UPPER AND LOWER POST LAKES

LANGLADE AND ONEIDA COUNTIES, WISCONSIN

COMPREHENSIVE LAKE MANAGEMENT PLANS

Prepared for the

Post Lakes Protection & Rehabilitation District

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SUMMARY

Comprehensive studies of Upper and Lower Post Lakes, Langlade County, Wisconsin were completed during 2001 and 2002. The studies were completed to provide information concerning the lakes and their watersheds so comprehensive lake management plans could be written for each lake. Funding for these studies and the development of the plans were provided by the Wisconsin Department of Natural Resources Lake Management Grant Program and the Post Lakes Protection and Rehabilitation District.

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

- Water quality within Upper and Lower Post Lakes generally fluctuates between fair and good and indicates that both lakes are and have been in a eutrophic state at least since the mid 70's.

- Both lakes appear to only weakly stratify at the water quality sampling sites. Upper Post Lake did not show signs of major occurrences of anoxic conditions, while Lower Post Lake followed this same course during all sampling events with the exception of the winter (February 2002) sample. During this profile event, there was a strong tendency towards anoxia likely as the result of plant decomposition.

- Field-verified land use data and subsequent modeling indicate that the majority of each lake's watershed is currently forested (Upper Post = 61% forested and Lower Post = 68% forested) and that these forested areas contribute about 50% of the annual total phosphorus load entering each lake.

- When compared to other flowages in the state and ecoregion, Upper Post Lake appears to support a relatively high quality plant community; however, when the size of the lake is considered along with the species that exist on a regular basis, it is likely that the plant population is not all it could be.

- Plant surveys within Lower Post Lake indicate that the lake's community has improved somewhat since the surveys that were completed in the 60's and 70's. However, these improvements have not elevated the quality of the plant community over those found in other flowages within the state and ecoregion.

- The plant biomass in Lower Post Lake reached nuisance levels during the current study causing navigational difficulties within the lake. Past nuisance levels have led to fishkills within Lower Post Lake due to anoxic conditions spurred by plant-decomposition under ice.

- The aquatic plant surveys also indicated that both lakes exhibit a definite lack of emergent plant species. Anthropogenic activities have likely played a role in minimizing the emergent community within both lakes.

- The exotic plant species, purple loosestrife was found around both lakes, while another exotic, curly-leaf pondweed, was only found in Upper Post Lake.

Major recommendations to the Post Lakes Protection and Rehabilitation District include the following:

- The best way to protect the water quality within both lakes will be to take steps minimize the external sources that feed phosphorus into the lakes; including continued septic system inspections, enforcement of state and county shoreland zoning laws, the support of local zoning regulations that would limit the conversion of forested and other natural areas into agriculture or developed areas, and the enforcement of state wetland regulations.

- Expanded water quality monitoring was recommended to include sample collections during the summer months on both lakes and dissolved oxygen profiles during the winter on Lower Post to monitor and assess the effectiveness of the plant harvesting in alleviating anoxic conditions within the lake.

- Trial enhancements of each lake's aquatic plant community through native, emergent plantings were recommended in conjunction with expanded slow-no-wake areas within both lakes in order to protect sensitive areas.

- Continued monitoring and potential herbicide treatment of curly-leaf pondweed within Upper Post Lake, as guided by the WDNR, were recommended.

- Continued aquatic plant harvesting, following the harvesting plan developed by the WDNR and the PLPRD, was recommended for Lower Post Lake in order to alleviate navigation difficulties and to help reduce the potential for anoxic conditions during winter stratification.

- Implementation of a boat launch monitoring program was recommended in order to help prevent the introduction of aquatic invasives and to raise lake user awareness of them.

- Continued lake user education was also stressed as a means to raise awareness of everyone's role in protecting the Post Lakes as important natural resources.

- The District was urged to seek professional advice concerning the controversial maintenance of the lakes' water levels.

- It was suggested that the District attempt to build its management capacity through the development of tools that would help it minimize controversy and maximize consensus-based decision making.

INTRODUCTION

Upper Post Lake, Langlade County, WI, is a 758-acre impoundment with a maximum depth of 14-feet and a mean depth of 6-feet (Figure 1). Upper Post Lake is linked to Lower Post Lake, a 378-acre impoundment with a maximum depth of 9-feet and a mean depth of 3-feet, to the south through the use of the same dam (Figure 1). Neither lake drains into the other, but instead each drains directly into the Wolf River. This results in separate watersheds for both Lower Post Lake (5660-acre) and Upper Post Lake (66,747-acre).

The Post Lakes Protection and Rehabilitation District (PLPRD) was formed in 1975 and has been very active in the protection and enhancement of the Post Lakes. For example, the PLPRD in partnership with the Post Lake Improvement Association, initiated an educational program on shoreland restoration that led to numerous completed and planned shoreland restorations on both Upper and Lower Post Lakes. The partnership also initiated fish stocking programs, the construction of a canoe portage at the dam, boat patrols, water quality monitoring, construction of a walleye-spawning reef, and the installation of marker buoys. Members of the PLPRD were also instrumental in organizing the newly formed Langlade County Waterways Association. Through partnerships with the countywide association, the Wisconsin Association of Lakes, and with other individual lake associations in the vicinity, the PLPRD has demonstrated its dedication to responsible management of our State's lakes.

The purpose of the project reported on here was to collect additional information concerning lake water quality, aquatic vegetation, and influences of each lake's watershed. These data along with data previously collected were then used to create lake management plans specific to the needs of the Post Lakes and the Post Lake Protection and Rehabilitation District. This document is a combination of the final report and the lake management plan.

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 Plans for both Upper and Lower Post Lakes. 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 (Appendix C.). Furthermore, the reporting of specific data is kept to a minimum within the text, but is wholly contained within the appendices. The management plans were combined as much as possible to reduce redundancy; however, some sections were naturally separated because even though the lakes are geographically similar, they are different in many ways.

Each 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 lakes display problems in different 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:

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 the growth rates of the plants within the lake.
2. **Chlorophyll-*a*** is the pigment in plants that is used during *photosynthesis*. Chlorophyll-*a* concentrations indicate 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, Wisconsin lakes and impoundments, 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, 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.

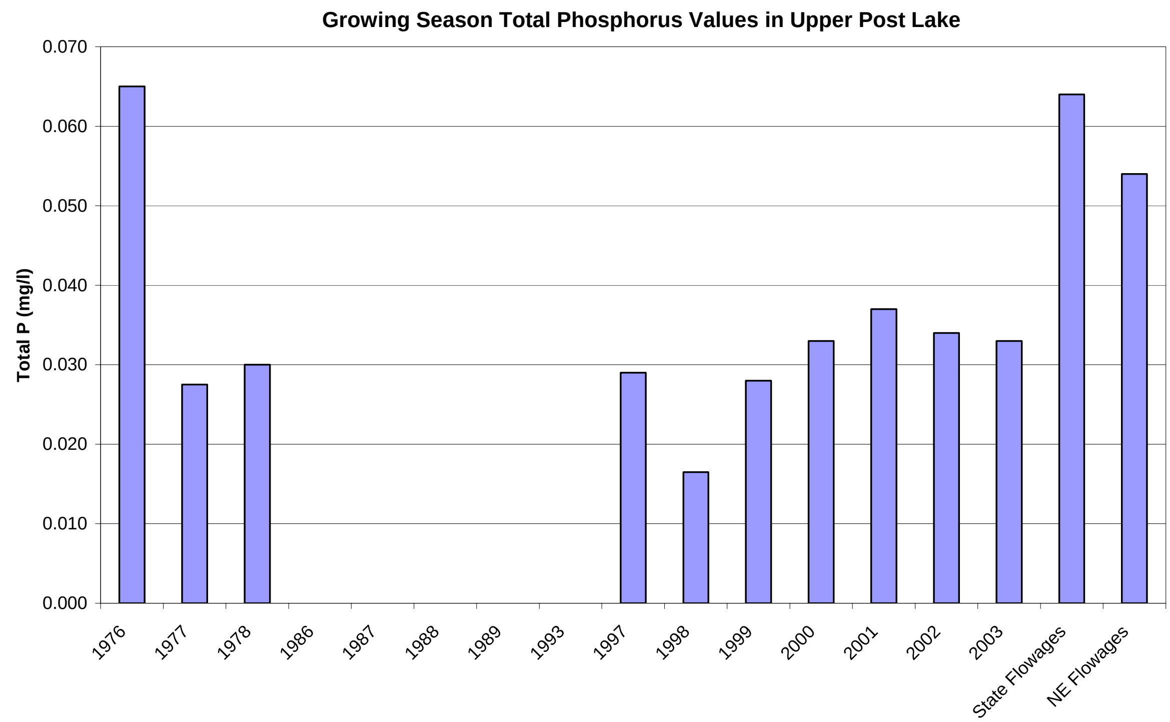
The complete results of these three parameters and the other chemical data that were collected at the Post Lakes can be found in Appendix A. The results and discussion of the analysis and comparisons described above can be found in the paragraphs and figures that follow.

Comparisons with Other Datasets

Lillie and Mason (1983) is an excellent source for comparing lakes within specific regions of Wisconsin and within the state itself. They divided the state's lakes into five regions each having lakes of similar nature or apparent characteristics. Langlade County lakes are included within the study's Northeast Region. These data along with data specific to impoundments within the Northeast Region and from the studies completed for this project are displayed in Figures 2 and 3. Please note that the data in these graphs represent concentrations and depths taken only during the growing season (spring turnover – fall turnover) in the deepest locations in the lakes (Figure 1). Furthermore, discussions concerning phosphorus and chlorophyll-*a* only include results from 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). Normally, summer month averages would also be included in this analysis and within the graphs, but there is very little summer month data available for either of the lakes. Additionally, the data collected concerning state means reflects only data collected during summer months; however, examination of the current study's data concerning differences between summer and growing season means revealed little difference, so comparisons between current study growing season means and statewide summer means are used. Unfortunately, chlorophyll-*a* samples were only collected on one previous occasion for each lake; therefore, these data are not reflected here, but are displayed in the trophic state index graphs (see the Lake Trophic State and Limiting Nutrient Section).

Considering the full set of Post Lakes data (historic and current), it is obvious that the values for phosphorus and water clarity fluctuate from year to year. This is normal because so many factors affect these parameters on a seasonal and annual basis. Precipitation, cloud-cover, nutrient forms (particulate, dissolved), lake use, among others, all play a role in these parameters. It must be noted, that for the data depicted in Figures 2 & 3, some of the annual values shown actually correspond to single values that may have occurred during a turnover event or during a single summer month; therefore, much of the annual fluctuation within these data are mostly accountable through seasonal differences.

The Water Quality Index (WQI) developed by Lillie and Mason (1983) (Table 1) is an excellent reference for gauging the quality of lake water through the three parameters that we concentrate on here. The total phosphorus values for Upper Post are largely centered on the line between good and fair while the water clarity values occur mostly in the range of very poor or poor. As mentioned above, the largest contributor to decreased water clarity in most Wisconsin lakes is algal abundance. Considering that the mean summer chlorophyll-*a* value for Upper Post Lake during the current study was 18 µg/l (within the poor range of the WQI), it is not surprising that the lake experiences decreased water clarity values. However, this chlorophyll-*a* level for Upper Post Lake does fall slightly below the state mean for flowages of 22.3 µg/l. Oddly, this similarity does not carry through concerning the state flowage mean Secchi disk depth. Normally, it would be expected that because the state average for chlorophyll-*a* is higher than that of Upper Post, the state average for Secchi disk would be similar or lower. However, this is not the case (Figure 3). Actually, the state summer mean is slightly better than that of Upper Post Lake. A possible explanation for this difference may be that the water clarity within Upper Post Lake may also be highly influenced by other factors such as suspended sediment and/or water color.



