ALPINE LAKE

WAUSHARA COUNTY, WISCONSIN

AQUATIC PLANT MANAGEMENT PLAN & PRELIMINARY WATERSHED INVESTIGATION

Prepared for

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Alpine Lake Protection & Rehabilitation District

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NES Ecological Services

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EXCUTIVE SUMMARY

A multi-component study of Alpine Lake, Waushara County, Wisconsin was completed during 2002 and 2003. The study was completed to provide information concerning the lake and its watershed so an aquatic plant management plan could be created for the lake. As a part of this plan, recommendations were also formulated concerning the watershed and lake water quality. Funding for this study and the development of the plan was provided by the Wisconsin Department of Natural Resources Lake Management Grant Program and the Alpine Lake Protection and Rehabilitation District.

The data from this study were analyzed with data collected during past studies and yielded the following major results:

- Alpine Lake has good water quality and normally fluctuates within the mesotrophic state.
- Abundant macrophytic and filamentous algae populations indicate that the lake is more eutrophic than is estimated by widely used trophic state indices
- Alpine Lake only weakly stratifies with a primarily oxygenated hypolimnion, reducing the likelihood of internal phosphorus loading
- Phosphorus is clearly the limiting plant nutrient.
- Modeling of field-verified land use indicates that phosphorus entering the lake from septic systems, agricultural lands planted in row crops, and residential development are the major contributors to the lake's total phosphorus load
- Two aquatic plant surveys were completed that identified 3 exotic species and 27 native species within the lake.
- Nearly the entire lake bottom is estimated to contain some coverage of aquatic plants.
- The most abundant species are Wild celery (*Vallisneria americana*) and Eurasian water-milfoil (*Myriophyllum spicatum*); closely followed by slender waterweed (*Elodea nuttallii*) and coontail (*Ceratophyllum demersum*).
- There is a distinct lack of floating-leaf and emergent aquatic plant communities within the lake.
- Alpine Lake periodically experiences nuisance filamentous algae blooms.

Major recommendations to the Alpine Lake Protection and Rehabilitation District include the following:

- The best way to reduce the eutrophic nature of Alpine Lake will be to minimize the external sources that feed phosphorus into the lake.
- Septic system inspections were recommended to identify and replace faulty septic systems that may be adding phosphorus to the lake.

- It was also recommended that the District determine the feasibility of connecting all shoreland and back lot properties to the Silver Lake Sanitary District.

- Shoreland buffer creation was recommended to reduce phosphorus and sediment loading from lakeshore properties.

- A winter water level drawdown was recommended in conjunction with native species enhancement to reduce Eurasian water-milfoil abundances and provide competitive advantage to the existing native species.

INTRODUCTION

Alpine Lake, Waushara County is a 56-acre, man-made lake that was created when Bruce (Thorstad) Creek was dammed in the fall of 1970. In 1975, the Lake Alpine Association was formed with covenants to enable a uniform programming for establishing a scheme of development and protection for the lands around the lake. The Lake Association was voluntarily dissolved following the formation of the Alpine Lake Protection and Rehabilitation District (ALPRD) in 1985.

Since its inception, the ALPRD has worked diligently to control nuisance macrophyte and algae problems through mechanical harvesting and chemical treatments. The past and current plant management activities have been conducted with the goal of controlling primarily exotic macrophytes, specifically curly-leaf pondweed (*Potamogeton crispus*) and Eurasian water-milfoil (*Myriophyllum spicatum*); and near-shore algae mats. Although the District believes that they have received some short-term relief through the management techniques that have been utilized in the past decades, they know that they need to objectively assess the situation and create a realistic plan for the future management of the lake. The plan not only provides guidance to the District for the control of algae and macrophytic plants, but also outlines methods to enhance and protect valuable native plant species within the lake and on its shores. The ALPRD has already initiated protection steps by requiring that chemical treatments within the lake avoid areas containing native plants. They have also been involved in the enhancement of Alpine Lake's plant community by supporting proposed natural shoreline restorations on private properties and within the county park that provides public access to the lake.

Notes on the Format of this Document

This document serves two purposes; 1) it fulfills the requirements for final reporting of a study that was partially funded through a Wisconsin Department of Natural Resources (WDNR) Lake Planning Grant, and 2) it is the Lake Management Plan for Alpine Lake. Care has been taken to keep the technical aspects of the document on laymen's terms as much as possible. To facilitate the ease of reading, certain topics are expanded upon and technical terms are defined in a glossary. Furthermore, the reporting of specific data is kept to a minimum within the text, but is wholly contained within the appendices. The appendices also contain the glossary mentioned above (terms contained in the glossary are italicized within the text).

The study contained four major components, watershed analysis, aquatic vegetation, water quality, and education. Each section of the report and plan are generally separated into these four components.

For ease of reading and document compilation, the large format (11"x17") maps are contained near the end of this report.

RESULTS AND DISCUSSION

Lake Water Quality

Judging the quality of lake water can be difficult because individual lakes display problems in variety ways. However, concentrating on certain aspects or parameters that are important to lake ecology and comparing those values to similar lakes within the same region and historical data from the same lake provides an excellent method to evaluate the quality of a lake's water. To complete this task, three water quality parameters are focused upon here:

1. **Phosphorus** is a nutrient that controls the growth of plants in the vast majority of Wisconsin lakes. It is important to remember that in lakes, the term "plants" includes both *algae* and *macrophytes*. Monitoring and evaluating concentrations of phosphorus within the lake helps to create a better understanding of what is controlling the growth rates and even presence of the plants within a lake.

2. **Chlorophyll-*a*** is the green pigment in plants that is used during *photosynthesis*. Chlorophyll-*a* concentrations are related to algal abundance within a lake.

3. **Secchi disk transparency** is a measurement of water clarity. Of all limnological parameters, it is the most used and the easiest for non-professionals to comprehend. Furthermore, measuring Secchi disk transparency over long periods of time is one of the best methods of monitoring lake health. The measurement is conducted by lowering a weighted, 20-cm diameter disk with alternating black and white quadrates (a Secchi disk) into the water and recording the depth just before it disappears from sight.

The parameters described above are inter-related. Phosphorus controls algal abundance, which is measured by chlorophyll *a* levels. Water clarity, as measured by Secchi disk transparency, is directly affected by the particulates that are suspended in the water. In the majority of natural and man-made, Wisconsin lakes, the primary particulate matter is algae; therefore, algal abundance directly affects water clarity. In addition, studies have shown that water clarity is used by most lake users to judge water quality – clear water equals clean water.

Each of these parameters is also directly related to the *trophic state* of the lake. As nutrients, primarily phosphorus, accumulate within a lake's water and sediment, its productivity increases and the lake progresses through three trophic states: *oligotrophic*, *mesotrophic*, and finally *eutrophic*. Every lake will naturally progress through these states; however, under natural conditions (i.e. not influenced by the activities of humans) this progress can take tens of thousands of years. Unfortunately, human influence has accelerated this natural aging process in most Wisconsin lakes. Monitoring the trophic state of a lake gives stakeholders a method by which to gauge the health of their lake over time. Yet, classifying a lake into one of three trophic states does not give clear indication of where a lake really exists in its aging process. To solve this problem, the parameters measured above can be used in an index that will indicate a lake's trophic state more clearly.

The complete water quality data set from this study can be found in Appendix A. The results and discussion of the analysis introduced above can be found in the text and figures that follow.

Lillie and Mason (1983) is an excellent source for comparing lakes within specific regions of Wisconsin. They divided the state's lakes into five regions each having lakes of similar nature or apparent characteristics. Waushara County lakes are included within the study's Central Region and are among 44 lakes randomly picked from the region that were analyzed for water clarity (Secchi disk), chlorophyll *a*, and total phosphorus. These data along with data corresponding to statewide means. historical. current. and average data from Alpine Lake are displayed in Figures 2-4. Please note that the data in these graphs represent concentrations and depths taken only during the growing season (April-November) or summer months in the deepest location in the lake (Figure 1). Furthermore. the phosphorus and chlorophyll *a* data represent only surface samples. Surface samples are used because they represent the depths at which algae grow and depths at which phosphorus levels are not greatly influenced by phosphorus being released from bottom sediments (see section on internal nutrient loading).

As indicated in Figure 2. the phosphorus levels within Alpine Lake vary from year to year and do not indicate apparent trends. Chlorophyll-*a* levels (Figure 3) and Secchi disk transparency (Figure 4) follow the same suit of variability from year to year. Interestingly, the two years with the highest summer phosphorus levels of the past decade, 1997 and 1998, exhibited some of the lowest chlorophyll-*a* concentrations over the same time period. It is unclear why this occurred, but one explanation may be that concentrations of total phosphorus (as reported here) include all forms of phosphorus found in lake water including particulate and dissolved forms and the phosphorus bound in *phytoplankton* and *zooplankton*. The only form that is readily available to algae is the dissolved phosphorus. Therefore. even though the total phosphorus concentrations were higher at that time. the dissolved form may have been low and did not spur higher algal abundance. This phenomenon was not apparent during the summer of 2002 when both total phosphorus and chlorophyll-*a* concentrations were higher than normal. The higher algal abundance resulted in reduced water clarity as indicated by the shallower Secchi disk depths found during the same time period. It is very likely that the elevated total phosphorus concentrations were brought on by higher than normal precipitation levels during the spring and early summer as increased runoff washed sediment and phosphorus into the lake from its drainage basin.

Figures 2-4 also indicate that Alpine Lake's water quality is much better than other flowages within the state and it is equal or better than average findings for lakes within the central region. Comparisons with the central region lakes are particularly interesting because 73% of the lakes sampled in the region were of natural origin (Lillie and Mason 1983). Natural lakes generally have better water quality than impoundments. so it would be expected that the water quality of Alpine Lake. an impoundment. would not compare well with the regional data. On the contrary, it compares very well. indicating that Alpine Lake has good water quality when these three parameters are considered. This is also the case when the data contained in Figures 2-4 are compared with the Water Quality Index (WQI) for Wisconsin lakes found in Table 1. These comparisons show, that for the most part. the WQI for Alpine Lake chlorophyll-*a* and water clarity levels fall within the good to very good categories and the total phosphorus levels fall with in the good classification.

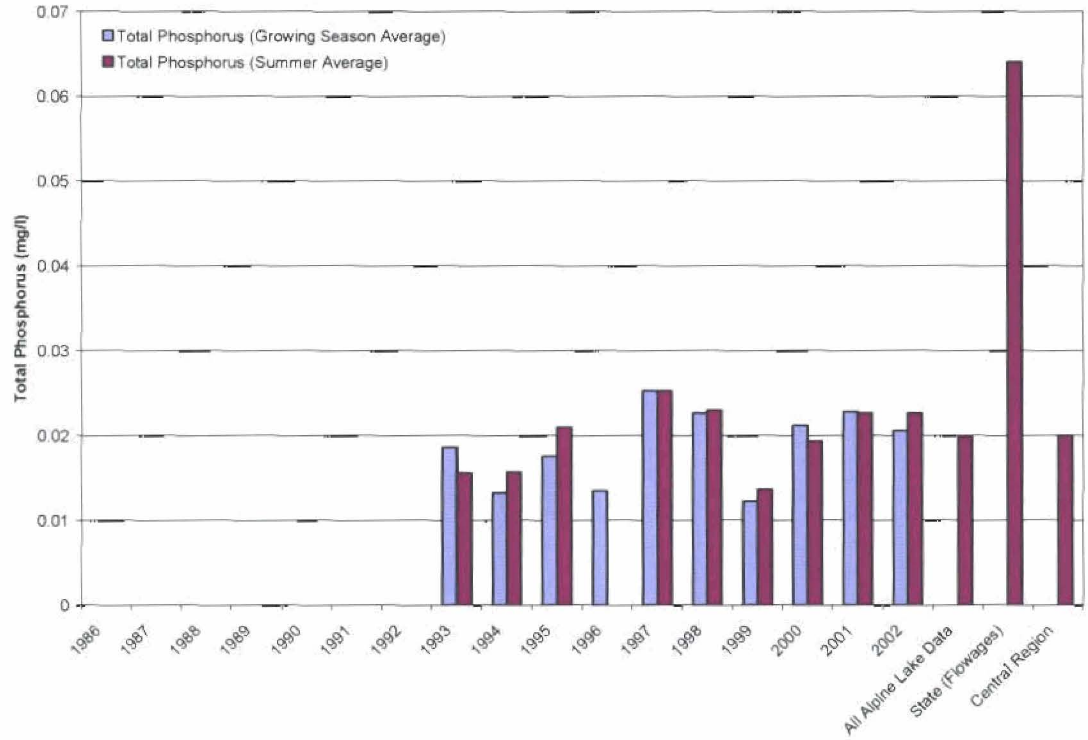

Figure 2. Mean total phosphorus concentrations from Alpine Lake, state and central region. All means were calculated from summer samples.

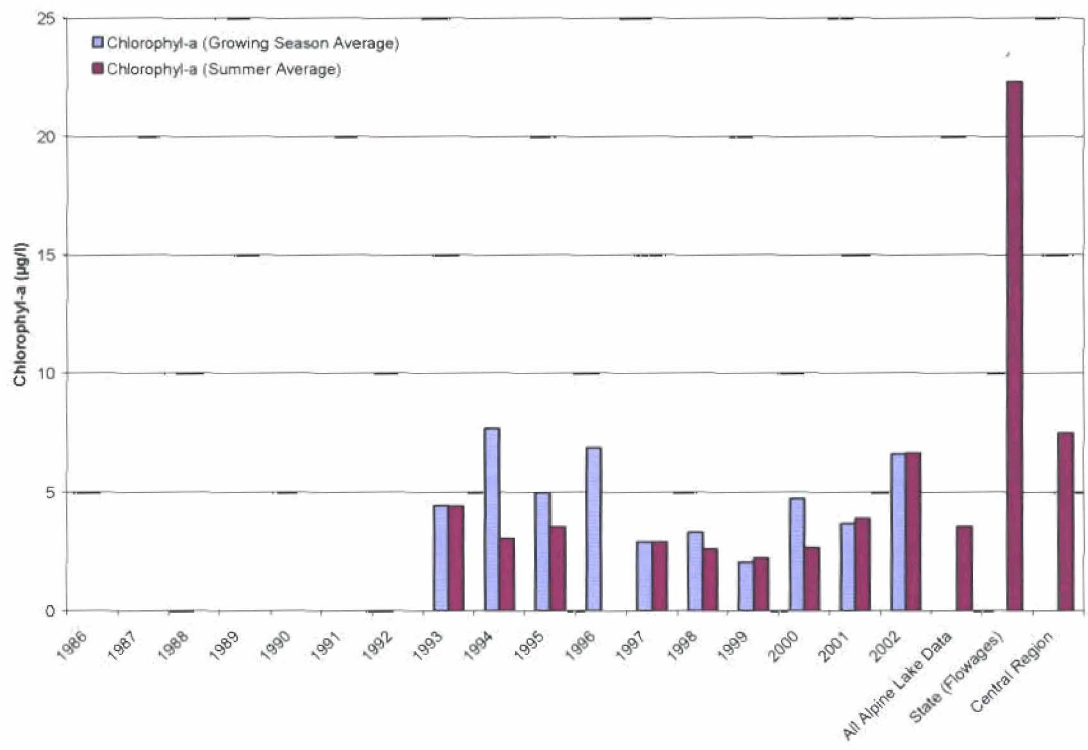

Figure 3. Mean chlorophyll-*a* concentrations from Alpine Lake, state and central region. All means were calculated from summer samples.

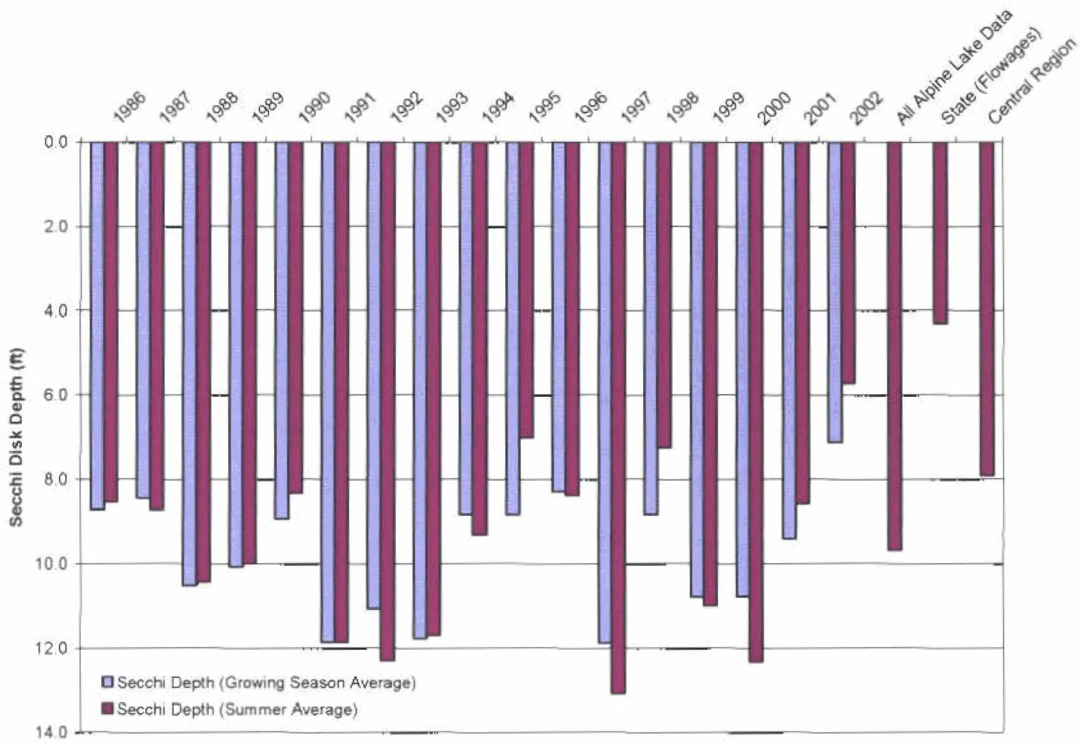

Figure 4. Mean Secchi disk transparencies from Alpine Lake, state and central region. All means were calculated from summer measurements.

