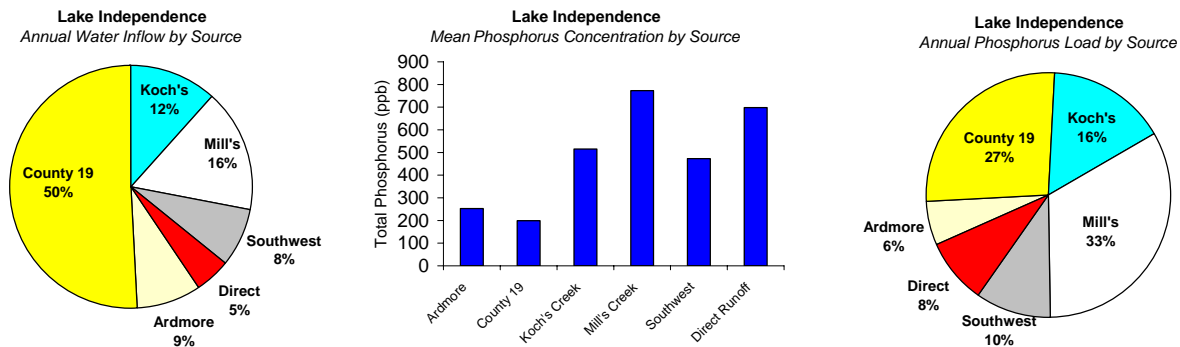


Calibrated FLUX and BATHTUB models predicted that 2339 pounds of phosphorus and 16,096 pounds of nitrogen entered Lake Independence annually from the surrounding watershed during the monitoring period (table 5 and figure 8). The largest loadings occurred at County Road 19, Koch’s Creek, and Mill’s Creek.

**Table 5.** Summary of the FLUX and BATHTUB model outputs for Lake Independence based upon current inflow.

Inflow Site	Water Inflow <i>acre-feet/year</i>	Avg TP Concentration <i>ppb</i>	Estimated TP Load <i>lb/year</i>	Avg TN Concentration <i>ppb</i>	Estimated TN Load <i>lb/year</i>
Ardmore	194.6	253	135	2440	1299
County 19	1159.3	199	626	1434	4515
Koch's Creek	267.5	515	370	4709	3386
Mill's Creek	372.9	773	776	3811	3825
Southwest	178.4	473	234	4000	1971
Direct Runoff	105.4	698	198	3874	1100
<b>Totals</b>	<b><u>2278.1</u></b>	-	<b><u>2339</u></b>	-	<b><u>7301</u></b>

**Figure 8.** Graphs showing the relative percent of the total annual water volume and phosphorus load entering Lake Independence by site, as well as the annual mean total phosphorus concentration for each monitored inflow site (as determined by FLUX model).



The phosphorus entering Lake Independence in the inflow streams originates from many sources. A significant amount of research has been done by the Environmental Protection Agency, numerous universities, state agencies, and others to determine phosphorus runoff rates from different land use types and activities (EPA 1980). Phosphorus export rates reported in the literature for each land use type in the Lake Independence watershed were used to estimate the phosphorus export from these sources (figure 9).

The portion of the exported phosphorus that actually flows into Lake Independence is likely reduced significantly from the initial export values by management practices, wetlands, infiltration areas, and biological uptake as the phosphorus moves through the watershed on its way to the lake, but the relative contribution from each source is expected to be roughly proportional to the amount initially exported. Using this method, the data suggest that 43% of the phosphorus entering Lake Independence originates from livestock, 36% from vacant and agricultural cropland, and 9% from urban runoff. The remaining 12% can be attributed to rural homes, sewage treatment effluent, park area, wind-blow soil, golf course runoff, erosion, and wildlife. While the total phosphorus export from many of these listed sources is small compared to the export from livestock feedlots and cropland, it is likely that larger portions of their exported phosphorus may enter Lake Independence due to the proximity of these areas to the lake. In order to improve the quality of the lake, phosphorus from all of these sources will need to be addressed.