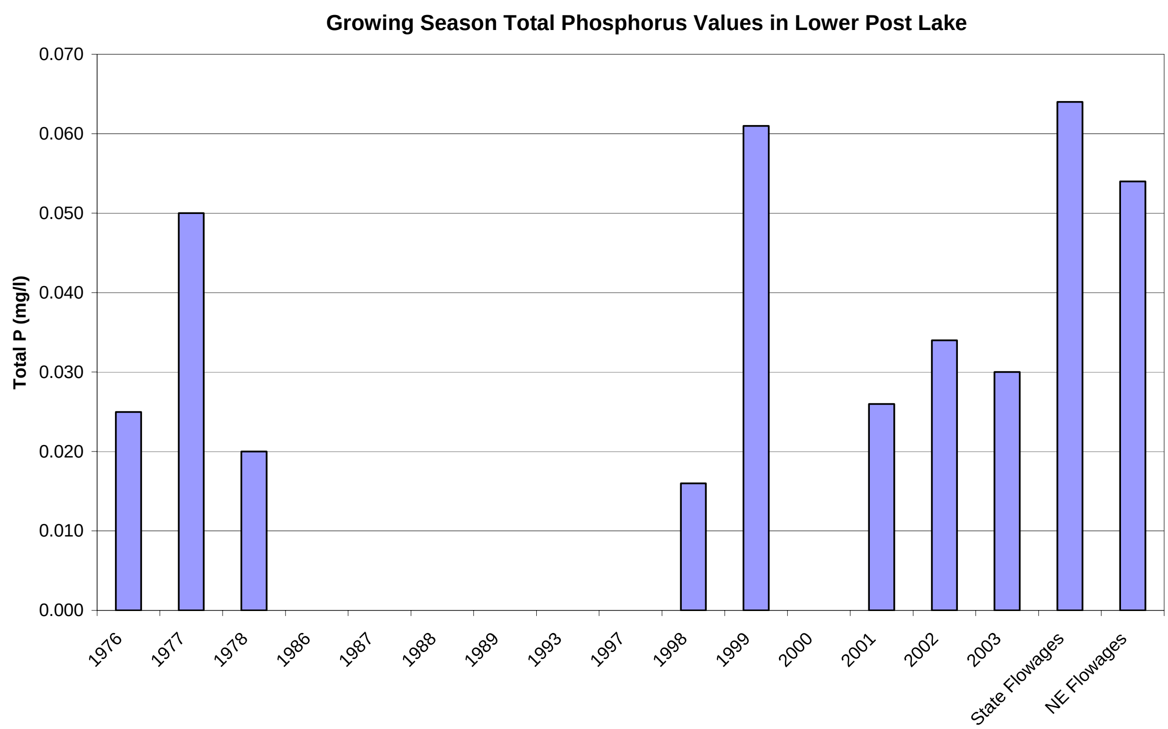
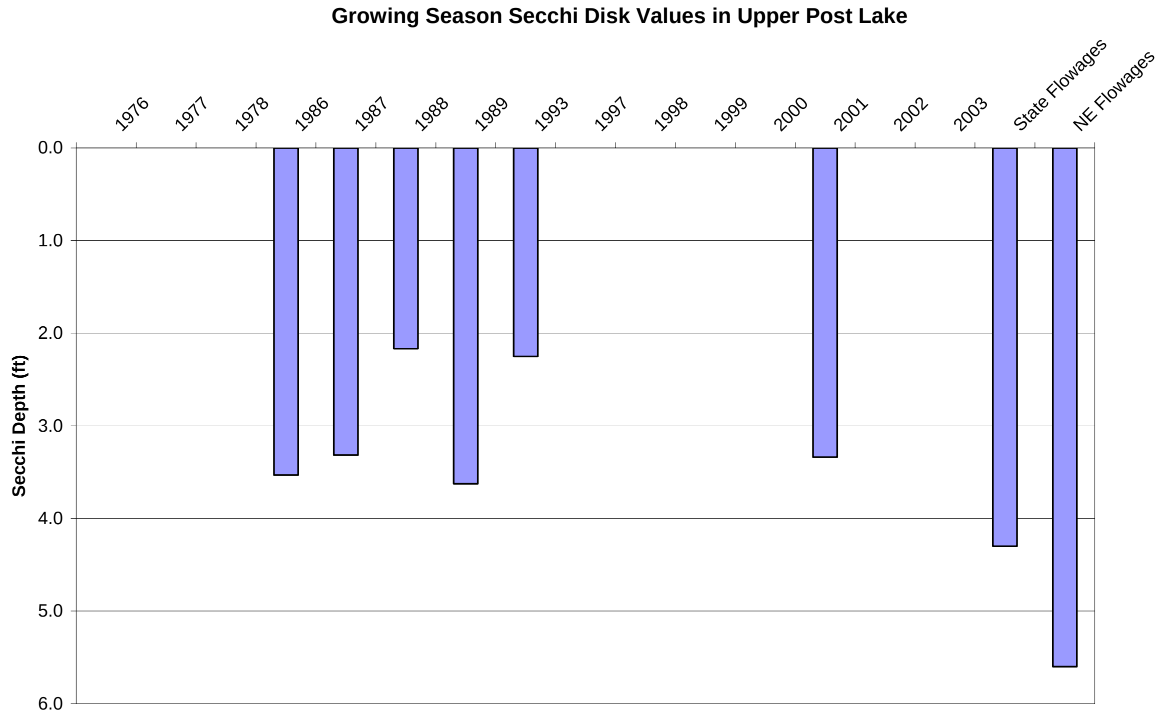


Figure 2. Total phosphorus concentrations from Upper (top) and Lower (bottom) Post Lakes, state and northeast region. All values/means were obtained from growing season surface samples.



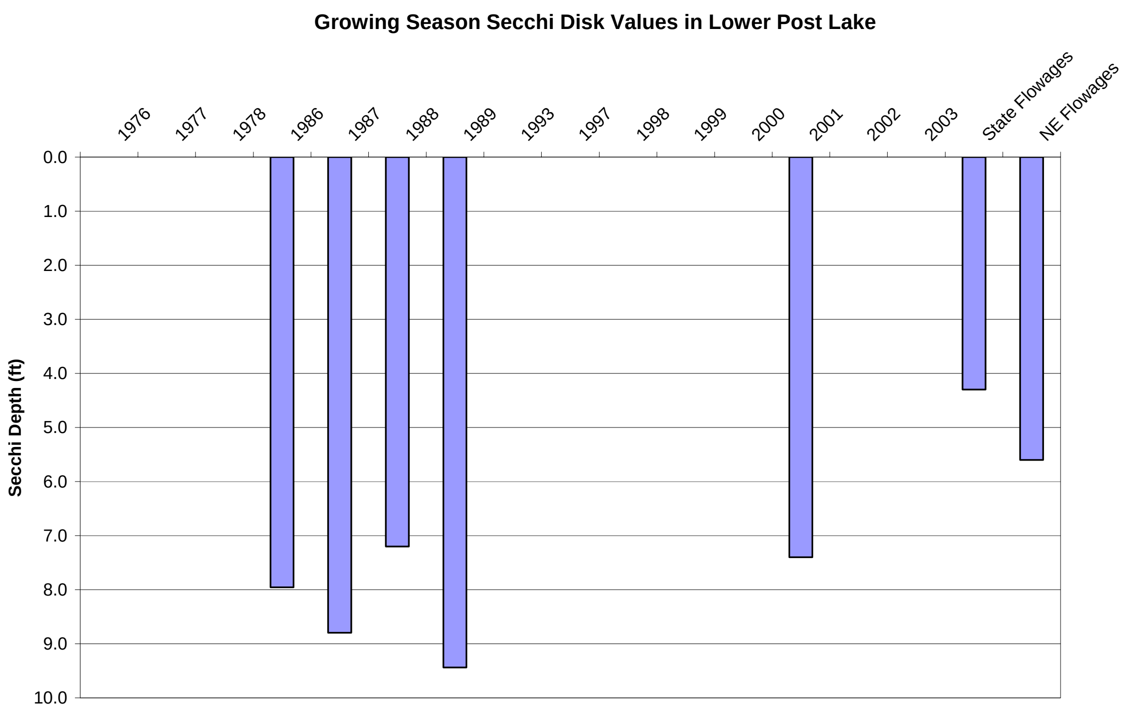


Figure 3. Secchi disk transparencies from Upper (top) and Lower (bottom) Post Lakes, state and northeast region. All values/means were obtained from growing season samples.

Water color (controlled primarily by dissolved organic acids within the water column) is likely the largest influence, next to algal abundance, causing the poor Secchi disk transparencies within Upper Post Lake. In fact, data collected by PLPRD volunteers during 1998-2002 (as analyzed by the University of Wisconsin Stevens Point Environmental Task Force), indicate that the color of Upper Post Lake is slightly higher (less clear) than those normally found within state flowages. This high color value is very apparent by the rich brown hue of Upper Post Lake and is very common within lakes of the Northwoods because of their predominately forested and wetland-dotted watersheds that supply ample amounts of organic acids via the decomposition of plant material. Incidentally, the high concentrations of organic acids are also responsible for the foam that occasionally collects on lakeshores. Many lake users mistakenly believe the myth that the foam is actually the result of high phosphorus concentrations from soap or other sources; which is not true.

When examining the water quality data of Upper Post Lake, we must take into account two factors, the size of the lake's watershed (discussed later) and the incidence of nuisance algae blooms. During our visits to the lake, we found no evidence of nuisance algae blooms as characterized by abundant algae scums or mats within the lake. Therefore, it must be concluded that although the levels of phosphorus and chlorophyll-*a* are, at times, relatively high, and there is evidence of reduced water clarity within the lake, the water quality of Upper Post Lake is acceptable and tolerable for the time-being.

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.

The water quality of Lower Post Lake, as represented by total phosphorus concentrations and Secchi disk transparency, are for the most part good to fair according to the values found in Table 1. They are also better than those values found in flowages within the Northeast Region and the state. Furthermore, the mean summer chlorophyll-*a* value of 4 µg/l found during this study is considered very good by the WQI and well below the averages found within lakes (including natural lakes) within the Northeast Region and state flowages (9.3 µg/l and 22.3 µg/l, respectively). The better than average water quality of Lower Post Lake is likely attributable to the incredible macrophyte biomass found within the lake. In general, lakes are dominated by only one of the major classes of plants – macrophytes or algae. Both of these plant types compete for light and nutrients. Lower Post Lake is clearly dominated by macrophytes. The macrophytes absorb phosphorus from the water column and the sediments leaving very little available to algal production. This decrease in algae results in better water clarity. However, the clearer water comes with the price of the nuisance plant population as discussed in the Aquatic Vegetation Section.

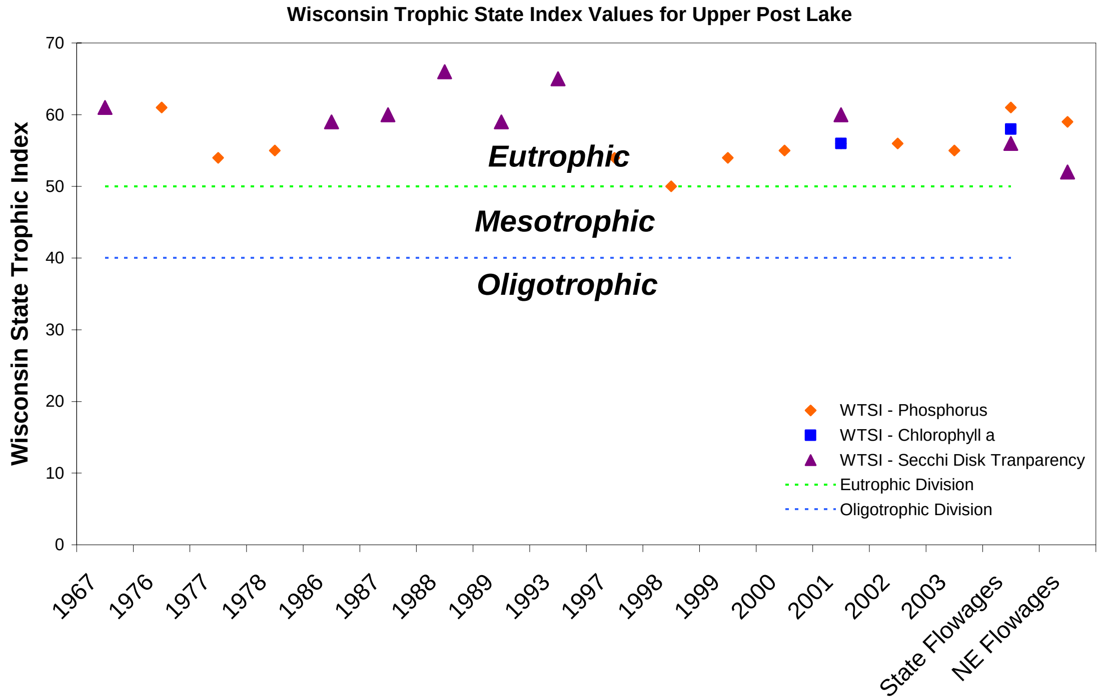
Lake Trophic State and Limiting Nutrient

Figure 4 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 growing season in the Post Lakes. 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.

These data clearly indicate that Upper Post Lake is eutrophic. It is very important that this eutrophic nature not be considered a bad aspect of the lake. The truth of the matter is that Upper Post Lake has a very large watershed and that lakes with large watersheds naturally experience higher phosphorus concentrations (this relationship is further explained in the Watershed Analysis Section). As explained above, these higher phosphorus concentrations usually lead to increased algae content and reduced water clarity. What truly matters is the way the lake exhibits its eutrophic state. Again, Upper Post Lake does not appear to have significant problems with nuisance algae blooms; probably as a result of the quality macrophyte community (see the Aquatic Vegetation Section) that occurs within the lake. The same macrophyte community that keeps algae blooms in check also provides valuable fisheries, insect, and wildlife habitat within the lake – a valuable component that is often lacking in lakes further down the trophic state. Furthermore, lake users must also remember that eutrophic lakes are not always on the road to "lake death" as many people believe. The fact is that lakes can remain in a healthy, eutrophic state for hundreds, if not thousands of years and that Upper Post Lake has likely been in this condition for many decades, maybe even as far back as its creation.

