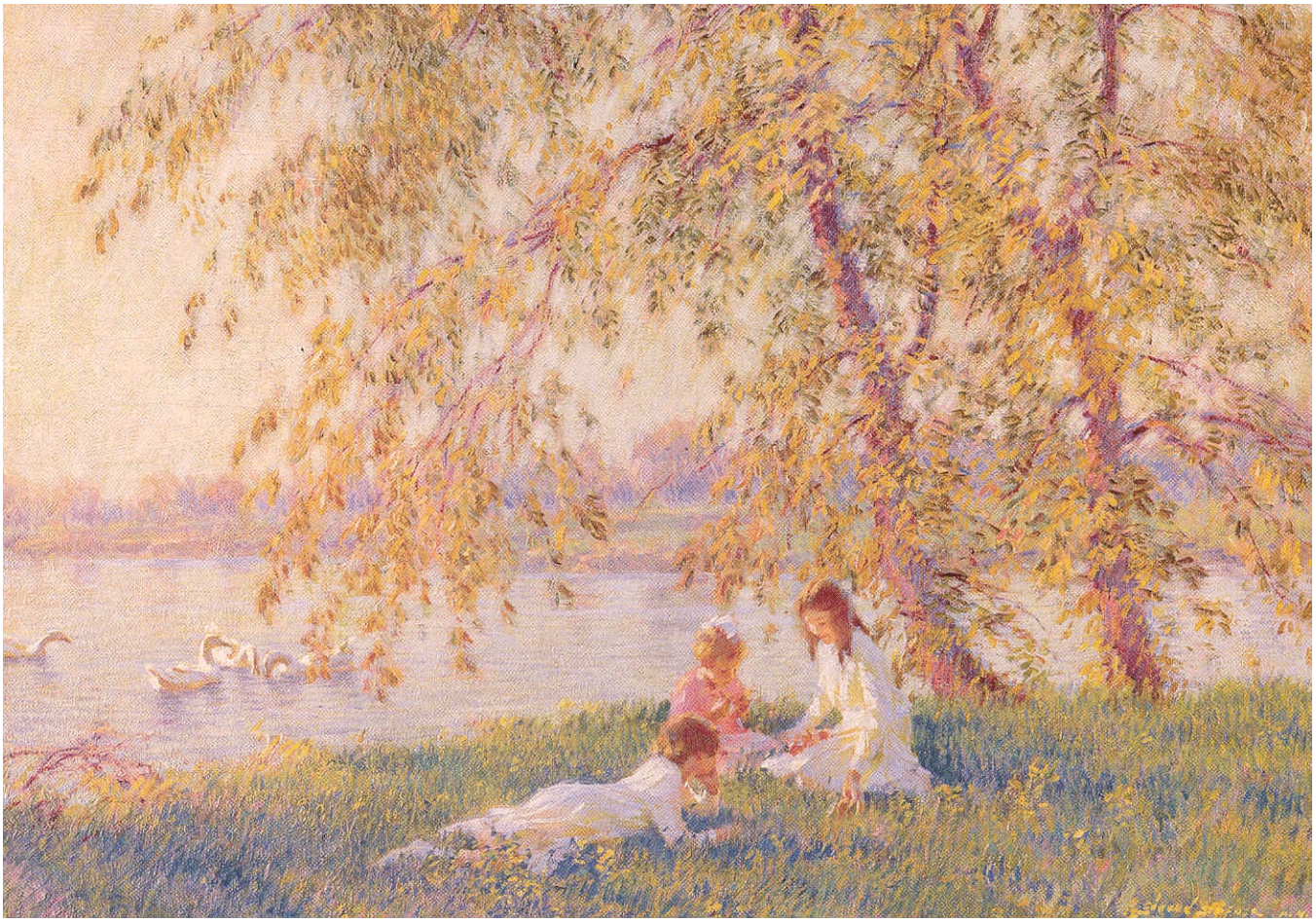

Edward Dufner: *Joyous Days*, **early-mid 1920s**

Lake Management Plan for Alimagnet Lake, Dakota County, Minnesota

March 2005

Prepared by Blue Water Science and Bonestroo, Rosene, Anderlik and Associates

with contributions from City of Apple Valley, City of Burnsville, and the Alimagnet Lake Association

Funded by the City of Apple Valley and the City of Burnsville

Lake Management Plan for
Alimagnet Lake, Dakota County, Minnesota

SUMMARY

Project Goals

The goals of this lake management report were:

- to examine existing lake conditions.
- to develop a lake management plan that protects, maintains, and enhances Alimagnet Lake water quality.
- meet the basic MPCA/EPA criteria for a TMDL

Watershed Characteristics

Alimagnet Lake's watershed is approximately 1,094 acres (includes the lake). Land use is primarily residential. Three subwatersheds (1, 6, and 7) contribute most of the watershed phosphorus to Alimagnet Lake (Table 1 and Figure 1).