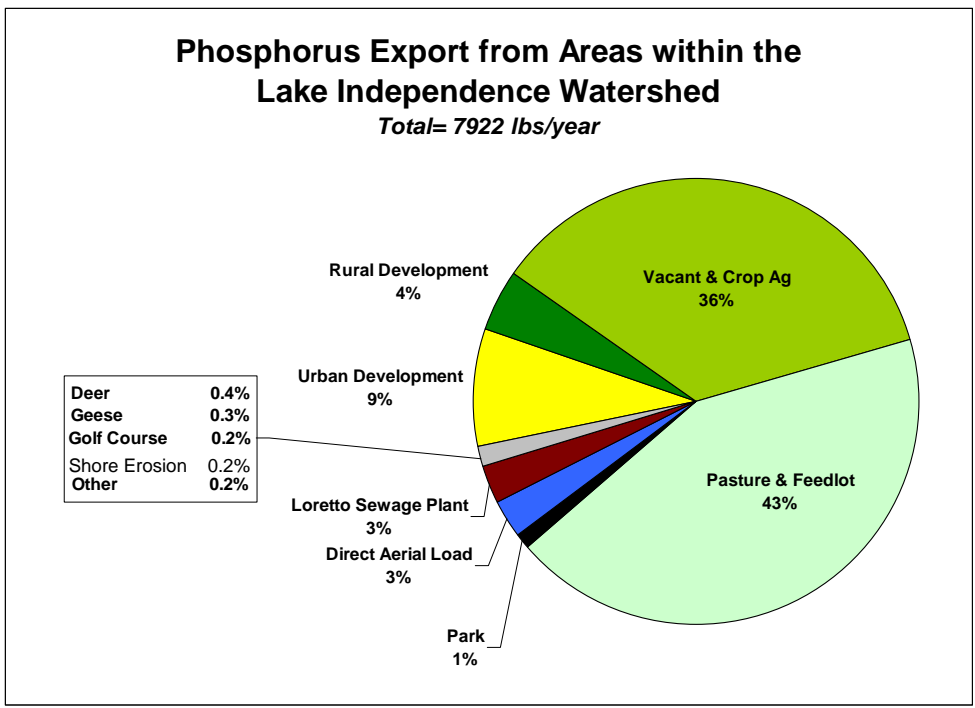


Figure 9. Phosphorus export from sources within the Lake Independence Watershed.

### 2.2.5 Water Quality Goals

#### *MINLEAP Computer Model*

MINLEAP was used to predict the expected water quality of Lake Independence. This model uses information about a lake to compare observed water quality to similar but less impacted lakes in the same ecoregion of Minnesota. Based upon physical, chemical, and geographic information about Lake Independence, the model estimated that if minimally impacted by humans, Lake Independence would be expected to experience a summer mean phosphorus concentration of 31 ppb. This represents a 16 ppb or 34% reduction from observed mean summer phosphorus values. This goal may be difficult to reach since it is based upon minimal human impacts in the watershed, but it provides a best-case scenario figure.

#### *User Perception*

The MPCA, Metropolitan Council, and Three Rivers Park District conducted lake user surveys to correlate people's impressions of a lake's usability to scientifically measured water quality data. The results of these surveys indicated that 75% of the people surveyed felt comfortable swimming in metro-area lakes that had mean summer total phosphorus levels at or below 36 ppb. While there is no inherent health risk at phosphorus levels higher than 36 ppb, this threshold value was used to define the level where phosphorus begins to impair recreational usability of a lake. For this reason, a target phosphorus concentration of 36 ppb has been adopted by the Three Rivers Park District Board as the goal for Lake Independence. This target is 11 ppb lower (23%) than the average observed summer concentration in 1990-2002. Given the level of development in the Lake Independence watershed, this may represent a more realistic goal than that provided by MINLEAP.