Examination of the Lower Post Lake data concerning its trophic state is not as straight forward as that for Upper Post Lake. The results of these analyses (Figure 4) 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 Lower Post 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, Lower Post 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, Lower Post Lake falls within a eutrophic/mesotrophic state. Yet, if we take into account the incredible macrophytic production with the lake, it is obvious that the trophic state of Lower Post Lake is much more eutrophic than shown by these three parameters.

As described above, most Wisconsin lakes are phosphorus limited and the Post Lakes are no exception. Data collected during the summer of 2001 result in nitrogen to phosphorus ratios greater than 22:1 for both lakes. Lakes with ratios greater than 15:1 are considered to be phosphorus limited. In other words, phosphorus controls the algal abundance within each lake.



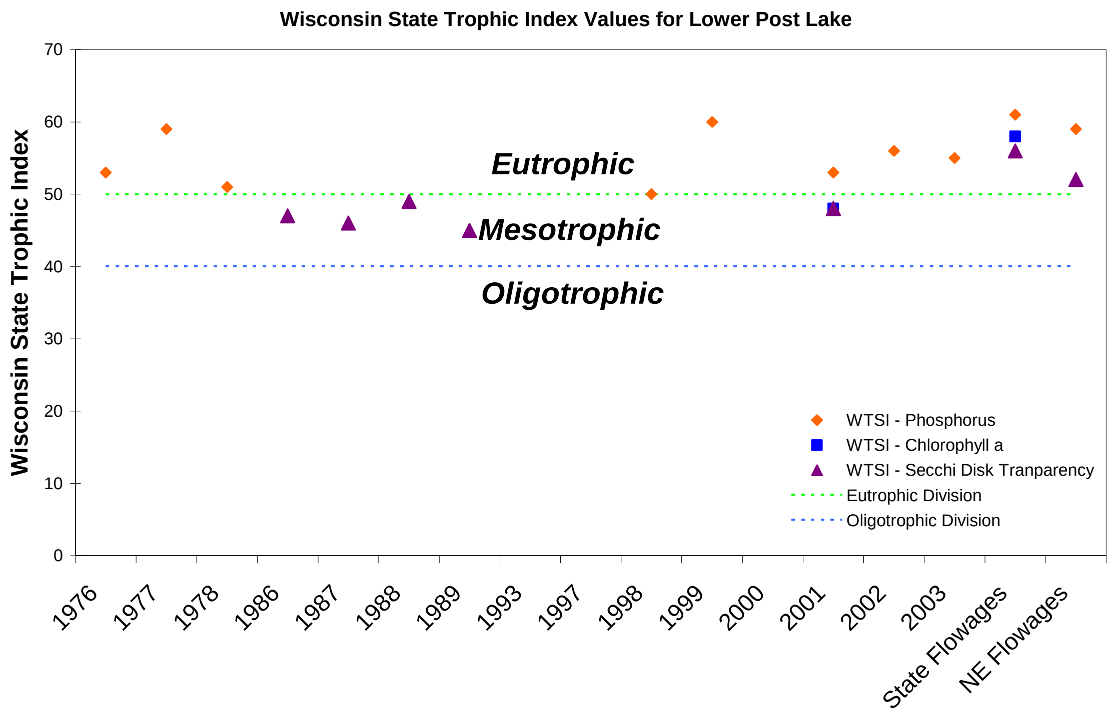


Figure 4. Wisconsin State Trophic Index results for Upper (top) and Lower (bottom) Post lakes.

Internal Phosphorus Loading / Temperature and Oxygen Profiles

In lakes that exhibit 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.

As detailed above, internal nutrient loading is only significant in lakes that exhibit strong levels of water column stratification. With the exception of the February 26, 2002 profile for Lower Post Lake (Figure 5), neither lake appears to support strong stratification. This is especially apparent if only the temperature profiles are considered. Overall, both lakes likely mix many times over the summer as the result of wind and tributary inflows, which reduces the opportunity for internal nutrient loading to become a major source of phosphorus. At a minimum, Lower Post Lake may experience limited internal loading during the spring turnover, but this is not apparent by the formation of spring algae blooms. Furthermore, water quality data collected during the February 2002 sample visit indicates that the winter hypolimnetic total phosphorus level of 0.028 mg/l is well below the 0.050 mg/l concentration that is usually considered the threshold level between lakes that have significant internal loading and those that do not.

The only significant concern resulting from these profiles is the low oxygen levels that can occur under the ice in Lower Post Lake. These low levels are caused by the consumption of oxygen by the decomposition of the exorbitant plant biomass that is produced during the growing season. Hopefully, continued harvesting will reduce this occurrence (see Aquatic Vegetation Section).

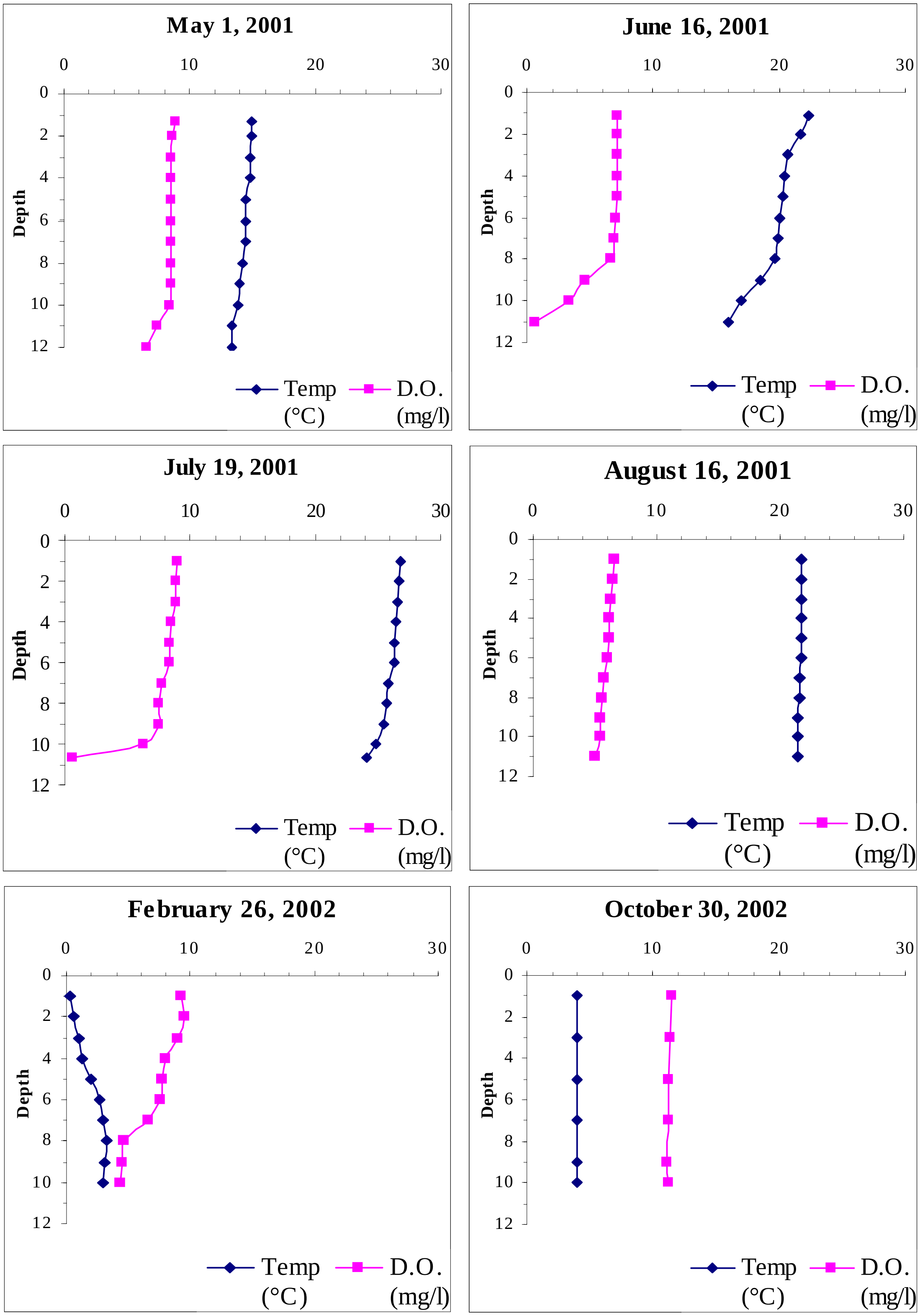


Figure 5. Results of temperature and dissolved oxygen profiles for Upper Post Lake.

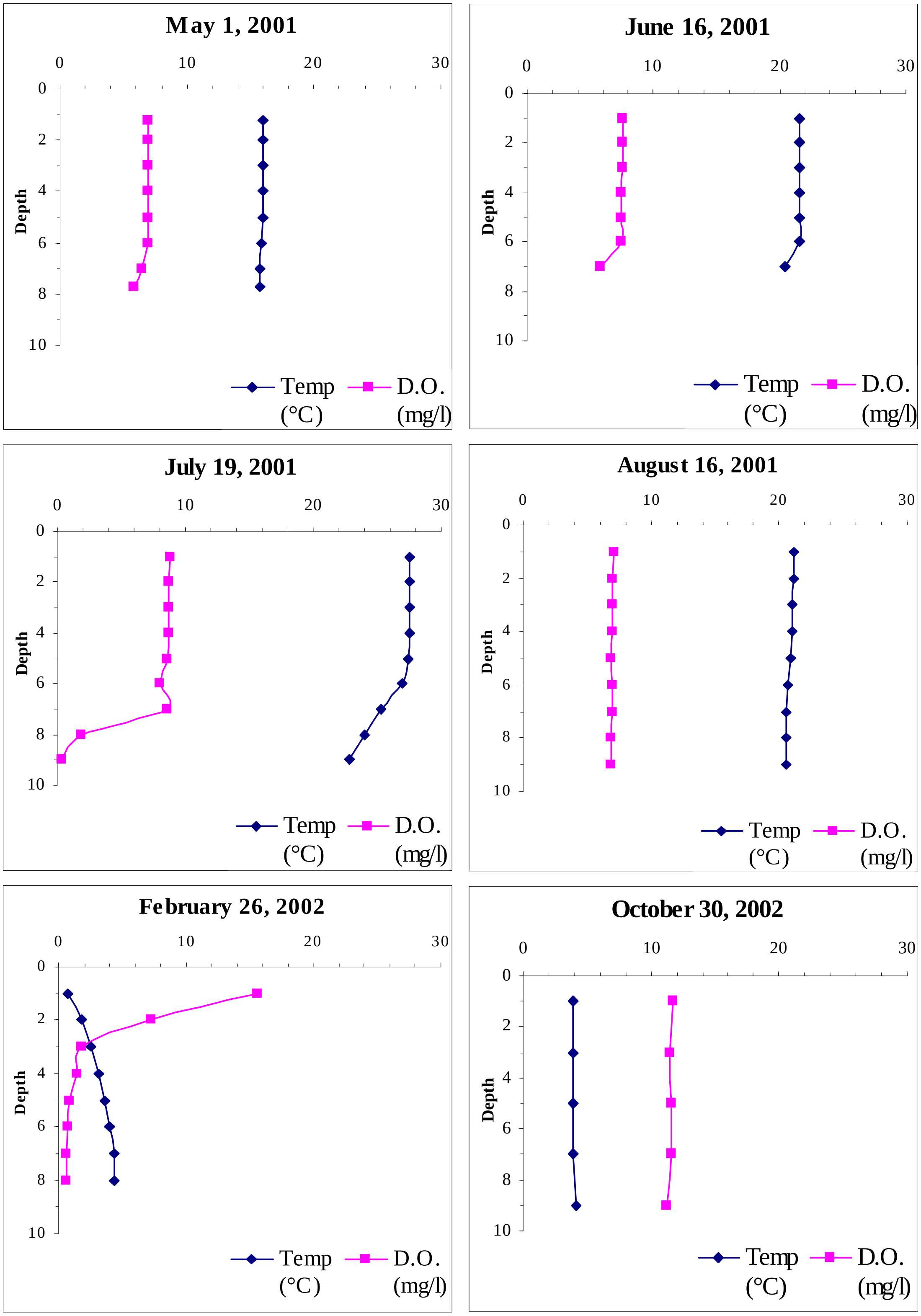


Figure 5 (con't). Results of temperature and dissolved oxygen profiles for Lower Post Lake.

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 where 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 (roto-tilling of bottom sediments to dislodge plants) 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 the Post Lakes, 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. If control methods are warranted, the applicability of certain methods is discussed within the recommendations.

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 contact period and is only applicable in whole lake treatments or in bays and backwaters where dilution can be controlled. It should be noted that Fluridone does not work well in flowage systems and that 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.

<u>Endothal</u> (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.

<u>2,4-D</u> (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.