Table 1. Phosphorus load by outfall based on P-8 model.

Storm Sewer Outfall	Total Drainage Area (acres)	Total Phosphorus Load (lbs/yr)	Unit Phosphorus Load (lbs/acre/yr)
1	**288.6**	**158.8**	**0.55**
2	6.6	3.8	0.58
3	7.2	3.9	0.54
4	29.0	14.5	0.50
5	3.4	1.7	0.50
6	**187.4**	**130.6**	**0.70**
7	**256.6**	**93.9**	**0.37**
8	16.0	9.2	0.58
9	30.2	10.5	0.35
10	47.7	17.4	0.36
Developed Shoreline	32.1	9.3	0.29
Undeveloped Shoreline	80.3	7.9	0.10

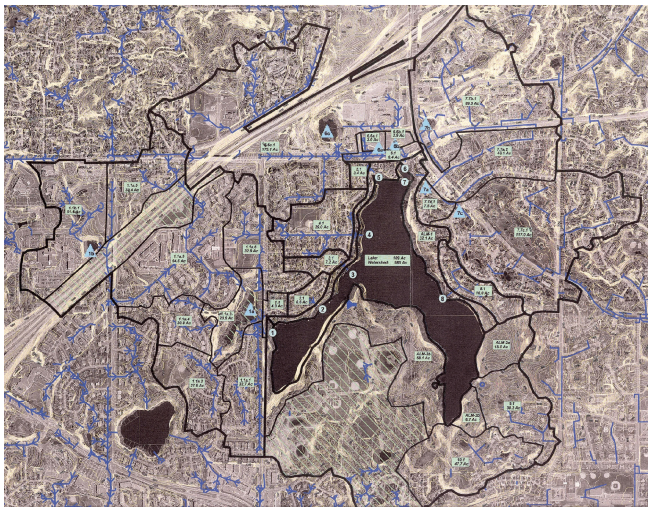

Figure 1. The Alimagnet Lake watershed and subwatersheds are outlined in black.

Shoreland Characteristics

The shoreland area is the transition area between the watershed and lake and encompass three components: the upland fringe, the shoreline, and the shallow nearshore area. Results of a shoreland inventory show over half of the parcels have existing natural conditions (Table 2). This is about average for urban lakes in the metro area.

Table 2. Summary of shoreline buffer and upland conditions in the shoreland area of Alimagnet Lake. Approximately 108 parcels were examined.

Alimagnet Lake	Natural Shoreline Condition		Natural Upland Condition		Undevel. Photo Parcels	Shoreline Structure Present	
	>50%	>75%	>50%	>75%		riprap	wall
TOTALS (no. of parcels = 108)	69% (75)	61% (66)	54% (58)	47% (51)	37% (40)	15% (16)	3% (3)

Lake Statistics

Alimagnet Lake is a 109 acre lake located in Dakota County, Minnesota with an average depth of 5 feet and a maximum depth of 11 feet.

Lake Dissolved Oxygen and Temperature

Alimagnet Lake does not strongly thermally stratify during the summer. This means that wind action can mix the entire lake during the summer. Dissolved oxygen concentrations are found throughout the water column most of the time, although there are days during the summer when dissolved oxygen is depleted on the bottom of the lake (Figure 2).

