA/NURP Criteria
4 Future Land Use: Upgrade Selected Existings Ponds to Meet MPCA/NURP Criteria and Add Ponds SW-AL-9 and NW-AL-19 Designed to Meet MPCA/NURP Criteria
5 Future Land Use: In-Lake Endothal Treatment to Southeast, Southwest, and Northwest Anderson Lakes
6 Future Land Use: In-Lake Alum plus Lime Treatment to Southeast, Southwest, and Northwest Anderson Lakes
7 Future Land Use: In-Lake Alum plus Lime Treatment and Endothal Treatments to Southeast, Southwest, and Northwest Anderson Lakes

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Figure EX-11a
Southwest Anderson Lake: Estimated TSI_{SD} Following BMP Implementation with the Normal Water Level at Elevation 839.0

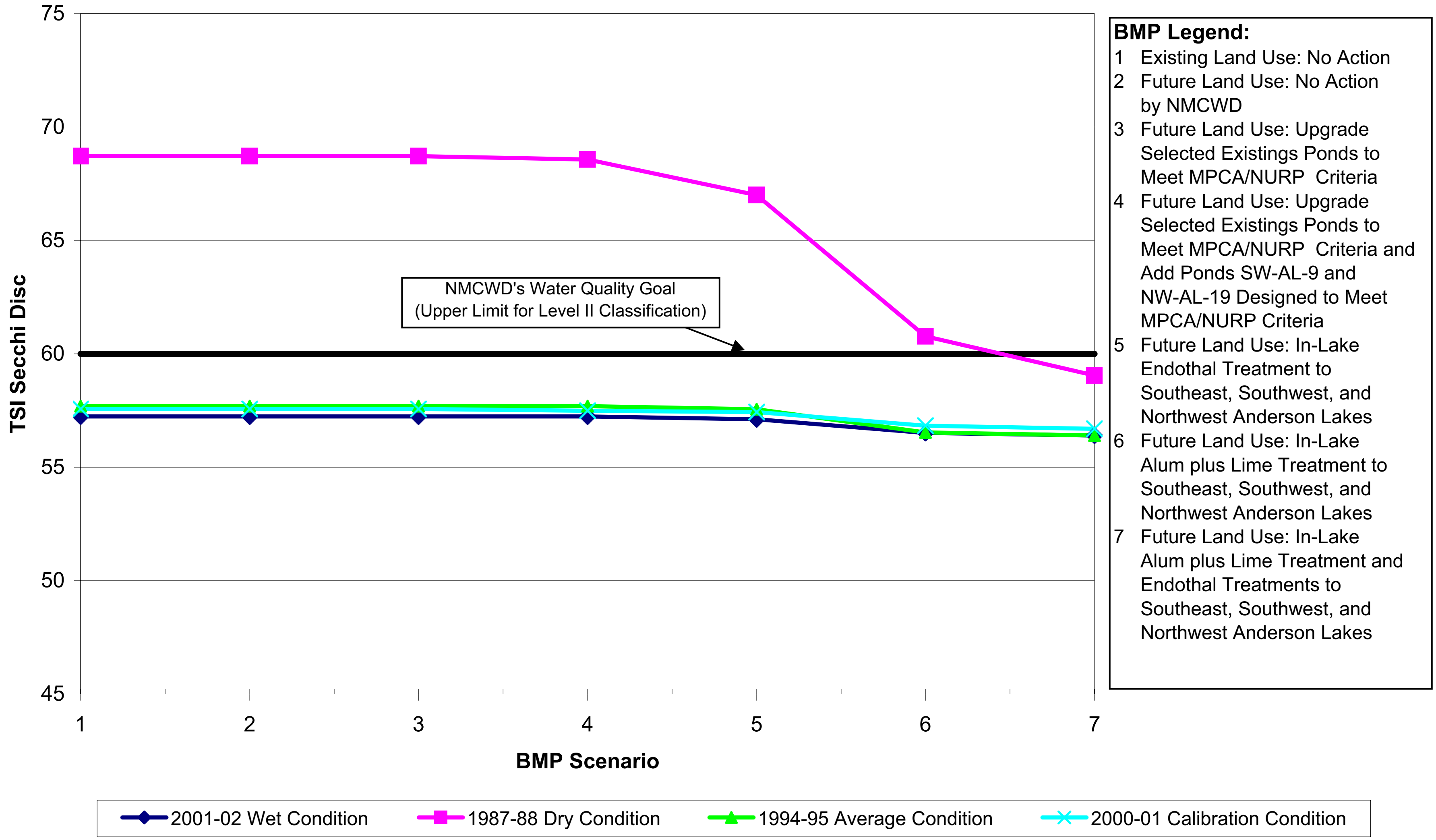

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Figure EX-11b
Southwest Anderson Lake: Estimated TSI_{SD} Following BMP Implementation with the Normal Water Level at Elevation 837.5

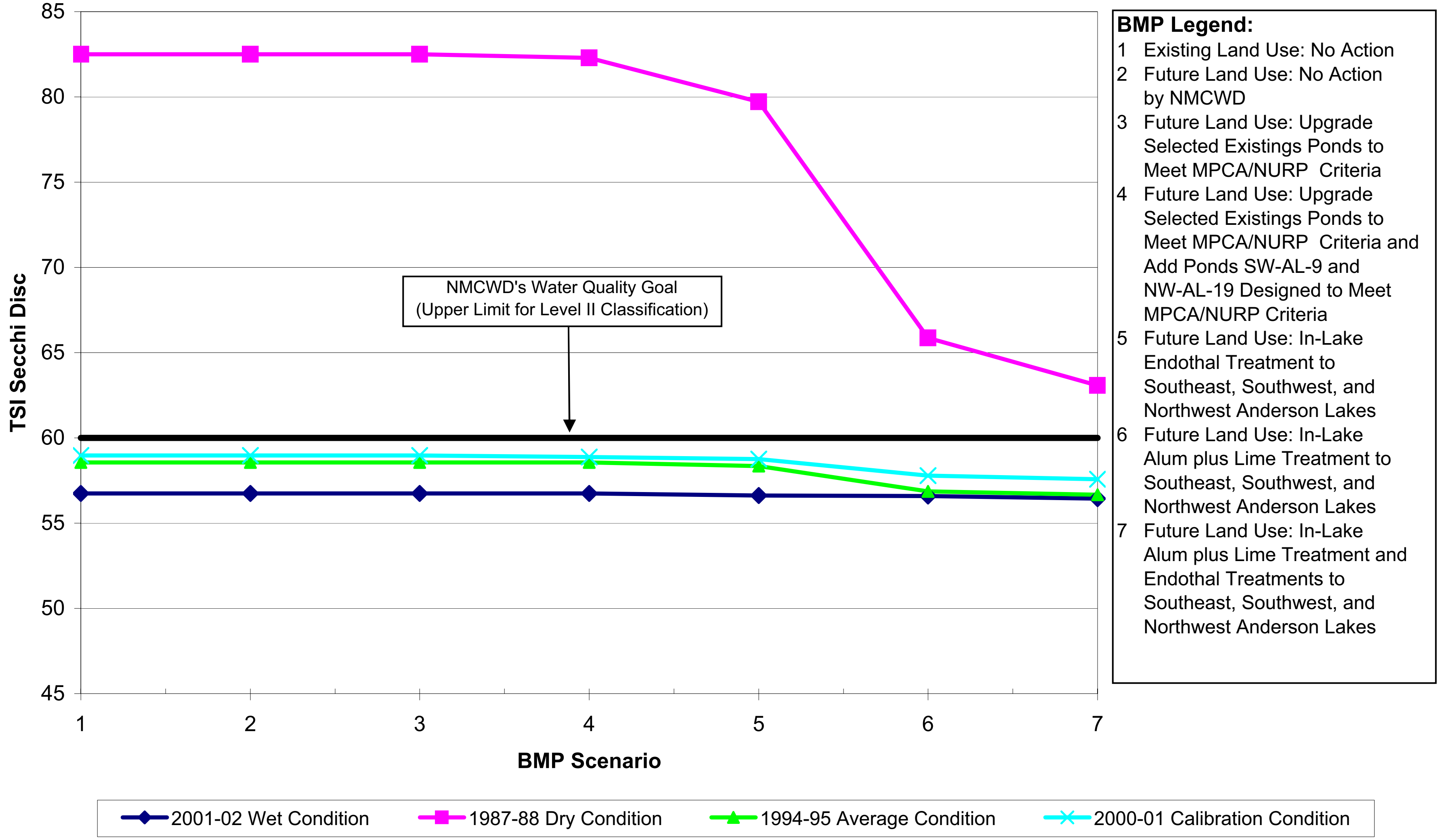


Figure EX-12a
Northwest Anderson Lake: Estimated TSI_{SD} Following BMP Implementation with the Normal Water Level at Elevation 839.0