#### *Effect of Water Quality on Property Values*

Research conducted by the University of Maine in 1995 showed that for every one meter decrease in secchi transparency, property values dropped by \$65-\$140 per foot of lake frontage (James et al. 1995). This generally translated to a 10-20% drop in property values. Conversely, for every one-meter increase in secchi transparency (water clarity), property values increased from \$18-\$50 per foot of lake frontage.

#### *Pollutant Reduction Goals*

The target in-lake phosphorus goal of 36 ppb adopted by the Three River Park District Board, which would require a 882 pound reduction in annual phosphorus loading to the lake, provides a benchmark for building an integrated lake management plan. The most effective strategy for improving the water quality of Lake Independence will need to include a combination of the management actions listed in table 7 and may include other options not listed. Additional discussion and assessments are necessary to fully explore the management options with considerations for available funding, technical feasibility, and public support.

#### *Modeled Lake Response*

LTROPHIC model predicted that if the target annual summer mean phosphorus concentration of 36 ppb was achieved, mean summer Secchi depths would be expected to increase by 0.25 meters (16%), and chlorophyll levels to decrease by 8 ppb (32%).

## Section 3: Discussion of Potential Management Activities

### 3.1 Overview of Identified Phosphorus Sources

#### 3.1.1 Mill's Creek

The inflow from Mill's Creek on the western shore of Lake Independence represents 16% of the annual water volume, 24% of the annual nitrogen load, and 33% of the annual phosphorus load entering the lake from the watershed. The combination of low water volume and high nutrient concentration makes Mill's Creek a good target for management. The area surrounding the mouth of Mill's Creek is predominantly wetland. Any plans for physical alterations of this area may need to consider the potential impact on this wetland system. An existing pond located near the inlet of Mill's Creek may be worth exploring for use as a treatment pond, but this would require some alterations to the existing flow route of the creek and may impact the water quality of the pond (see Appendix A).

#### 3.1.2 Loretto Sewage Effluent Discharge

The municipal wastewater treatment facility in Loretto, Minnesota is currently permitted to periodically release treated sewage effluent into a wetland complex that flows to Spurzem Lake and eventually to Lake Independence (roughly 2 km downstream). In recent years, the Loretto treatment facility has been applying alum to their treatment ponds prior to discharge. This measure drastically reduces the concentration of phosphorus in the effluent. Currently, the treatment facility is permitted to discharge up to 7 lbs of phosphorus per day, at a maximum effluent concentration of 1000 ppb. Actual discharges have been reported annually to the MPCA and are given in table 6 below.

**Table 6.** Reported effluent discharge volumes and concentrations reported by the Loretto Municipal Wastewater Treatment Facility to the MPCA in 2001 and 2002. Also included are the calculated loads of phosphorus for each reported discharge. Note that discharge periods may include multiple days.

<b>Discharge Period</b>	<b>Discharged Vol. (million gallons)</b>	<b>Phosphorus Conc. (ppb)</b>	<b>Exported Phosphorus (lb)</b>
<b>April 2001</b>	<b>2.24</b>	<b>1090</b>	<b>20.4</b>
<b>Sept 2001</b>	<b>1.03</b>	<b>2730</b>	<b>23.5</b>
<b>Nov 2001</b>	<b>7.28</b>	<b>260</b>	<b>15.5</b>
<b>May 2002</b>	<b>9.90</b>	<b>380</b>	<b>31.4</b>
<b>Sept 2002</b>	<b>1.60</b>	<b>1200</b>	<b>16.0</b>
<b>Nov 2002</b>	<b>8.00</b>	<b>490</b>	<b>32.7</b>