Table 1. Water Quality Index (WQI) developed by Lillie and Mason (1983) for Wisconsin Lakes.

	Approximate Equivalents				
WQI	**Water Clarity (m)**	**Water Clarity (ft)**	**Chlorophyll-a (µg/l)**	**Total Phosphorus (mg/m^3)**	**WTSI***
Excellent	>6	>19.7	<1	<1	>34
Very Good	3.0-6.0	9.8-19.7	1-5	1-10	34-44
Good	2.0-3.0	6.6-9.8	5-10	10-30	44-50
Fair	1.5-2.0	4.9-6.6	10-15	30-50	50-54
Poor	1.0-1.5	3.3-4.9	15-30	50-150	54-60
Very Poor	<1.0	<3.3	>30	>150	<60

*Calculated from water clarity values.

Alpine Lake Trophic State

Figure 5 contains the Wisconsin Trophic State Index (WTSI) (Lillie, et al. 1993) values calculated from average surface levels of chlorophyll-*a*, total phosphorus, and Secchi disk transparencies measured during the summer months in Alpine Lake. The WTSI is based upon the widely used Carlson Trophic State Index (TSI) (Carlson 1977), but is specific to Wisconsin lakes. The WTSI is used extensively by the Wisconsin Department of Natural Resources (WDNR) and is reported along with lake data collected by Self-Help Volunteers. For the most part, the chlorophyll-*a* and Secchi disk data indicate that Alpine Lake fluctuates within the mesotrophic state, while the total phosphorus levels indicate the lake is closer to a mesotrophic-eutrophic state. As with the WQI, the WTSI analysis indicates that the Alpine Lake is in relatively good health. Remember, values that fall into the mesotrophic or eutrophic categories are not indicative of poor lake health. There are benefits associated with the higher rates of productivity found in these lakes. For instance, lakes that are not as productive are unable to support a large fishery.

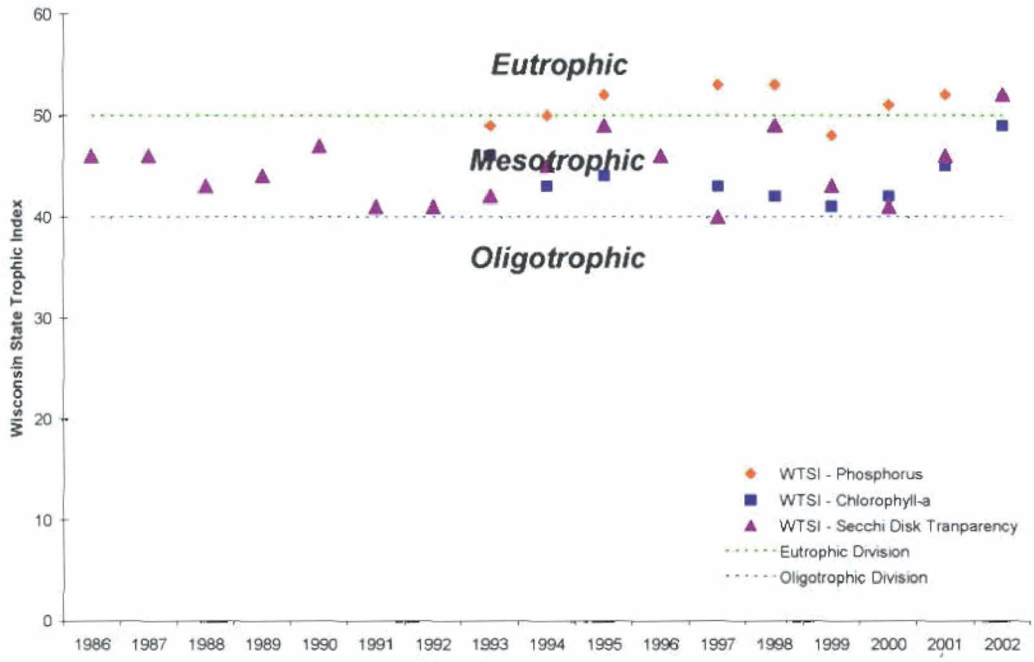

Figure 5. Wisconsin State Trophic Index values for Alpine Lake..

Limiting Nutrient

As described above, most Wisconsin lakes are phosphorus limited and Alpine Lake is no exception. Data collected during the summer of 2002 result in a nitrogen to phosphorus ratio of 37.5:1. Lakes with ratios greater than 15:1 are considered to be phosphorus limited. In other words, phosphorus controls the algal abundance within the lake. Obviously, Alpine Lake is strongly phosphorus limited.

Dissolved Oxygen and Temperature Profiles

Figure 6 contains the results from the dissolved oxygen and temperature profiles that were completed at Alpine Lake during 2002 and the winter of 2003. It appears that the lake did not show strong stratification during any of the visits with maybe the exception of the profile completed on March 16, 2002. However, this was a weak stratification that was broken during the visit on June 17, 2002. Furthermore, the lake experienced low hypolimnetic oxygen levels only during the month of July and these were soon recharged as indicated by the August 23, 2002 profile. The weak stratification of the lake and sufficient hypolimnetic oxygen levels through out most of the summer and the winter (January 14, 2003 profile) are likely cause by a combination of three factors; 1) the incoming water from Bruce Creek is likely well-oxygenated and relatively cool, which aids in maintaining the oxygen levels within the lake while minimizing stratification, 2) there is an abundant amount of coontail (*Ceratophyllum demersum*) in the deepest area of the lake where the profiles were completed that add oxygen to the water throughout the summer, and 3) a major portion of the water that leaves the lake at the dam is discharged through a pipe located at the bottom of the lake which reduces the build up of *anoxic* waters within the hypolimnion and weakens stratification. Overall, these finding are quite good because it lessens the chance of internal nutrient loading (see below) and protects the lake from occurrence of winter and summer fishkills.

Examination of the data collected in 1994 indicates the same tendencies towards only weak stratification and sufficient dissolved oxygen concentrations throughout the year.

Internal Phosphorus Loading

In lakes that support strong stratification, the hypolimnion, can become devoid of oxygen both in the water column and within the sediment. When this occurs, iron changes from a form that normally binds phosphorus within the sediment to a form that releases it to the overlaying water. This can result in very high concentrations of phosphorus in the hypolimnion. Then, during the spring and fall turnover events, these high concentrations of phosphorus are mixed within the lake and utilized by algae. This cycle continues year after year and is termed "internal phosphorus loading", a phenomenon that can support nuisance algae blooms decades after external sources are controlled. Results from the Wisconsin Lakes Modeling Suite (WiLMS) Phosphorus Prediction and Uncertainty Analysis Module indicated that internal nutrient loading is likely not a problem within Alpine Lake (at least not at the sampling site). In fact, a portion of the model specific to shallow impoundments, overestimated the spring overturn phosphorus values by 36%, indicating that the actual phosphorus levels are lower than would be expected considering the land use and septic inputs from the watershed. On the contrary, if the model would have significantly underestimated the phosphorus levels, it could be assumed that the difference is the result of internal loads, an input that is not accounted for in the model.

These results are not surprising considering the oxygen levels that were maintained during the summer and winter and the fact that the lake only experiences weak stratification on a periodic basis.

The Role of Macrophytes in Alpine Lake's Trophic Status.

It is true that the data and analyses presented above indicate that the water quality of Alpine Lake is for the most part "good"; especially compared to other flowages within the state and lakes within the central region. Nonetheless, the results of these analyses tend to be a bit misleading because they revolve around the fact that most Wisconsin lakes exhibit phosphorus levels by increased algal abundances as indicated by increased chlorophyll-*a* concentrations. The increased algal abundances, in turn, exhibit themselves with decreased water clarity as indicated by shallower Secchi disk depths. To some extent, these relationships are apparent in Alpine Lake. However, it must be noted that both the WQI and WTSI analyses only rely on algal productivity and not that of the lake's macrophyte population. As is discussed in more detail within the vegetation survey results, Alpine Lake has a considerable macrophyte population. Some researchers (Canfield et al. 1983) discuss at length that macrophyte populations and their productivity should be taken into account when determining a lake's trophic status. Current and historic levels of chlorophyll-*a*, phosphorus and water clarity indicate that for the most part, Alpine Lake falls within the mesotrophic state. Yet, if we take into account the incredible macrophytic production with the lake, it is obvious that the trophic state of Alpine Lake is much more eutrophic than shown by these three parameters.

In the long-term, the two major classes of aquatic plants, algae and macrophytes, compete for the phosphorus available within the system; therefore, lakes do not commonly have similar production levels for these two classes. In other words, a lake is dominated by either macrophytic or algal production. Occasionally, shallow lakes can move from being dominated by algae to being dominated by macrophytes, and vise-versa. This conversion can happen for a variety of reasons. One example is what occurred in Little Wall Lake located in central Iowa (Bachmann, et al. 1992 and Hoyman 1994). Little Wall Lake was once a very apparent algae dominated lake with very little macrophytic vegetation occurring in its shallow waters. Studies showed that a large rough fish population consisting of carp and bullhead was responsible for the resuspension of bottom sediments that elevated the phosphorus levels within the water column. A large-scale rotenone treatment was successfully carried out at the lake to reduce the rough fish populations. As the water cleared due to decreased algal abundances and suspended sediments, the plant population began to rebound. Within two years nearly 90% of the lake bottom held macrophytes, the water was drastically clearer and open water phosphorus levels had decreased significantly. In the end, the water was much clearer and the open water concentrations of chlorophyll-*a* and total phosphorus had significantly decreased, yet the plant production and thus the trophic state of the lake had not changed. The same basically holds true with Alpine Lake; even though the water is relatively clear and the levels of chlorophyll-*a* and phosphorus are lower than other lakes in the region, the lake is still very eutrophic.

Filamentous Algae in Alpine Lake

Algal analysis beyond that of chlorophyll-*a* determinations was outside the scope of this project; nevertheless, it is obvious that filamentous algae play an important role in the ecology, aesthetic value, and nutrient dynamics of Alpine Lake. Like macrophytes, filamentous algae production is not normally accounted for in conventional methods of determining lake water quality and trophic state. The fact of the matter is that most lake samples used for these determinations are collected in open water near the deepest part of the lake in order to obtain a sample indicative of the majority of the lake. In most lakes, filamentous algae are not found in these open water areas, but are instead found tangled in macrophytes or clumped on the windward side of the lake (Photo 1). As a result, this type of algae is not included in the water quality analyses.

During our sampling runs, it was quite obvious that Alpine Lake has an overabundance of filamentous algae, especially in the small bays near the inflow and in the main arm as a whole. The same nutrient loads fueling the macrophyte population in the lake are also fueling these filamentous algae blooms. Additionally, it is likely that these algae are acting somewhat like a filter by removing some the phosphorus that enters the lake through the inlet before it reaches the sample site located near the dam; further supporting the fact that the WTSI is underestimating the trophic state of Alpine Lake.

Photo 1. Filamentous algae at Alpine Lake during June 2002.

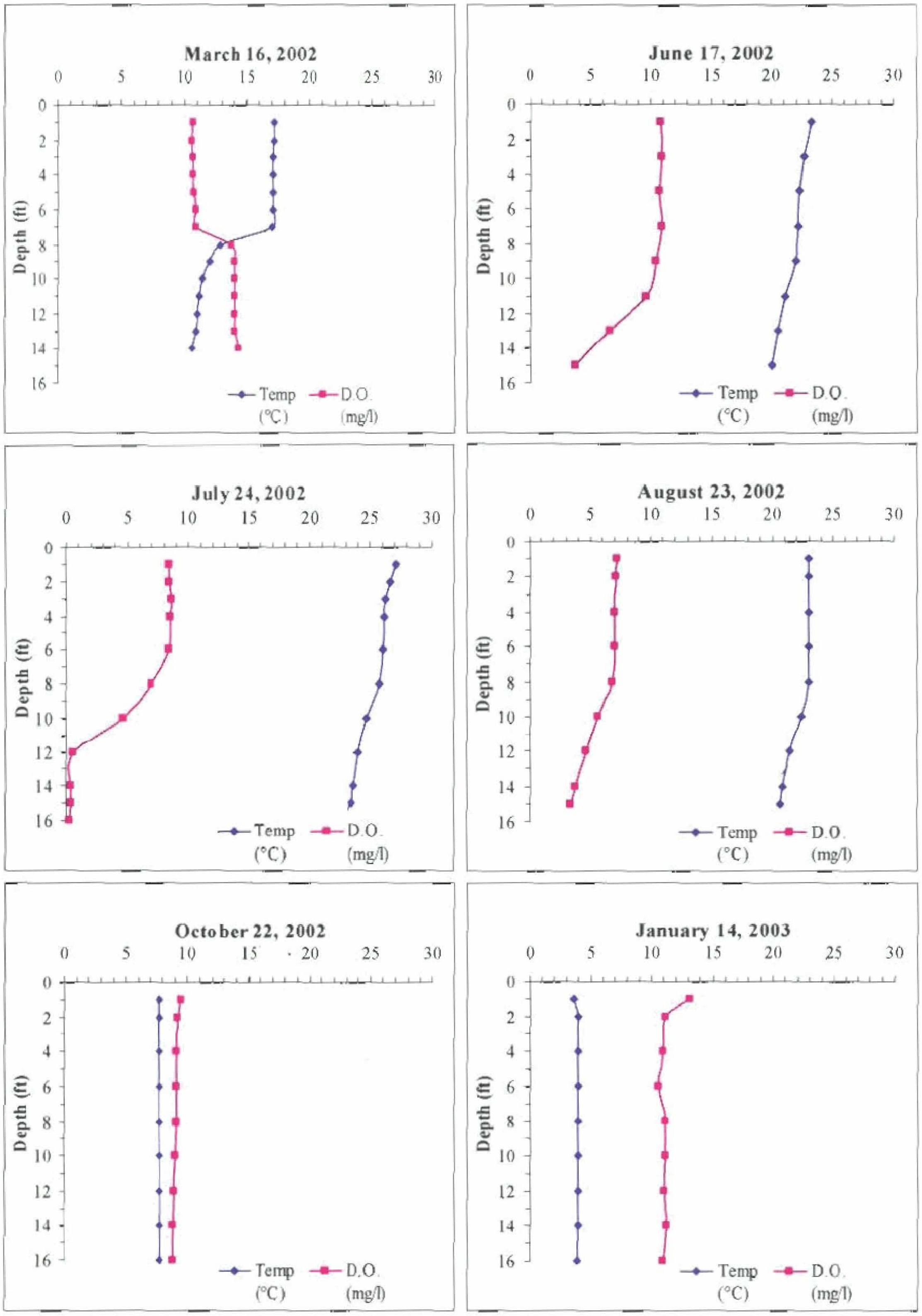

Figure 6. Dissolved oxygen and temperature profiles recorded at Alpine Lake..

Aquatic Vegetation

Although many lake users consider aquatic macrophytes to be "weeds" and a nuisance to the recreational use of the lake, they are actually an essential element in a healthy, functioning lake ecosystem. It is very important that the lake stakeholders understand the importance of lake plants and the many functions they serve in maintaining and protecting a lake ecosystem. With increased understanding and awareness, most lake users will recognize the importance of the aquatic plant community and their potential negative affects on it.

Diverse aquatic vegetation provides habitat and food for many kinds of aquatic life, including fish, insects, amphibians, waterfowl, and even terrestrial wildlife. For instance, wild celery (*Vallisneria americana)* and wild rice (*Zizania aquatica* and *Zizania palustris*) both serve as excellent food sources for ducks and geese. In addition, many of the insects that are eaten by young fish rely heavily on aquatic plants and the *periphyton* attached to them as their primary food source. The plants also provide cover for feeder fish and *zooplankton*, stabilizing the predator-prey relationships within the system. Furthermore, rooted aquatic plants prevent shoreline erosion and the resuspension of sediments and nutrients by absorbing wave energy and locking sediments within their root masses. In areas were plants do not exist, waves can resuspend bottom sediments decreasing water clarity and increasing plant nutrient levels that may lead to algae blooms. Lake plants also produce oxygen through photosynthesis and use nutrients that may otherwise be used by *phytoplankton*, which helps to minimize nuisance algal blooms.

Under certain conditions, plant populations may become a problem and require control measures. Excessive plant growth can limit recreational use by deterring navigation, swimming, and fishing activities. It can also lead to changes in fish population structure by providing too much cover for feeder fish resulting in reduced numbers of predator fish and a stunted pan-fish population. *Exotic* plant species, such as Eurasian water-milfoil (*Myriophyllum spicatum*) and curly-leaf pondweed (*Potamogeton crispus*) can also upset the delicate balance of a lake ecosystem by out competing *native* plants and reducing *species diversity*. These *invasive* plant species can form dense stands that are a nuisance to humans and provide low-value habitat for fish and other wildlife.

When plant biomass negatively affects the lake ecosystem and limits the use of the resource, plant management may be necessary. The management goals should always include the control of invasive species and restoration of native communities through environmentally sensitive and economically feasible methods.

Aquatic plant Management and Protection

Many times an aquatic plant management plan is aimed at only controlling nuisance plant growth that has limited the recreational use of the lake, usually navigation, fishing, and swimming. It is important to remember the vital benefits that aquatic plants provide to lake users and the lake ecosystem, as described above. Therefore, all aquatic plant management plans also need to address the enhancement and protection of the aquatic plant community. Below are general descriptions of the many techniques that can be utilized to control and enhance aquatic plants.

Each alternative has benefits and limitations that are explained in its description. Please note that only legal and commonly used methods are included. For instance, grass carp (*Ctenopharyngodon idella*) are illegal in Wisconsin and rotovation is not commonly used. Unfortunately, there are no "wonder drugs" that can completely cure all aquatic plant problems, which makes planning a crucial step in any aquatic plant management activity. Many of the plant management and protection techniques commonly used in Wisconsin are described below. Although all of these techniques may not be applicable to Alpine Lake, it is still important for lake users to have a basic understanding of all the techniques so they can better understand why they are or are not applicable.