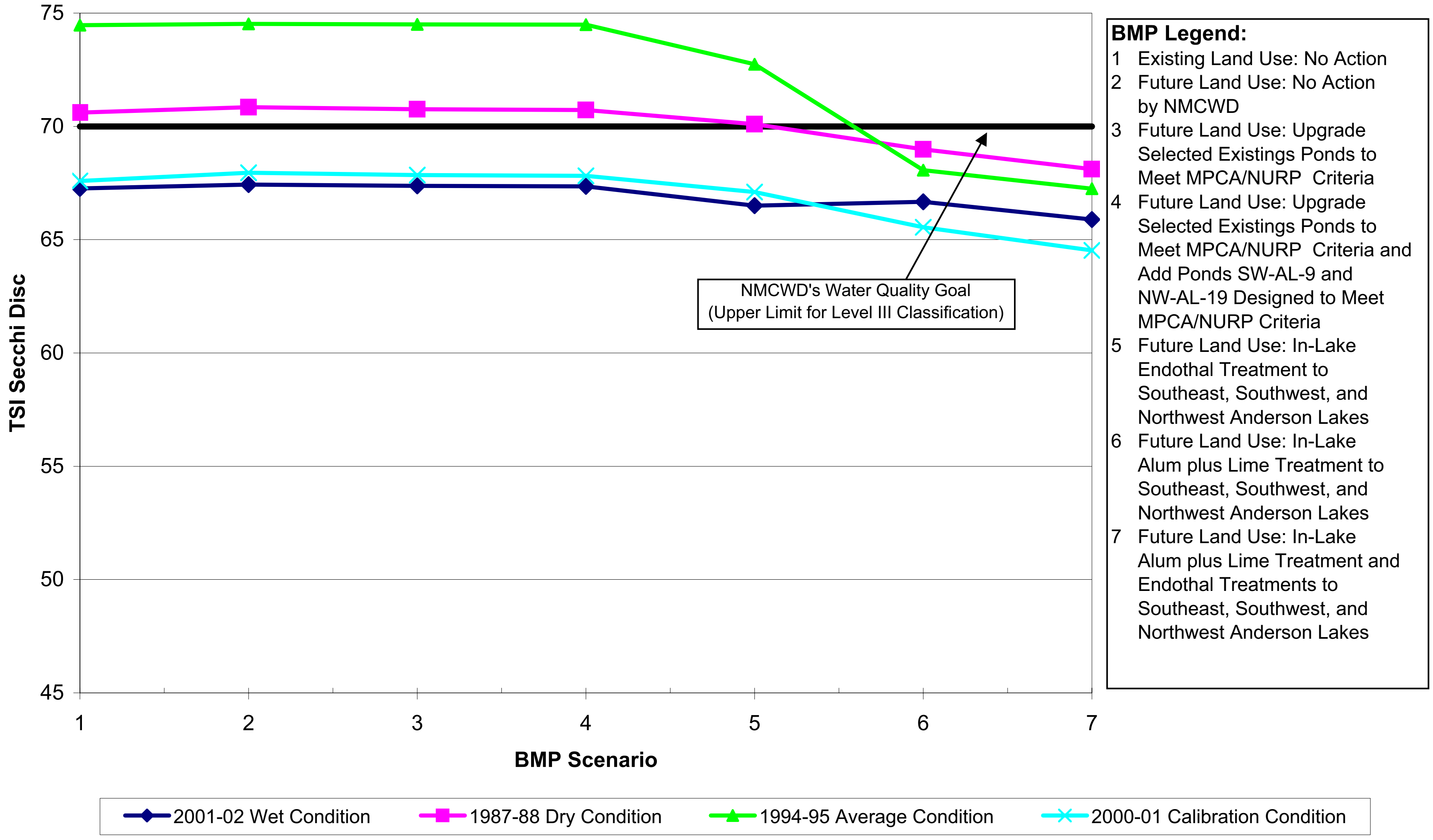
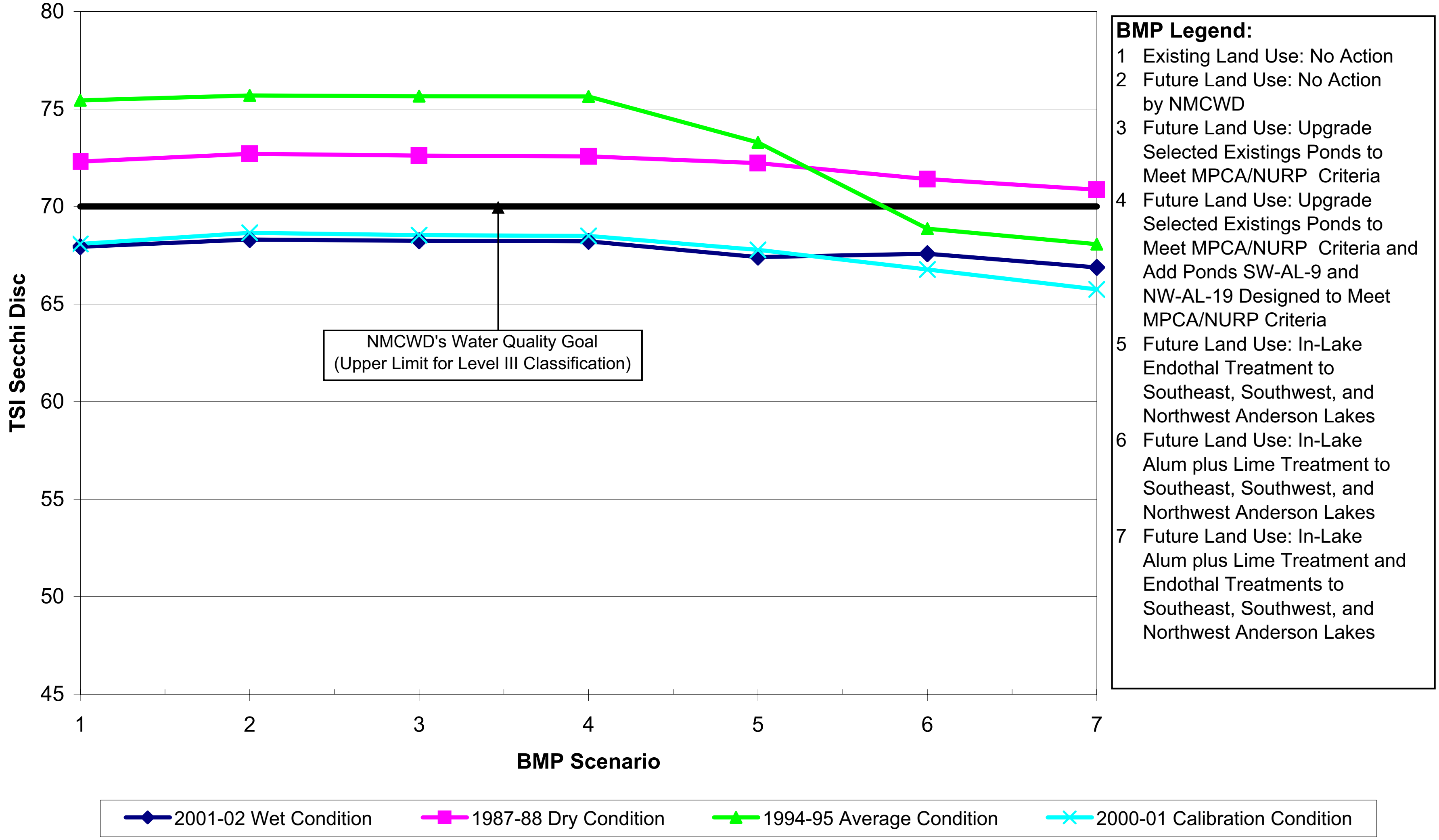


Figure EX-12b
Northwest Anderson Lake: Estimated TSI_{SD} Following BMP Implementation with the Normal Water Level at Elevation 837.5



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In-Lake Management

Water quality simulations using the P8 model indicated dry climatic conditions produce the greatest strain upon water quality in Southeast, Southwest, and Northwest Anderson Lake. The increased internal phosphorus release from sediment, during relatively dry years, delivers a large phosphorus load to the lake. As previously stated, the internal release of phosphorus from curlyleaf pondweed die-back and lake sediments accounted for 33 to 42 percent of the lakes' annual loads. Curlyleaf pondweed was estimated to contribute 29, 5, and 9 percent of the annual phosphorus loads to Southeast, Southwest and Northwest Anderson Lakes during 2001.