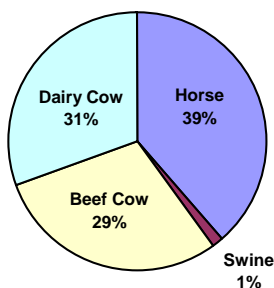
In 2001 and 2002, the treatment facility reported discharging 59 and 80 lbs of phosphorus respectively, or 70 lbs as a two-year annual average. Due to some additional removal by small lakes and wetland systems downstream, the annual loading to Lake Independence from this source was estimated to be 53 lbs. Monitoring data from Spurzem Lake indicate that it has experienced substantially higher nutrient levels and poorer water quality than expected if it experienced nutrient inflows typical of this region of Minnesota. While the effluent discharge has appeared to be leading to nutrient enrichment of Spurzem Lake, downstream wetlands, and Lake Independence, the latest measures used by the Loretto treatment facility to reduce the phosphorus concentration in discharged effluent (alum treatment and settling ponds) have effectively reduced the potential impact of such discharges to Lake Independence. Stricter adherence to the 1000 ppb concentration limit would yield even greater reductions.

### 3.1.3 Agricultural Non-point Sources

The stream data collected in 1996, 1997, and 2001 indicated that the highest nutrient concentrations occurred in Mill's Creek and Koch's Creek (table 5). Recent studies conducted by the Three Rivers Park District showed that these two subwatersheds had substantially more area devoted to livestock rearing and crop agriculture than the other subwatersheds. This suggests that these land-uses may be major contributors to the nutrient levels in these two creeks. In addition, a 1997 survey conducted by Three Rivers Park District staff determined that there was a conservative estimate of 572 livestock animals within the watershed (figure 10). This translates to an estimated annual production of 19 million pounds of manure which contains 16,755 lbs of phosphorus and 85,000 lbs of nitrogen (MSUE). The exact amount of this manure that washes into Lake Independence is difficult to determine, but previous research and computer model simulations of the Lake Independence watershed suggest that some livestock production areas are sources of nutrients that contribute to the water quality degradation of the lake. These agricultural non-point sources are an attractive management targets if cost-effective ways to control nutrient export can be implemented (see *buffer strips along streams*, and *livestock waste management* in table 7).

**Figure 10.** Summary of livestock animals and their associated annual manure production within the Lake Independence Watershed. Based upon a 1997 survey of livestock areas conducted by the Suburban Hennepin Regional Park District and literature values for manure production (MSUE).

**Livestock Animals  
in Lake Independence Watershed**  
(total # = 572)

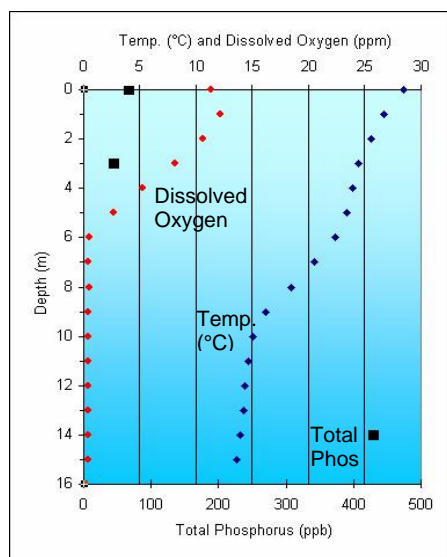


**Annual Manure Production Summary**

<b>Manure (wet)</b>	19 million lbs
<b>Phosphorus</b>	16,755 lbs
<b>Nitrogen</b>	85,186 lbs

### 3.1.4 Nutrient Recycling within Lake Independence

Lake Independence regularly experiences stratification that is sufficiently stable to promote the near total loss of oxygen below the thermocline (figure 11). This typically results in a significant accumulation of phosphorus, released from the sediments, in deeper areas of the lake. Data collected by an automated sampling raft (RUSS unit) in 1999 and 2000 indicated that the lake often experiences significant partial mixing during thunderstorms and windy days. This periodic partial destratification mobilizes phosphorus that had accumulated in the deeper waters and mixes it into the surface layer of the lake where it becomes available to algae and plants. Additional internal loading may occur due to the substantial release of phosphorus when curlyleaf pondweed dies off and begins to break down in early summer.