Permits

The signing of the 2001-2003 State Budget by Gov. McCallum enacted many new aquatic plant management regulations. The rules for the new regulations have been set forth by the WDNR as NR 109. A major change includes that all forms of aquatic plant management, even those that did not require a permit in the past, require a permit now; including manual and mechanical removal. Manual cutting and raking are exempt from the permit requirement if the area of plant removal is no more than 30 feet along the shoreline and any piers, boatlifts, swim rafts, and other recreational and water use devices are located within the 30 feet. Furthermore, installation of aquatic plants, even natives, requires approval from the WDNR. For more information on permit requirements, please contact the WDNR Regional Water Management Specialist or Aquatic Plant Management and Protection Specialist.

Native Species Enhancement

The development of Wisconsin's shorelands has increased dramatically over the last century and with this increase in development a decrease in water quality and wildlife habitat has occurred. Many people that move to or build in shoreland areas attempt to replicate the suburban landscapes they are accustomed to by converting natural shoreland areas to the "neat and clean" appearance of manicured lawns and flowerbeds. The conversion of these areas immediately leads to destruction of habitat utilized by birds, mammals, reptiles, amphibians, and insects. The maintenance of the newly created area helps to decrease water quality by considerably increasing inputs of phosphorus and sediments into the lake. The negative impact of human development does not stop at the shoreline. Removal of native plants from shallow, near-shore areas for boating and swimming activities destroys habitat used by fish, mammals, birds, insects, and amphibians, while leaving bottom and shoreline sediments vulnerable to wave action caused by boating and wind. Furthermore, the dumping of sand to create beach areas destroys spawning, cover and feeding areas utilized by aquatic wildlife.

In recent years, many lakefront property owners have realized increased aesthetics, fisheries, property values, and water quality by restoring portions of their shoreland to mimic its unaltered state. An area of shore restored to its natural condition, both in the water and on shore, is commonly called a *shoreland buffer zone.* The shoreland buffer zone creates or restores the ecological habitat and benefits lost by traditional suburban landscaping.

Enhancement activities also include additions of *submergent*, *emergent*, and *floating-leaf* plants within the lake itself. These additions can provide greater species diversity and may compete against exotic species.

Cost

The cost of native, aquatic and shoreland plant restorations are highly variable and depend on the size of the restoration area, planting densities, the species planted, and the type of planting (e.g. seeds, bare-roots, plugs, live-stakes) being conducted. Other factors may include grading requirements, removal of shoreland stabilization (e.g., rip-rap, seawall), measures used to protect the newly planted area from wildlife predation, wave-action, and erosion. In general, a restoration project with the characteristics described below would have an estimated materials and supplies cost of approximately $4,050.

- The single site used for the estimate indicated above has the following characteristics:
  - An upland buffer zone measuring 35' x 100'.
  - An aquatic zone with shallow-water and deep-water areas of 10' x 100' each.
  - Site is assumed to need little invasive species removal prior to restoration.
  - Site has a moderate slope.
  - Trees and shrubs would be planted at a density of 435 plants/acre and 1210 plants/acre, respectively.
  - Plant spacing for the aquatic zone would be 3 feet.
  - Each site would need 100' of biolog to protect the bank toe and each site would need 100' of wavebreak and goose netting to protect aquatic plantings.
  - Each site would need 100' of erosion control fabric to protect plants and sediment near the shoreline (the remainder of the site would be mulched).
  - There is no hard-armor (rip-rap or seawall) that would need to be removed.

Advantages

Improves the aquatic ecosystem through species diversification and habitat enhancement.
Assists native plant populations to compete with exotic species.
Increases natural aesthetics sought by many lake users.
Decreases sediment and nutrient loads entering the lake from developed properties.
Reduces bottom sediment resuspension and shoreline erosion.
Lower cost when compared to rip-rap and seawalls.
Restoration projects can be completed in phases to spread out costs.
Many educational and volunteer opportunities are available with each project.

Disadvantages

Property owners need to be educated on the benefits of native plant restoration before they are willing to participate.
Stakeholders must be willing to wait 3-4 years for restoration areas to mature and fill-in.
Monitoring and maintenance are required to assure that newly planted areas will thrive.
Harsh environmental conditions (e.g., drought, intense storms) may partially or completely destroy project plantings.

Manual Removal

Manual removal methods include hand-pulling, raking, and hand-cutting. Hand-pulling involves the manual removal of whole plants, including roots, from the area of concern and disposing them out of the waterbody. Raking entails the removal of partial and whole plants from the lake by dragging a rake with a rope tied to it through plant beds. Specially designed rakes are available from commercial sources or an asphalt rake can be used. Hand-cutting differs from the other two manual methods because the entire plant is not taken out, rather the plants are cut similar to mowing a lawn. One manual cutting technique involves throwing a specialized "V" shaped cutter into the plant bed and retrieving it with a rope. The other cutting method entails a two-sided straight blade on a telescoping pole that is swiped back and forth at the base of the plants.

In addition to the hand-cutting methods described above, powered cutters are now available for mounting on boats. Some are mounted in a similar fashion to electric trolling motors and offer a 4-foot cutting width, while larger models require complicated mounting procedures, but offer an 8-foot cutting width.

When using the methods outlined above, it is very important to remove all plant fragments from the lake to prevent rerooting and drifting onshore followed by decomposition. It is also important to preserve fish spawning habitat by timing the treatment activities after spawning. In Wisconsin, a general rule would be to not start these activities until after June 15th.

Cost

Commercially available hand-cutters and rakes range in cost from $85 to $150. Power-cutters range in cost from $1200 to $11,000.

Advantages

Very cost effective for clearing areas around docks, piers, and swimming areas.
Relatively environmentally safe if treatment is conducted after June 15th.
Allows for selective removal of undesirable plant species.
Provides immediate relief in localized area.
Plant biomass is removed from waterbody

Disadvantages

Labor intensive.
Impractical for larger areas or dense plant beds.
Subsequent treatments may be needed as plants recolonize and/or continue to grow.
Uprooting of plants stirs bottom sediments making it difficult to harvest remaining plants
May disturb *benthic* organisms and fish-spawning areas.
Risk of spreading invasive species if fragments are not removed.

Bottom Screens

Bottom screens are very much like landscaping fabric used to block weed growth in flowerbeds. The gas-permeable screen is placed over the plant bed and anchored to the lake bottom by staking or weights. Only gas-permeable screen can be used or large pockets of gas will form under the mat as the result of plant decomposition. This could lead to portions of the screen becoming detached from the lake bottom, creating a navigational hazard. Normally the screens are removed and cleaned at the end of the growing season and then placed back in the lake the following spring. If they are not removed, sediments may build up on them and allow for plant recolonization on top of the screen.

Cost

Material costs range between $.20 and $1.25 per square-foot. Installation costs vary greatly depending on the size of the area to be covered and the depth of overlaying water.

Advantages

Immediate and sustainable control.
Long-term costs are low.
Excellent for small areas and around obstructions.
Materials are reusable.
Prevents fragmentation and subsequent spread of plants to other areas.

Disadvantages

Installation may be difficult over dense plant beds.
Installation in deep water may require SCUBA.
Not species specific.
Disrupts benthic fauna.
May be navigational hazard in shallow water.
Initial costs are high.
Labor intensive due to the seasonal removal and reinstallation requirements.
Does not remove plant biomass from lake.

Water Level Drawdown

The primary manner of plant control through water level drawdown is the exposure of sediments and plant roots/tubers to desiccation and either heating or freezing depending on the timing of the treatment. Winter drawdowns are more common in temperate climates like that of Wisconsin and usually occur in reservoirs because of the ease of water removal through the outlet structure. An important fact to remember when considering the use of this technique is that only certain species are controlled and that some species may even be enhanced. Furthermore, the process will likely need to be repeated every two or three years to keep target species in check.

Cost

The cost of this alternative is highly variable. If an outlet structure exists, the cost of lowering the water level would be minimal; however, if there is not an outlet, the cost of pumping water to the desirable level could be very expensive.

Advantages

Inexpensive if outlet structure exists.
May control populations of certain species, like Eurasian water-milfoil for up to two years.
Allows some loose sediments to consolidate.
May enhance growth of desirable emergent species.
Other work, like dock and pier repair and/or dredging may be completed more easily and at a lower cost while water levels are down.

Disadvantages

May be cost prohibitive if pumping is required to lower water levels.
Drastically upsets lake ecosystem with significant effects on fish and other aquatic wildlife.
Adjacent wetlands may be altered due to lower water levels.
Disrupts recreational, hydroelectric, irrigation and water supply uses.
May enhance the spread of certain undesirable species, like common reed (*Phragmites australis*) and reed canary grass (*Phalaris arundinacea*).
Unselective.

Harvesting

Aquatic plant harvesting is frequently used in Wisconsin and involves the cutting and removal of plants much like mowing and bagging a lawn. Harvesters are produced in many sizes that can cut to depths ranging from 3 to 10 feet with cutting widths of 4 to 10 feet. Plant harvesting speeds vary with the size of the harvester, density and types of plants, and the distance to the off-loading area. Equipment requirements do not end with the harvester. In addition to the harvester, a shore-conveyor would be required to transfer plant material from the harvester to a dump truck for transport to a landfill or compost site. Furthermore, if off-loading sites are limited and/or the lake is large, a transport barge may be needed to move the harvested plants from the harvester to the shore in order to cut back on the time that the harvester spends traveling to the shore conveyor.

Some lake organizations contract to have nuisance plants harvested, while others choose to purchase their own equipment. If the later route is chosen, it is very important for the lake group to be very organized and realize that there is a great deal of work and expense involved with the purchase, operation, maintenance, and storage of an aquatic plant harvester. In either case, planning is very important to minimize environmental effects and maximize benefits.

Costs

Equipment costs vary with the size and features of the harvester, but in general, standard harvesters range between $45,000 and $100,000. Larger harvesters or stainless steel models may cost as much as $200,000. Shore conveyors cost approximately $20,000 and trailers range from $7,000 to $20,000. Storage, maintenance, insurance, and operator salaries vary greatly.

Advantages

Immediate results.
Plant biomass and associated nutrients are removed from the lake.
Select areas can be treated, leaving sensitive areas intact.
Plants are not completely removed and can still provide some habitat benefits.
Opening of cruise lanes can increase predator pressure and reduce stunted fish populations.
Harvested plant materials produce excellent compost.

Disadvantages

Initial costs are high if the lake organization intends to own and operate the equipment.
Multiple treatments may be required during the growing season because lower portions of the plant and root systems are left intact.
Many small fish, amphibians and invertebrates may be harvested along with plants.
There is little or no reduction in plant density with harvesting.
Invasive and exotic species may spread because of plant fragmentation associated with harvester operation.
Larger harvesters are not easily maneuverable in shallow water or near docks and piers.
Bottom sediments may be resuspended leading to increased turbidity and water column nutrient levels.

Chemical Treatment

There are many herbicides available for controlling aquatic macrophytes and each compound is sold under many brand names. Aquatic herbicides fall into two general classifications:

1. *Contact herbicides* act by causing extensive cellular damage, but usually do not affect the areas that were not in contact with the chemical. This allows them to work much faster, but does not result in a sustained effect because the root crowns, roots, or rhizomes are not killed.
2. *Systemic herbicides* spread throughout the entire plant and often result in complete mortality.

Both types are commonly used throughout Wisconsin with varying degrees of success. The use of herbicides is potentially hazardous to both the applicator and the environment; so all lake organizations should seek consultation and/or services from professional applicators with training and experience in aquatic herbicide use.

Below are brief descriptions of the aquatic herbicides currently registered for use in Wisconsin.

Fluridone (Sonar®) Broad spectrum, systemic herbicide that is effective on most submersed and emergent macrophytes. It is also effective on duckweed and at low concentrations has been shown to selectively remove Eurasian water-milfoil. Fluridone slowly kills macrophytes over a 30-90 day period and is only applicable in whole lake treatments or in bays and backwaters were dilution can be controlled. Irrigation restrictions apply.

Glyphosate (Rodeo®) Broad spectrum, systemic herbicide used in conjunction with a *surfactant* to control emergent and floating-leaved macrophytes. It acts in 7-10 days and is not used for submergent species. This chemical is commonly used for controlling purple loosestrife (*Lythrum salicaria*).

Diquat (Reward®, Weedtrine-D®) Broad spectrum, contact herbicide that is effective on all aquatic plants and can be sprayed directly on to foliage (with surfactant) or injected in the water. It is very fast acting, requiring only 12-36 hours of exposure time. Diquat readily binds with clay particles, so it is not appropriate for use in turbid waters. Consumption restrictions apply.

Endothal (Hydrothol®, Aquathol®) Broad spectrum, contact herbicides used for spot treatments of submersed plants. The mono-salt form of Endothal (Hydrothol®) is more toxic to fish and aquatic invertebrates, so the dipotassium salt (Aquathol®) is most often used. Fish consumption, drinking, and irrigation restrictions apply.

2,4-D (Navigate®, Aqua-Kleen®, etc.) Selective, systemic herbicide that only works on broad-leaf plants. The selectivity of 2,4-D towards broad-leaved plants (dicots) allows it to be used for Eurasian water-milfoil without affecting many of our native plants, which are monocots. Drinking and irrigation restrictions apply.

Advantages

Herbicides are easily applied in restricted areas, like around docks and boatlifts.
If certain chemicals are applied at the correct dosages, they can selectively control certain invasive species, such as Eurasian water-milfoil.
Some herbicides can be used effectively in spot treatments.

Disadvantages

Fast-acting herbicides may cause fishkills due to rapid plant decomposition if not applied correctly.
Many people adamantly object to the use of herbicides in the aquatic environment; therefore, all stakeholders should be included in the decision to use them.
Many herbicides are nonselective.
Most herbicides have a combination of use restrictions that must be followed after their application.
Many herbicides are slow-acting and may require multiple treatments throughout the growing season.

Cost

Herbicide application charges vary greatly between $250 to $1000 per acre depending on the chemical used, who applies it, permitting procedures, and the size of the treatment area.

Biological Controls

There are many insects, fish and pathogens within the United States that are used as biological controls for aquatic macrophytes. For instance, the herbivorous grass carp has been used for years in many states to control aquatic plants with some success and some failures. However, it is illegal to possess grass carp within Wisconsin. Other states have also used insects to battle invasive plants, such as waterhyacinth weevils (*Neochetina spp.*) and hydrilla stem weevil (*Bagous spp.*) to control waterhyacinth (*Eichhornia crassipes*) and hydrilla (*Hydrilla verticillata*), respectively. Fortunately, Wisconsin's climate is a bit harsh for these two invasive plants, so we do not use either biocontrol insect. However, Wisconsin, along with many other states, is currently experiencing the expansion of lakes infested with Eurasian water-milfoil and as a result has supported the experimentation and use of the milfoil weevil (*Euhrychiopsis lecontei*) within its lakes. The milfoil weevil is a native weevil that has shown promise in reducing Eurasian water-milfoil stands in Wisconsin, Washington, Vermont, and other states. Research is currently being conducted to discover the best situations for the use of the insect in battling Eurasian water-milfoil. Wisconsin is also using two species of leaf-eating beetles (*Galerucella calmariensis* and *G. pusilla*) to battle purple loosestrife. These biocontrol insects are not covered here because purple loosestrife is predominantly a wetland species.

Advantages

Milfoil weevils occur naturally in Wisconsin.
This is likely an environmentally safe alternative to controlling Eurasian water-milfoil.

Disadvantages

Stocking and monitoring costs are high.
This is an unproven and experimental treatment.
There is a chance that a large amount of money could be spent with little or no change in Eurasian water-milfoil density.

Cost

Stocking with adult weevils costs about $1.00/weevil and they are usually stocked in lots of 1000 or more.

Nutrient Reduction

Every plant, whether it is algal or vascular, requires nutrients to grow. The three primary macronutrients include phosphorus, nitrogen, and carbon. Under normal conditions, lakes in Wisconsin are phosphorus limited and occasionally, nitrogen limited. In other words, one of these nutrients is in short enough supply that it controls plant growth. If more of the nutrient is added to the system, the plant population expands; if the nutrient is taken away, the plant population decreases. However, rooted, vascular plants will not respond to nutrient reductions in the open water as quickly as algal populations will because they have the ability to take up nutrients from the sediment, and unfortunately, there is not a method currently available that will reduce or deactivate phosphorus and nitrogen in lake sediments. Nevertheless, it should be the goal of every lake organization to promote the minimization of all sources of nutrients and pollution entering the lake, whether they are in the form of a *nonpoint-source pollution* like runoff from agricultural and residential lands or *point-source pollution*, like an agricultural drain tile or storm sewer outfall. The reduction of these pollutants will slow the filling of the lake and reduce plant growth in the long-term.

Analysis of Current and Historic Plant Data

We found 29 aquatic plant species within Alpine Lake during the comprehensive survey completed in early July of 2002 (Table 2). Of these species, three are considered to be exotic, reed canary grass (*Phalaris arundinacea*), Eurasian water-milfoil (*Myriophyllum spicatum*), and curly-leaf pondweed (*Potamogeton crispus*). Reed canary grass is an invasive grass common to wetlands and often the shorelines of Wisconsin. It was originally recommended for planting in wet farmlands so the farmers could use the "wasted areas". It has since spread to many areas of the state. Eurasian water-milfoil is an invasive species, native to Europe, Asia and North Africa, that has spread to most Wisconsin counties (Figure 7). Eurasian water-milfoil is unique in that its primary mode of propagation is not by seed. It actually spreads by shoot fragmentation, which has supported its transport between lakes via boats and other equipment. In addition to its propagation method, Eurasian water-milfoil has two other competitive advantages over native aquatic plants, 1) it starts growing very early in the spring when water temperatures are too cold for most native plants to grow, and 2) once its stems reach the water surface, it does not stop growing like most native plants, instead, it continues to grow along the surface creating a canopy that blocks light from reaching native plants. Eurasian water-milfoil can create dense stands and dominate submergent communities, reducing important natural habitat for fish and other wildlife, and hampering recreational activities such as swimming, fishing, and boating. Curly-leaf pondweed is a European exotic first discovered in Wisconsin in the early 1900's that has an unconventional lifecycle that gives it a completive advantage over our native plants. Curly-leaf pondweed begins to *senesce* during mid-July when other plants are at the peak of their growing season. Earlier in July, it produces many turions, which lie dormant until the water temperatures reach approximately 75° F. At that time, the turions germinate to produce winter foliage, which thrives under the winter snow and ice. It remains in this state until spring foliage is produced in May, giving the plant an early jump on native vegetation. Like Eurasian water-milfoil, curly-leaf pondweed can become so abundant that it hampers recreational activities with the lake. It can also cause mid-summer algal blooms spurred from the nutrients released during the plant's decomposition after it dies in July.