The first step in the restoration of the Anderson Lakes is the management of curlyleaf pondweed. This should involve not just the management of curlyleaf pondweed such that the phosphorus inputs are reduced, but rather to remove it from the Anderson Lakes such that native plants can replace curlyleaf pondweed. Removal of curlyleaf pondweed should have the added benefit of preserving native pondweed species adversely affected by algal blooms that follow curlyleaf pondweed die-off. Research has shown that the appropriate herbicide for curlyleaf pondweed control is endothal, and that this herbicide should be applied in the spring (when water is approximately 55-60^{o}F) and at a dose of 1 mg/L (Poovey et al. 2002). Preliminary results from studies in Eagan, MN by John Skogerboe of the US Army Corps of Engineers have shown that four subsequent years of endothal treatment have essentially eliminated curlyleaf pondweed from two of the study lakes and that after the 4th year of treatment no viable turions (pondweed seeds) remained in the sediment. To remove curlyleaf pondweed, treatment will need to continue until no viable turions remain after treatment is completed. Treatment is expected to continue for 4 years. Sediment treatment should not be performed until curlyleaf pondweed is completely controlled. Sediment treatment prior to curlyleaf pondweed control could possibly increase the light availability to this plant and stimulate curlyleaf pondweed growth.

In-lake application of alum plus lime (aluminum sulfate) to prevent sediment phosphorus release in the main lake basin during the summer and fall months is another BMP scenario analyzed. Following an alum plus lime treatment of all three Anderson Lakes, modeling simulations indicate the internal summer phosphorus load would be reduced by about 80 percent. This reduction in sediment phosphorus release would significantly reduce the total loadings to the three lakes, up to 14, 70, and 125 pounds for Southeast, Southwest, and Northwest Anderson Lakes, respectively.

The 20-year management plan and associated costs are illustrated on Figure EX-13. Below is the expected sequence of the lake management activities for the first 5 years.

- **Year 1 (2006)** Herbicide (endothal) treatment begins in the spring and summer water quality and macrophyte monitoring.
- **Year 2 (2007)** Endothal treatment and summer water quality and macrophyte monitoring.
- **Year 3 (2008)** Endothal treatment and summer water quality and macrophyte monitoring.
- **Year 4 (2009)** Final endothal treatment and summer water quality and macrophyte monitoring.
- **Year 5 (2010)** Alum plus lime treatment in the fall and summer water quality and macrophyte monitoring.

This BMP alternative is estimated to result in predicted TSI_{SD} in Southeast, Southwest, and Northwest Anderson Lakes of 56, 59, and 68, respectively for dry climatic conditions (the climatic condition estimated to produce the poorest water quality) with a NWL of 839.0, thus achieving the NMCWD's goals (see Table EX 1a).

Table EX-1a Benefits and Costs of Goal Achievement Alternative (Curlyleaf Pondweed Control and In-Lake Alum plus Lime Treatments) for Southeast, Southwest, and Northwest Anderson Lakes with the NWL of 839.0

Lake	Lake NWL	Trophic State Index (TSI_{SD}) Value				
		NMCWD Goal	Wet Year (1982-83)	Model Calibration Year (2000-01)	Average Year (1994-95)	Dry Year (1987-88)*
Southeast Anderson Lake	839.0	$50 < TSI_{SD} \leq 60$	50	48	49	52
Southwest Anderson Lake	839.0	$50 < TSI_{SD} \leq 60$	58	58	58	59
Northwest Anderson Lake	839.0	$60 < TSI_{SD} \leq 70$	64	64	64	65

* The May 1, 1987 through April 30, 1988 precipitation total excludes the 10-inch 1987 superstorm because of the events rarity.

Water quality modeling indicates that if the NWL of Southwest and Northwest Anderson Lakes is lowered to Elevation 837.5 the summer average TSI_{SD} values for dry climatic conditions would fail to achieve the District's goals (see Table EX-1b). However the District's TSI_{SD} goal would be achieved during the other climatic conditions analyzed.

Table EX-1b Benefits and Costs of Goal Achievement Alternative (Curlyleaf Pondweed Control and In-Lake Alum plus Lime Treatments) for Southeast, Southwest, and Northwest Anderson Lakes with the NWL of 837.5

Lake	Lake NWL	Trophic State Index (TSI_{SD}) Value				
		NMCWD Goal	Wet Year (1982-83)	Model Calibration Year (2000-01)	Average Year (1994-95)	Dry Year (1987-88)*
Southeast Anderson Lake	839.0	$50 < TSI_{SD} \leq 60$	50	48	49	52
Southwest Anderson Lake	837.5	$50 < TSI_{SD} \leq 60$	56	58	57	63
Northwest Anderson Lake	837.5	$60 < TSI_{SD} \leq 70$	67	66	68	71

* The May 1, 1987 through April 30, 1988 precipitation total excludes the 10-inch 1987 superstorm because of the events rarity.

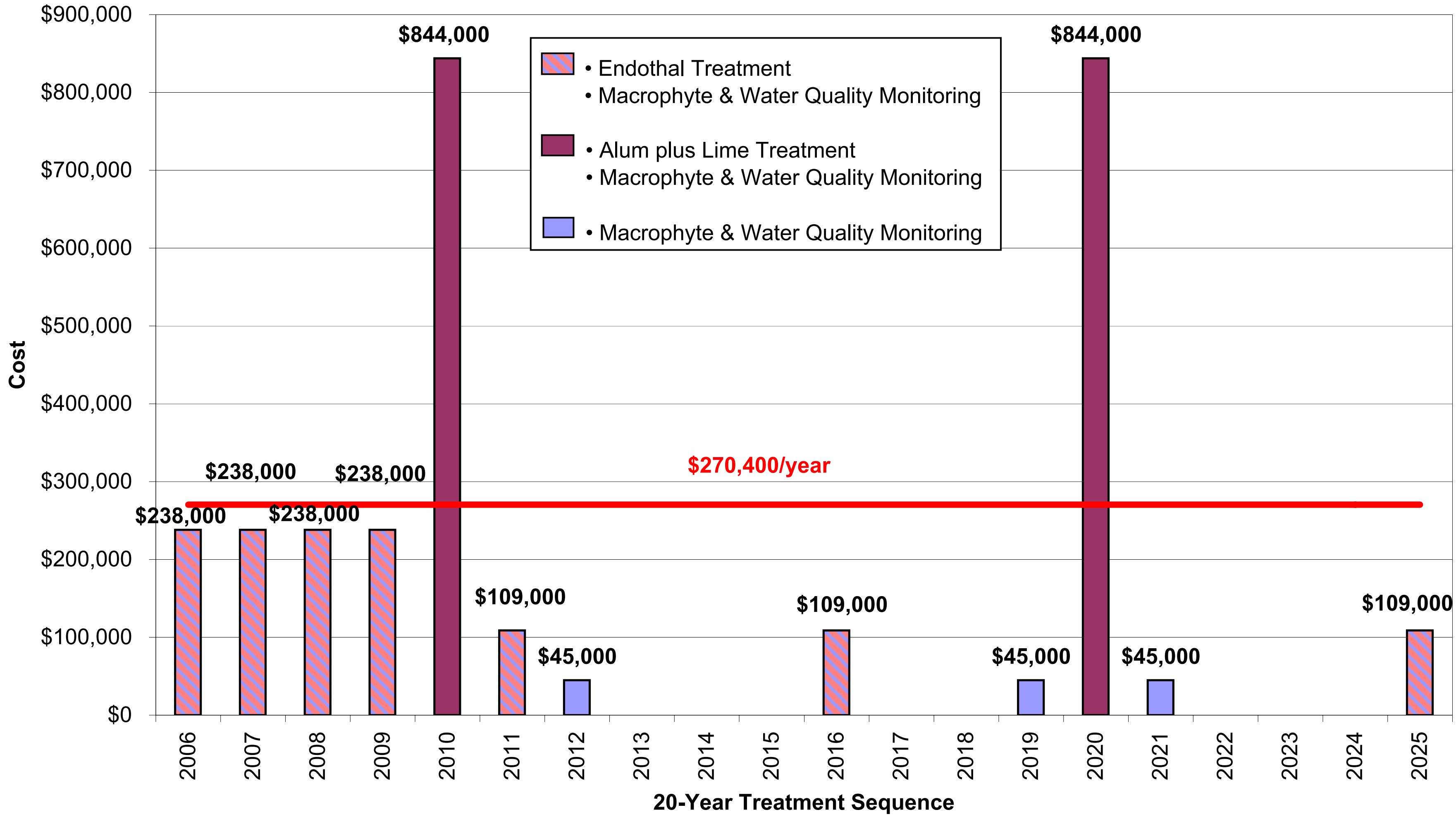
The recommended implementation plan is BMP Scenario 7: herbicide (endothal) treatment and alum plus lime treatment. This BMP alternative is estimated to cost $3,102,000 or an annualized cost of $270,400 per year over a 20 year period. Below is the expected sequence of the lake management activities for the first 5 years. This implementation plan has been selected because the overall productivity of all three Anderson Lakes needs to be significantly reduced to restore the lake to a more ecologically balanced condition. This means that both significant internal phosphorus sources, the aquatic plant curlyleaf pondweed and phosphorus release from sediments, need to be controlled.