**Figure 11.** Water column profile of Lake Independence from August of 2000 showing lake stratification.

LTROPHIC model was used to estimate the total phosphorus load to Lake Independence. It predicted that the lake would have to receive 3858 lbs of phosphorus loading per year to explain the observed water quality. By subtracting the estimated external load discussed earlier, 2339 lbs., from this predicted total load, we get an estimate of the internal nutrient recycling; 1519 lbs/year or 39% of the total annual phosphorus load.

Internal phosphorus recycling has likely been a major factor in producing the frequent algae blooms that have impaired the water quality of Lake Independence in recent decades. Management alternatives that focus on reducing this internal nutrient recycling would likely result in a drastic nutrient reduction and greatly improved water quality within the lake, but the longevity of such a treatment would likely be shortened by years if the external loading of phosphorus was not reduced first.

### **3.2 Assessment of Management Option Feasibility**

Based upon the information discussed thus far in this report, the Three Rivers Park District has assembled a list of potential management alternatives that could be used to address the water quality issues in Lake Independence. This list includes several options which would likely have little effect on the lake or are probably too expensive to be truly feasible, but they were included for the sake of comparison. Table 7 gives an overview of effectiveness, cost, expected longevity, and other important considerations for each given management alternative.

**Table 7.** Summary of potential effectiveness, costs, and other important considerations for each given Lake Independence management alternative

Management Option	Annual Reduction of P Loading to Lake <sup>1</sup>	Decrease of In-Lake P <sup>2</sup> (at surface)	Predicted Increase in Water Clarity <sup>3</sup>	Estimated Capital Cost	Estimated Annual O&M Cost	Annual Cost per kg of P	Other Considerations
No Management	0	0.0%	None	\$0	\$0	\$0	Loss of money due to degraded water quality (residential value, tax base, lost tourism business)
Lake Shoreline Stabilization	8 kg/year	<1 ppb Initially available P only (Soil may release P for many years once in lake)	May decrease non-algal turbidity, but would likely not reduce algae	Minimal for sites with little erosion, Moderate to High for sites with severe erosion	Minimal	Moderate to High due to low amount of phosphorus released annually	Properly stabilized shorelines prevent property loss and can increase the habitat value of the shoreline for wildlife if properly vegetated. Rip-rap should only be used at sites with severe damage.
Goose Control along Shoreline	8 – 15 kg/year  (0.1–0.2 kg per goose/year)	0.2-0.4 ppb (<1%)	<0.1 m	Low to Medium (deterrents or landscaping)	Low (additional deterrents)	Low	Assume 100 resident geese over 9 months of the year. Geese acclimate to disturbances quickly. Need to regularly change types of deterrent used.
Buffer Strips along Streams <i>primarily along stretches with high nutrient loading</i>	200-400 kg (11-23% of total)  65-75% of phosphorus removed from runoff.	2-5 ppb (3-9%)	0.1 m (5%)	Minimal for “no-mow” areas  Moderate to High if landscaped and ornamental vegetation used	\$0-350 / acre	Minimal for “no-mow” areas  Low to Moderate if landscaped and ornamental vegetation used	Phosphorus removal depends upon buffer width, percentage of streambank involved, and proximity to areas with high phosphorus runoff. Capital and O&M costs depend greatly upon buffer width and the desired vegetative cover.
Raingarden Installation <i>For properties immediately adjacent to the lake</i>	23 kg (=65% removal) Assumes 200 homes at 0.18 kg of P per home/year	1 ppb	<0.1 m	Low to Medium (depends upon amount of landscaping and plants used)	Minimal	Moderate	Assumes 65% P removal. In addition to reducing nutrient loading from direct runoff, raingardens will add to the aesthetic/habitat quality of the shoreline.
Septic System Maintenance	Difficult to predict, but the MPCA estimates 50-75% of septic systems failing state-wide	Difficult to predict without further data collection at actual septic sites	None if few septic systems are failing  Minimal if many septic systems failing	Depends upon number of failing systems and method of fixing these systems	Minimal	Difficult to determine without additional data collection at actual septic sites	Failing septic systems may also be major contributors to the bacterial levels in the lake and may pose a health risk to swimmers. By law, failing systems must be repaired.