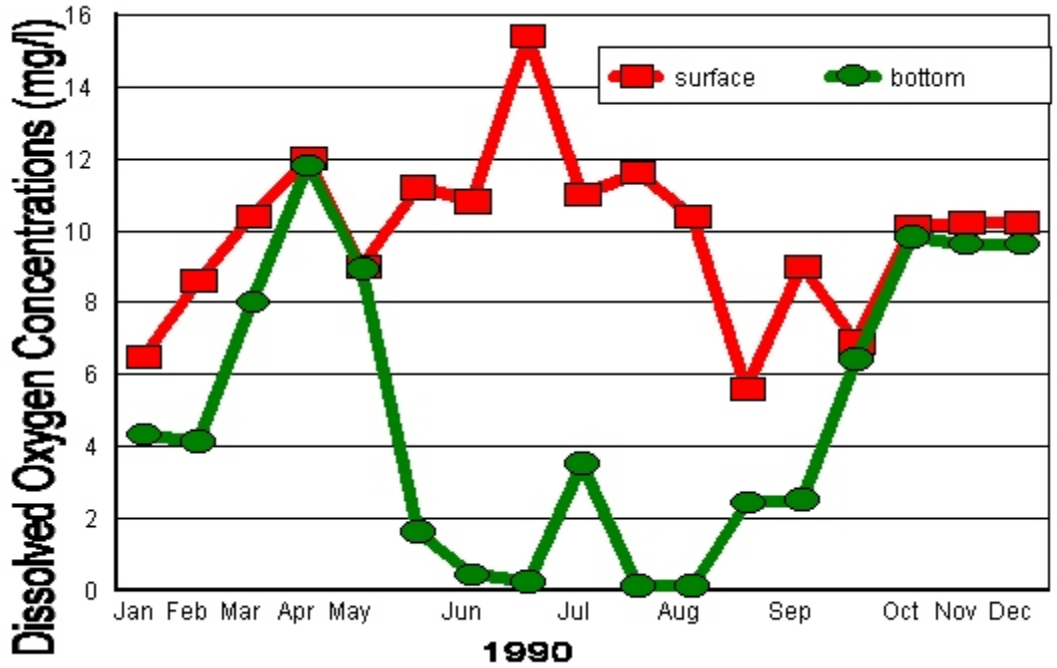

Figure 2. Monthly dissolved oxygen readings for top and bottom conditions for Alimagnet Lake in 1990 (source: JM Montgomery Engineers).

Lake Transparency and Nutrient Status

Phosphorus concentrations in Alimagnet are higher compared to other lakes in the North Central Hardwood Forest ecoregion. The 2003 growing season phosphorus average was 113 ppb. A predicted phosphorus concentration based on ecoregion values and ecoregion modeling is predicted to be 54 ppb. This indicates Alimagnet Lake has the potential to have better water quality than it presently has. Reducing lake nutrient levels is a primary goal for Alimagnet Lake.

Summer average Secchi disc readings have fluctuated over the years (Figure 3). Some of the variability may be influenced by winterkill events that have occurred in the past.

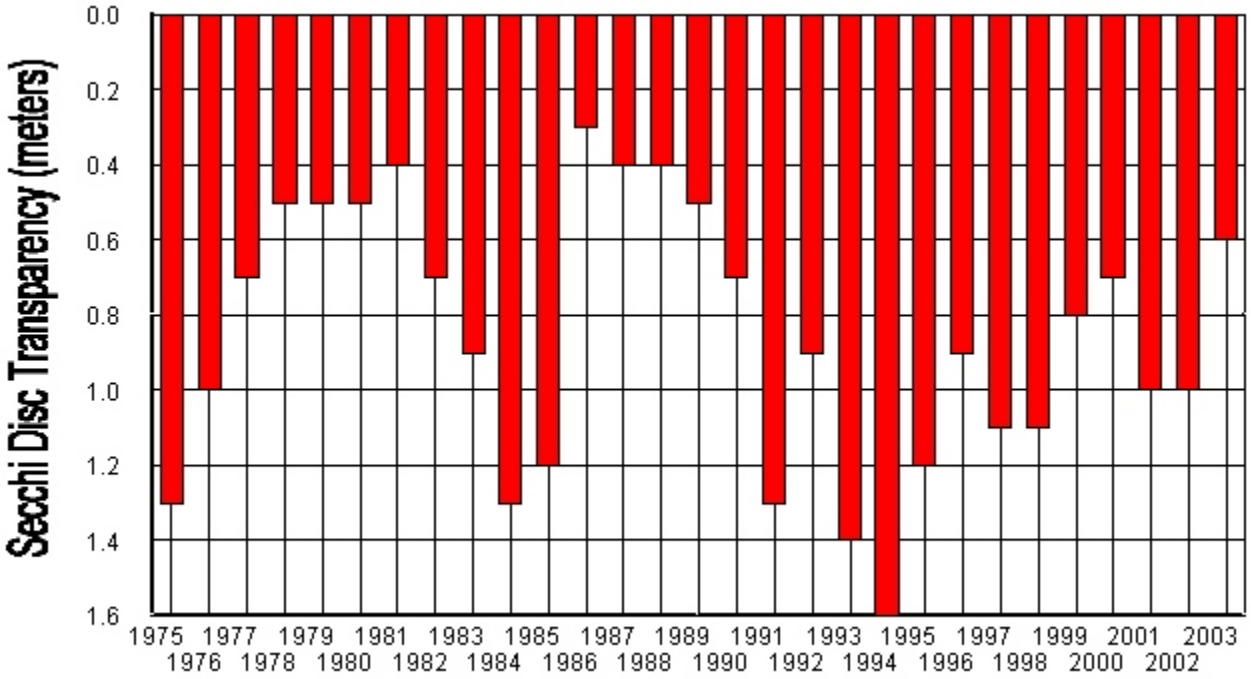

Figure 3. Summer average for Secchi disc readings from 1975-2003.