This plan will require monitoring during the various stages of the restoration effort to evaluate effectiveness and determine whether the prescribed components and sequence of management efforts remains appropriate. Aquatic plants and lake water quality should be monitored during the 5 years of treatment and for 3 years following treatment. Water quality monitoring should include total phosphorus, chlorophyll *a*, and Secchi disc monitoring from May through September each year. Sediment monitoring should occur 1 year before and for 3 years after alum plus lime treatment. Sediment monitoring should include an evaluation of the location of the treatment layer and collection of mobile phosphorus samples.

Coordination with the City of Eden Prairie and Three Rivers Park District

Southwest and Northwest Anderson Lakes lie predominately within the borders of the City of Eden Prairie and Three Rivers Park District. The City and Park District also plan to pursue a draw down of the lake such that the normal water level will be maintained at Elevation 837.5. The management alternatives discussed in this study have been developed with consideration of the Three Rivers Park District's 1999 Water Quality Management Plan and the intended efforts by the City of Eden Prairie and the Park District to improve the water quality and wildlife habitat of the Anderson Lakes. Management recommendations provided in this report include additional efforts beyond those discussed with the City and Parks District. We have designed the management alternatives recommended in this study so that there will be time to evaluate the effectiveness of management efforts such as herbicide treatment and discuss the appropriate timing for additional management efforts such as an alum plus lime treatment.

Figure EX-13
Anderson Lakes
20-Year Treatment Sequence and Estimated Project Costs



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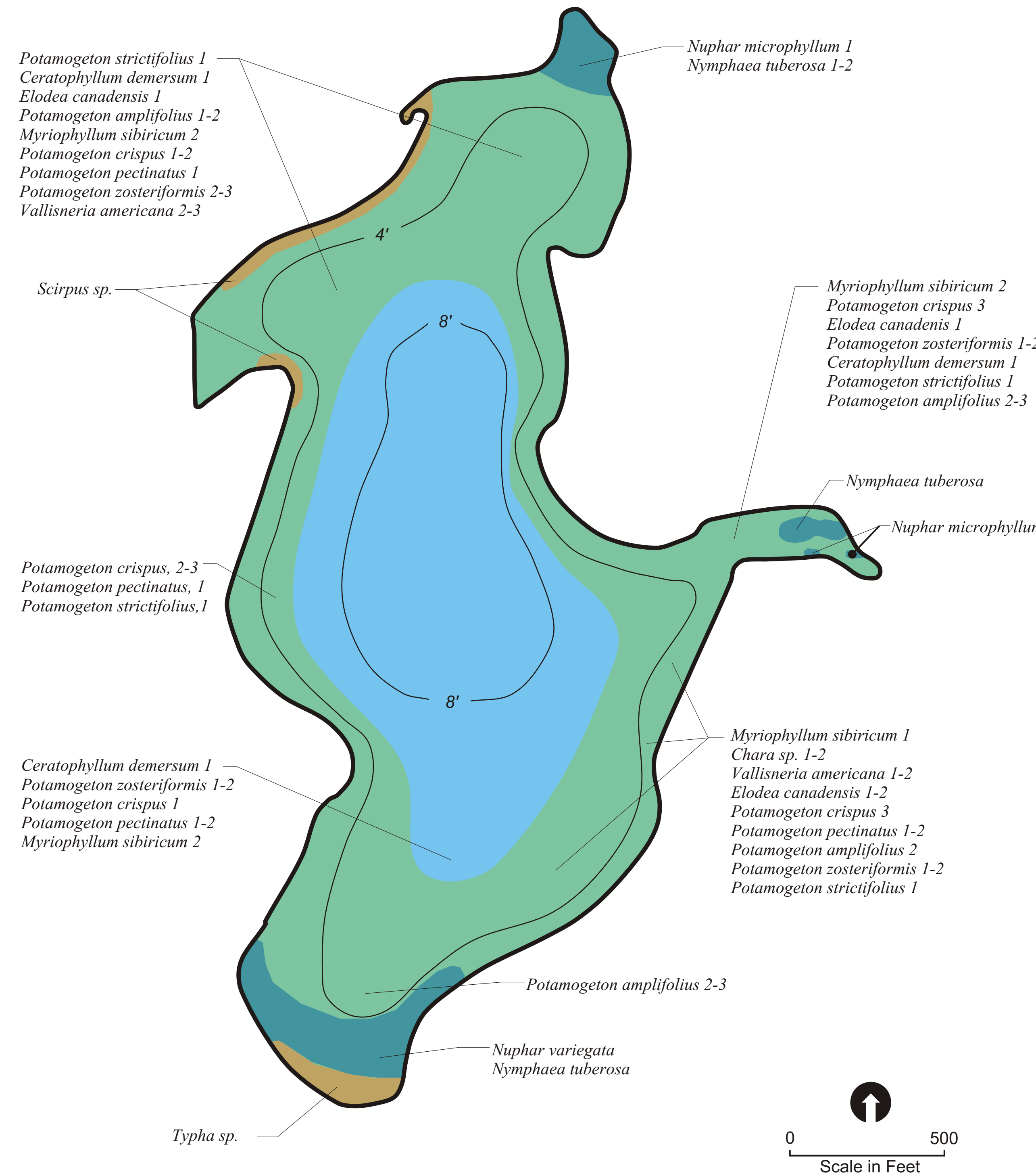
Appendix C

1996, 2000, and 2001 Southeast Anderson Lake Aquatic Plant Survey Data

- No Macrophytes Found in Water >7.0'.
- Macrophyte Densities Estimated as Follows: 1 = light; 2 = moderate; 3 = heavy

	Common Name	Scientific Name
Submerged Aquatic Plants:	Northern watermilfoil	*Myriophyllum sibiricum*
	Large-leaf pondweed	*Potamogeton amplifolius*
	Curlyleaf pondweed	*Potamogeton crispus*
	Sago pondweed	*Potamogeton pectinatus*
	Elodea	*Elodea canadensis*
	Flatstem pondweed	*Potamogeton zosteriformis*
	Coontail	*Ceratophyllum demersum*
	Stiff pondweed	*Potamogeton strictifolius*
	Muskgrass	*Chara sp.*
	Wild celery	*Vallisneria americana*
Floating Leaf:	White waterlily	*Nymphaea tuberosa*
	Little yellow waterlily	*Nuphar microphyllum*
	Yellow waterlily	*Nuphar variegata*
Emergent:	Cattail	*Typha sp.*
	Bulrush	*Scirpus sp.*
No Aquatic Vegetation Found:		