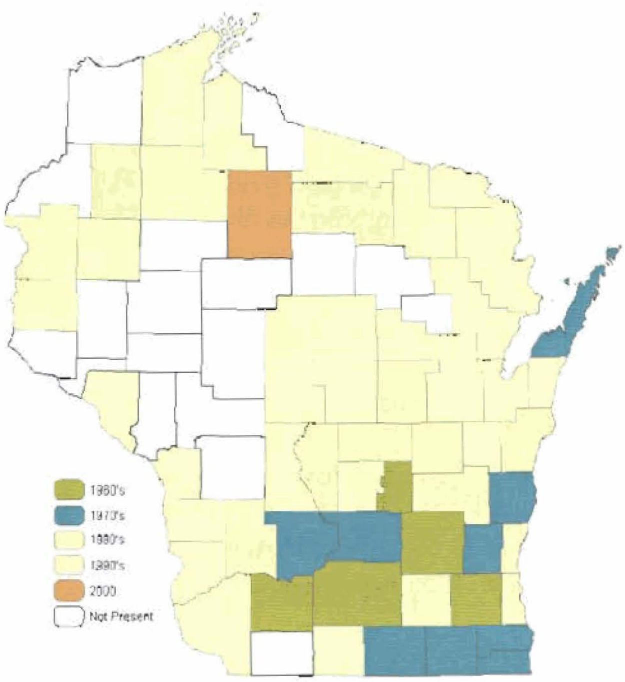

Figure 7. Eurasian water-milfoil spread in Wisconsin counties. Wisconsin DNR data.

Table 2. Aquatic plant species found in Alpine Lake during July 2002. Incidental indicates that the plant was found outside of designated plot and transect locations.

	Scientific Name	Common Name	Coefficient of Conservatism (C)	Notes
Emergent	*Carex comosa*	Bristly sedge	5	
	Typha latifolia	Broad-leaved cattail	1	
	Sagittaria latifolia	Common arrowhead	3	
	Eupatorium perfoliatum	Common boneset	4	
	Sparganium eurycarpum	Common bur-reed	5	Incidental
	Eleocharis palustris	Creeping spikerush	6	
	Caltha palustris	Marsh marigold	6	
	Typha angustifolia	Narrow-leaved cattail	1	
	Eleocharis acicularis	Needle spikerush	5	
	Phalaris arundinacea	Reed canary grass		Exotic
	Carex stricta	Sedge	4	
	Scirpus validus	Softstem bulrush	4	
	Iris versicolor	Wild blueflag	5	
Floating-leaf	*Spirodela polyrhiza*	Great duckweed	5	
	Lemna minor	Small duckweed	5	
	Nymphaea odorata	White water lily	6	
Submergent	*Elodea canadensis*	Common waterweed	3	
	Ceratophyllum demersum	Coontail, hornwort	3	
	Potamogeton crispus	Curly-leaf pondweed		Exotic
	Myriophyllum spicatum	Eurasian water-milfoil		Exotic
	Potamogeton zosteriformis	Flat-stem pondweed	6	
	Utricularia vulgaris	Great bladderwort	7	Incidental
	Potamogeton illinoensis	Illinois pondweed	6	
	Chara sp.	Muskgrasses	7	
	Potamogeton pectinatus	Sago pondweed	3	
	Elodea nuttallii	Slender waterweed	7	
	Potamogeton gramineus	Variable pondweed	7	
	Bidens beckii	Water marigold	8	
	Zosterella dubia	Water stargrass	6	
	Vallisneria americana	Wild celery	6	

Excluding the three exotic species, Alpine Lake has a *species richness* of 27. This is quite high when compared to other lakes within the ecoregion (Figure 8) and the state (Figure 9). Species richness should not be confused with species diversity. Richness is simply the number of species, while diversity is an index of the number of species and their respective abundances relative to the other species. A diverse plant community has many species that are nearly equally abundant. Although Alpine Lake has many species within it, only a few of the species are actually abundant. This is quite evident in Figure 10 which displays the frequencies and relative frequencies of occurrence for the species found during the comprehensive survey. It is obvious that the lake is dominated by only a few species. This trend is also exhibited in the coverage data displayed in Figure 11. The most abundant species are Wild celery (*Vallisneria americana*) and Eurasian water-milfoil (*Myriophyllum spicatum*); closely followed by slender waterweed (*Elodea nuttallii*) and coontail.

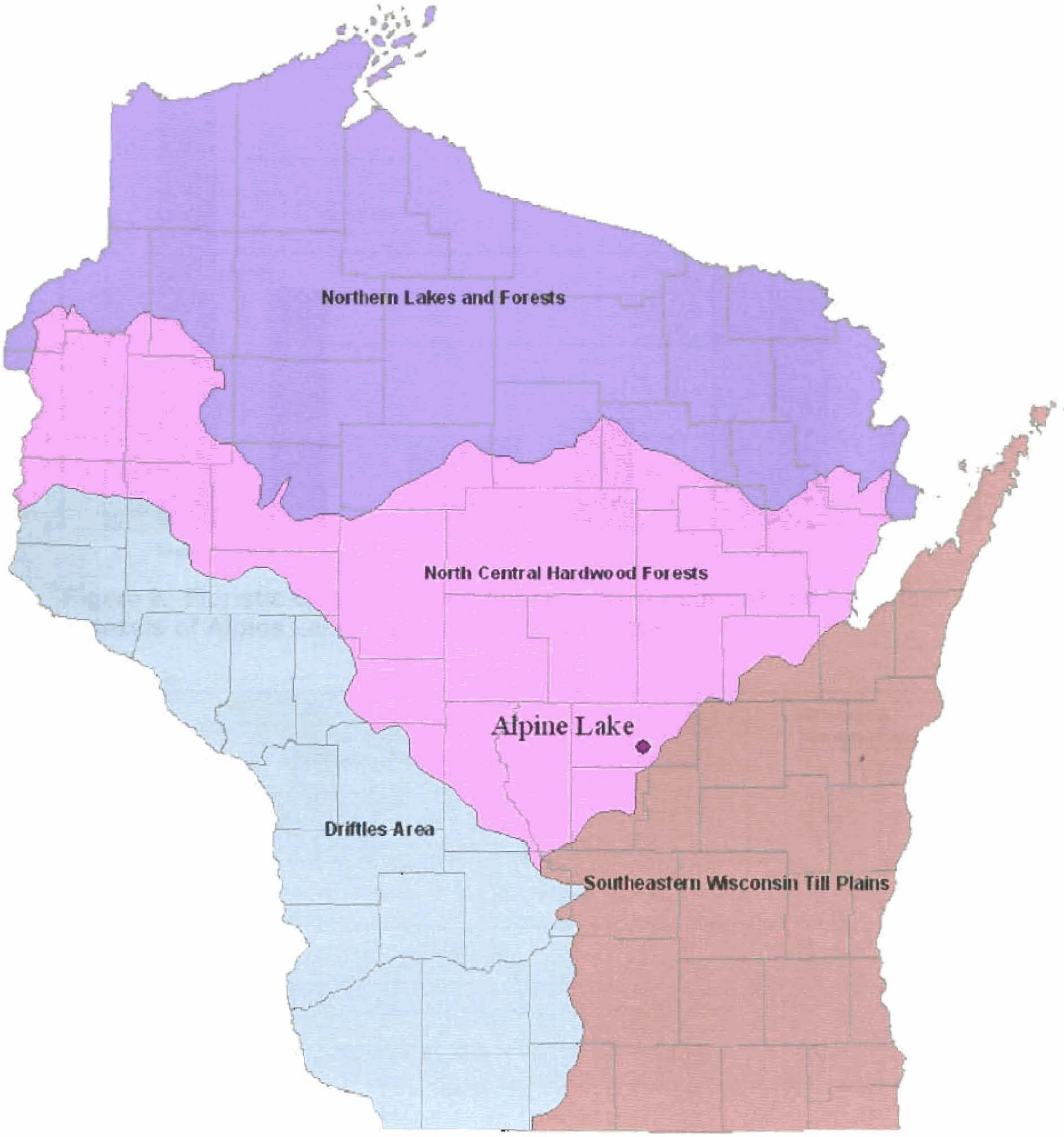

Figure 8. Location of Alpine Lake relative to the ecoregions of Wisconsin after Nichols 1999 and Omernick and Gallant 1988.

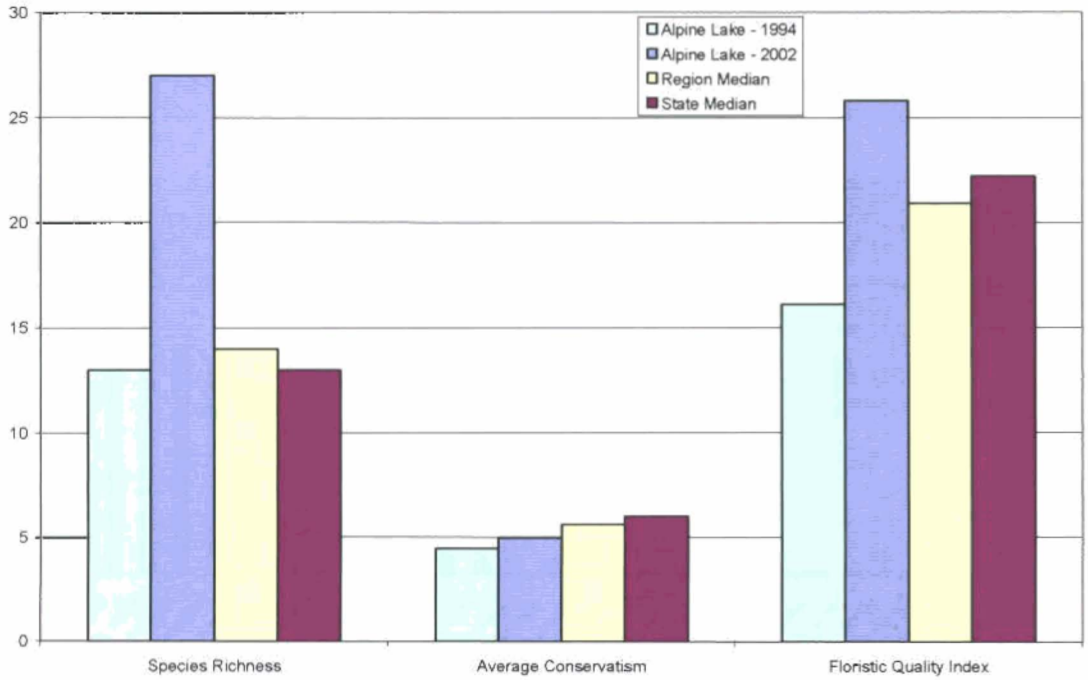

Figure 9. Floristic Quality Assessment results for current and historic datasets of Alpine Lake, the ecoregion, and state.

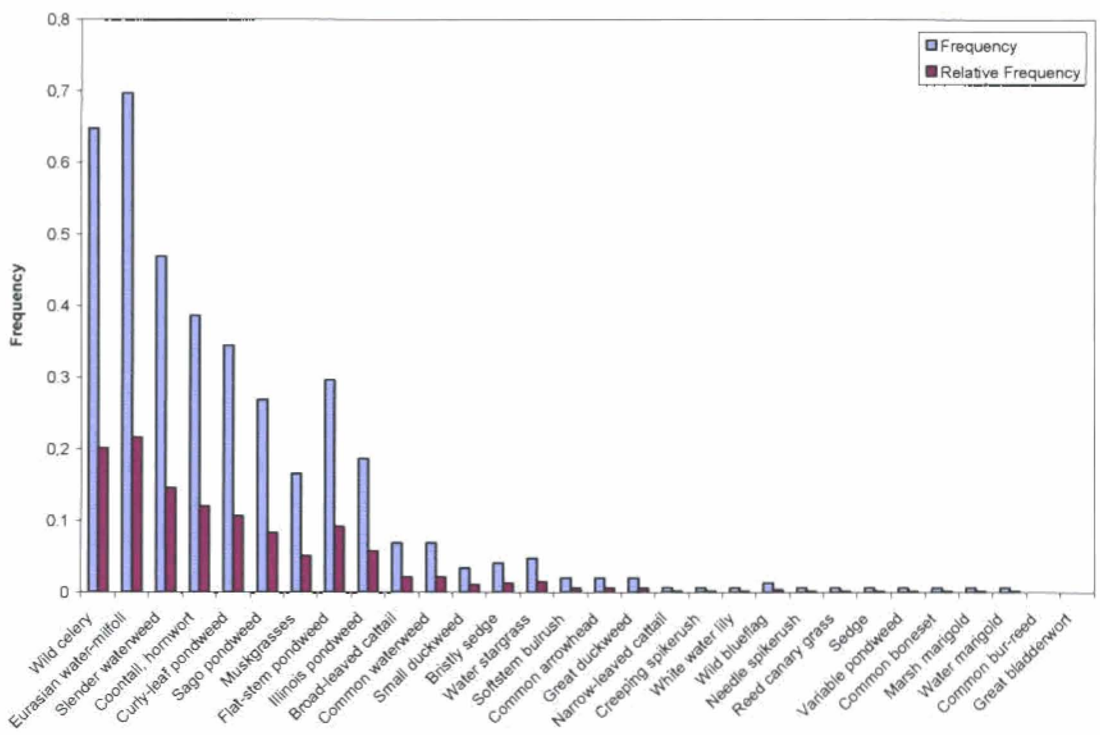

Figure 10. Aquatic plant frequencies for Alpine Lake.

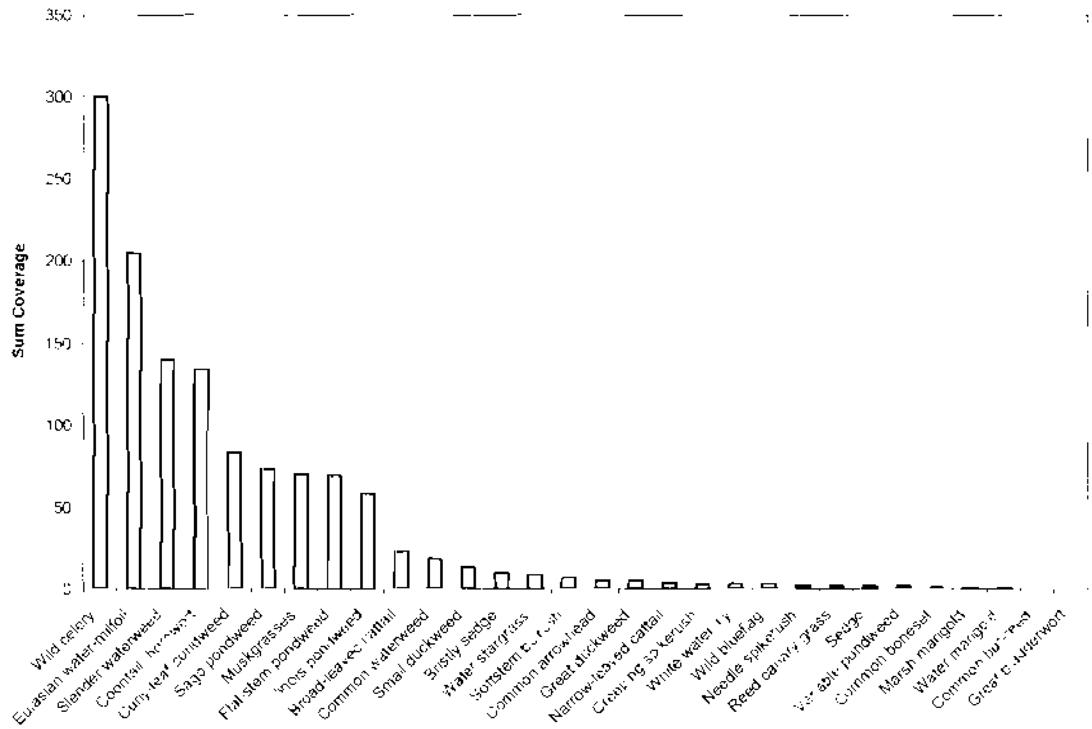

Figure 11. Sum coverages for plant species identified in Alpine Lake.

Floristic Quality Analysis (see Methods Section) completed for the data collected during the comprehensive survey, as mentioned above, indicate that Alpine Lake has significantly higher species richness than other lakes in the ecoregion and the state. However, this trend does not occur when considering the average conservatism (Figure 9) for the species found within the lake. Remember, conservatism is an indication of how sensitive a species is to disturbance. The higher the coefficient of conservatism is for a plant, the less likely that plant will occur in a disturbed system. These findings are not unexpected, considering Alpine Lake is a relatively new lake when compared to natural lakes in the state. The fact that the lake was created only a little over 3 decades ago essentially makes it a somewhat disturbed system. However, when the conservatism values are combined with species richness values to calculate the Floristic Quality Index (FQI) (Figure 9), it seems as though the lake is not as disturbed as indicated by the average conservatism values alone. It is likely that the FQI is overestimating the nature of the lake because as mentioned above, the lake does not exhibit a diverse plant community and many of the species that were used in the FQI calculation occur at very low frequencies.

Overall the FQA indicates that Alpine Lake supports many aquatic plant species, but most of those species would commonly occur in a disturbed or somewhat disturbed system.