Lake Algae

Alimagnet Lake has algae species that are common to eutrophic lakes in this part of the state. By mid-summer, blue-green algae concentrations increase dramatically and water clarity decreases. Elevated phosphorus levels produce the excessive algal growth.

Lake Aquatic Plants

Alimagnet Lake has a low diversity of native aquatic plants. Elodea is common but the only other rooted native plant observed has been sago pondweed and it is rare in the lake. Curlyleaf pondweed, an exotic plant, is present in Alimagnet and grows to moderate nuisance conditions throughout the shallow waters of the lake. Lake sediment analysis predicts sediment characteristics would produce moderate nuisance conditions around most of the lake (Table 3 and Figure 4).

Table 3. Alimagnet Lake sediment data and ratings for potential nuisance curlyleaf pondweed growth.

Sample ID	Bulk density (g/cm^3)	Organic Matter (%)	pH (su)	Fe:Mn Ratio	Potential for Nuisance Curlyleaf Pondweed Growth
non-nuisance	1.04	5	6.8 (6.7-6.9)	4.5 (2-5)	Low
light nuisance	0.94	11	6.2	5.9	Med
heavy nuisance	<0.51	>20	>7.7	<1.6	High
1	1.18	2.7	6.6	9.3	Medium
2	0.71	15.8	5.9	8.0	Medium
3	1.13	2.9	6.2	5.5	Medium
4	1.2	2.3	6.3	6.5	Medium
5	1.16	2.0	6.6	5.5	Medium
6	0.88	4.6	6.2	4.7	Medium
7	0.94	4.7	6.7	9.7	Medium
8	1.01	2.7	6.9	10.9	Low
9	0.85	7.1	6.1	4.5	Medium
10	1.09	4.1	6.6	11.9	Medium
11	0.89	6.6	6.6	7.5	Medium
12	0.94	3.3	6.7	7.4	Medium
13	1.02	3.8	6.8	11.5	Low
14	1.01	3.7	6.2	8.3	Medium
15	1.29	1.3	6.2	11.0	Medium
16	0.75	22.0	6.3	9.0	Medium
17	1.44	0.5	6.6	13.5	Medium
18	0.66	10.4	6.0	9.8	Medium
19	0.70	34.1	6.4	7.9	Medium
20	0.78	12.2	6.0	10.1	Medium
21	0.38	34.2	6.0	5.6	High

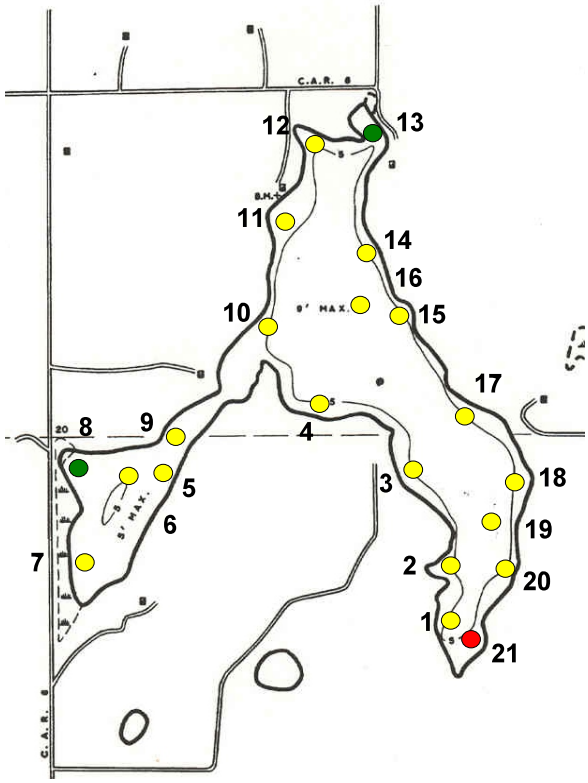

Figure 4. Areas that are predicted to support various types of curlyleaf pondweed growth are shown by colored dots. Green = non-nuisance, yellow = medium nuisance, and red = heavy nuisance.

Figure 5. The Alimagnet Lake Association has developed a curlyleaf control technique, where a cable strung between two boats, is pulled through the curlyleaf beds.

Fish

The fish community of Alimagnet Lake was last surveyed by the MnDNR in 2000. Black bullhead (at 84 fish/trapnet) were the dominant species. The black bullhead density may be even higher in 2004 and could be producing adverse impacts on lake water quality. The number of northern pike and black crappie were also above average. Largemouth bass and bluegill sunfish were also present at typical densities for a shallow lake like Alimagnet.

Lake Assessment

- Lake water quality results are below-average compared to Ecoregion values, meaning there is room for improvement.
- Phosphorus concentrations in watershed runoff are estimated at 336 ppb based on the P-8 model. This is above Ecoregion values which are around 150 ppb-P.
- The water clarity data base shows fluctuating seasonal averages over the years. However, Alimagnet Lake has the potential to get better.