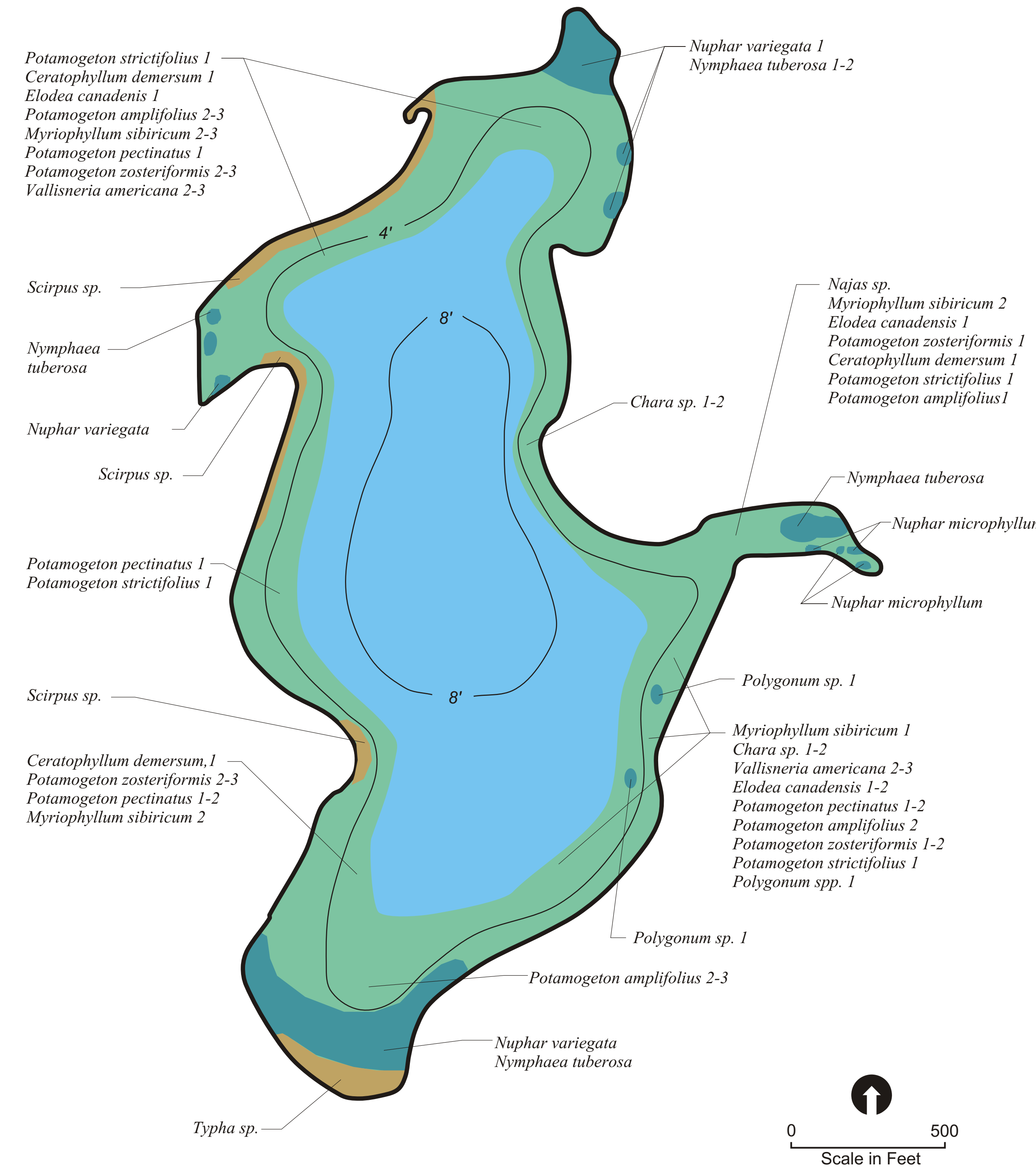


SOUTHEAST ANDERSON LAKE
MACROPHYTE SURVEY
JUNE 20, 1996

P:\23127\003\LAKEMACROPHYTEMAPS\SOUTHEASTANDERSON\1996\JUNE1996.CDR RLG 06-21-04

- No Macrophytes Found in Water >4.0'-5.0'.
- Macrophyte Densities Estimated as Follows: 1 = light; 2 = moderate; 3 = heavy
- *Lythrum salicaria* (Purple loosestrife) Observed Along Shoreline.
- Spoardic *Saggitaria sp.* (Arrowhead) Also Observed Along Areas of Shoreline.

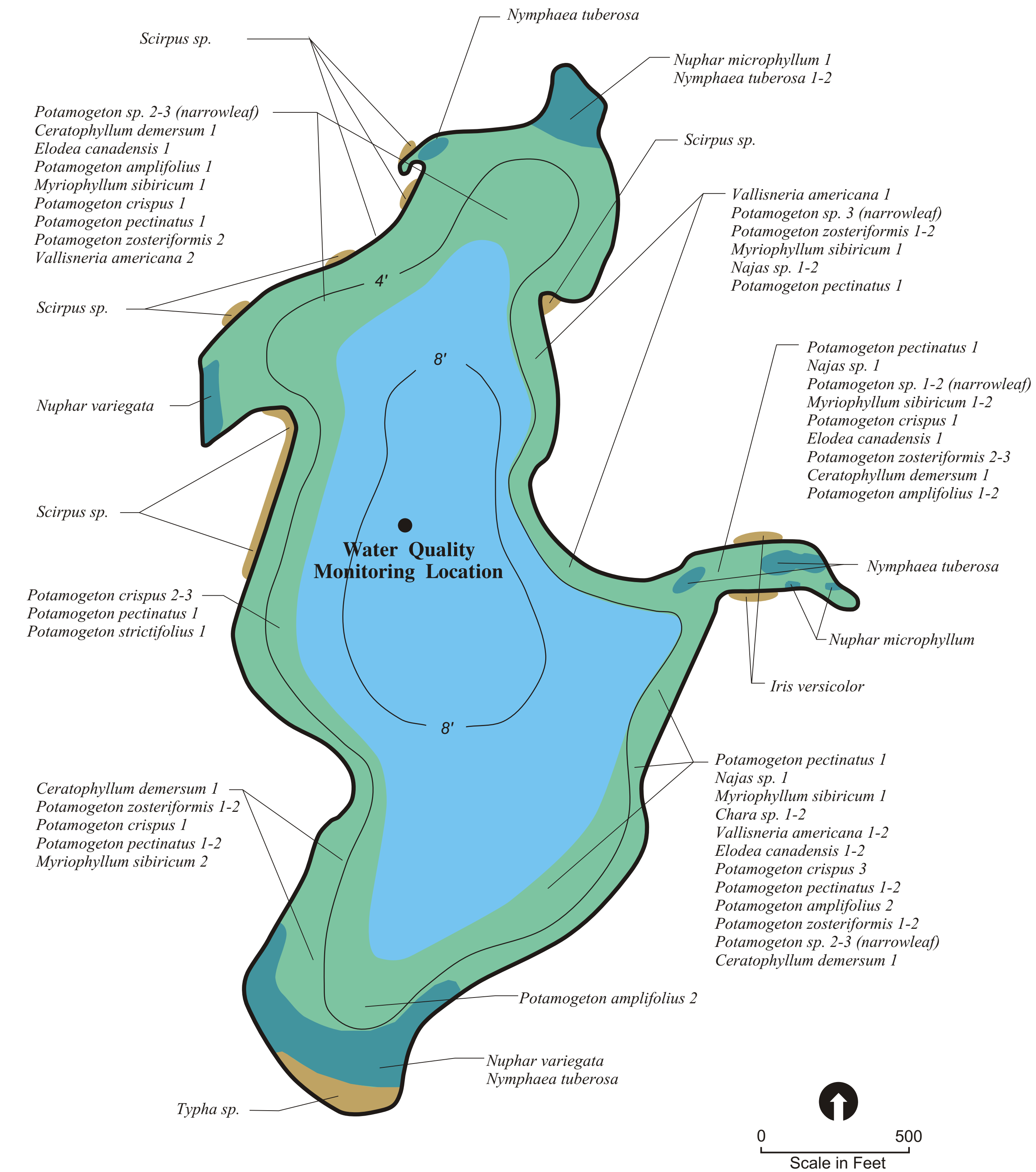
	Common Name	Scientific Name
Submerged Aquatic Plants:	Northern watermilfoil	*Myriophyllum sibiricum*
	Large-leaf pondweed	*Potamogeton amplifolius*
	Sago pondweed	*Potamogeton pectinatus*
	Elodea	*Elodea canadensis*
	Flatstem pondweed	*Potamogeton zosteriformis*
	Coontail	*Ceratophyllum demersum*
	Stiff pondweed	*Potamogeton strictifolius*
	Muskgrass	*Chara sp.*
	Wild celery	*Vallisneria americana*
	Bushy pondweed and naiad	*Najas sp.*
Floating Leaf:	White waterlily	*Nymphaea tuberosa*
	Little yellow waterlily	*Nuphar microphyllum*
	Yellow waterlily	*Nuphar variegata*
	Water smartweed	*Polygonum sp.*
Emergent:	Cattail	*Typha sp.*
	Bulrush	*Scirpus sp.*
No Aquatic Vegetation Found:		



SOUTHEAST ANDERSON LAKE
MACROPHYTE SURVEY
AUGUST 21, 1996

- No Macrophytes Found in Water >5.0'-6.0'.
- Macrophyte Densities Estimated as Follows: 1 = light; 2 = moderate; 3 = heavy