<u>Biological Controls</u>

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 – Upper Post Lake

We found 28 species during our field surveys on Upper Post Lake (Table 2). This is a slight increase in *species richness* compared to the 25 species found in 1977 (WDNR 1978) and is probably the result of a combination of varying survey methods and species introductions by *anthropogenic* and natural means. Two exotic species were discovered, purple loosestrife (*Lythrum salicaria*) and curly-leaf pondweed (*Potamogeton crispus*). Both are considered invasive species, but have the possibility of being controlled if detected early.

Purple loosestrife is an invasive exotic species that was brought over from Europe during the 1800's as an ornamental garden plant. It is tolerant of a wide range of physical and chemical conditions, and as a result, has aggressively spread to 70 of the 72 counties in Wisconsin (WDNR Data 2001). The aggressive spread has been facilitated by the mature plant's ability to produce over 2 million seeds per year. Although seeds require wet conditions to germinate, they can remain viable in soil for over a year, allowing transport and dispersal by a variety of methods. The extreme proliferation abilities of purple loosestrife allow it to completely dominate whole wetlands; destroying habitat and providing no value to wildlife. Fortunately, only three areas containing two to three plants were found during the Upper Post Lake survey.

Table 2. Aquatic vegetation identified during summer of 2001 survey at Upper Post Lake.

	Common Name	Scientific Name	Coefficient of Conservatism (C)	Notes
Emergent	Common arrowhead	*Sagittaria latifolia*	3	
	Floating-leaf bur-reed	*Sparganium fluctuans*	10	
	Grass-leaved arrowhead	*Sagittaria graminea*	9	Incidental
	Marsh cinquefoil	*Potentilla palustris*	6*	
	Pickerelweed	*Pontederia cordata*	9	Incidental
	Purple loosestrife	*Lythrum salicaria*		Incidental/Exotic
	Softstem bulrush	*Scirpus validus*	4	Incidental
Floating-leaf	Forked duckweed	*Lemna trisulca*	6	
	Great duckweed	*Spirodela polyrhiza*	5	
	Lesser duckweed	*Lemna minor*	5	
	Spatterdock	*Nuphar variegata*	6	
	White water lily	*Nymphaea odorata*	6	
Submergent	Common bladderwort	*Utricularia vulgaris*	7	
	Common waterweed	*Elodea canadensis*	3	
	Coontail	*Ceratophyllum demersum*	3	
	Curly-leaf pondweed	*Potamogeton crispus*		Exotic
	Fern pondweed	*Potamogeton robbinsii*	8	
	Flat-stem pondweed	*Potamogeton zosteriformis*	6	
	Illinois pondweed	*Potamogeton illinoensis*	6	
	Large-leaf pondweed	*Potamogeton amplifolius*	7	
	Leafy pondweed	*Potamogeton foliosus*	6	
	Muskgrasses	*Chara sp.*	7	
	Northern water milfoil	*Myriophyllum sibiricum*	7	
	Sago pondweed	*Potamogeton pectinatus*	3	
	Slender waterweed	*Elodea nuttallii*	7	
	Stonewarts	*Nitella sp.*	7	
	Water stargrass	*Zosterella dubia*	6	Incidental
	Wild celery	*Vallisneria americana*	6	

*Mean C value was used based on other species present because no C value was available.

Curly-leaf pondweed is a European exotic first discovered in Wisconsin in the early 1900's that has an odd lifecycle, allowing it to out compete 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. This exotic plant can become so abundant it hampers navigation, fishing, and other recreational activities. It can also cause mid-summer algal blooms spurred from the nutrients released during the plant's decomposition after it dies in July.

Two separate areas were found containing curly-leaf pondweed (Figure 6); a small patch (<0.5-acres) near the southern most tributary entrance on the east side of the lake and another, much larger patch (approximately 8.5-acres), at the mouth of Pollock Creek.

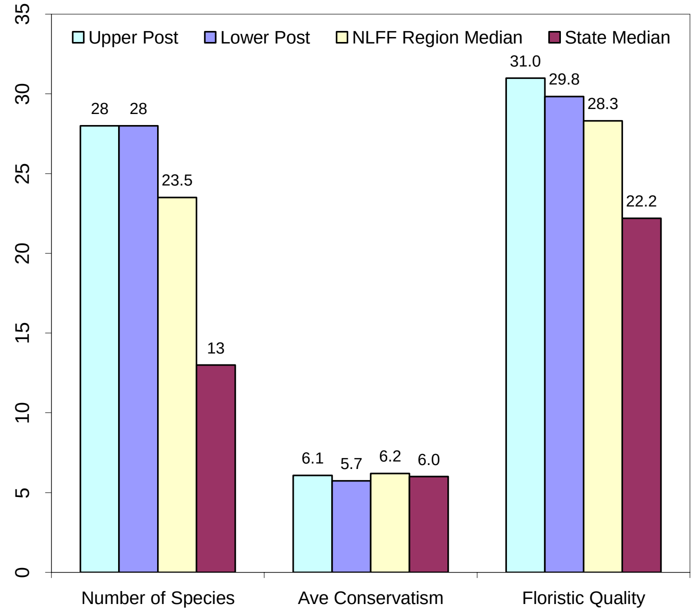


Figure 7. Results of Floristic Quality Assessment for Upper and Lower Post Lakes. Note: Number of species used in FQA does not include exotics (Upper Post: 26, Lower Post: 27)

As mentioned above, we located 28 species within Upper Post Lake. Excluding the two exotic species, the *species richness* for Upper Post Lake (Figure 7) is well above the state median and slightly above the Northern Lakes and Forests, flowages (NLFF) (Figure 8) regional median (Nichols 1999). This pattern carries through when comparing the Floristic Quality Index (FQI) value of Upper Post Lake with the median values for the NLFF and the state (Figure 7). This is expected because the FQI is a function of species richness and average C values, which were similar for the region, state and Upper Post Lake (Figure 7). Overall, these findings indicate that Upper Post Lake's floristic quality is similar or slightly above that of other lakes found in the NLFF and much higher than the state median. The fact that most of the NLFF region is forested and undeveloped has allowed the lakes and flowages of that area to retain their quality plant communities (Nichols 1999).

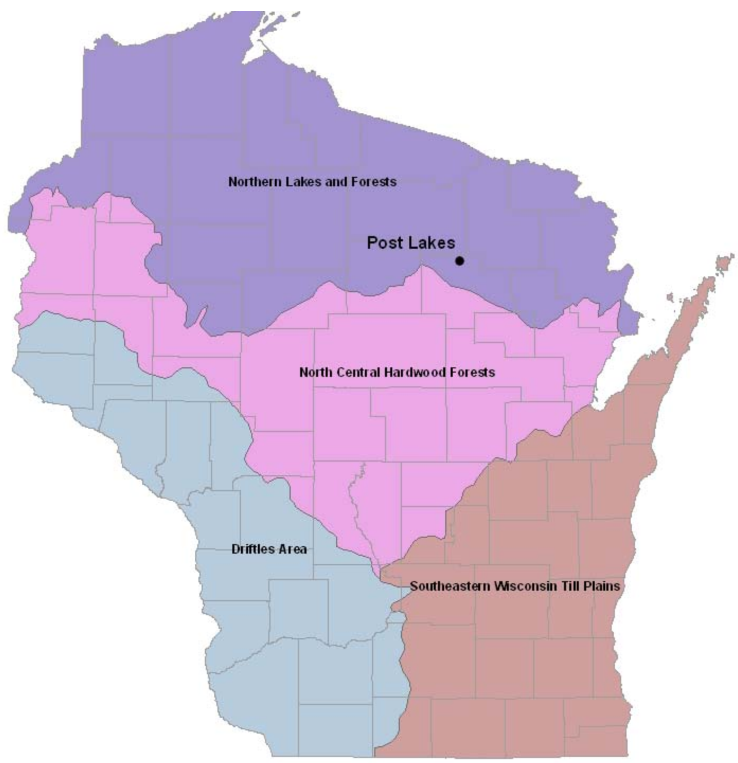


Figure 8. Location of Post Lakes relative to the ecoregions of Wisconsin after Nichols 1999 and Omernick and Gallant 1988.

As indicated in Figure 9, wild celery (*Vallisneria americana)* is the most prevalent species in Upper Post Lake, both in terms of its occurrence and its coverage (Figure 10). This species is turbidity tolerant and has an affinity for hard substrates (Nichols 1999), which explains why it is so commonly found in the sandy areas of the Upper Post Lake. Wild celery is considered a beneficial plant because it is an excellent food source for waterfowl and provides cover and food for fish.

There is a definite lack of emergent plants within Upper Post Lake (<0.7%), which is unfortunate because this type of macrophyte community provides excellent aquatic habitat and is the preferred spawning substrate for northern pike (*Esox lucius*) and yellow perch (*Perca flavescens)* (Becker 1983). The lack of this community type is likely related to boat traffic and the reduction of suitable substrate from shoreline rip-rapping and development. Examination of the aquatic plant survey data (Figure 6) supports this because the existing emergent populations within Upper Post Lake are primarily located in protected bays or in areas that are currently enforced as slow-no-wake zones.

The FQI for Upper Post Lake is slightly above the *median* value for lakes in the NLFF region. However, this may be misleading because the FQI does not consider the frequency of occurrence or the coverage of each species. In Upper Post Lake, wild celery is by far the most dominant species considering frequency of occurrence and coverage estimates. With the exception of coontail (*Ceratophyllum demersum*) and slender waterweed (*Elodea nuttallii*), all other species had frequency of occurrences well below 0.2. Furthermore, wild celery covers a great deal more of the *littoral zone* than any other plant (Figure 10). This indicates that Upper Post Lake has a relatively high quality species composition, but it has a relatively low *species diversity*. Considering the low diversity along with two other facts; 1) that larger lakes are significantly correlated with higher FQI values (Nichols 1998), and 2) that Upper Post Lake is over four times larger than the average lake in northern Wisconsin (Lillie and Mason 1983), leads to the conclusion that the macrophytic community in Upper Post Lake is not all it could be. As mentioned above, this possible shortcoming could be the result of human activity in the lake and on its shores (i.e., development and recreation) and impacts due to boating (Asplund and Cook 1997). Upper Post Lake certainly has the possibility of supporting a higher quality and possibly more diverse macrophytic community as evidenced by the presence of three species that prefer undisturbed habitat: grass-leaved arrowhead (*Sagittaria graminea)* and pickerelweed (*Pontederia cordata*), each with C values of 9, and floating-leaf bur-reed (*Sparganium fluctuans*) with a C value of 10.

Sensitive Areas

Seven areas of Upper Post Lake are classified as Sensitive Areas in Figure 6. These designations were made because these areas contain higher levels of species richness relative to other areas of the lake and contain aquatic emergent communities, which are considered critical components of Wisconsin's biodiversity by the WDNR Bureau of Endangered Resources because they may provide the habitat for rare, threatened, and endangered species.

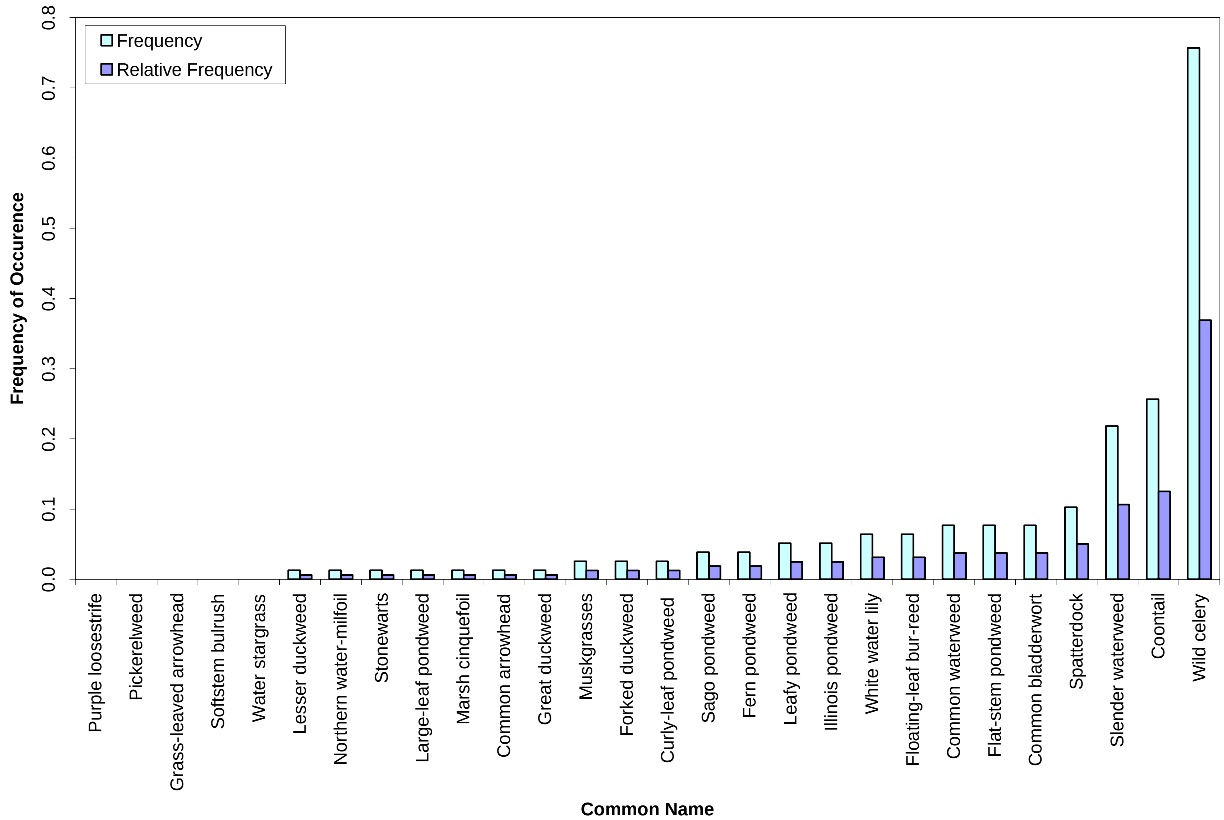


Figure 9. Species occurrence data for Upper Post Lake. Species without data were incidentals.