Table 4. Summer average water quality characteristics for lakes in the Western Corn Belt Plains and the North Central Hardwood Forest Ecoregions compared to water quality for Alimagnet Lake.

Parameter	North Central Hardwood Forest	Alimagnet (2003)
Total phosphorus (ug/l) - top	23-50	113
Algae [as Chlorophyll (ug/l)]	5-22	45
Chlorophyll - max (ug/l)	7-37	130
Secchi disc (ft)	4.9-10.5	2.0

These comparisons indicate that the water quality of Alimagnet Lake are out of range compared to the North Central Hardwood Forest ecoregion water quality values. The challenge will be to bring water quality values within ecoregion ranges. The estimated nutrient load to Alimagnet Lake is shown in Figure 6.

Total estimated load: 600 pounds of phosphorus per year (272 kg-P/yr)

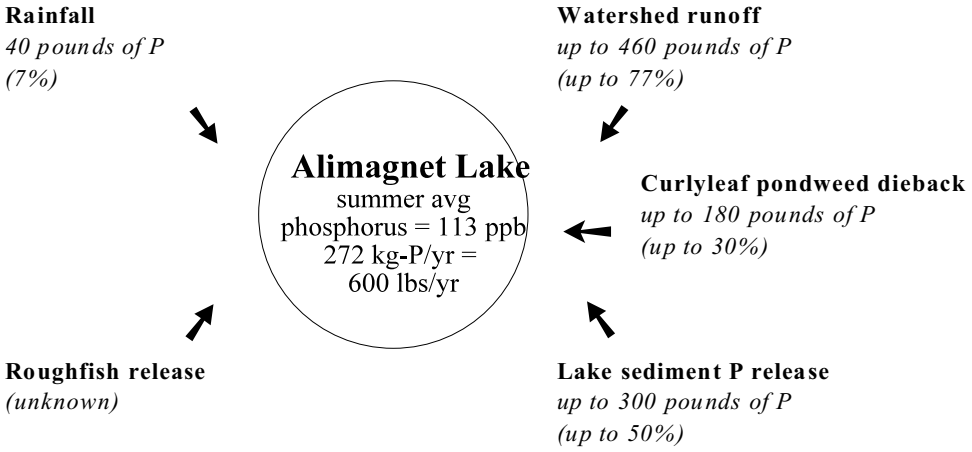

Figure 6. Estimated annual phosphorus loads to Alimagnet Lake.

Setting Water Quality Goals for Alimagnet Lake

Water quality in Alimagnet Lake has the potential to be better. Lake models were run to help determine feasible water quality goals for Alimagnet Lake. A lake model is a mathematical equation that uses phosphorus inputs along with lake and watershed characteristics to predict what a lake phosphorus concentration should be. Once a lake phosphorus concentration is determined, then seasonal water clarity and algae concentrations can be calculated as well.

Several lake models were run based on nutrient inputs using the Canfield-Bachmann natural lake model. Lake model runs were conducted for existing watershed runoff conditions (using a flow weighted mean concentrations of 336 ppb-P), predicted watershed runoff after watershed practices are implemented (FWMC 161 ppb-P), and for an ecoregion FWMC runoff P-concentration of 150 ppb. The existing observed conditions for lake phosphorus chlorophyll a, and Secchi depth are shown with red bar (Figures 7 and 8). Existing conditions are assumed to be dictated by an estimated phosphorus loading of 600 lbs/yr. The estimated phosphorus load for existing conditions was back-calculated for Alimagnet Lake based on a lake concentration of 113 ppb. The 113 ppb-P lake concentration was the summer average for 2003.