	Common Name	Scientific Name
Submerged Aquatic Plants:	Narrowleaf pondweed	*Potamogeton sp. (narrowleaf)*
	Northern watermilfoil	*Myriophyllum sibiricum*
	Large-leaf pondweed	*Potamogeton amplifolius*
	Curlyleaf pondweed	*Potamogeton crispus*
	Sago pondweed	*Potamogeton pectinatus*
	Elodea	*Elodea canadensis*
	Flatstem pondweed	*Potamogeton zosteriformis*
	Coontail	*Ceratophyllum demersum*
	Stiff pondweed	*Potamogeton strictifolius*
	Muskgrass	*Chara sp.*
	Wild celery	*Vallisneria americana*
	Bushy pondweed and naiad	*Najas sp.*
Floating Leaf:	White waterlily	*Nymphaea tuberosa*
	Little yellow waterlily	*Nuphar microphyllum*
	Yellow waterlily	*Nuphar variegata*
Emergent:	Cattail	*Typha sp.*
	Bulrush	*Scirpus sp.*
	Blue flag iris	*Iris vericolor*
No Aquatic Vegetation Found:		



SOUTHEAST ANDERSON LAKE
MACROPHYTE SURVEY
JUNE 12, 2000

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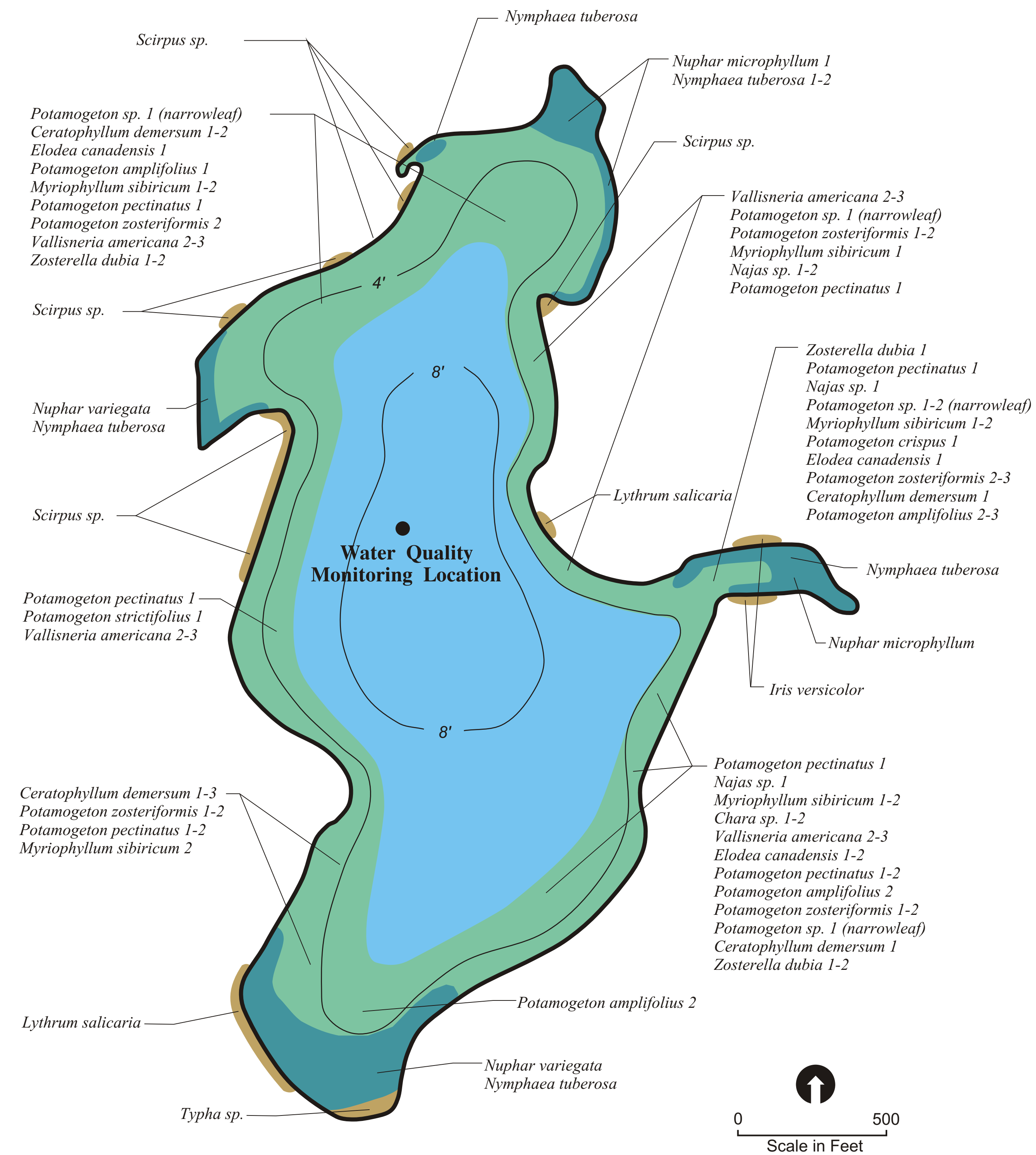
- No Macrophytes Found in Water >5.0'-6.0'.
- Macrophyte Densities Estimated as Follows: 1 = light; 2 = moderate; 3 = heavy

	Common Name	Scientific Name
Submerged Aquatic Plants:	Narrowleaf pondweed	*Potamogeton sp. (narrowleaf)*
	Northern watermilfoil	*Myriophyllum sibiricum*
	Large-leaf pondweed	*Potamogeton amplifolius*
	Curlyleaf pondweed	*Potamogeton crispus*
	Sago pondweed	*Potamogeton pectinatus*
	Elodea	*Elodea canadensis*
	Flatstem pondweed	*Potamogeton zosteriformis*
	Coontail	*Ceratophyllum demersum*
	Stiff pondweed	*Potamogeton strictifolius*
	Muskgrass	*Chara sp.*
	Water celery	*Vallisneria americana*
	Water stargrass	*Zosterella dubia*
	Bushy pondweed and naiad	*Najas sp.*
Floating Leaf:	White waterlily	*Nymphaea tuberosa*
	Little yellow waterlily	*Nuphar microphyllum*
	Yellow waterlily	*Nuphar variegata*
Emergent:	Cattail	*Typha sp.*
	Bulrush	*Scirpus sp.*
	Purple loosestrife	*Lythrum salicaria*
	Blue flag iris	*Iris vericolor*
No Aquatic Vegetation Found:		



SOUTHEAST ANDERSON LAKE
MACROPHYTE SURVEY
AUGUST 28, 2000

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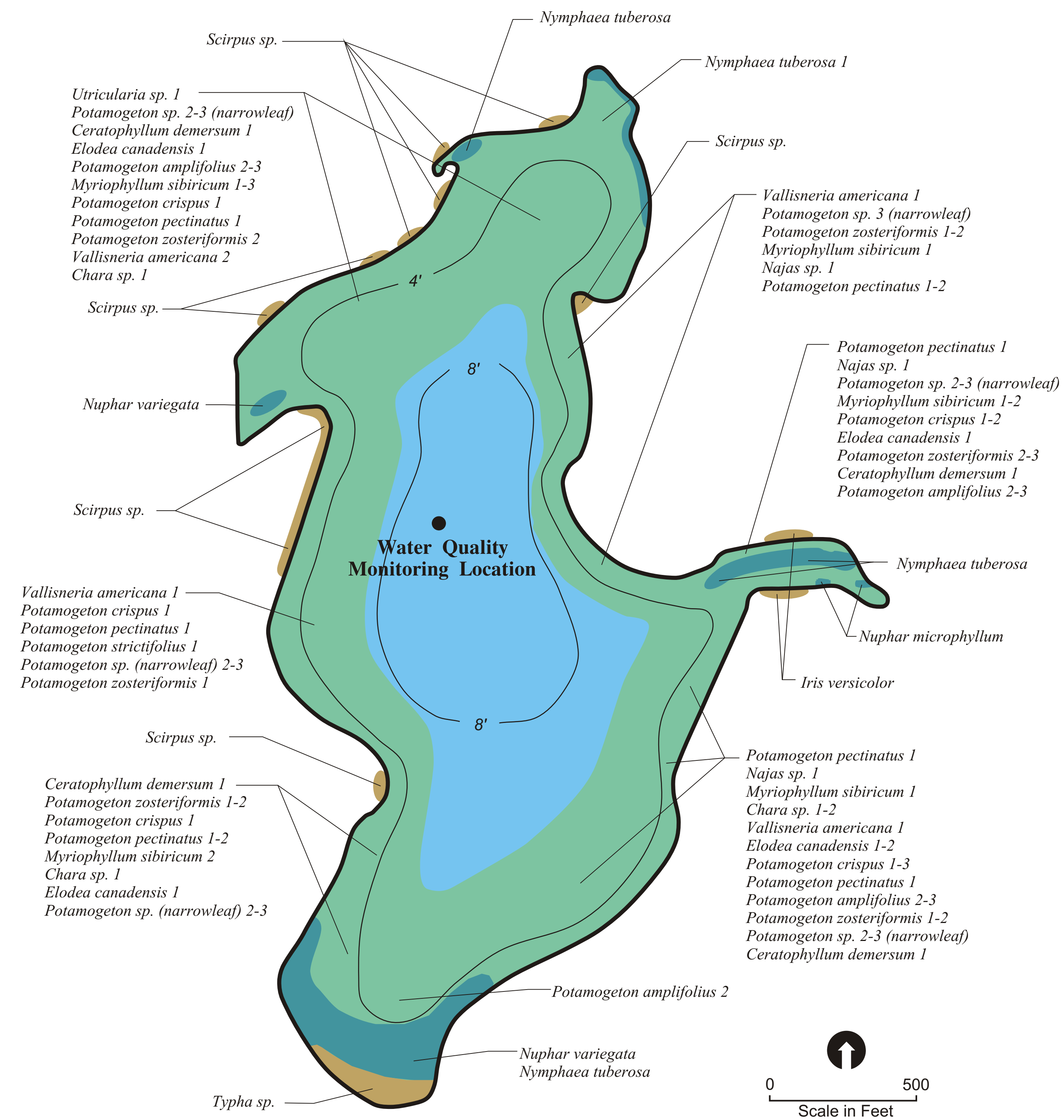
- No Macrophytes Found in Water >7.0'-8.0'.
- Macrophyte Densities Estimated as Follows: 1 = light; 2 = moderate; 3 = heavy