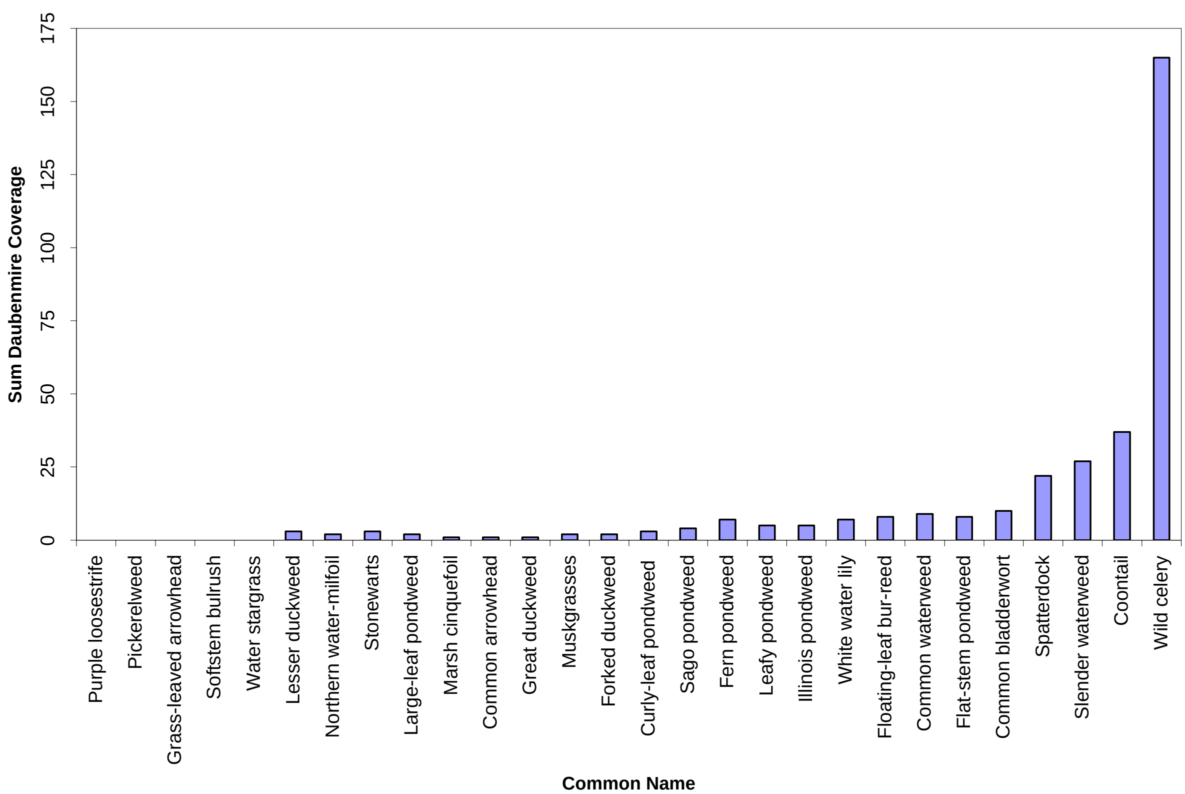


Figure 10. Sum Daubenmire coverage data for Upper Post Lake. Species without data were incidentals.

Analysis of Current and Historic Plant Data – Lower Post Lake

During our survey, we discovered 27 native species of aquatic macrophytes in Lower Post Lake. This is a great improvement over the 14 species found in 1967 and 1976 surveys (WDNR 1978). It is likely that a portion of this increase may be attributable to differences in survey methods; however, it is still apparent that the species diversity in Lower Post Lake has increased in the last 25 to 34 years. In fact, this improvement has elevated the lake's species richness to that of the upper half of lakes in the NLFF region (Figure 7). Unfortunately, all the species that were gained have C values below 7, which allowed the average C value for Lower Post Lake to remain below the median value for lakes in the NLFF region (Figure 7). Combining the species richness values and average C value resulted in a FQI slightly below that of the regional median (Figure 7).

While the comparisons of Lower Post Lake with other lakes in NLFF indicate that Lower Post Lake's floristic quality is not outstanding, comparisons with the 1976 macrophyte survey indicate that its quality is increasing. The 1976 survey found 14 species with an average C value of 5.3 and a FQI of only 19.8. Obviously the lake's floristic quality has improved over the past 25 years. The reason for this increase is not clear, but can probably be accounted through differing survey methods and anthropogenic and natural introductions.

Clearly, the submergent community dominates Lower Post Lake with an approximate coverage of greater than 95% (Figure 11). This is also evident in the fact that the six species with the highest frequencies of occurrence are submergent varieties (Figure 12) and that the top five total coverage values are for submergent species (Figure 13). The nearly complete submergent plant coverage of Lower Post Lake is undoubtedly a function of the lakes shallow depth, excellent water clarity, and soft sediments that were originally wetland soils. At the time of our survey, navigation was hampered by the presence of submergent vegetation in the southern portions of Lower Post Lake because plant growth, primarily slender waterweed, had reached the surface. Navigation was also hindered by floating mats of slender waterweed in that area of the lake. Submergent plants in the rest of the lake had not reached the surface, remaining in excess of four feet below it.

The survey also indicated an incredible lack of emergent plants within Lower Post Lake, which is unfortunate because this type of community provides excellent aquatic habitat and are the preferred spawning substrate for northern pike and yellow perch (Becker 1983). The lack of this community type is likely related to boat traffic and the reduction of suitable substrate by shoreline rip-rapping and development. Examination of the aquatic plant survey data (Figure 11) supports this in that the existing emergent populations within Lower Post Lake are primarily located in protected bays or in areas that are currently enforced as slow-no-wake zones.

The evaluation of floristic quality based on the species list of the 1976 vegetation survey indicated a species composition that was likely indicative of a disturbed system. Over the last 25 years the species richness and quality has improved to the point that the lake's floristic quality is inline with most other flowages in the region. This improvement is a good sign that the plant community is not wholly deteriorating in Lower Post Lake despite development pressures on its shores and within its drainage basin.

However, with this floristic quality improvement, a problem has developed with one of the species that has been introduced since 1976. That species is slender waterweed and it is responsible for recent concerns of District members with regards to recreation boating and fishing and even natural aesthetics. As referred to above, slender waterweed in the southern portion of Lower Post Lake had grown to the water surface making navigation difficult. Floating mats of loose slender waterweed also created navigational difficulties (Figure 14). At the time of our survey, navigation was not difficult in the northern portion of the lake; however, anecdotal information from District members indicates that navigation has been hindered throughout most of the lake in recent years as a result of nuisance levels of slender waterweed.

Table 3. Aquatic vegetation identified during summer of 2001 survey at Lower Post Lake.

	Common Name	Scientific Name	Coefficient of Conservatism (C)	Notes
Emergent	Common bur-reed	*Sparganium eurycarpum*	5	
	Common tussock sedge	*Carex stricta*	6*	Incidental
	Needle spikerush	*Eleocharis acicularis*	5	
	Pickerelweed	*Pontederia cordata*	9	Incidental
	Purple loosestrife	*Lythrum salicaria*		Incidental/Exotic
	Sedge	*Carex sp.*	6*	Incidental
	Softstem bulrush	*Scirpus validus*	4	Incidental
	Spikerush	*Eleocharis sp.*	6*	Incidental
Floating-leaf	Common watermeal	*Wolffia columbiana*	5	
	Forked duckweed	*Lemna trisulca*	6	
	Great duckweed	*Spirodela polyrhiza*	5	
	Lesser duckweed	*Lemna minor*	5	
	Spatterdock	*Nuphar variegata*	6	
	White water lily	*Nymphaea odorata*	6	
Submergent	Clasping-leaf pondweed	*Potamogeton richardsonii*	5	
	Common bladderwort	*Utricularia vulgaris*	7	Incidental
	Common waterweed	*Elodea canadensis*	3	
	Coontail	*Ceratophyllum demersum*	3	
	Fern pondweed	*Potamogeton robbinsii*	8	
	Flat-stem pondweed	*Potamogeton zosteriformis*	6	
	Illinois pondweed	*Potamogeton illinoensis*	6	
	Large-leaf pondweed	*Potamogeton amplifolius*	7	Incidental
	Leafy pondweed	*Potamogeton foliosus*	6	
	Muskgrasses	*Chara sp.*	7	Incidental
	Northern water-milfoil	*Myriophyllum sibiricum*	7	
	Sago pondweed	*Potamogeton pectinatus*	3	
	Slender waterweed	*Elodea nuttallii*	7	
	Wild celery	*Vallisneria americana*	6	

*Mean C value was used based on other species present because no C value was available.

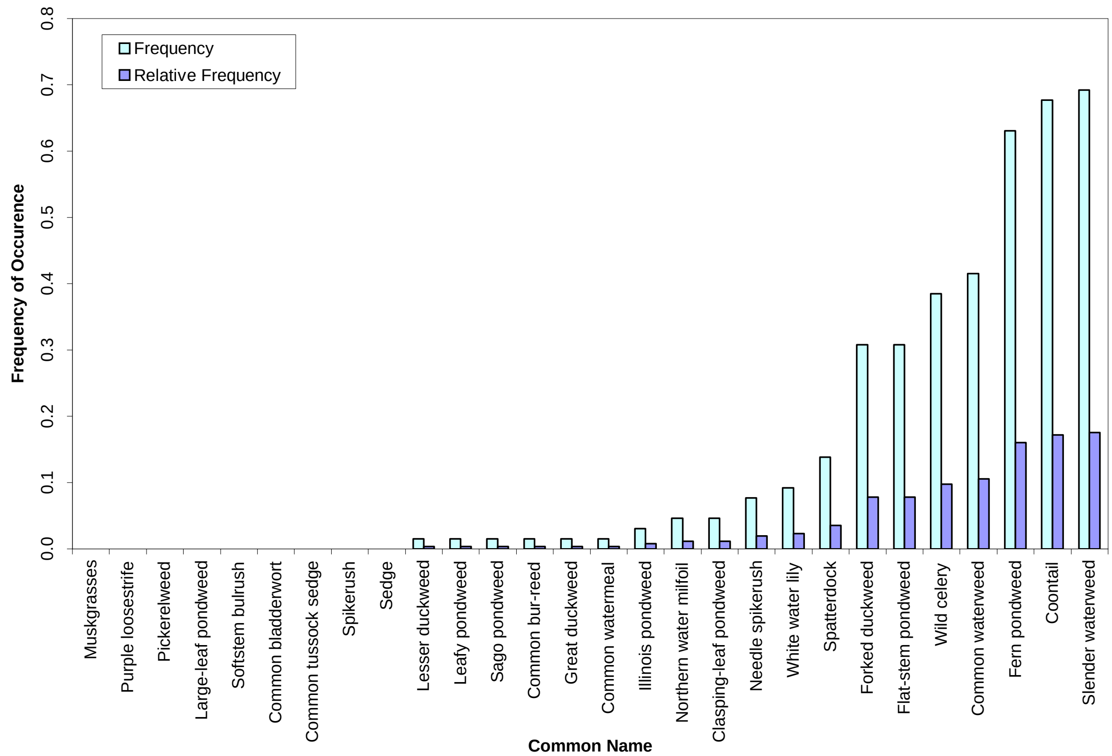


Figure 12. Species occurrence data for Lower Post Lake. Species without data were incidentals.