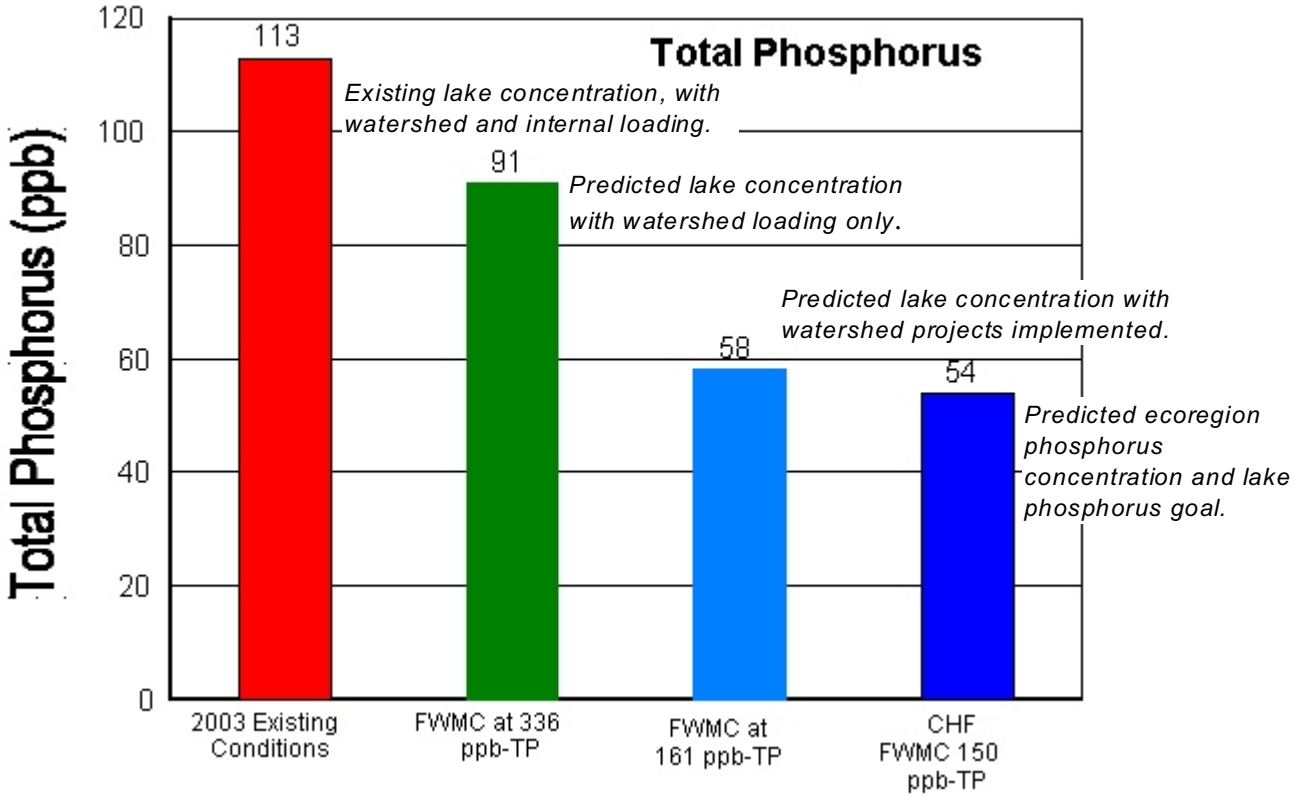

Figure 7. Comparison of total phosphorus concentration for Alimagnet Lake in 2003 to lake phosphorus concentrations based on estimated concentrations for a watershed runoff flow weighted mean concentration (FWMC) of 336 ppb-phosphorus (current watershed runoff conditions), for a watershed runoff FWMC of 161 ppb-P (predicted after watershed practices are implemented) and for a lake with a watershed the size of Alimagnet Lake situated in the Central Hardwood Forest (CHF) with a phosphorus runoff concentration of 150 ppb.