	Common Name	Scientific Name
Submerged Aquatic Plants:	Narrowleaf pondweed	*Potamogeton sp. (narrowleaf)*
	Stiff pondweed	*Potamogeton strictifolius*
	Curlyleaf pondweed	*Potamogeton crispus*
	Flatstem pondweed	*Potamogeton zosteriformis*
	Large-leaf pondweed	*Potamogeton amplifolius*
	Sago pondweed	*Potamogeton pectinatus*
	Northern watermilfoil	*Myriophyllum sibiricum*
	Coontail	*Ceratophyllum demersum*
	Wild celery	*Vallisneria americana*
	Elodea	*Elodea canadensis*
	Muskgrass	*Chara sp.*
	Bushy pondweed and naiads	*Najas sp.*
	Bladderwort	*Utricularia sp.*
Floating Leaf:	White water lily	*Nymphaea tuberosa*
	Yellow water lily	*Nuphar variegata*
	Little yellow water lily	*Nuphar microphyllum*
Emergent:	Bulrush	*Scirpus sp.*
	Cattail	*Typha sp.*
	Blue flag iris	*Iris versicolor*
No Aquatic Vegetation Found:		



SOUTHEAST ANDERSON LAKE
MACROPHYTE SURVEY
JUNE 13, 2001

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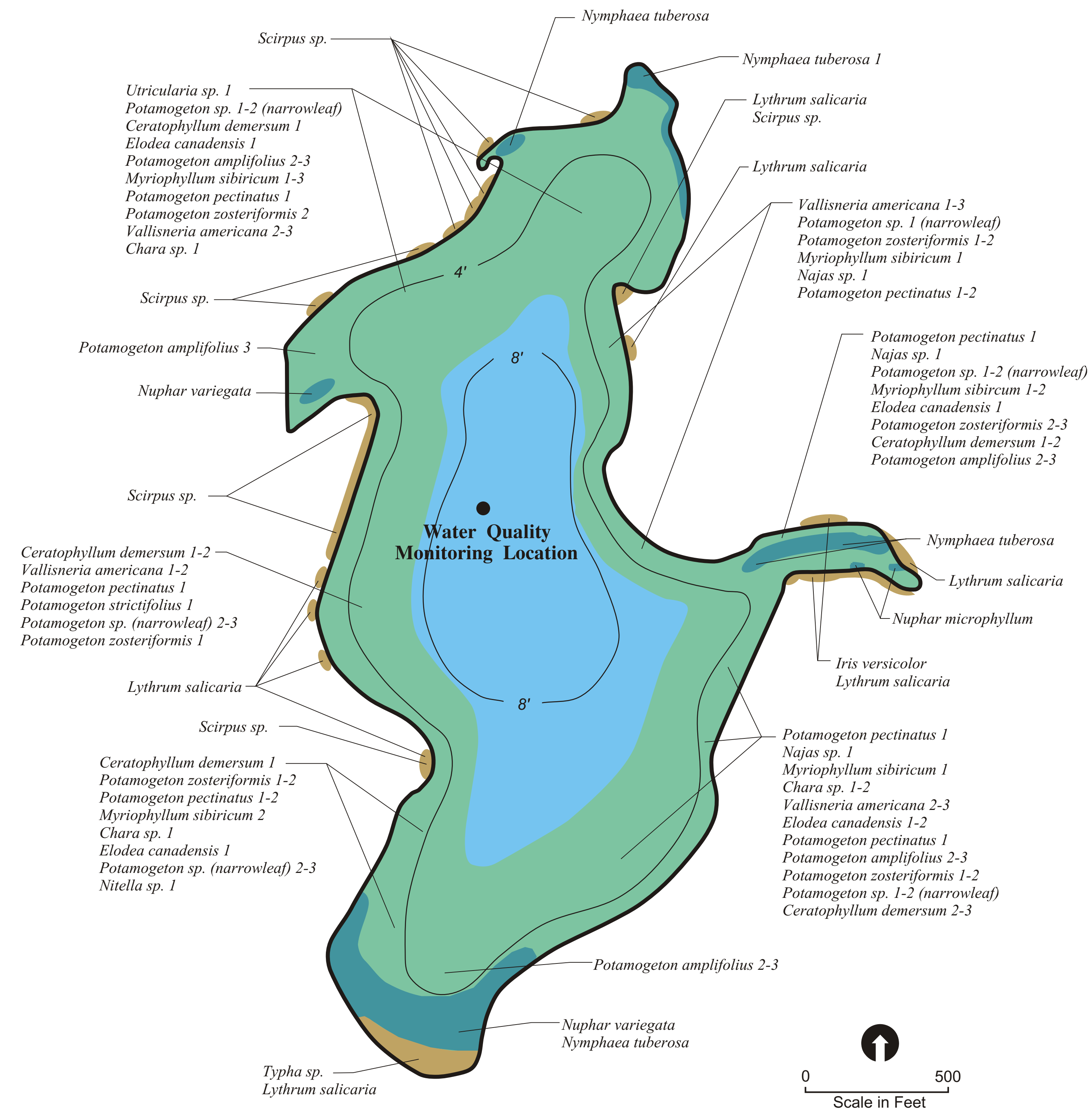
- No Macrophytes Found in Water >7.0'-8.0'.
- Macrophyte Densities Estimated as Follows: 1 = light; 2 = moderate; 3 = heavy
- *Polygonum sp., Sagittaria sp.* Sporadic Along Shoreline of Entire Lake.

	Common Name	Scientific Name
Submerged Aquatic Plants:	Narrowleaf pondweed	*Potamogeton sp. (narrowleaf)*
	Stiff pondweed	*Potamogeton strictifolius*
	Flatstem pondweed	*Potamogeton zosteriformis*
	Large-leaf pondweed	*Potamogeton amplifolius*
	Sago pondweed	*Potamogeton pectinatus*
	Northern watermilfoil	*Myriophyllum sibiricum*
	Coontail	*Ceratophyllum demersum*
	Water celery	*Vallisneria americana*
	Elodea	*Elodea canadensis*
	Muskgrass	*Chara sp.*
	Bushy pondweed and naiads	*Najas sp.*
	Bladderwort	*Utricularia sp.*
	Stonewort	*Nitella sp.*
Floating Leaf:	White water lily	*Nymphaea tuberosa*
	Yellow water lily	*Nuphar variegata*
	Little yellow water lily	*Nuphar microphyllum*
Emergent:	Bulrush	*Scirpus sp.*
	Cattail	*Typha sp.*
	Purple loosestrife	*Lythrum salicaria*
	Blue flag iris	*Iris versicolor*
No Aquatic Vegetation Found:		



SOUTHEAST ANDERSON LAKE
MACROPHYTE SURVEY
AUGUST 23, 2001

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Appendix D

Affected Property Owners

SE Anderson Lake Shoreline (79 acres)

SE Anderson Lake 150 ft from shore (67 acres)

Parcels Adjacent to SE Anderson Lake

N

0 200 400 800 Feet

0 75 150 300 Meters

Figure X

PROPERTIES AROUND
SOUTH EAST ANDERSON LAKE
Nine Mile Creek Watershed District
Eden Prairie, Minnesota