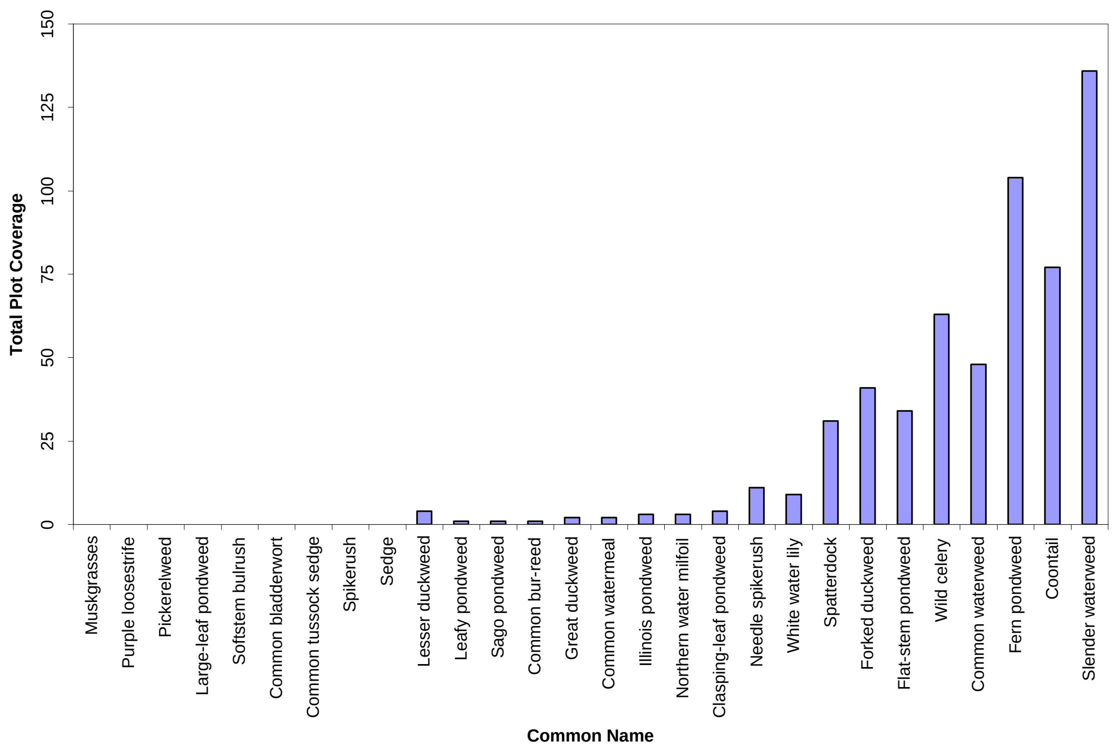


Figure 13. Sum Daubenmire plot coverages for Lower Post Lake. Species without data were incidentals.

Figure 14. Slender waterweed in Lower Post Lake, August 2001.

Sensitive Areas

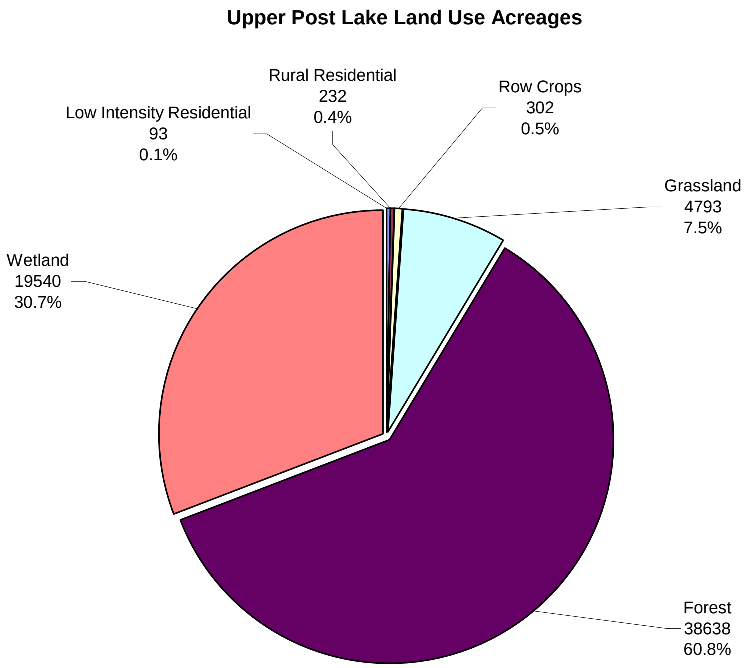
Four areas of Lower Post Lake are indicated as Sensitive Areas in Figure 11. Three of the designated areas contain higher levels of species richness than were found elsewhere in the lake and have aquatic emergent habitat associated with them. The WDNR Bureau of Endangered Resources considers aquatic emergent communities critical components of Wisconsin's biodiversity because they may provide habitat for rare, threatened, and endangered species. The fourth area, located in the bay on the southeastern end of Lower Post Lake, contains suitable habitat for spawning muskellunge (*Esox masquinongy*), including a muck bottom containing detritus matter (Becker 1983).

Watershed Analysis

Both Upper and Lower Post Lakes have relatively large watersheds at 66,747-acres and 5,661-acres, respectively. These large watersheds yield watershed to lake area ratios of 88:1 for Upper Post Lake and 15: for Lower Post Lake. 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, wetlands, and meadows, allow the water to infiltrate into the ground and do not produce excessive 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 Post Lakes watersheds are displayed in Figures 15 and 16. Currently, the majority of land within both watersheds is forested. As mentioned above, forested areas produce very little surface runoff; in fact, these areas allow over 80% of the precipitation that falls on them to infiltrate the ground. Having a large proportion of the watershed in forested land does a great deal to prevent excessive phosphorus loading to the lakes.

Modeling results of the land use types for both watersheds are shown in Figure 17. These results are favorable considering the sizes of the watersheds. Fortunately for both lakes, the land use types that normally create the most concern because they contribute the most to a lake's annual phosphorus load, urban development and agricultural use, are actually contributing very little of the total loads (Upper Post: 6631 lbs P/yr, Lower Post: 638 lbs P/yr) entering the lakes. In the end, these results indicate that the watersheds of Upper and Lower Post Lakes are contributing the minimal amounts of phosphorus to the lakes that can be expected for watersheds of these sizes. This is the case because the majority of each lake's watershed is currently in land use categories that tend to leach minimal amounts of phosphorus to the lakes.



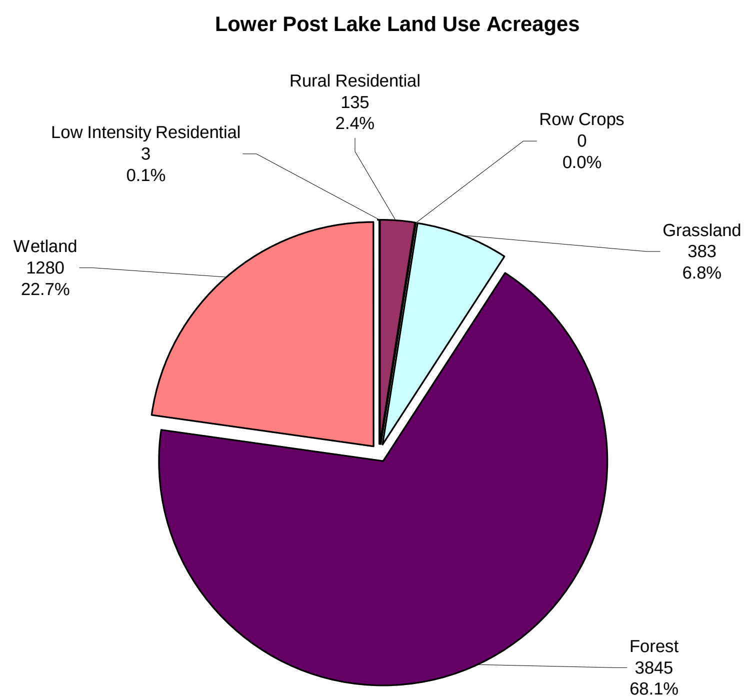
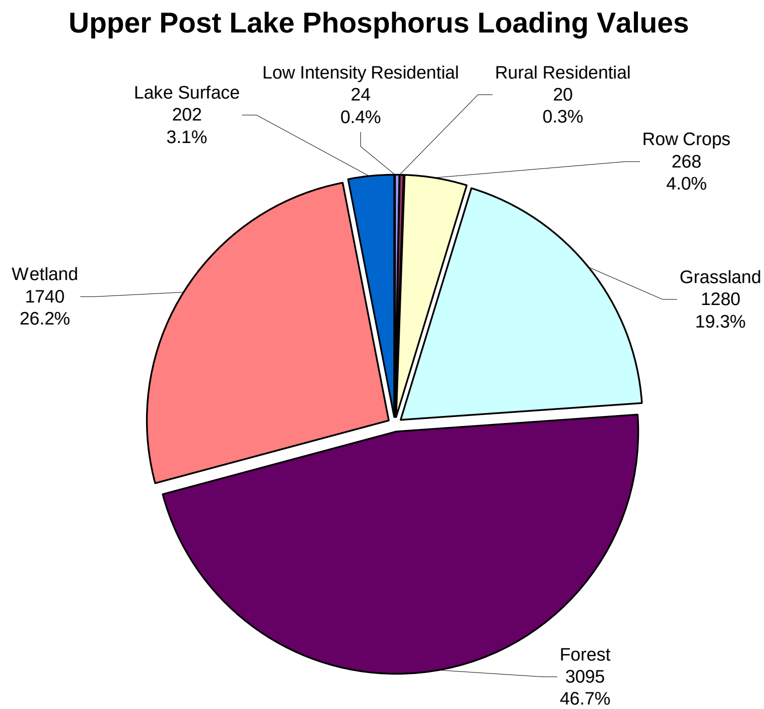


Figure 16. Land use acreages for the Upper and Lower Post Lakes watersheds.



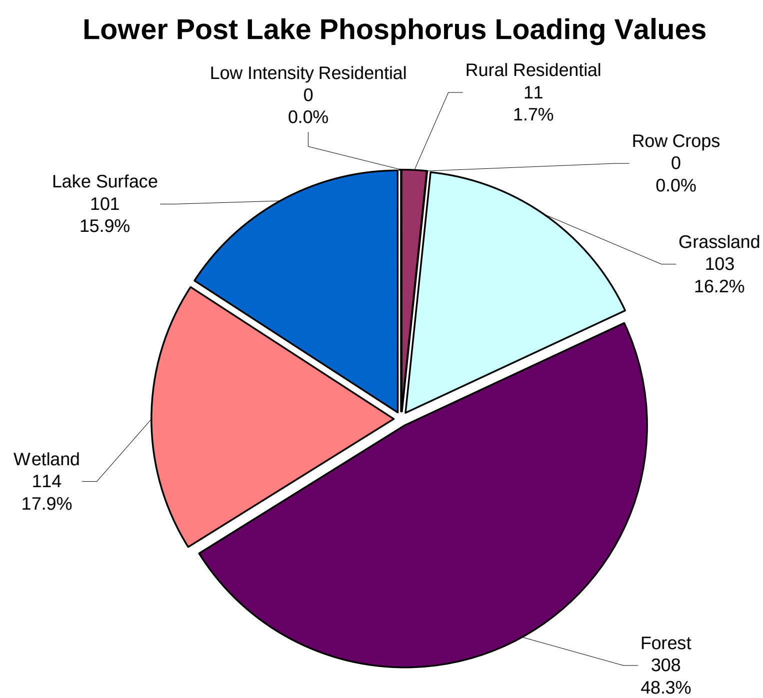


Figure 17. Land use loading values for Upper and Lower Post Lakes. Loadings are in lbs of phosphorus per year.

RECOMMENDATIONS

Lake Water Quality

Water Quality Protection

As outlined in the Results and Discussion Section, the water quality of both Upper and Lower Post Lakes appears to be about as good as it can be based on the size of each lake's watershed.; therefore, the most appropriate plan is to protect, and maybe even enhance slightly, the current water quality of the lake through implementation of the recommendations stated in the Watershed and Aquatic Vegetation sections. In other words, at this time, there is no call for in-lake techniques such as alum treatments to reduce internal phosphorus loading or aeration to control oxygen levels.

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's or season's worth of data. Important parameters to include are, chlorophyll-*a*, total phosphorus, Secchi disk transparency, and dissolved oxygen profiles. Secchi disk information may currently be collected through the efforts of a district Self-Help Volunteer, if not; the lake coordinator with the WDNR Northern Region office should be contacted to enlist a District representative for each lake. The other data would not necessarily need to be collected on an annual basis, but should be collected at least every three years and should include samples taken during the summer months - which is lacking in the District's current program of sampling only during the turnover events. Furthermore, it is recommended that dissolved oxygen levels be sampled under the ice on Lower Post Lake to monitor and assess the effectiveness of the harvesting program on alleviating anoxic conditions within the lake. 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 the Post Lakes. 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 the Post Lakes 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

Upper Post Lake

As stated above, two exotic and potentially invasive species were discovered during our survey of Upper Post Lake; curly-leaf pondweed and purple loosestrife. Only a few individual plants of purple loosestrife were located on the shores of Upper Post Lake (Figure 1). These plants should be carefully removed, including the roots, bagged, and burned. In addition, visual surveys should be completed during early to mid August on an annual basis in order to find and destroy any additional colonies that may appear. The best method for preventing the spread of purple loosestrife is early detection followed by eradication.

Update: In order to eliminate and prevent further spread of purple loosestrife, District volunteers have raised and released purple loosestrife beetles for the last four years and have completed numerous attacks on this invasive plant using controlled applications of the herbicide, Rodeo®.