Figure 12 contains the dominant species found for the emergent, floating-leaf, and submergent communities within Alpine Lake. It is quite evident that Alpine Lake has a substantial amount of plant biomass within it. In fact, of the 145 plot samples that were completed at Alpine Lake, only one was found not to have vegetation in it. It is also quite evident that for a lake with such a plant population, that there is a definite lack of emergent and floating-leaf vegetation occurring within the system. Northern pike use emergent vegetation for spawning, so the lack of suitable habitat may affect their success. It is unclear why these plant communities have such low occurrence, but likely causes may include the repeated chemical treatments that have occurred at the lake and/or removal by lakefront property owners.

Curly-leaf pondweed coverages were mapped during June of 2002 (Figure 13). The results show that nearly half (26 acres) of the lake's surface area has some occurrence of curly-leaf pondweed. Furthermore, approximately 7 acres (13%) of the lake's surface area has a percent coverage of curly-leaf pondweed of 80% (Figure 13). For many lakes, these results would raise great concern amongst lake users, but in Alpine Lake it does not seem to have the same effects as it does on other lakes. For instance, even though the lake clearly has an abundant population of the plant in spring in early summer, by the beginning of July when the comprehensive survey was completed, curly-leaf pondweed does not dominate any of the areas. In fact, only one out of 145 plots that were completed during the comprehensive survey was found to have an aerial coverage greater than 50%. Furthermore, dissolved oxygen levels do not seem to be affected by the plants die off as is found in many other lakes and may actually lead to summer fishkills. For the time being, it seems as the though the curly-leaf pondweed infestation at Alpine Lake should not be much of a concern.

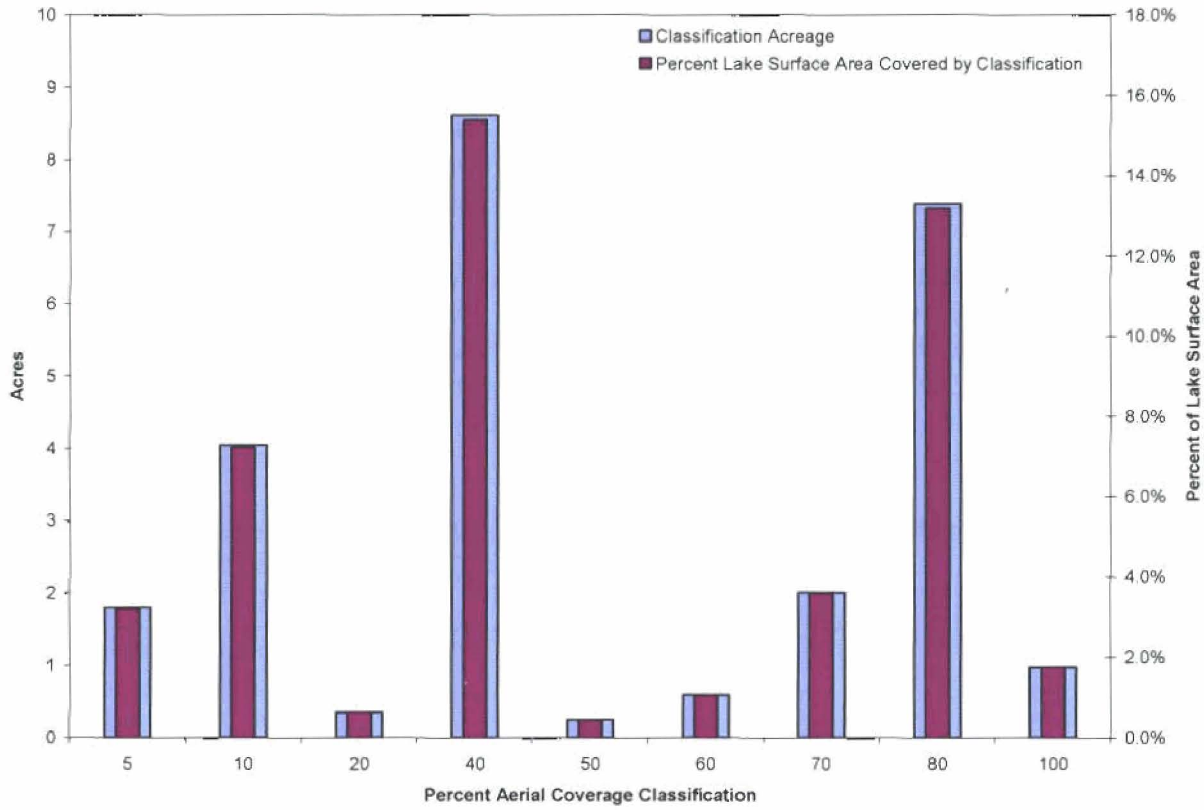

Figure 14. Curly-leaf percent aerial coverage comparisons for Alpine Lake.

Watershed Analysis

Please note. The original project scope for this study only included an initial review of the watershed that would have been largely based upon a windshield survey of the Alpine Lake drainage basin and an investigative walk along Bruce Creek. As the project progressed, concerns over the affects of the Irogami diversion, septic systems around the lake, and land uses within the watershed were expressed by District members. At our discretion, the decision was made to expand the project scope to include modeling of the potential loads by these sources. Also note, that unless otherwise stated, the term watershed refers to the historic watershed of Alpine Lake and does not include the additional drainage area of Irogami Lake and its watershed.

The Alpine Lake watershed is approximately 2,240 acres, which yields a potentially problematic watershed to lake area ratio of 40:1. In general, lakes with a ratio greater than 10:1 tend to have management problems that revolve around excessive amounts of phosphorus and/or sediments that enter the lake from its drainage basin. This is true because as the drainage area increases so does the amount of nutrients and sediments that are delivered to the lake. This is not to say that every lake with a watershed to lake area ratio greater than 10:1 experiences problems, because the amount of pollutants (nutrients, sediment, toxins, etc.) depends greatly on how the land within the watershed is used. Vegetated areas, such as forests, grasslands, and meadows, allow the water to infiltrate the ground and do not produce significant amounts surface runoff. On the other hand, agricultural areas, particularly row crops, along with residential/urban areas reduce infiltration and increase surface runoff. The increased surface runoff associated with these land coverage types leads to increased pollutant loading; which, in turn, can lead to nuisance algal blooms, increased sedimentation, and/or overabundant macrophyte populations.

Field-verified land use data for the Alpine Lake watershed are contained in Table 3 and displayed in Figure 15. Fortunately, the majority of the acreage draining to Alpine Lake is currently forested, which helps reduce the affect of having such a high watershed to lake area ratio. The second highest land use type is in some sort of grass cover. Again, this is good because as explained above, areas with vegetative cover do not usually contribute much to the phosphorus load of the lake.

Table 3. Land use types and acreages of the Alpine Lake watershed. Initial coverages were supplied by Waushara County and then field verified.

Land Use Type	Acreage	Percent of Total
Johns & Tippetts Lake Surface	88.60	4.0
Pasture/Grass/Fallow Fields	309.60	13.8
Row Crops	108.12	4.8
Forest	1315.24	58.7
Wetlands	60.86	2.7
Rural Residential	108.19	4.8
Medium Density Residential	145.38	6.5
Road Right-of-Ways	103.75	4.6
Total	**2239.74**	

The land use acreages listed in Table 3 were used to model their potential loadings of phosphorus to Alpine Lake using WiLMS. A stepwise analysis was used to include the affects of Johns and Tippetts Lakes within the analysis. To facilitate these affects, the watersheds for the two lakes were delineated separately. Then, the loadings for Johns Lake were calculated and added to the Tippetts Lake land use analysis as a point source. Finally, the Tippetts Lake contribution was added to the remaining Alpine Lake analysis as a point source. Furthermore, with data supplied by the District, contributions of phosphorus by septic systems (Table 4) used by properties located around Alpine Lake were also estimated and added to the model. The results of these analyses are contained in Figure 16.

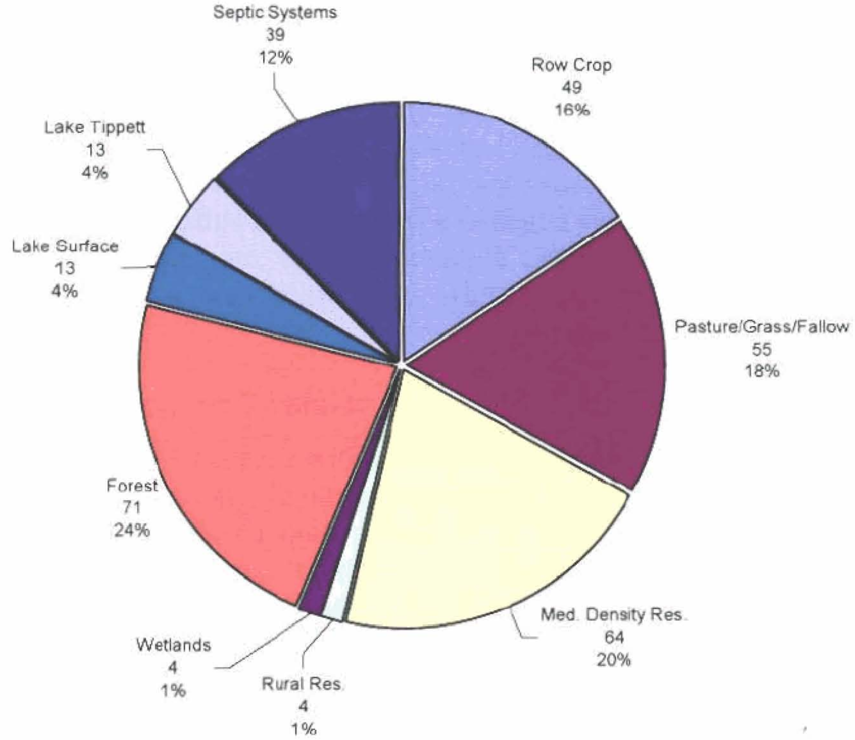

Figure 16. Estimated phosphorus loadings and percent of total load for the land uses modeled in the historic Alpine Lake watershed.

Table 4. Input parameter values for septic system phosphorus loads modeling.

	Residencies		Capita Years			Soil
	Permanent	**Seasonal**	**Permanent**	**Seasonal**	**Total**	**Retention Efficiency**
Model Inputs	25	45	87.5	25.9	113.4	65%

The affects of a watershed on a lake can be tremendous, especially if the lake is a flowage and the watershed to lake area ratio is high, as is the case with Alpine Lake. The modeling indicates that there are five major sources that contribute the most phosphorus to Alpine Lake; septic systems, forested areas, agricultural areas in pasture, grasslands, left fallow, and in row crops, and areas of medium density residential use. The areas that are currently forested or in some type of agricultural use other than row crops contribute the high percentages of phosphorus indicated primarily because they cover so much of the watershed area (see Table 3). Other inputs, such as those entering from row crops and medium density residential areas have comparably high percentages not because they cover so much of the lake's watershed, but because those land use types typically have high rates of surface water runoff associated with their impermeable nature. These high rates of surface runoff contain high concentrations of phosphorus. The septic system inputs are controlled by a number of factors – how much they are used, the types of soils the drainfield is in, and the age of the system. The last two attributes can be accounted for in the WiLMS model by increasing or decreasing the Soil Retention Efficiency Coefficient (Table 4). The total Capita Years value represents how much the system is used on a yearly basis and was calculated with data supplied by the District. The soil efficiency value of 65% was chosen because most of the systems around Alpine Lake are in excess of 20 years old and the vast majority of these systems are in soils that are not appropriate for conventional septic systems around lakes.

The soils around Alpine Lake consist basically of four types: Plainfield sands, Okee loamy sands, Richard loamy sands, Meehan loamy sands, and Zittau Variant clays. With the exception of the Okee loamy sands, all of these soil types are not suitable for conventional septic systems (USDA 1989). Unfortunately, this is the only type of septic system that occurs on the properties around Alpine Lake. Furthermore, the soil retention coefficient of 65% was a conservative estimate; it is likely that it is well below 50%, which would result in a much higher rate of loading for this source.

Potential Affects of the Irogami Diversion

As mentioned above, there is concern within the District about the potential affects on Alpine Lake from the Irogami diversion. Estimating these affects with the limited data available is difficult and should be considered quite rough. The watershed phosphorus loadings were modeled in the same manner as those for Johns and Tippetts Lakes and then added to the Alpine Lake loadings as a point source. The results are displayed in Figure 17. Please note that the loading value for Irogami Lake displayed in Figure 17 represent only 33% of the total estimate and correspond to the estimated time that the diversion actually flows as estimated in the study conducted by Northern Environmental Technologies, Inc. in 1994.

According to the results of these analyses, the Irogami diversion contributes roughly 3% of the total phosphorus load that enters Alpine Lake. This is a very negligible amount compared to the other, more serious sources like the residential areas around Alpine Lake and the septic systems that service them. However, these results are not the only consideration that should be taken into account concerning the diversion. As indicated above, Northern Environmental Technologies, Inc. completed a study of the potential affects of the diversion on Alpine Lake. Their conclusion was that sediment (and attached phosphorus) that originated in Silver Lake did not enter Alpine Lake. It is our belief that this project was studying the incorrect phenomenon. Instead, the study should have investigated the affects of the flows on the wetlands they drain through before entering Bruce Creek and their affects on Bruce Creek itself. It is our belief that the periodic flows that discharge from Irogami Lake through the diversion actually flush sediments and nutrients from wetland into Bruce Creek and they are then carried by Bruce Creek into Alpine Lake.

After attending a meeting in early February 2002, NES was asked to review the report created by Northern Environmental Technologies, Inc. The conclusions reached by that review are contained in their entirety in Appendix F.

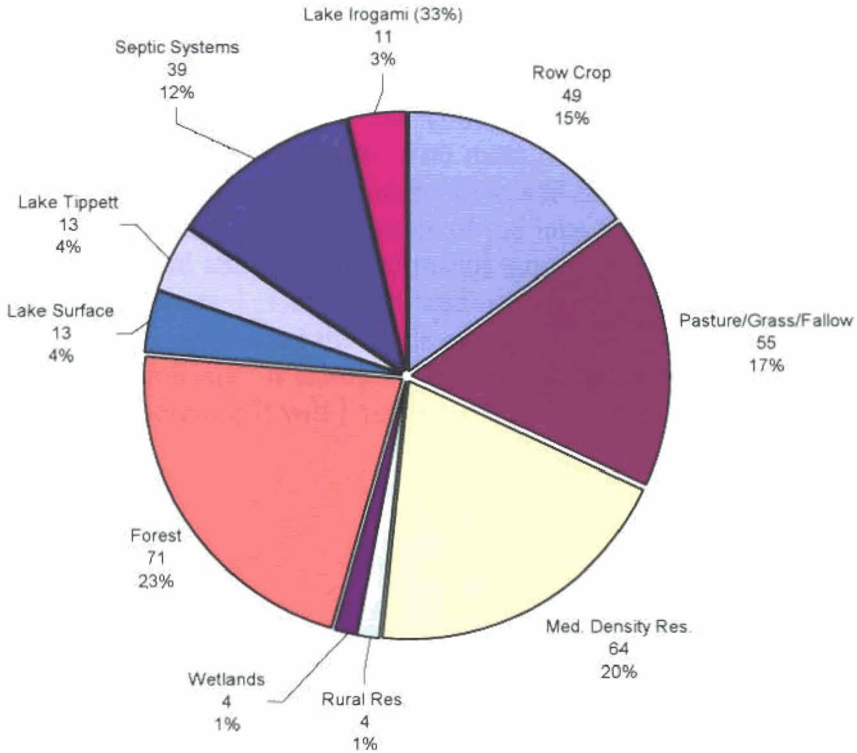

Figure 17. Estimated phosphorus loadings and percent of total load for the land uses modeled in the historic Alpine Lake watershed including the estimated inputs from the Irogami diversion.

RECOMMENDATIONS

The recommendations for the management of Alpine Lake are described below. It must be remembered that even though the recommendations are separated into the same sections as used above, they are very much interrelated and that concentrating on only a portion of them will likely not help Alpine Lake in the long-term. The most obvious problem that Alpine Lake is currently dealing with is the over abundant macrophyte and filamentous algae populations that have hampered the aesthetic and recreational value of the lake for many years. These problems have been treated with chemical and mechanical means since the 1970's and have only provided short-term relief for lake users. Continued use of these methods and/or the methods recommended below without minimizing the loads of phosphorus entering the lake will still only provide relief on a short-term basis. It should also be noted that it took decades for the lake to reach the state that it is in; therefore it will likely take decades to see the results should this plan be carried through.

Lake Water Quality

Water Quality Protection

As described in the Results and Discussion section, the Alpine Lake water quality appears to be relatively good. However, it was also indicated that the lake is likely much more eutrophic than indicated by the WTSI results. The best way to revert Alpine Lake to a less eutrophic state will be to minimize the nutrient inputs as described in the Watershed Recommendations section.

Water Quality Monitoring

Continuous water quality monitoring is an essential component in any lake management plan. Long-term datasets help lake managers detect subtle trends in water quality that cannot be detected with only a year or season's worth of data. Important parameters to include are, chlorophyll-*a*, total phosphorus, Secchi disk transparency, and dissolved oxygen profiles. The Secchi disk information is currently being collected on an annual basis through the efforts of the District's Self-Help Volunteers; this should continue. The other data would not necessarily need to be collected on an annual basis, but should be collected at least every three years. The additional data collection over Secchi disk transparency could be implemented in one of the following fashions:

- The Wisconsin Department of Natural Resources has recently initiated a volunteer sampling program through their Small-scale Lake Planning Grant program. Through this program, a lake organization can receive the equipment and chemicals necessary to collect phosphorus and chlorophyll-*a* data for five years. Applications for this grant program are only accepted during the August cycle. For more information, please contact your local WDNR Lakes Coordinator.
- The Water and Environmental Analysis Lab (WEAL) of UW-Stevens Point offers many lake monitoring packages through their Lake Water Quality Program. The Chlorophyll and Phosphorus Monitoring Program would be the most appropriate for use at Alpine Lake. Through this program, a volunteer from the District would collect water samples using equipment and chemicals supplied by WEAL and then ship them to WEAL for analysis. For more information please visit: https://www.uwsp.edu/cnr/etf/Lake.htm.
- A natural resource consultant could be contracted to collect periodic samples from Alpine Lake and then have them analyzed by a certified lab. If this course were followed, the

District should be sure to hire a qualified consultant that would provide annual reports and data analysis.