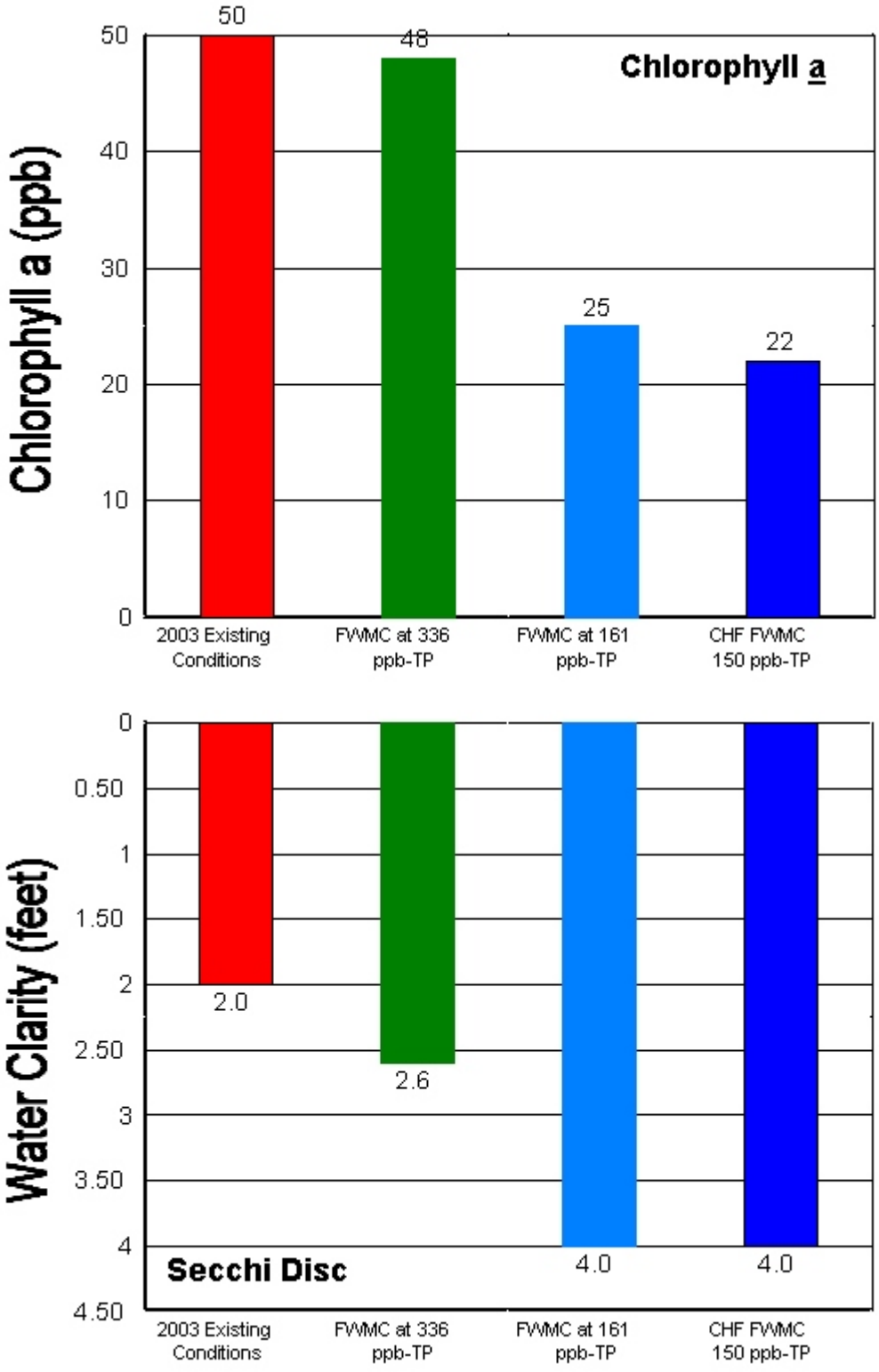

Figure 8. Comparison of chlorophyll a concentration (top) and water clarity (bottom) for Alimagnet Lake in 2003 to predicted lake chlorophyll concentrations and clarity for a watershed runoff flow weighted mean concentration (FWMC) of 336 ppb-phosphorus (current watershed runoff conditions), for a watershed runoff FWMC of 161 ppb-P (predicted after watershed practices are implemented) and for a lake with a watershed the size of Alimagnet Lake situated in the Central Hardwood Forest (CHF) with a phosphorus runoff concentration of 150 ppb.

Water Quality Improvement Strategy

There appears to be a need to reduce a significant amount of annual phosphorus loading to Alimagnet Lake in order to meet lake water quality goals.

An important finding of the watershed and in-lake modeling was that Alimagnet Lake will need both watershed and lake projects to meet the water quality goal of 54 ppb. This should produce a summer average Secchi disc reading of 1.2 m (4.0 ft). The water quality of a shallow lake system, like Alimagnet Lake, is greatly affected by in-lake processes such as internal recycling of nutrients that have accumulated in bottom sediment and relationships between fish, rooted aquatic plants, and algae. This underlines the importance of sound in-lake management programs while reducing watershed phosphorus inputs. Therefore, it will be difficult for watershed-based BMPs alone to meet lake water quality goals. The water quality improvement strategy will be to reduce watershed pollutant inputs to the maximum extent practical while implementing in-lake water quality improvement projects.

Algae blooms are an annual occurrence in Alimagnet Lake. The water quality improvement strategy will not eliminate algae blooms, but should reduce the number of days they occur as well as their intensity.

Recommended Lake Management Programs and Projects

Lake management programs are recommended to improve watershed nutrient inputs (Table 5) as well as in-lake conditions (Table 6).

Table 5. Phosphorus load reductions associated with watershed projects.

Priority Watershed Projects	Description	TP Load Reduction
1a	Barley straw treatment in Ponds 1A, 6C, and 7A.	123 lbs/yr
1b	Expand wet volume of Pond 7A (located in Apple Valley) through excavation.	16 lbs/yr
1c and 1d	Expand wet volume of north cell of Pond 1A (located in Burnsville) through excavation and develop pre-treatment basin prior to north cell of Pond 1A.	56 lbs/yr
2	Improve fertilizer management in the watershed, particularly emphasizing the urbanized direct drainage area.	13 lbs/yr

Table 6. Lake improvement benefits associated with lake projects.