By far, the best control method for curly-leaf pondweed and other exotics is preventing introduction. The next best possibility for control is early detection before the plant becomes a nuisance. There were only two condensed colonies of curly-leaf pondweed found in Upper Post Lake during our macrophyte survey, so early detection may have been accomplished. However, it must be stated that our survey was conducted in mid July, during the peak-growing season for most aquatic macrophytes, which is actually 4-6 weeks after curly-leaf pondweed's growing season has ended and the plant has actually started to senesce. As a result, the actual areas containing the plant may be larger than what was located during the study.

The unusual lifecycle of curly-leaf pondweed makes its management difficult because a reduction in plant biomass does not necessarily lead to long-term control. In most cases, chemical treatments are applied in warm water conditions during late May or early June and even though curly-leaf pondweed is extremely susceptible to contact herbicide treatments at that time, turion formation has already occurred. Short-term control is apparent when the mature plants dieback; however, the lack of a long-term control is even more apparent in the fall when the turions sprout to produce the winter form of the plant. Recent field and laboratory studies have shown that turion production is significantly reduced if contact herbicides are applied in early spring while curly-leaf pondweed growth rates are high (Netherland et al. 2000). This treatment schedule also reduces the herbicide's affect on native plants because they are metabolically inactive at the time application. With this in mind, and the fact that it is likely the colonies are still relatively small, it is recommended that the Post Lakes Protection and Rehabilitation District (PLPRD) consider contracting for an early spring herbicide treatment to help control the spread of curly-leaf pondweed. Additional guidance with this alternative, including the duration of treatments (how many years the program should continue), permit needs and contractor recommendations, can be acquired from the WDNR, Northern Region Aquatic Plant Specialist.

Update: As of this writing, the District has contracted to have the curly-leaf pondweed chemically treated, as outlined here, during the springs of 2002 and 2003.

Both infested areas are located at inlet sites, which increase the chance that turions that are attached to plant fragments will drift to other areas of the lake and start additional colonies. Therefore, it is also recommended that boat traffic be kept to a minimum in the infested areas. Posting signs at the boat landings indicating the areas of concern and asking boaters to stay out of those areas would likely help in reducing the possible spread of the plants. Furthermore, harvesting operations should not be considered for these areas because of the high possibility of plant fragmentation and subsequent colonization of the remainder of the lake as mentioned above.

Recent studies conducted by the WDNR have shown the significant negative affects of increased shoreland development on the quality of Wisconsin's lakes. Upper Post Lake may be exhibiting some of these same trends in its aquatic plant community. Recreational boating, waterfront development, and shoreline stabilization are probably responsible for the low occurrence of emergent plant communities in Upper Post Lake. As mentioned above, emergent plants are an important from of habitat for aquatic wildlife, especially the prized northern pike and yellow perch. Consequently, it is recommended that the PLPRD consider restoring native, emergent plant communities along the less disturbed, shallow areas of Upper Post Lake on a trial basis to discover if they will establish and expand. Possible starting points for these experimental introductions would include the areas between Transects 8 and 10 (Figure 6) and Transects 15 and 17 (Figure 6). Ultimately, the District's knowledge of boating patterns within the lake would need to be used to determine what areas receive the least amount of pressure, and thus would be the most applicable for these plantings. Any of the native, emergent species contained within Table 2 would be appropriate for planting within Upper Post Lake. Temporary wavebreaks (permit required) should be used to protect the newly installed plants for the first and second growing seasons. By that time the plant beds should be established. Continued monitoring over the next few years should be completed to track how well the new beds are surviving. If they appear to be dying back, the District should seriously consider expanding the slow-no-wake zone, for these replanted portions of the lake, to at least 300' for two or more growing seasons. If the plants continue to die-back, there is likely another cause other than boat-traffic that is affecting them and the District may want to cease further introductions. If the plant beds do establish and survive, the District should initiate a program to expand the project to other portions of the lake.

Additionally, the District should seriously consider introducing native submergent plants in the areas of lake treated for curly-leaf pondweed, if the control methods seem to be working to reduce curly-leaf pondweed densities. As an analogy, consider how quickly weedy (invasive) species like dandelions and thistles invade an area of lawn that had the grass killed off. It works much the same way in the aquatic environment. Once the curly-leaf pondweed is eliminated, native species should be introduced to compete with possible reintroductions and establishment of invasives.

As mentioned above, preventing the introduction of non-natives is the best way to control them. It is recommended that the District implement a monitoring program at the lake's boat launches in order to educate lake users concerning invasive species and to help prevent their introduction to the lake. In 2004, the WDNR will begin a new program aimed at aquatic invasive control including funding for local efforts. The WDNR Northern Region Lake Specialist should be contacted for more information concerning the monitoring of boat landings, sign design, and funding for such activities.

Above all, the protection of current native plant populations, especially Sensitive Areas, is the most important recommendation that the PLPRD can adhere to. Limiting motorboat-induced wave action through expanded no-wake zones will do much to protect these important communities; as will the expansion of *shoreland buffers*.

Lower Post Lake

The PLPRD is currently attempting to control purple loosestrife infestation through the release of *Galerucella* beetles. This practice should be continued (and commended) with annual surveys to monitor its affect on purple loosestrife densities. In areas of light infestation, plants should be carefully removed, including the roots, bagged, and burned.

The largest concern expressed by PLPRD members is the loss of recreational opportunities on Lower Post Lake due to nuisance growth of slender waterweed and other native species. The vegetation survey has confirmed the validity of these concerns. Three control alternatives have been discussed at length within the District, with consultants and with the WDNR: herbicide treatment, water level drawdown, and mechanical harvesting. At this juncture, mechanical harvesting is most likely the best alternative for minimizing the problems associated with nuisance levels of slender waterweed – both recreational difficulties and low dissolved oxygen levels as discussed in the Water Quality Section. This alternative is recommended over the other two for the following reasons:

- Water Level Drawdown
    - Water level drawdown would be difficult because one dam controls the water levels of both Lower Post Lake and Upper Post Lake. Upper Post Lake has a relatively healthy submergent and to some extent, floating-leaf plant population that would likely suffer because of a drawdown in Lower Post Lake.
    - Winter recreational opportunities would be forfeited during the drawdown.
    - Drawdowns must be applied every two to three year to maintain control of target plants.
    - Slender waterweed may not be sensitive to water level drawdown.

- Chemical Treatment
    - Non-selective, contact herbicides would be required to treat slender waterweed because it would not be affected by systemic herbicides.
    - Large areas may need to be treated on Lower Post Lake because so much of it is infested with nuisance levels of slender waterweed. If large areas are treated, there is a definite risk that plant decomposition may cause oxygen levels to fall below lethal concentrations and result in a fish kill.
    - Treatment of large areas may lead to excessive algal growth and would be quite expensive.
    - Chemical treatments leave plants in the lake to decompose, adding nutrients and sediments to the lake.
    - Chemical treatment would not remove floating mats of uprooted plants.

- Mechanical Harvesting
    - Harvesting would allow for select areas of Lower Post Lake to be treated. For example, access channels can be created so property owners can boat to open water areas cleared for recreation.
    - Access channels would also function as fish cruising lanes and provide predator fish with improved access to feeder fish.
    - Harvesting operations would remove nutrients and plant biomass from Lower Post Lake.
    - Harvesting does not remove the entire plant, leaving cover for fish, invertebrates, and *zooplankton*.
    - The harvester could also be used to collect floating plant mats.

Harvesting operations should be limited to deep areas, near the center of the lake, where plant growth has reached the surface and is hampering navigation. Additionally, harvesting operations should be used to create a minimal amount of access lanes to allow property owners clear access to the deeper areas. Harvesting must not be attempted in shallow water or near docks. Other methods, such as hand-pulling and cutting and benthic barriers can be used in conjunction with harvesting to clear plants from around docks and swimming areas.

Update: As of this writing, the PLPRD has purchased, through partial funding from a WDNR grant, a harvester that was used to remove approximately 1.3 million and 2.0 million pounds of plant material from Lower Post Lake in 2002 and 2003, respectively.

Considering 50 acres or more may be harvested once or twice during the growing season, it would likely be feasible for the PLPRD to own and operate their own harvester. If this path is chosen, they would need to have a WDNR-approved Harvesting Plan and obtain the proper permits. **NOTE: Maps depicting harvesting areas agreed upon by the WDNR and the PLPRD are contained in Appendix D.**

Recent studies conducted by the WDNR have shown the significant negative affects of increased shoreland development on the quality of Wisconsin's lakes. Lower Post Lake may be exhibiting some of these same trends in its aquatic plant community. Recreational boating, waterfront development, and shoreline stabilization are probably responsible for the low occurrence of emergent plant communities in Lower Post Lake. As mentioned above, emergent plants are an important from of habitat for aquatic wildlife, especially northern pike. Consequently, it is recommended that the PLPRD consider restoring native, emergent plant communities along the less disturbed, shallow areas of Lower Post Lake as described in the Upper Post Lake Vegetation Recommendation Section. Possible areas for these introductions would include the small bays and coves located in the southern part of the lake. Any of the native, emergent species contained within Table 3 would be appropriate for planting within Lower Post Lake.

As described above, preventing the introduction of non-natives is the best way to control them. It is recommended that the District implement a monitoring program at the lake's boat launches in order to educate lake users concerning invasive species and to help prevent their introduction to the lake. In 2004, the WDNR will begin a new program aimed at aquatic invasive control including funding for local efforts. The WDNR Northern Region Lake Specialist should be contacted for more information concerning the monitoring of boat landings, sign design, and funding for such activities.

Above all, the protection of current native plant populations, especially Sensitive Areas, is the most important aquatic plant-related recommendation that the PLPRD can adhere to. Limiting motorboat-induced wave action through expanded no-wake zones around the sensitive areas will do much to protect these important communities; as will the expansion of *shoreland buffers*. The District should seriously consider the expansion of the existing slow-no-wake zone near the dam channel to further include the channel that leads to Lower Post Lake.

Watersheds

As mentioned in the Results and Discussion Section, the watersheds of both Upper and Lower Post Lakes are contributing close the minimal amount of phosphorus to their respective lakes consider the sizes of the watersheds. The fact that the majority of each watershed is currently forested, in wetlands, or vegetated in some other fashion assures that excess runoff carrying phosphorus and other pollutants will not enter the lakes. However, there should be some concern over present and future septic systems near the lake. With the exception of conversion of forested areas to residential lots or agricultural use, an increased loading rate from septic systems will likely have the greatest impact on the health of both lakes. Increased loading from septic systems could occur in primarily two ways: 1) septic system failure and/or decreased efficiency, and 2) additional septic systems being installed around the lake.

Newer septic systems tend to function better than older systems, so the immediate concern should be with the existing, older systems on the lake that have not been recently 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 the lakes. The Wisconsin Department of Commerce estimates that nearly 1-in-5 septic systems are failing in Wisconsin.

Unfortunately, dealing with septic system issues on lakes is traditionally a very touchy subject because restoring a failing system can result in a large expense for the property owner. However, if the protection of the Post Lakes is truly the goal of the District and its members, these inhibitions towards septic system problems must be overcome to meet this goal. According to the summary of the PLPRD Lake Plan of 1996 (Appendix E), 1/3 of the septic systems were tested in 1994, and anecdotal information indicates that faulty systems were replaced. The document also states that additional systems were to be tested in the future. The willingness of the District to confront these problems in the past (nearly a decade ago) indicates that there is a base to expand upon concerning the septic systems around the lakes.

It is recommended that the District pass a resolution to have all systems not covered by previous inspections, inspected within the next two-three years. Grants may be available to fund up to 75% of these efforts through the WDNR Lake Planning Grant Program. 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 grant mentioned above.

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.

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 on 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. The removal of fallen trees and other woody debris from shoreline areas in an attempt to maintain a clean appearance also removes habit and food for aquatic and terrestrial flora and fauna. Combined, these actions have helped lead to noticeable decreases in the quality of Wisconsin's lakes.

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 before it was developed. 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.

NES ecologists pay particular attention to the condition of a lake's shorelands during our site visits, especially during the vegetation surveys. There are many properties along the shores of the Post Lakes which are maintained as unnatural landscapes that are not appropriate for these delicate areas. This includes both lawns that are maintained to the water's edge and properties that still have many large trees, but are void of the understory and herbaceous layers that naturally occur in woodlands. During May 2003, the PLPRD applied for a WDNR Lake Protection Grant with the intensions of creating a program that would provide financial and technical assistance to shoreland property who that are interested in restoring the natural habitat that once existed on their property. We recommend that all property owners restore a shoreland buffer zone on their properties regardless if the project is funded through the grant described above. The benefits to the lake ecosystem and the property owners are numerous and far outweigh the costs of the restorations (see above). Creating a contiguous buffer zone around both lakes would do much to preserve them.

Update: As of this writing, the PLPRD has been awarded the grant and will assist with numerous shoreland restoration projects around the lakes.