Aquatic Vegetation

As discussed above, the aquatic vegetation, both macrophytic and algal, in Alpine Lake have been treated with chemicals and through mechanical means for many years. Although these treatments provide the District with some short-term relief, they are really nothing more than a "band-aid" approach to solving the problem and cost the District a great deal of money on an annual basis. Continued, widespread uses of these treatments are not recommended for Alpine Lake. More specifically, harvesting should not be continued because it is likely spreading Eurasian water-milfoil within the lake through the fragments the harvester creates and does not collect. Chemical treatments may be used on a limited basis to treat small, dense colonies of Eurasian water-milfoil as described below. Chemical applications can also be used for the treatment of nuisance algal blooms. However, the treated areas should only included very dense blooms in limited areas where navigation is hampered.

Recommendation: Winter Water Level Drawdown

To provide more long-term relief from the over abundant macrophyte populations of Alpine Lake, especially those of Eurasian water-milfoil, it is recommended that the District draw Alpine Lake's water levels down to the 9-ft contour as indicated in Figure 18. Drawing the lake down to this level (based on current bathymetry data) would expose the majority of the areas that are currently dominated or partially dominated by Eurasian water-milfoil (Figure 18). The drawdown should begin in the fall and last through the winter to provide the most benefit through the desiccation and freezing of lake bottom sediments.

Winter drawdowns affect different plant species in a number of ways. Table 5 contains a list of the species found in Alpine Lake and their response to winter drawdown (Nichols and Vennie 1991).

It is obvious by the amount of plants that do not have reported responses or are considered to have variable responses, that there needs to be more research conducted concerning the effects of this lake management method on aquatic macrophytes. Although it is not indicated in Table 5, researchers from the Washington State Department of Ecology have documented reductions in Eurasian water-milfoil abundances following winter drawdowns. Furthermore, as indicated in Table 5, a much desired plant, wild celery, actually increases in abundance following winter drawdowns. Therefore, we could expect to have good success with reducing Eurasian water-milfoil within Alpine Lake while increasing at least one of the beneficial, native plants.

Table 5. Reported responses of aquatic plant species found in Alpine Lake to winter water level drawdown. (Nichols and Vennie 1991)

Species		Reported Response to Winter Drawdown
Scientific Name	Common Name	
Bidens beckii	Water marigold	Not Reported
Caltha palustris	Marsh marigold	Not Reported
Carex comosa	Bristly sedge	Not Reported
Carex stricta	Sedge	Not Reported
Ceratophyllum demersum	Coontail, hornwort	Variable Response
Chara sp.	Muskgrasses	Variable Response
Eleocharis acicularis	Needle spikerush	Decreases
Eleocharis palustris	Creeping spikerush	Not Reported
Elodea canadensis	Common waterweed	Variable Response
Elodea nuttallii	Slender waterweed	Not Reported
Eupatorium perfoliatum	Common boneset	Not Reported
Iris versicolor	Wild blueflag	Not Reported
Lemna minor	Small duckweed	Variable Response
Myriophyllum spicatum	Eurasian water-milfoil	Variable Response
Nymphaea odorata	White water lily	Not Reported
Phalaris arundinacea	Reed canary grass	Not Reported
Potamogeton crispus	Curly-leaf pondweed	Not Reported
Potamogeton gramineus	Variable pondweed	Variable Response
Potamogeton illinoensis	Illinois pondweed	Not Reported
Potamogeton pectinatus	Sago pondweed	Increases
Potamogeton zosteriformis	Flat-stem pondweed	Variable Response
Sagittaria latifolia	Common arrowhead	Not Reported
Scirpus validus	Softstem bulrush	Increases
Sparganium eurycarpum	Common bur-reed	Not Reported
Spirodela polyrhiza	Great duckweed	Decreases
Typha angustifolia	Narrow-leaved cattail	Not Reported
Typha latifolia	Broad-leaved cattail	Variable Response
Utricularia vulgaris	Great bladderwort	Decreases
Vallisneria americana	Wild celery	Increases
Zosterella dubia	Water stargrass	Not Reported

Other advantages to this method include:

- Tremendous cost savings over chemical and harvester treatments.
  - The design of the Alpine Lake outlet structure is very conducive to controlled drawdown of Alpine Lake to the levels we desire. This means that the drawdown could be completed with only minimal cost to the District (see section on Other Considerations).
  - An additional advantage of the dam's design is that much of the water that would continue to flow in from Bruce Creek during the winter could be removed from the hypolimnion: reducing the chance of a fishkill while water levels are their lowest.

- Consolidation of flocculent bottom sediments
  - Much of the lake bottom of Alpine Lake consists of flocculent mucks. Exposing these sediments to desiccation and freezing would help to consolidate these sediments reducing their susceptibility to resuspension and nutrient release.
- Reduced costs of dredging the lake near the entrance of Bruce Creek.
  - The District wishes to remove sediments from the lake bottom near the inlet of Bruce Creek. Having these sediments removed during the drawdown would provide significant cost savings to the District.
- Other areas could be more easily dredged.
  - Concern has been raised about the stagnant conditions that occur in the two small bays located on the north and south sides of Alpine Lake near the inlet of Bruce Creek. Nuisance plant populations, consisting mostly of Eurasian water-milfoil and curly-leaf pondweed were also found to occur in these areas during our vegetation survey. These over abundant plant populations make navigation through these areas very difficult and reduce lake access to the people that own property around them. If these areas were dredged to increase their volume and to remove nutrient-rich sediments and remaining plant fragments and seeds, it would likely greatly reduce these problems. Completing the excavation activities during the drawdown would allow better access to these areas for excavation equipment and greatly reduce the cost.
- Concentrations of predator and prey fish species.
  - A great disadvantage of an over abundant aquatic plant community is the affect it has on predator/prey relationships within a lake. High plant densities provide excellent cover for prey fish, reducing the effectiveness of predator species. As a result, predator species are reduced and prey species may become stunted. Concentrating the species into a smaller area of less volume can help to alleviate this problem and result in a healthier fishery.
- Enhancement of emergent and floating-leaf plant communities.
  - It would be beneficial if the District completed enhancement activities concerning the emergent and floating-leaf plant communities. Installing emergent and floating-leaf stock during the spring before the lake returned to normal levels would help reduce the recolonization of those areas by exotics, increase the diversity of the lake's plant population, add aesthetic value, and increase fish habitat. Therefore, it is highly recommended that the District complete this task if the drawdown is completed.
- Dam Inspection
  - The dam and berm that maintain the water levels of Alpine Lake could be easily inspected during the drawdown.

Other Considerations

There are a number of considerations that need to be addressed concerning the proposed drawdown of Alpine Lake.

Contour data for Alpine Lake.

During our vegetation surveys and other visits to the lake, we found that the current bathymetric data for Alpine Lake is not completely accurate. On many occasions we found discrepancies between depths at known locations using GPS technology and those locations on the current contour map. One such location was the water quality sample site where we consistently measured 17-feet of depth, yet the map showed we should have been over approximately 12-feet of water. Furthermore, we had a very difficult time lining up the lake outline on the current contour map with aerial photography produced in 2000. As a result, we needed to adjust the some of the contours and the outline on the map to better portray the areas that were sampled during the vegetation surveys. The differences between the current contour map and the lake outline taken from aerial photography are displayed in Figure 19.

Although some of these differences may appear to be trivial, accurate data would be very useful in future surveys, determining the actual drawdown levels and the areas that would remain inundated, and in the assessment of the project's success. Therefore, we recommend that a new contour map be created for Alpine Lake before the drawdown is to take place. The cost of this type of project is highly variable and depends largely on the time of year it would be conducted. The costs could be partially funded through a WDNR Lake Planning or Protection Grant.

Fisheries

The local fisheries specialist with the WDNR should be consulted prior to this project taking place. Based on their knowledge of the Alpine Lake fishery, they would be able to project how the fisheries population would react to the drawdown. If they conclude that the detrimental effects of the drawdown would outweigh the potential benefits regarding the fishery it would then be up to the WDNR and the District as to whether or not the project should proceed.

Dissolved Oxygen

There is a risk that the dissolved oxygen within the remaining inundated areas could drop below tolerable levels for fish and that a fishkill could result. This risk could be avoided by periodic (weekly) monitoring of dissolved oxygen levels and by having an aeration system ready for use if need be. Availability for rental aeration systems and their power needs should be investigated by the District before the project is started. Dissolved oxygen could be monitored by District volunteers using leased equipment, the WDNR, or by a consultant.

Post Drawdown Monitoring and Treatments

An aquatic plant survey should be completed after the water levels have returned to their pre-drawdown depths to locate remaining populations of Eurasian water-milfoil and to document the preliminary results of the drawdown. If Eurasian water-milfoil colonies remain 2,4-D treatments should be considered to further reduce these exotics and their competitive advantage over the native plants that would be attempting to re-establish themselves. Monitoring specifically for reoccurrence of Eurasian water-milfoil should be completed later in the summer and in the fall to determine if further chemical treatments would be feasible. The initial survey should be completed by experienced professionals, but the Eurasian water-milfoil monitoring conducted later in the summer and in the fall could be completed by volunteers from the District. The costs of the professional survey could be partially funded by a WDNR Planning or Protection Grant.

For the most part, the success of the project would dictate what steps should be taken concerning future aquatic plant management activities in the lake. These activities may involve additional chemical treatments, drawdowns, or other less intense measures, such as hand-removal and sediment barriers.

Recommendation: Aquatic Plant Community Enhancement

Whether the recommended drawdown is completed or not, it is highly recommended that the District takes steps to enhance the aquatic macrophyte community within Alpine Lake. These enhancements would primarily include emergent and floating-leaf species, which are distinctly lacking within Alpine Lake. Secluded areas should be selected through out lake (e.g. near the islands and county park) along with lesser used areas in front of private properties. Qualified advice should be obtained from the WDNR or a qualified consultant concerning species selection, planting times, and installation methods.

The cost of these enhancements would depend on the extent of the areas planted, but would be well qualified for the WDNR's Lake Protection Grant category that has been recently implemented to fund shoreland enhancements.

Watershed

To many District members and other lake users, the most glaring problem with Alpine Lake is the over abundant plant populations that develop on a yearly basis. Yet, most fail to understand that this is only a symptom of a much larger problem; that problem being the loading of phosphorus from the lake's watershed that are responsible for fueling these nuisance growths. As discussed in the Results and Discussion section, lakes with a watershed to lake area ratio greater than 10:1 tend to have management problems. Alpine Lake's ratio is 40:1. Although this may present some difficulties it does not mean that if the District is truly dedicated to minimizing the sources that improvements will not be made. This dedication will have to be sustained for many years or possibly decades to see the result. The truth of the matter is that the development around Alpine Lake is likely the most responsible for the problems that are so apparent in the lake and without the commitment of the entire District; it is probable that these problems will continue to exist and may even worsen.

Figure 16 displays the percent that each source is responsible for in the loading of phosphorus to the lake. Sources such as the lake surface (precipitation and atmospheric fallout) and the areas that are forested cannot be reduced to any extent. It would be impossible to prevent phosphorus from entering the lake through its surface. The forested areas cannot get any better as they already have the lowest rate of loading per acre for any type of land use. Therefore, other significant sources that can be minimized must be the focus of our management efforts. Management efforts that are aimed at minimizing the amount of phosphorus that enters the lake with the hope that over time, the phosphorus content of the lake and its sediments will be reduced to the point that these nuisance plant abundances will not be sustained. It is with these thoughts in mind, the following recommendations are made.

Septic Systems

Conservative modeling indicates the septic systems around the lake contribute approximately 12% of the total phosphorus load to Alpine Lake. The modeling is considered conservative because soil retention values used to estimate this source's loading are probably much worse than what was used in the model based on the age of the systems and the soils that there drain fields are located in. Minimizing or even completely removing these sources should be one of the top priorities of the District.

To minimize this source <u>all</u> septic systems around the lake, including the back lots should be professionally inspected. By state law, a septic system is considered to be failing if untreated wastewater is backed up into the building, seeps to the soil surface, enters surface or groundwater, or moves into the soil's saturated zone. With the exception of being backed up into the building, all of these failures could potentially increase nutrient loading to Alpine Lake. The Wisconsin Department of Commerce estimates that nearly 1-in-5 septic systems are failing in Wisconsin. Inspections should include soil test and possibly ground water monitoring to determine if the soils are truly retaining phosphorus and other contaminants or just passing them through to the groundwater and on to the lake. If systems are found to be failing, they may be required by county or state regulations to be corrected. The Wisconsin Department of Commerce partially funds private sewage system replacements through their Wisconsin Fund, Private Sewage System Replacement and Rehabilitation Grant Program, but the requirements are stringent and include that the system must be serving the owner's principal residence and that the owners not make in excess of a specified annual income. More information about this grant program can be found on the Dept. of Commerce website or by calling (608) 267-7113.

Furthermore, many lake groups have successfully applied for WDNR Planning Grants to pay for 75% of these inspection costs.

Furthermore, the District should require all properties to have their septic tanks pumped at least every three years, depending on the size of the tank and the amount the system is used. Determining the schedule for different classifications of systems based on their size and use could likely be determined by the company that would be contracted to complete the inspections. This plan should go as far as having reminder cards sent out to property owners that would require their return and the signature of a licensed plumber or sanitation service after the pumping is completed. Records would be maintained by the District. Penalties for non-compliance could be determined by the District, but it is likely that the possibility of a property being listed in the District's newsletter as not performing its maintenance pumping would be enough to keep most owners in compliance. The cost involved with the development of this program, including the cost of card printing, could also be partially funded through the WDNR grant mentioned above.

Our highest recommendation is to completely remove this loading source by having all properties around the lake, including back lots connected to the Silver Lake Sanitary system. Although this may be the most expensive method to control these phosphorus inputs, it would provide the greatest long-term benefits to the lake. It is recommended that the District form a sub-committee to investigate the costs and logistics of being included in the Silver Lake Sanitary District, and if it is found to be feasible, that the District follows through with this project.

Residential Properties

The WiLMS modeling estimated that residential properties around the lake contribute 20% of the total phosphorus load to the lake. Fortunately, minimizing these loads is relatively simple. The vast majority of properties located on the lake do not contain a natural, functioning buffer between the lake and the maintained landscapes of the properties. Creation of a least a 35-foot wide buffer strip, consisting of native trees, shrubs, and herbaceous plants would greatly reduce the loadings of sediment and phosphorus from these shoreland properties. Additional benefits include the increased aesthetic value that would be added to each property; and the prevention of shoreland sloughing that is occurring on many properties. As with the aquatic plant enhancements recommended in the Aquatic Vegetation section, the District should seek professional advice concerning the creation of buffer strips from either the WDNR or a qualified consultant. Partial funding for these types of projects is available through WDNR Lake Protection Grant program.

Again, it is recommended that the District create a sub-committee to facilitate these projects. Once a few of the buffer creations are completed, it is likely that this committee will be able to continue the process without professional assistance.

It is strongly recommended that only phosphate-free fertilizers be used on shoreland properties and back lots. This type of fertilizer is readily available for retail purchase. The local UW-Extension may be contacted for a list of suppliers.

Agricultural Areas Containing Row Crops

Lands containing row crops can contribute some of the highest rates of phosphorus loading of any land use type. Although there is only a little over 100 acres of row cropped land within the Alpine Lake watershed, modeling estimated that they contribute 16% of the total phosphorus load entering the lake. We did not have access to these lands during our land use verification survey, so we do not have the necessary information to make specific recommendations. However, Mr. Mark Schumacher, Waushara County Land Conservationist (920-787-0443) can be contacted to receive advice concerning the minimization of this source.

Irogami Diversion

Our thoughts on the Irogami diversion are clearly stated in the attached document and do not need to be described here. We recommend that the District attempt to block the reissuing of the permit allowing the diversion. At a minimum, the District should insist that the Silver Lake Sanitary District sponsor a more accurate study aimed at discovering the true affects of the diversion on Alpine Lake. It is not recommended that the District settle for having the Silver Lake Sanitary District pay for all or a portion of the costs associated with the dredging of the sediments that are suspected to be entering the lake as a result of the diversion. Although the dredging would alleviate the sedimentation problem, it will do little to reduce the phosphorus that is entering the lake along with the sediments.

Education

Continued education of lake users is an incredibly important aspect of any lake management plan. Informing District members about District activities is very import, but the education of its members is as important, if not more important. Educational topics should include:

- Lake Stewardship
    - A lake steward understands their affect on the lake ecosystem and takes measures to protect and enhance it. They also understand that protecting the ecosystem as a natural resource and not just a recreational resource is important to all lake uses, including fishing, swimming, boating, and enjoying the aesthetics of the lake.
- The Use of Herbicides in Lakes
    - This is an especially important topic for Alpine Lake. Education on this topic should include the benefits and drawbacks of herbicide use along with information on why these chemicals have an acceptable risk associated with their use.
- Property Management
    - This topic can be tied to lake stewardship and should include information on the use of lawn fertilizers, the maintenance of septic systems, and methods of blending structures with the natural landscape. This topic should also include information on natural buffer strips that can be used to minimize soil erosion and nutrient loading to the lake from private properties.

METHODS

Lake Water Quality

Water Quality Monitoring

Baseline water quality conditions were studied to assist in identifying potential water quality problems in Alpine Lake (e.g., elevated phosphorus levels, anaerobic conditions, etc.). Water quality was monitored at the deepest point in the lake. Samples were collected with a 3-liter Van dorn bottle at the subsurface (S) and near bottom (B), and occurred once in spring, fall, and winter and three times during summer. Samples were kept cool and preserved with acid following normal protocols. All samples were shipped to the Wisconsin State Laboratory of Hygiene for analysis. The parameters measured included:

	Spring		June		July		August		Fall		Winter	
Parameter	**S**	**B**	**S**	**B**	**S**	**B**	**S**	**B**	**S**	**B**	**S**	**B**
Total Phosphorus	●	●	●	●	●	●	●	●	●	●	●	●
Dissolved Phosphorus	●	●			●	●						
Chlorophyll a	●	●	●		●		●		●			
Total Kjeldahl Nitrogen	●	●			●	●					●	●
Nitrate-Nitrite Nitrogen	●	●			●	●					●	●
Ammonia Nitrogen	●	●			●	●					●	●
Conductivity	●	●			●	●						
Laboratory pH	●	●			●	●						
Total Alkalinity	●	●			●	●						
Total Suspended Solids	●	●			●	●	●	●	●	●	●	●
Calcium	●	●			●							

In addition, during each sampling event Secchi disk transparency was recorded and a temperature, pH, conductivity, and dissolved oxygen profile was be completed using a Hydrolab DataSonde 4.