<sup>1</sup> Predicted reduction from the loading values estimated by FLUX and BATHTUB models based upon monitoring data collected in 1996, 1997, and 2001

<sup>2</sup> Predicted decrease from the 1990-2002 surface total phosphorus (0-2m) mean summer value; determined using BATHTUB and LTROPHIC models

<sup>3</sup> Predicted increase from the 1990-2002 mean summer Secchi depth value; determined using BATHTUB and LTROPHIC models

**Table 7. (continued)**

Management Option	Annual Reduction of P Loading to Lake <sup>1</sup>	Decrease of In-Lake P <sup>2</sup> (at surface)	Predicted Increase in Water Clarity <sup>3</sup>	Estimated Capital Cost	Estimated Annual O&M Cost	Annual Cost per kg of P	Other Considerations
Bio-manipulation	Minimal or None	0.0%	Moderate or High if successfully implemented  (difficult to predict due to complex biological interactions)	Low or Moderate for stocking alone  Higher if rotenone or netting used	Minimal to Moderate depending upon need for periodic stocking and additional maintenance	Little or no phosphorus removed	This management technique requires restructuring of the fish community to balance the proportion of piscivores to planktivores. This has the potential to affect fishing positively or negatively. Large <i>Daphnia</i> species are present in the lake at low densities.
Livestock Waste Management	150 kg (9% of total) Estimated with computer model of watershed	2 ppb (4%)	< 0.1 m	Moderate to High	\$12-117 per animal	Depends upon number of sites, type of livestock, and # of animals	The amount of manure leaving each individual site is very dependent upon topography, soil type, vegetative cover, distance from water, and density of livestock.
Treatment Pond at Mill's Creek Inflow (See appendix A)	251 kg (14% of total)  (71% removal of phosphorus from Mill's Creek Inflow)	6.0 ppb (13%)	0.1 – 0.2 m	High  (exact amount depends upon bid from contractor)	Minimal or Low	Likely Low or Moderate due to high removal (71%) and expected longevity	This may degrade the water quality of the pond. Additional management may be required to keep pond area usable; including dredging new access to lake and planning to maintain pond aesthetics
Iron Injection at Spurzem Lake Outlet	93 kg (5% of total)	1.5 ppb (3%)	< 0.1 m	\$70,000	\$5,000	\$150 (for 8 years)	Halfmoon Lake would act as a settling basin, allowing for more removal than seen at Mill's Creek.
Iron Injection at Mill's Creek	55 kg (3% of total)	1 ppb (2%)	< 0.1 m	\$70,000	\$5,000	\$250 (for 8 years)	Expect a minimum of 8 years before major maintenance needed
Alum Injection at Mill's Creek	317 kg (18% of total)	8 ppb (17%)	0.20 m (13%)	\$250,000	\$50,000	\$325 (for 5 years)	Assumes 90% removal of phosphorus
Alum Injection at County Road 19	255 kg (15% of total)	7 ppb (15%)	0.15 m (9%)	\$250,000	\$50,000	\$400 (for 5 years)	Assumes 90% removal of phosphorus
Alum Treatment of Lake Independence	551kg (31% of total)	17 ppb (34%)	0.50 m (30%)	\$ 500,000 (\$600 /acre)	Minimal (monitoring)	\$91 (for 10 years)	Assumes 80% reduction of internal phosphorus recycling and an expected 10-year lifespan. The curlyleaf pondweed infestation may also reduce the effectiveness of the alum by acting as a transport mechanism for phosphorus from the sediment to the water column.