Southeast Anderson Lake Property Owners

PID_NO	PIN	BLDG NUM	STREETNAME	CITY	ZIP	PLAT_NAME	OWNER_NAME	TAX_NAME	TAX_ADD_L1	TAX_ADD_L2
1811621340001	053-1811621340001	8300	84TH ST W	BLOOMINGTON	55438	UNPLATTED 18 116 21	CITY OF BLOOMINGTON	CITY OF BLOOMINGTON	1800 OLD SHAKOPEE RD W	BLOOMINGTON MN 55431
1911621210002	053-1911621210002	8748	WEST BUSH LAKE RD	BLOOMINGTON	55438	UNPLATTED 19 116 21	CITY OF BLOOMINGTON	CITY OF BLOOMINGTON	1800 OLD SHAKOPEE RD W	BLOOMINGTON MN 55431
1911621210010	053-1911621210010	8206	OAKMERE RD	BLOOMINGTON	55438	DIXONS OAKMERE	D V & J FAULISE	DAVID V & JOANNE FAULISE	8206 OAKMERE RD	BLOOMINGTON MN 55438
1911621210011	053-1911621210011	8212	OAKMERE RD	BLOOMINGTON	55438	DIXONS OAKMERE	D & A ELLINGS	DAVID L & ANDREA J ELLINGS	8212 OAKMERE RD	BLOOMINGTON MN 55438
1911621210012	053-1911621210012	8218	OAKMERE RD	BLOOMINGTON	55438	DIXONS OAKMERE	T J JENNINGS & J M JENNINGS	THOMAS J & JAYNE M JENNINGS	8218 OAKMERE RD	BLOOMINGTON MN 55438
1911621210013	053-1911621210013	8226	OAKMERE RD	BLOOMINGTON	55438	DIXONS OAKMERE	K W REGER & J Y REGER	KEVIN W REGER	8226 OAKMERE RD	BLOOMINGTON MN 55438
1911621210014	053-1911621210014	8232	OAKMERE RD	BLOOMINGTON	55438	DIXONS OAKMERE	JONATHAN G GILBERTSON ET AL	SARA L GILBERTSON	8232 OAKMERE RD	BLOOMINGTON MN 55438
1911621210015	053-1911621210015	8300	OAKMERE RD	BLOOMINGTON	55438	DIXONS OAKMERE	DAVID D KOECHEL ETAL	DAVID D KOECHEL	8300 OAKMERE RD	MPLS MN 55438
1911621210016	053-1911621210016	8306	OAKMERE RD	BLOOMINGTON	55438	DIXONS OAKMERE	D J LEH & L L HOLM	DANIEL J LEH & LAURIE L HOLM	8306 OAKMERE RD	BLOOMINGTON MN 55438
1911621210017	053-1911621210017	8312	OAKMERE RD	BLOOMINGTON	55438	DIXONS OAKMERE	T E DUNLAY & D L DUNLAY	TERRANCE E & DIANNE L DUNLAY	8312 OAKMERE ROAD	BLOOMINGTON MN 55438
1911621210018	053-1911621210018	8307	OAKMERE RD	BLOOMINGTON	55438	DIXONS OAKMERE	R L SACKETT & R E SACKETT	RONALD & ROSEMARY SACKETT	8307 OAKMERE RD	BLOOMINGTON MN 55438
1911621210019	053-1911621210019	8301	OAKMERE RD	BLOOMINGTON	55438	DIXONS OAKMERE	DEAN L ROSENOW ETAL	DEAN L ROSENOW	8301 OAKMERE ROAD	BLOOMINGTON MN 55438
1911621210039	053-1911621210039	8108	86TH STREET CIR W	BLOOMINGTON	55438	BOGENS ANDERSON LAKE ADDN	T M GRUGGEN & J A GRUGGEN	TERRY M & JUDITH A GRUGGEN	8124 W 86TH ST CIR	BLOOMINGTON MN 55438
1911621210050	053-1911621210050	8124	86TH STREET CIR W	BLOOMINGTON	55438	GRUGGEN GRANT ADDN	T M & J A GRUGGEN	TERRY & JUDITH GRUGGEN	8124 86TH STREET CIR W	BLOOMINGTON MN 55438
1911621220001	053-1911621220001	8601	TOWN LINE AVE S	BLOOMINGTON	55438	UNPLATTED 19 116 21	CITY OF BLOOMINGTON	CITY OF BLOOMINGTON	1800 OLD SHAKOPEE RD W	BLOOMINGTON MN 55431
1911621230002	053-1911621230002	8901	TOWN LINE AVE S	BLOOMINGTON	55438	UNPLATTED 19 116 21	CITY OF BLOOMINGTON	CITY OF BLOOMINGTON	1800 OLD SHAKOPEE RD W	BLOOMINGTON MN 55431
1911621240006	053-1911621240006	8924	BIRCHWOOD LA	BLOOMINGTON	55438	BIRCHWOOD SHORES	R H TROUSDALE & D TROUSDALE	ROBERT TROUSDALE	8924 BIRCHWOOD LANE	BLOOMINGTON MN 55438
1911621240009	053-1911621240009	8900	BIRCHWOOD LA	BLOOMINGTON	55438	BIRCHWOOD SHORES	RICK J WIEDERHOLT ET AL	RICK J WIEDERHOLT	8900 BIRCHWOOD LA	BLOOMINGTON MN 55438
1911621240010	053-1911621240010	8854	BIRCHWOOD LA	BLOOMINGTON	55438	BIRCHWOOD SHORES	D M DREHNER & J N DREHNER	DENNIS M & JUNE N DREHNER	8854 BIRCHWOOD LA	BLOOMINGTON MN 55438
1911621240011	053-1911621240011	8850	BIRCHWOOD LA	BLOOMINGTON	55438	BIRCHWOOD SHORES	GORDON FLATTUM ETAL	GORDON FLATTUM	8848 BIRCHWOOD LN	BLOOMINGTON MN 55438
1911621240012	053-1911621240012	8848	BIRCHWOOD LA	BLOOMINGTON	55438	BIRCHWOOD SHORES	ANNAMARIE FLATTUM ET AL	ANNAMARIE FLATTUM	8848 BIRCHWOOD LA	BLOOMINGTON MN 55438
1911621240013	053-1911621240013	8842	BIRCHWOOD LA	BLOOMINGTON	55438	BIRCHWOOD SHORES	KENNETH B SKRIVSETH ET AL	KENNETH B SKRIVSETH	8836 BIRCHWOOD LA	BLOOMINGTON MN 55438
1911621240014	053-1911621240014	8836	BIRCHWOOD LA	BLOOMINGTON	55438	BIRCHWOOD SHORES	KENNETH B SKRIVSETH ET AL	K B SKRIVSETH	8836 BIRCHWOOD LA	MPLS MN 55438
1911621240015	053-1911621240015	8830	BIRCHWOOD LA	BLOOMINGTON	55438	BIRCHWOOD SHORES	MARK SALITERMAN	MARK SALITERMAN	7128 MOUNT CUR RD	BLOOMINGTON MN 55438
1911621240016	053-1911621240016	8818	WEST BUSH LAKE RD	BLOOMINGTON	55438	BIRCHWOOD SHORES	CITY OF BLOOMINGTON	CITY OF BLOOMINGTON	1800 OLD SHAKOPEE RD W	BLOOMINGTON MN 55431
1911621240028	053-1911621240028	8300	AMSDEN RD	BLOOMINGTON	55438	FRISSELLS LAKE SHORE ADDN	CITY OF BLOOMINGTON	CITY OF BLOOMINGTON	1800 OLD SHAKOPEE RD W	BLOOMINGTON MN 55431
1911621240029	053-1911621240029	8220	AMSDEN RD	BLOOMINGTON	55438	FRISSELLS LAKE SHORE ADDN	HENNEPIN FORFEITED LAND	CITY OF BLOOMINGTON	1800 OLD SHAKOPEE RD W	BLOOMINGTON MN 55431
1911621240038	053-1911621240038	8916	BIRCHWOOD LA	BLOOMINGTON	55438	BIRCHWOOD SHORES 2ND ADDN	DAVID J & DIANE H BAUSMAN	DAVID J & DIANE H BAUSMAN	8916 BIRCHWOOD LA	BLOOMINGTON MN 55438
1911621320035	053-1911621320035	8500	AMSDEN RD	BLOOMINGTON	55438	AMSDEN RIDGE	CITY OF BLOOMINGTON	CITY OF BLOOMINGTON	1800 OLD SHAKOPEE RD W	BLOOMINGTON MN 55431