Aquatic Vegetation

Transect Surveys and Macrophyte Community Mapping

Quantitative aquatic vegetation surveys were conducted on July 30, 2002 by sampling transects located along the shoreline of the lake (Figure 12). Sampling was completed via boating, wading, and snorkeling. In order to map the macrophyte communities and to assist in determining the frequency and location of transects, visual inspections were completed throughout the lake using a combination of sketches and notes created on hardcopy maps and position data recorded with a Trimble GeoExplorer 3 GPS/Data Collector. On each transect, a ten-foot diameter circle was sampled within each of five different depth ranges (Table 6). The maximum depth of sampling was determined through field observation of the approximate maximum depth of aquatic vegetation growth. At each sampling location, substrate type and species composition were recorded.

Table 6. Depth codes and ranges sampled during transect surveys.

Depth Code	Depth Range (feet)
1	0.0-1.5
2	1.5-3.0
3	3.0-5.0
4	5.0-10.0
5	>10.0

A visual estimate of percent foliage cover for each species was also recorded at the sampling locations. Coverage is determined as the perpendicular projection to the ground from the outline of the aerial parts of the plant species and is typically reported as the percent of total area (e.g., substrate or water surface) covered (Brower et al. 1990). For emergent and floating-leaf vegetation, the percent of water surface covered was used in the visual estimate, and for submergent vegetation the percent of substrate covered was used. After the collection of field data, the Daubenmire Classification Scheme (Mueller-Dumbois and Ellenberg 1974) was used to rank each species observed according to estimated foliage cover (Table 7). By providing a range of percent foliage cover for each rank, the Daubenmire Classification Scheme helps to minimize errors due to observer bias, visual estimation, etc.

Table 7. Daubenmire Classification Scheme cover ranking system.

Percent Foliage Cover	Rank
0-5	1
5-25	2
25-50	3
50-75	4
75-95	5
95-100	6

The collected transect data was used to estimate frequency of occurrence and relative frequency of occurrence for each species observed. The frequency of occurrence is defined as the number of times a given species occurred on the total plots of all transects sampled. The relative frequency of occurrence is the frequency of that species divided by the sum of the frequencies of all species in the community (Brower et al. 1990). Sum coverage is the total Daubenmire cover found for each plant.

Curly-leaf Pondweed Survey

Surveys of curly-leaf pondweed were completed during June 13 and 17, 2002 field visits to Alpine Lake in order to correspond with the anticipated peak growth of the plant. Visual inspections were completed throughout the lake using a combination of sketches and notes created on hardcopy maps and position data recorded with a Trimble GeoExplorer 3 GPS/Data Collector.

Floristic Quality Assessment

A Florist Quality Assessment (FQA) was applied to the aquatic vegetation species lists generated for Alpine Lake using the methodology of Nichols (1999). FQA is a rapid assessment metric used to assist in evaluating the floristic and natural significance of a given area. The assessment system is not intended to be a stand alone tool, but is valuable as a complementary and corroborative method of evaluating the natural floristic quality of a lake ecosystem.

The primary concept in FQA is species conservatism. Each native species found in the lake was assigned a coefficient of conservatism (C) ranging from 0 to 10. The coefficient of conservatism estimates the probability that a plant is likely to occur in a landscape relatively unaltered from what is believed to be pre-settlement condition. A C of 0 indicates little fidelity to a natural community, and a C of 10 is indicative of restriction to high quality, natural areas. The FQA was applied by calculating a mean coefficient of conservatism for all species observed in the lake. The mean C was then multiplied by the square root of the total number of species to yield a Floristic Quality Index (FQI). Examination of the floristic quality index within the context of statewide and regional trends was used to provide an overall evaluation of the floristic quality of Alpine Lake.

Watershed Analysis

The watershed analysis began with an accurate delineation of Alpine Lake's drainage area using U.S.G.S. topographic survey maps. The watershed delineation was then transferred to a Geographic Information System (GIS). These data, along with land use data supplied by Waushara County were then combined to determine the preliminary watershed land use classifications. The watershed delineation and land use classifications were field verified during the fall of 2002.

The preliminary data were then corrected with the field verified data within the GIS and watershed area and acreages for each land use type were calculated. These data, along with historic and current water quality data were inputted into the Wisconsin Lake Modeling Suite (WiLMS) to determine potential phosphorus loads to the lake. Watersheds leading to Johns, Tippetts, and Irogami Lakes were separated and analyzed independently. These data were then used to determine nutrient outflow from the each lake using WiLMS Water and Nutrient Outflow Module. The nutrient outflow was then added to the downstream lake as a point-source during the phosphorus loading prediction for that lake.

Education

Educational components were accomplished through a "Kick-off Meeting" held in May 2002, project updates created for inclusion in the District's newsletter, an article that appeared in the Oshkosh Northwestern, and a "Project Completion Meeting" at which the final report and recommendations were presented to the District. All of these materials are included in Appendix D.

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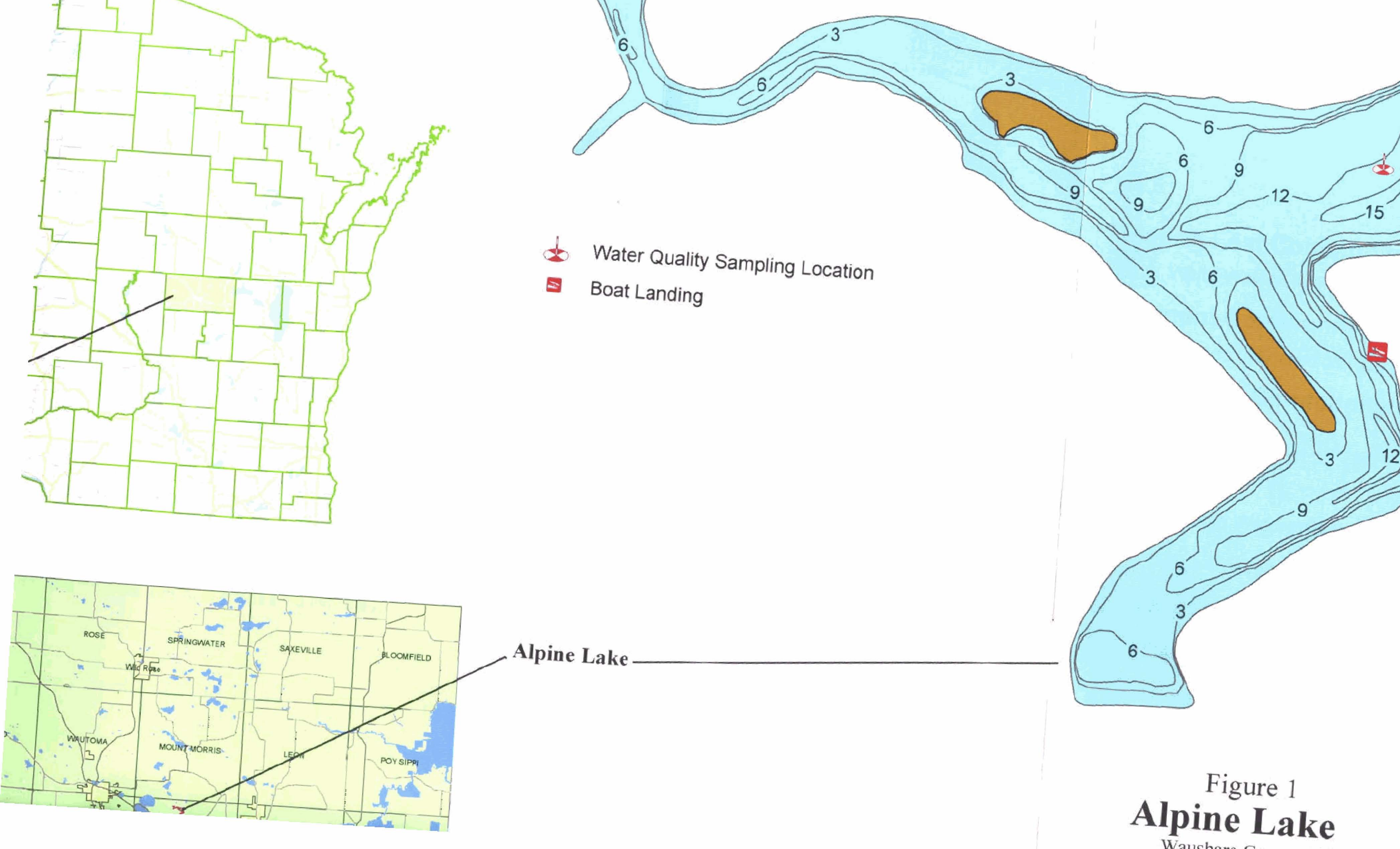
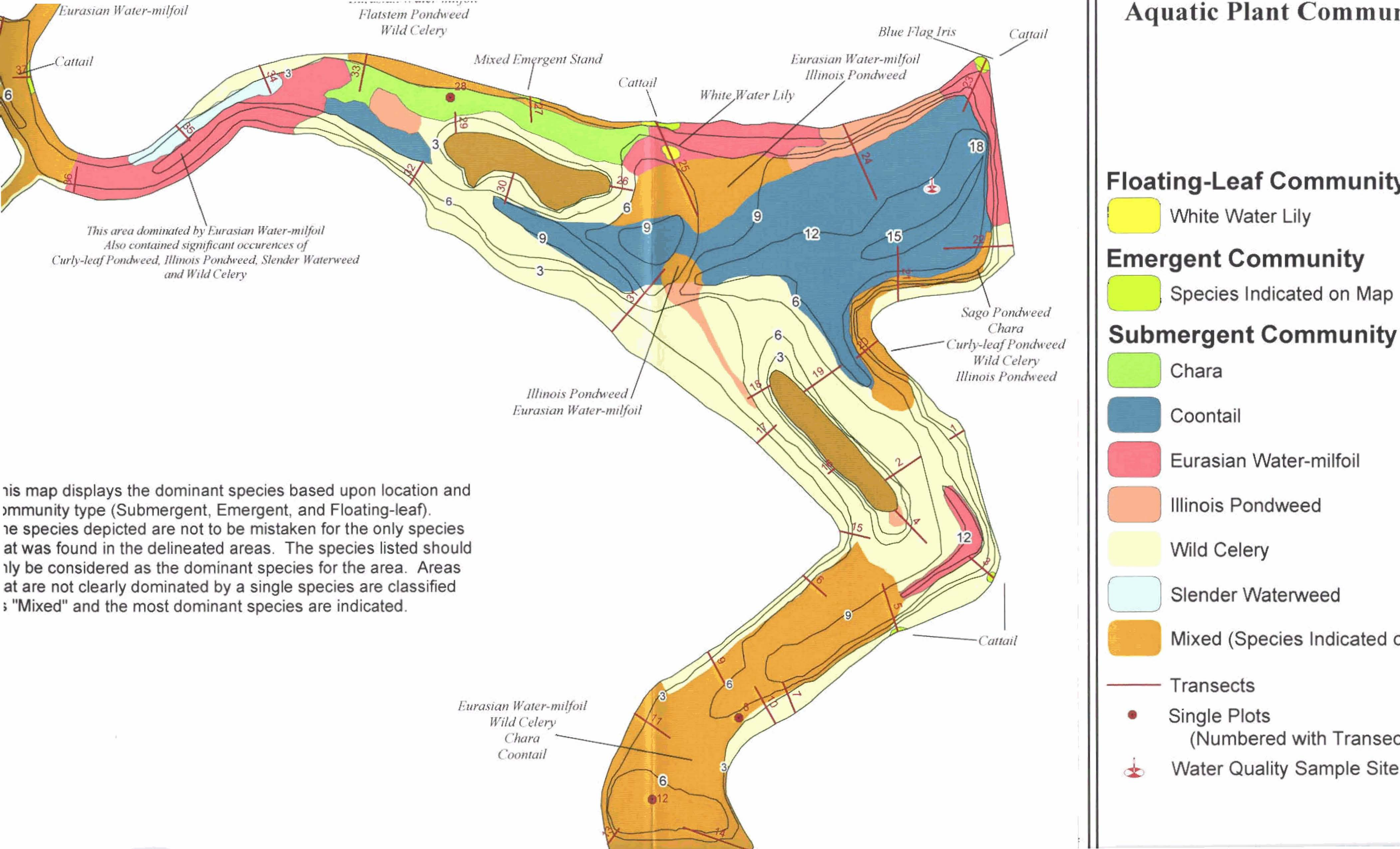
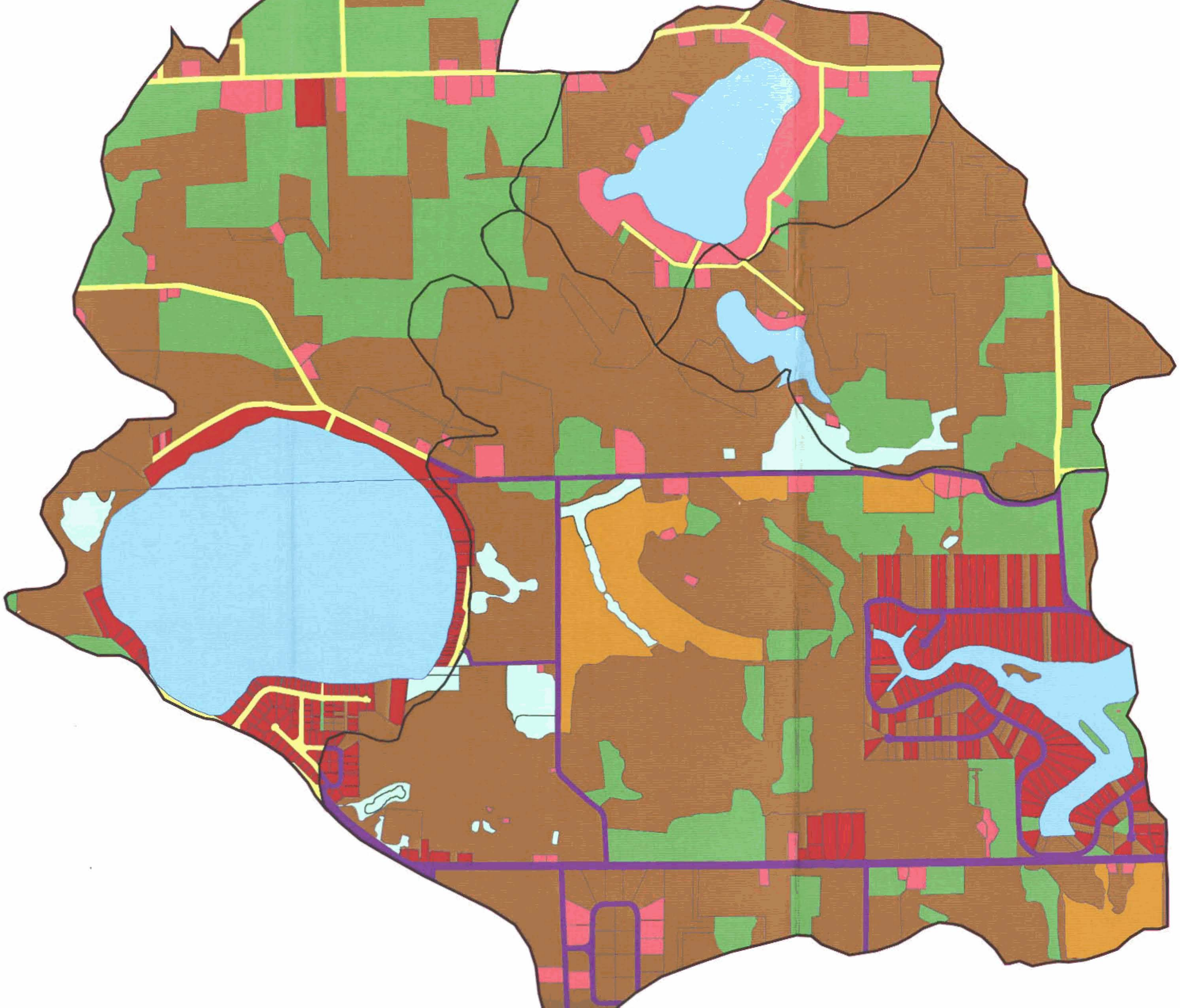


Figure 1
Alpine Lake



ıis map displays the dominant species based upon location and ›mmunity type (Submergent, Emergent, and Floating-leaf). ıe species depicted are not to be mistaken for the only species at was found in the delineated areas. The species listed should ıly be considered as the dominant species for the area. Areas at are not clearly dominated by a single species are classified ; "Mixed" and the most dominant species are indicated.