<sup>1</sup> Predicted reduction from the loading values estimated by FLUX and BATHTUB models based upon monitoring data collected in 1996, 1997, and 2001

<sup>2</sup> Predicted decrease from the 1990-2002 surface total phosphorus (0-2m) mean summer value; determined using BATHTUB and LTROPHIC models

<sup>3</sup> Predicted increase from the 1990-2002 mean summer Secchi depth value; determined using BATHTUB and LTROPHIC model



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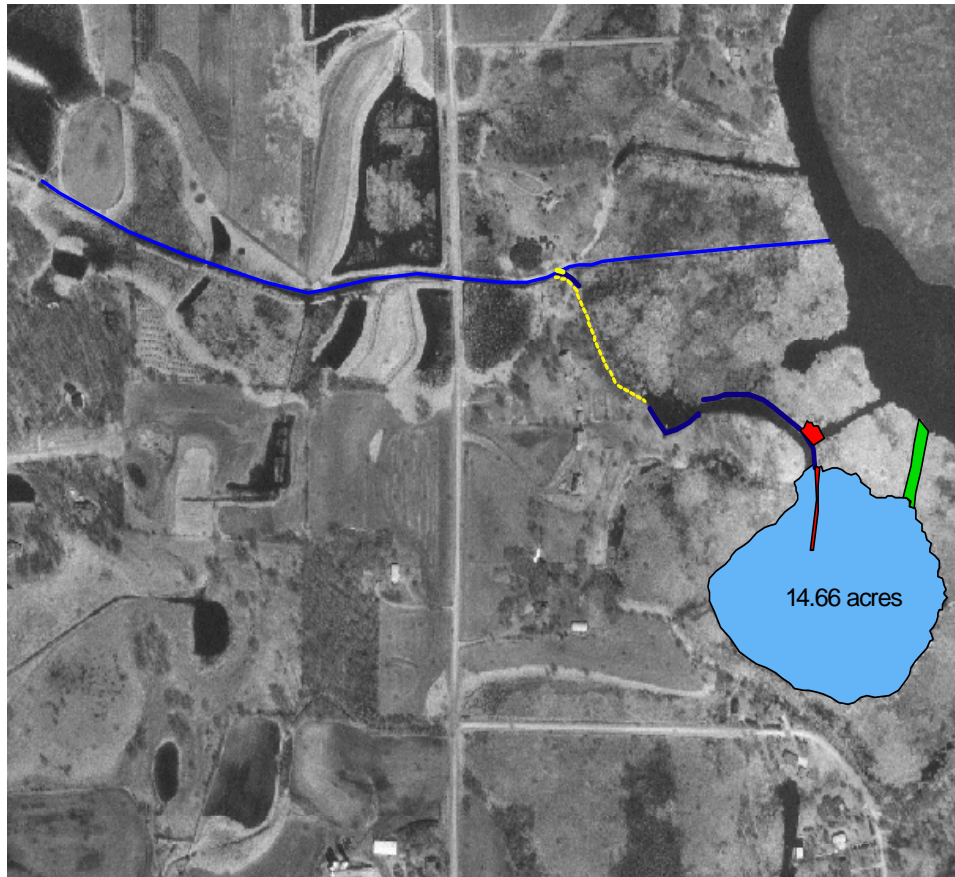
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## APPENDICES

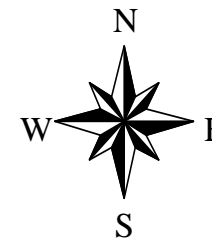
### Appendix A – Potential Mill’s Creek Treatment Pond

# Appendix A

## Potential Mill's Creek Treatment Pond



- Fill Area
- Dredged Area
- - - Enhanced Channel
- - - Control structure.shp
- - - Bank Protection
- - - Mills Creek
- Existing Pond



0 100 200 300 400 500 Meters