Priority Lake Projects	Description	TP Load Reduction (lbs-P/yr)	Other Benefits
1	Shoreland projects	4	Wildlife enhancement, aesthetics
2a	Continue to control curlyleaf pondweed	90	Improved recreational use
2b	Harvesting nuisance aquatic plant growth	15	Improved recreational use
3a	Black bullhead removal	0 - 60	Improves fishing
3b	Stock catfish and bass	0	Improves fishing, controls roughfish
4	Organic carbon amendment	150*	No herbicides used, improved fishing

* 150 pounds of phosphorus per year is made unavailable to algae with this organic carbon amendment. This type of phosphorus redirection has been documented in lakes that used barley straw, where significant water column phosphorus concentrations have decreased.

Project Costs

Estimated project costs for the Alimagnet Lake improvement program are summarized in Table 7.

Table 7. Summary of recommended projects and costs.

	Estimated Phosphorus Reduction (pounds/year)	Capital Cost	Average Annual O & M (5 yr)	5 Year Cost
Watershed Projects				
1. Stormwater pond improvements.				
1a. Barley straw for three ponds.	123	0	4,000	20,000
1b. Excavation of pond 7A.	16	65,000	0	65,000
1c. Excavation of pond 1A.	37	150,000	0	150,000
1d. Construction of pre-treatment pond for 1A.	19	240,000	0	240,000
2. Fertilizer management and control.	13	0	2,000	10,000
Subtotal	***208***	***455,000***	***6,000***	***485,000***
Lake Projects				
1. Shoreland buffers.	4	0	3,000	15,000
2. Aquatic plant projects.				
2a. Continue curlyleaf control program	90	5,000	1,000	10,000
2b. Harvest nuisance plant growth.	--	0	3,000	15,000
3. Fish management				
3a. Black bullhead removal.	30	0	4,200	21,000
3b. Predator stocking.	--	0	800	4,000
4. Organic carbon amendment.	150	0	16,000	80,000
Subtotal	***274***	***5,000***	***28,000***	***145,000***
Watershed and Lake Programs				
1. Information and education	10	0	3,000	15,000
2. Watershed and lake monitoring	--	0	2,500	12,500
Subtotal	***10***	***0***	***5,500***	***27,500***
TOTAL	***492***	***460,000***	***39,500***	***657,500***
Reserve Projects				
Street sweeping	9	0	4,500	22,500
Infiltration and rain gardens	22	300,000	0	300,000
Lake sediment iron treatment for curlyleaf pondweed	150	30,000	0	30,000
Install winter aeration in two additional locations	100	30,000	3,000	45,000
Lake sediment alum project	150	100,000	0	150,000

Project Sequence

A five-year project sequence is summarized in Table 8. Several projects will occur annually for the next five years. After five years, lake conditions will be evaluated. It is anticipated that lake goals will be met by the end of year 5 and that several projects with high annual costs (for example the organic carbon amendment) can be curtailed or eliminated.

Table 8. Alimagnet Lake improvement project sequence, annual costs, and total project cost for a 5-year program.

	Year 1	Year 2	Year 3	Year 4	Year 5	5 Year Cost
Watershed Projects						
1. Stormwater pond improvements.						
1a. Barley straw for 3 ponds.	4,000	4,000	4,000	4,000	4,000	20,000
1b. Excavation of pond 7A.	--	65,000	--	--	--	65,000
1c. Excavation of pond 1A.	--	60,000	90,000	--	--	150,000
1d. Construction of pre-treatment pond for 1A.	--	40,000	120,000	80,000	--	240,000
2. Fertilizer management and control.	2,000	2,000	2,000	2,000	2,000	10,000
Subtotal	***6,000***	***171,000***	***216,000***	***86,000***	***6,000***	***485,000***
Lake Projects						
1. Shoreland buffers.	3,000	3,000	3,000	3,000	3,000	15,000
2. Aquatic plant projects.						
2a. Continue curlyleaf control program	6,000	1,000	1,000	1,000	1,000	10,000
2b. Harvest nuisance plant growth.	--	--	5,000	5,000	5,000	15,000
3. Fish management						
3a. Black bullhead removal.	7,000	7,000	7,000	--	--	21,000
3b. Predator stocking.	1,500	900	800	800	--	4,000
4. Organic carbon amendment.	16,000	16,000	16,000	16,000	16,000	80,000
Subtotal	***33,500***	***27,900***	***32,800***	***25,800***	***25,000***	***145,000***
Watershed and Lake Programs						
1. Information and education	3,000	3,000	3,000	3,000	3,000	15,000
2. Watershed and lake monitoring	2,500	2,500	2,500	2,500	2,500	12,500
Subtotal	***5,500***	***5,500***	***5,500***	***5,500***	***5,500***	***27,500***
TOTAL	***45,000***	***204,400***	***254,300***	***117,700***	***36,500***	***657,500***