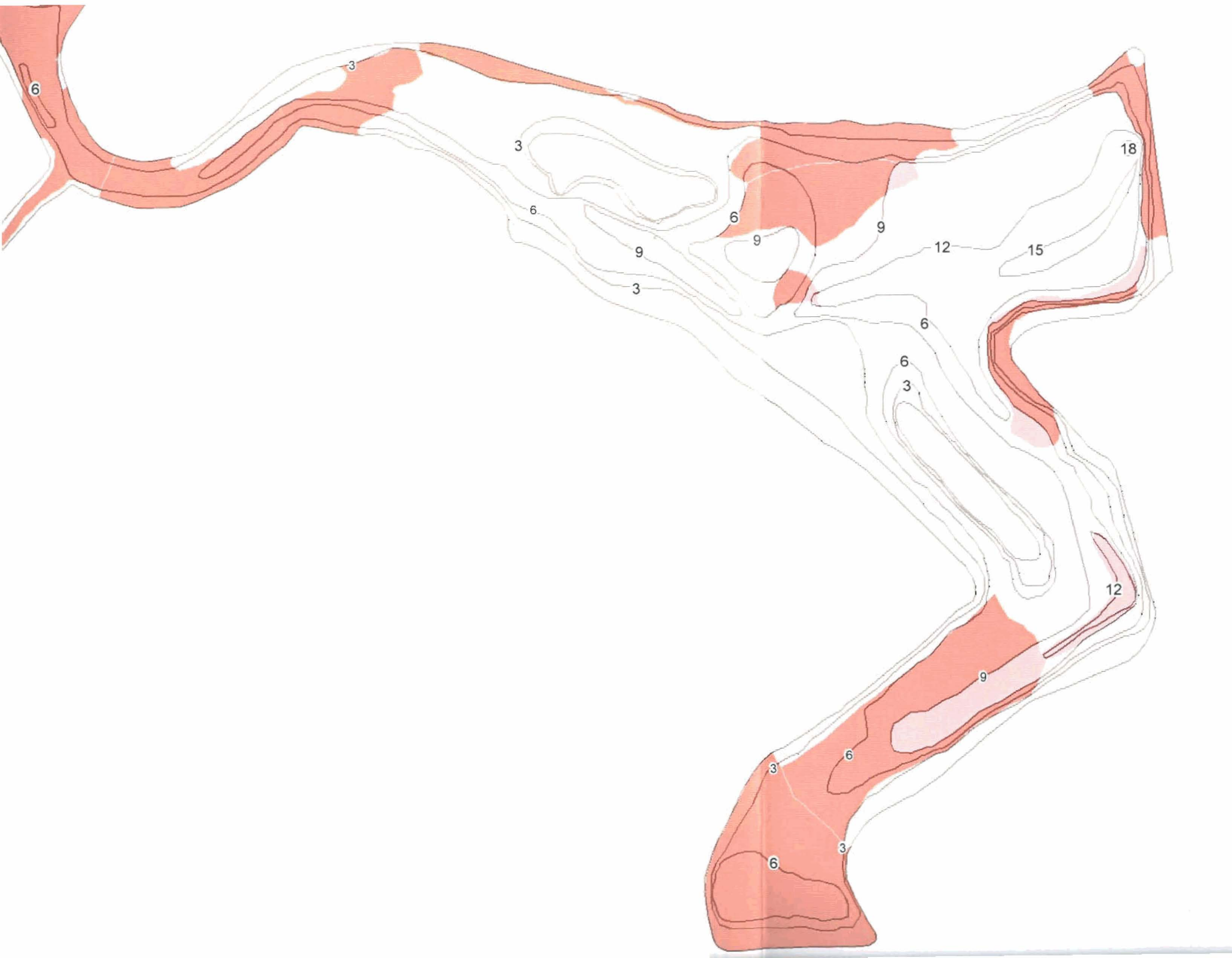
Waushara County,

Watershed Land Us

Land Use Classificat

- Lake Water Surface
- Forest
- Pasture/Grassland/F
- Row Crops
- Medium Density Res
- Rural Residential
- Wetland
- Road Right-of-Way

Following Water L
Drawdown



Areas Containing Highe
Eurasian Water-milfoil C

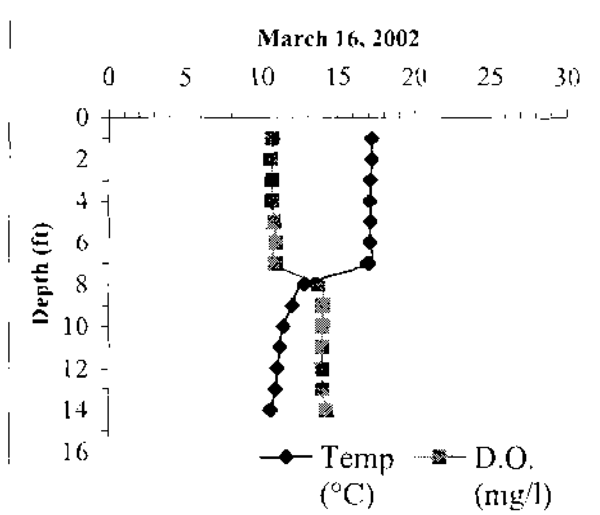
Inundated Area

Alpine Lake

Date:	04-16-02	**Max Depth (ft):**	15.6
Time:	13:00	**ALPLS Depth (ft):**	3.0
Weather:	80degrees, clear, breezy, N westerly	**ALPLB Depth (ft):**	12.5
Ent:	BGN **Verf:** BN/JE	**Secchi Depth (ft):**	7.8

Depth (ft)	Temp (°C)	D.O. (mg/l)	pH	Sp. Cond (μS/cm)
1.0	17.2	10.7	8.6	272
2.0	17.2	10.6	8.6	272
3.0	17.1	10.7	8.5	272
4.0	17.1	10.7	8.6	272
5.0	17.1	10.8	8.6	272
6.0	17.1	10.9	8.6	273
7.0	17.0	10.9	8.6	272
8.0	12.8	13.7	8.7	268
9.0	12.0	14.0	8.7	266
10.0	11.4	14.0	8.7	266
11.0	11.2	14.0	8.7	266
12.0	11.0	14.0	8.7	265
13.0	10.9	14.0	8.7	264
14.0	10.6	14.3	8.7	265

Parameter	ALPLS	ALPLB
Total P (mg/l)	0.019	0.018
Dissolved P (mg/l)		
Chl a (μg/l)	5.00	18.00
TKN (mg/l)	0.51	0.55
NO_4+NO_3-N (mg/l)	0.322	0.268
NH_3-N (mg/l)	0.015	
Total N (mg/l)	0.83	0.82
Lab Cond. (μS/cm)	315	310
Lab pH	8.48	8.60
Alkal (mg/l $CaCO_3$)	146	145
Total Susp Sol (mg/l)		
Calcium (mg/l)	31.6	31.5



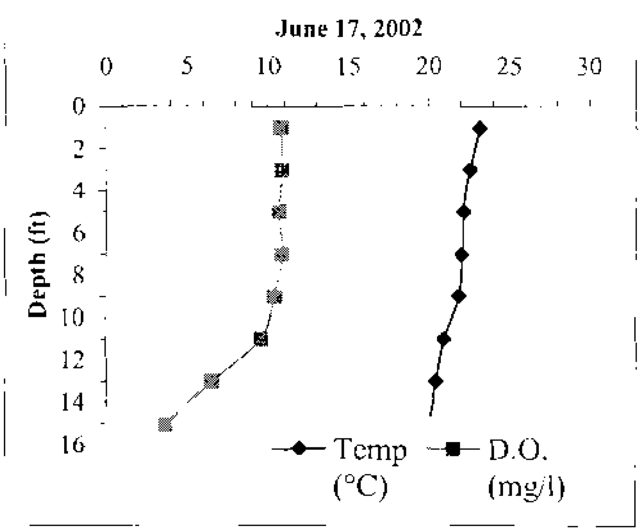
Notes:

Alpine Lake

Date: 06-17-02		**Max Depth (ft):**	16.5
Time: 14:55		**ALPLS Depth (ft):**	3.0
Weather: partly cloudy 75		**ALPLB Depth (ft):**	13.0
Ent: BGN	**Verf:** BN/JE	**Secchi Depth (ft):**	6.3

Depth (ft)	Temp (°C)	D.O. (mg/l)	pH	Sp. Cond (µS/cm)
1.0	23.2	10.8	9.0	270
3.0	22.6	10.9	9.1	269
5.0	22.2	10.7	9.1	270
7.0	22.1	10.9	9.1	273
9.0	21.9	10.4	8.9	285
11.0	21.0	9.6	8.6	314
13.0	20.5	6.6	8.3	320
15.0	20.0	3.7	8.1	334

Parameter	ALPLS	ALPLB
Total P (mg/l)	0.018	0.022
Dissolved P (mg/l)		
Chl a (µg/l)	1.00	
TKN (mg/l)		
NO_4+NO_3-N (mg/l)		
NH_3-N (mg/l)		
Total N (mg/l)		
Lab Cond. (µS/cm)		
Lab pH		
Alkal (mg/l $CaCO_3$)		
Total Susp Sol (mg/l)	4	3
Calcium (mg/l)		



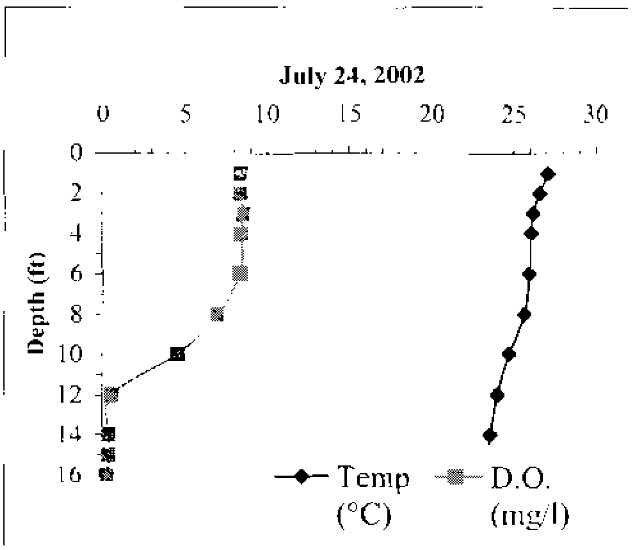
Notes:

Date: 07-24-02
Time: 14:35
Weather: 75, partly cloudy breezy
Ent: BGN **Verf:** BN/JE

Max Depth (ft): 17.0
ALPLS Depth (ft): 3.0
ALPLB Depth (ft): 13.0
Secchi Depth (ft): 4.0

Depth (ft)	Temp (°C)	D.O. (mg/l)	pH	Sp. Cond (µS/cm)
1.0	27.1	8.4	9.0	277
2.0	26.6	8.4	9.0	277
3.0	26.2	8.6	8.9	276
4.0	26.1	8.5	8.9	275
6.0	26.0	8.4	8.9	276
8.0	25.7	7.0	8.8	284
10.0	24.7	4.6	8.6	316
12.0	24.0	0.6	8.6	330
14.0	23.6	0.4	10.6	344
15.0	23.4	0.4	12.2	363
16.0	22.6	0.3	12.3	406

Parameter	ALPLS	ALPLB
Total P (mg/l)	0.031	0.027
Dissolved P (mg/l)	0.000	*
Chl a (µg/l)	11.90	
TKN (mg/l)	0.85	0.76
NO_4+NO_3-N (mg/l)	0.000	0.135
NH_3-N (mg/l)	0.063	0.118
Total N (mg/l)	0.85	0.90
Lab Cond. (µS/cm)	286	330
Lab pH	8.84	7.98
Alkal (mg/l $CaCO_3$)	136	156
Total Susp Sol (mg/l)	6	6
Calcium (mg/l)	27.1	



Notes: Mistakenly, no sample was collected for Diss P for the bottom sample.

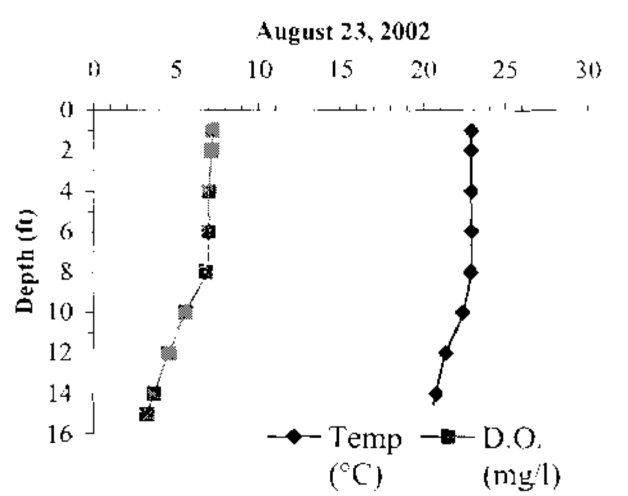
Alpine Lake

Date: 08-23-02
Time: 14:46
Weather: misting 65
Ent: BGN **Verf:** TH/TN

Max Depth (ft): 16.2
ALPLS Depth (ft): 3.0
ALPLB Depth (ft): 13.0
Secchi Depth (ft): 6.9

Depth (ft)	Temp (°C)	D.O. (mg/l)	pH	Sp. Cond (µS/cm)
1.0	22.9	7.2	8.8	297
2.0	22.9	7.1	9.0	298
4.0	22.9	7.0	9.1	299
6.0	22.9	7.0	9.1	299
8.0	22.9	6.8	9.0	301
10.0	22.4	5.6	8.6	326
12.0	21.4	4.6	8.3	331
14.0	20.8	3.7	8.1	336
15.0	20.6	3.3	8.0	339

Parameter	ALPLS	ALPLB
Total P (mg/l)	0.019	0.021
Dissolved P (mg/l)		
Chl a (µg/l)	7	
TKN (mg/l)		
NO_4+NO_3-N (mg/l)		
NH_3-N (mg/l)		
Total N (mg/l)		
Lab Cond. (µS/cm)		
Lab pH		
Alkal (mg/l $CaCO_3$)		
Total Susp Sol (mg/l)	4	0
Calcium (mg/l)		



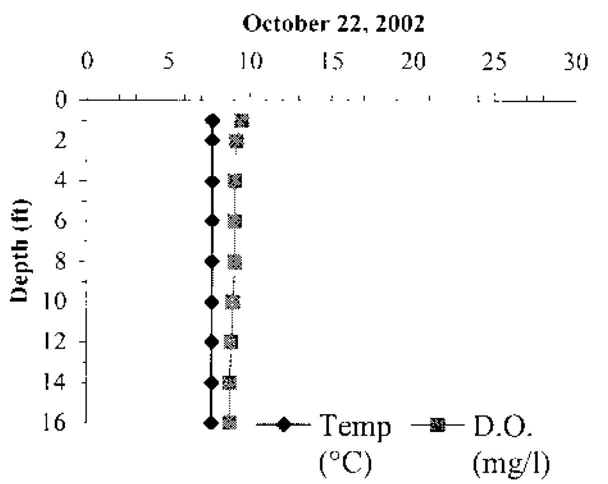
Notes:

Alpine Lake

Date:	**10-22-02**	**Max Depth (ft):**	16.0
Time:	14:35	**ALPLS Depth (ft):**	3.0
Weather:	Partly cloudy, 40°F.	**ALPLB Depth (ft):**	13.0
Ent:	TSN **Verf:** TH/TN	**Secchi Depth (ft):**	10.6

Depth (ft)	Temp (°C)	D.O. (mg/l)	pH	Sp. Cond (µS/cm)
1.0	7.7	9.5	8.5	338
2.0	7.7	9.2	8.5	338
4.0	7.7	9.1	8.6	338
6.0	7.7	9.1	8.6	338
8.0	7.7	9.1	8.5	338
10.0	7.7	9.0	8.5	338
12.0	7.7	8.9	8.5	338
14.0	7.7	8.8	8.5	338
16.0	7.7	8.8	8.5	338

Parameter	ALPLS	ALPLB
Total P (mg/l)	0.016	0.014
Dissolved P (mg/l)		
Chl a (µg/l)	8.09	
TKN (mg/l)		
NO_4+NO_3-N (mg/l)		
NH_3-N (mg/l)		
Total N (mg/l)		
Lab Cond. (µS/cm)		
Lab pH		
Alkal (mg/l $CaCO_3$)		
Total Susp Sol (mg/l)	0	0
Calcium (mg/l)		



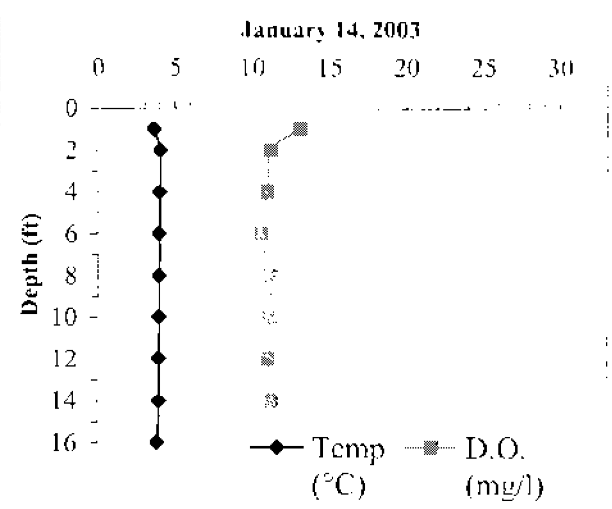
Notes:

Alpine Lake

Date:	**01-14-03**	**Max Depth (ft):**	17.9
Time:	13:50	**ALPLS Depth (ft):**	3.0
Weather:	7F, Sunny, Breezy	**ALPLB Depth (ft):**	13.0
Ent:	tsn **Verf:** TH/TN	**Secchi Depth (ft):**	10.6

Depth (ft)	Temp (°C)	D.O. (mg/l)	pH	Sp. Cond (µS/cm)
1.0	3.6	13.1	8.1	380
2.0	4.0	11.2	8.1	378
4.0	4.0	11.0	8.1	378
6.0	4.0	10.6	8.2	378
8.0	4.0	11.2	8.2	380
10.0	4.0	11.2	8.2	378
12.0	4.0	11.1	8.2	376
14.0	4.0	11.3	8.2	379
16.0	3.9	11.0	8.2	379

Parameter	ALPLS	ALPLB
Total P (mg/l)	0.013	0.014
Dissolved P (mg/l)		0.000
Chl a (µg/l)		
TKN (mg/l)	0.26	0.40
NO_2+NO_3-N (mg/l)	0.465	0.483
NH_3-N (mg/l)	0.112	0.117
Total N (mg/l)	0.73	0.88
Lab Cond. (µS/cm)		
Lab pH		
Alkal (mg/l $CaCO_3$)		
Total Susp Sol (mg/l)	0	
Calcium (mg/l)		



Notes: Ice thickness = 0.6