Finally, the ultimate goal of the PLPRD, concerning the watersheds of the Post Lakes, should be to preserve these lands as they are today. The fact is that both lakes are impoundments with large areas of land draining to them. At this time, most of the land provides minimal loads of phosphorus to the lakes; preserving this state will do a great deal to maintain both lakes in their present condition. To accomplish this goal, the PLPRD and its members, should:

- Support and even spur zoning regulations that limit the development of forested and other natural areas for residential, commercial, industrial, and agricultural uses. For instance, the District should urge local leaders to create and enforce regulations that set up buffer zones around quality, natural areas. The purpose of these buffers is to limit encroachment on Environmentally Sensitive Areas (ESAs).

- Enforce and support stricter county shoreland zoning regulations that are based on the quality and sensitivity of lakes to developmental impacts (lake classification-based zoning).
- Monitor and enforce state wetland impact regulations.
- Support county soil and water conservation departments in the monitoring and enforcement of agricultural runoff issues.

The first step concerning this recommendation should be the creation of a sub-committee to gather information regarding the current zoning regulations for the municipalities that have jurisdiction over the Post Lakes watersheds (Figure 18). The Smart Growth plans for each municipality should also be reviewed to discover each municipality's plan for the future. Details concerning Wisconsin's Smart Growth legislation and other pertinent information can be found at: http://www.dnr.state.wi.us/org/es/science/landuse/smart_growth/. Familiarization with the zoning and planning information from the municipalities of concern will help the sub-committee determine what actions should be taken to carry out the recommendations defined above.

Education

Education 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 his or her affect on the lake ecosystem and takes measures to protect and enhance it. Lake stewards 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 both Upper and Lower Post Lakes. 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.

Water Level Management

Based upon communications with District members (both direct and indirect) and the questions and comments received during the Kick-off meeting, it is rather obvious that the largest controversy within the District concerns water levels with in both lakes. There is a tremendous range of opinions within the District's membership as to where the water level should be maintained and to how it should be managed throughout the year. It is recommended that the

District obtain professional advice concerning management of water levels throughout the year. Specific questions that need to be answered include, but are not limited to:

- What are the limitations of the current dam concerning its water release capacity?
- Based upon the release capacity, what fluctuation in water level can the District expect for a range of flows calculated from annual and seasonal averages?
- If the fluctuation determined above are not acceptable to the District, what modifications would need to be made to the existing dam in order to increase release capacity and reduce those fluctuations?
- How do the current fluctuations affect Upper and Lower Post Lakes in both positive and negative ways?

An excellent starting point to begin this project would be to contact Ms. Cathy Wendt of the Wisconsin Valley Improvement Company at: 715.848.2976.

District Management Capacity

In the nearly fours years that NES has been working with the PLPRD, we have had many opportunities to communicate with District representatives, both the general membership and the board of directors. These communications included emails, letters, and face-to-face discussions during District meetings and our field visits along with those held at three Wisconsin Lakes Conferences. Through these interactions, it is apparent that the PLPRD is an organization that deals with many controversies, including, but not limited to those that revolve around water level management, the aquatic plant management and protection in both lakes, and the basic trust in the board of directors by the general membership. The PLPRD is a large district that oversees two lakes with complicated management issues; therefore, controversy is to be expected. However, with the PLPRD, it appears that the controversy distracts from the well-intended management efforts of the District. Many non-profit organizations involved with environmental management find great benefit in building their organization's capacity by seeking professional and experienced guidance. The improved capacity comes from increasing the organization's "tool box" of methods and procedures aimed at minimizing controversy and maximizing consensus-based decision making. The "tools" may include changes to the group's organizational structure (e.g. committee and sub-committee structure), methods to better educate the organization's general membership concerning controversial and non-controversial topics, and step-by-step systems to help decision-makers arrive at a consensus.

Information concerning the management of non-profit organizations can be found at the University of Wisconsin – Extension website (http://www1.uwex.edu/). Information on seminars and workshops may be obtained by contacting Mr. Ken Genskow, Interim Director, Wisconsin Basin Education Initiative, at 608.262.8756. Please note: Mr. Genskow's information is provided here because the basin educator position for the Wolf and Upper Fox Basin was vacant as of this writing.

Recommendation Priorities

Prioritization of the recommendations expressed in this document should be made at the discretion of the District based on immediacy of need, cost, availability of funds to offset District costs, and the willingness of volunteers to undertake the particular tasks. Table 4 contains a generalized priority list of the recommendations based upon what we believe would provide the most favored results concerning the short-term and long-term benefits to the lakes. Please remember, the list indicates the overall order in which the District should undertake the recommendations, not whether or not they should undertake them.

Table 4. Recommendation priorities.

Recommendation	Priority Level	Comments
Dissolved Oxygen Monitoring in Lower Post Lake	High	This is important to assess the affects of the harvesting program on Lower Post Lake and it would be relatively inexpensive if a WDNR Small-Scale Planning Grant were used to help fund it.
Chemical Treatments & Monitoring of Curly-leaf Pondweed in Upper Post Lake	High	The chemical treatments should be continued based upon visual inspections by the District and/or professionals.
Boat Launch Monitoring	High	This would be an important project that may reduce the chance of further introductions of invasive species. Partial funding would be available through the WDNR Lake Management Grant Program.
Shoreland Buffer Creation	High	A WDNR Lake Protection Grant has already been obtained to create shoreland buffers on some properties.
Harvesting on Lower Post Lake	High	The implementation of this recommendation is already in place and should continue adhering to the harvest plan.
Education	High	This is an important function of every lake management district.
Water Level Management	High	This is the most controversial topic concerning Upper and Lower Post Lakes. Getting over this hurdle would do much to ease the burden of the District's board of directors.
District Management Capacity	High	This may be a difficult recommendation to implement, but it would do a great deal to increase the effectiveness of the District in managing both lakes and their watersheds.
Introduction of Native Species in Curly-leaf Pondweed Areas	Medium	This is dependant on the findings of the visual inspections.
Experimental Emergent Plantings	Medium	This could be a time-consuming and expensive project; however, costs could be offset with a WDNR Lake Protection Grant.
Protection of Sensitive Areas	Medium	Most of these areas are currently protected by slow-no-wake zones. The expansion of the slow-no-wake zone south past the channel that leads to the dam would be inexpensive, yet important, to complete.
Long-term Water Quality Monitoring	Low	The District already has a monitoring program in place and the lake was sampled in 2001 as a part of this study, so this may be able to be put off for a year or two.
Septic System Inspections	Low	This could be a potentially expensive project even with the funds available through the WDNR Planning Grant Program. Its need is not immediate because limited inspections were completed in the 1990's.
Watershed Protection	Low	Implementing this recommendation would be inexpensive, but time-consuming. It would also require a group of detailed-oriented volunteers willing to complete the research. Its need is not immediate because it the watersheds are not likely to see significant change in the next 5 years.

METHODS

Lake Water Quality

Baseline water quality conditions were studied to assist in identifying potential water quality problems in the Post Lakes (e.g., elevated phosphorus levels, anaerobic conditions, etc.). Water quality was monitored at the deepest point in each lake. Samples were collected with a 3-liter Van Dorn bottle at the subsurface (S) and near bottom (B), and occurred once in spring 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:

Parameter	Spring		June		July		August		Winter	
	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 during July 16-19, 2001 by sampling transects located along the shoreline of each lake (Appendix B). Twenty transects were sampled in Upper Post Lake (Figure 6) and 17 transects were sampled in Lower Post Lake (Figure 11). For ease of data analysis and reporting, County Highway K was used as the division of Upper Post Lake from Lower Post Lake. Sampling was completed via boating, wading, and snorkeling. Visual inspections were completed throughout each lake in order to map the macrophyte communities present and to assist in determining the frequency and location of transects. On each transect, a ten-foot diameter circle was sampled within each of the four different depth ranges (Table 5). 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 5. 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

Community maps were produced by sketching approximate community locations on a bathymetric map of the respective lake. Notes were taken on the dominant plant species present and a list of incidental species was also created for plant species not found in the transect survey. GIS software was then utilized to create the finished maps supplied with this report.

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 leaved 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 5). 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 6. 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).

Floristic Quality Assessment

A Florist Quality Assessment (FQA) was applied to the aquatic vegetation species lists generated for Upper and Lower Post Lakes 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 each 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 each lake. The mean *C* was then multiplied by the square root of the total number of plants 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 both Upper and Lower Post Lakes.

Watershed Analysis

The watershed analysis began with an accurate delineation of the Upper and Lower Post Lakes drainage areas 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 compiled from the Wisconsin Initiative for Statewide Cooperation on Landscape Analysis and Data (WISCLAND) were then combined to determine the preliminary watershed land use classifications. The watershed delineation and land use classifications were field verified by PLPRD volunteers during the summer 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. Please note: normally, the watersheds of lakes that feed into other lakes (e.g. Pine Lake into Upper Post Lake) are analyzed separately and then added to the downstream lake as a point-source. This method was not utilized during the Post Lakes analysis because sufficient data relating to in-lake chemistry was not available to complete the WiLMS analysis for the tributary lakes.

Education

Educational components were accomplished through a "Kick-off Meeting" held in June 2001, project updates created for inclusion in the District's newsletter, an article that appeared in the Antigo Daily Journal, 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 E.

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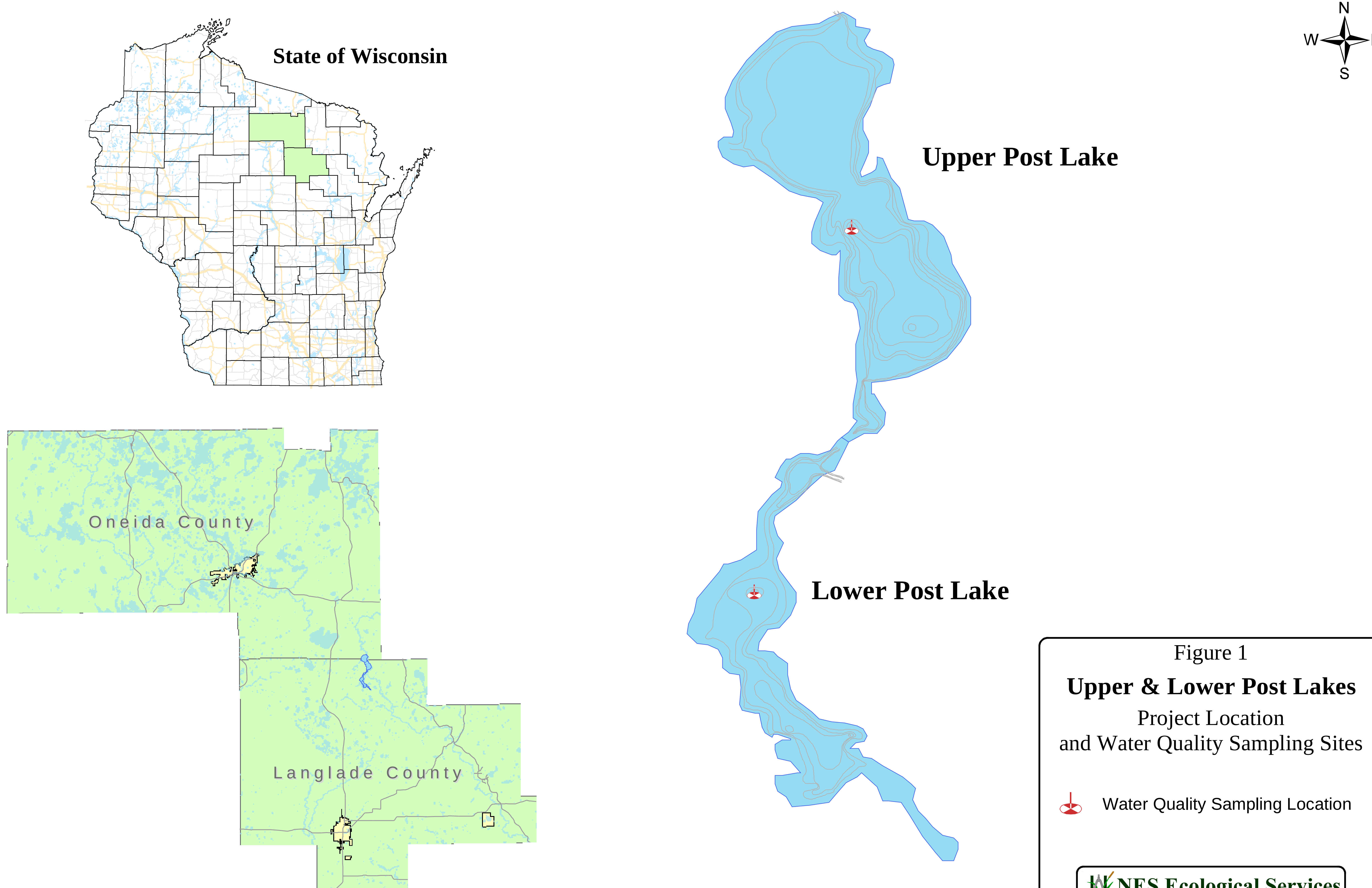


Figure 1
Upper & Lower Post Lakes
Project Location
and Water Quality Sampling Sites

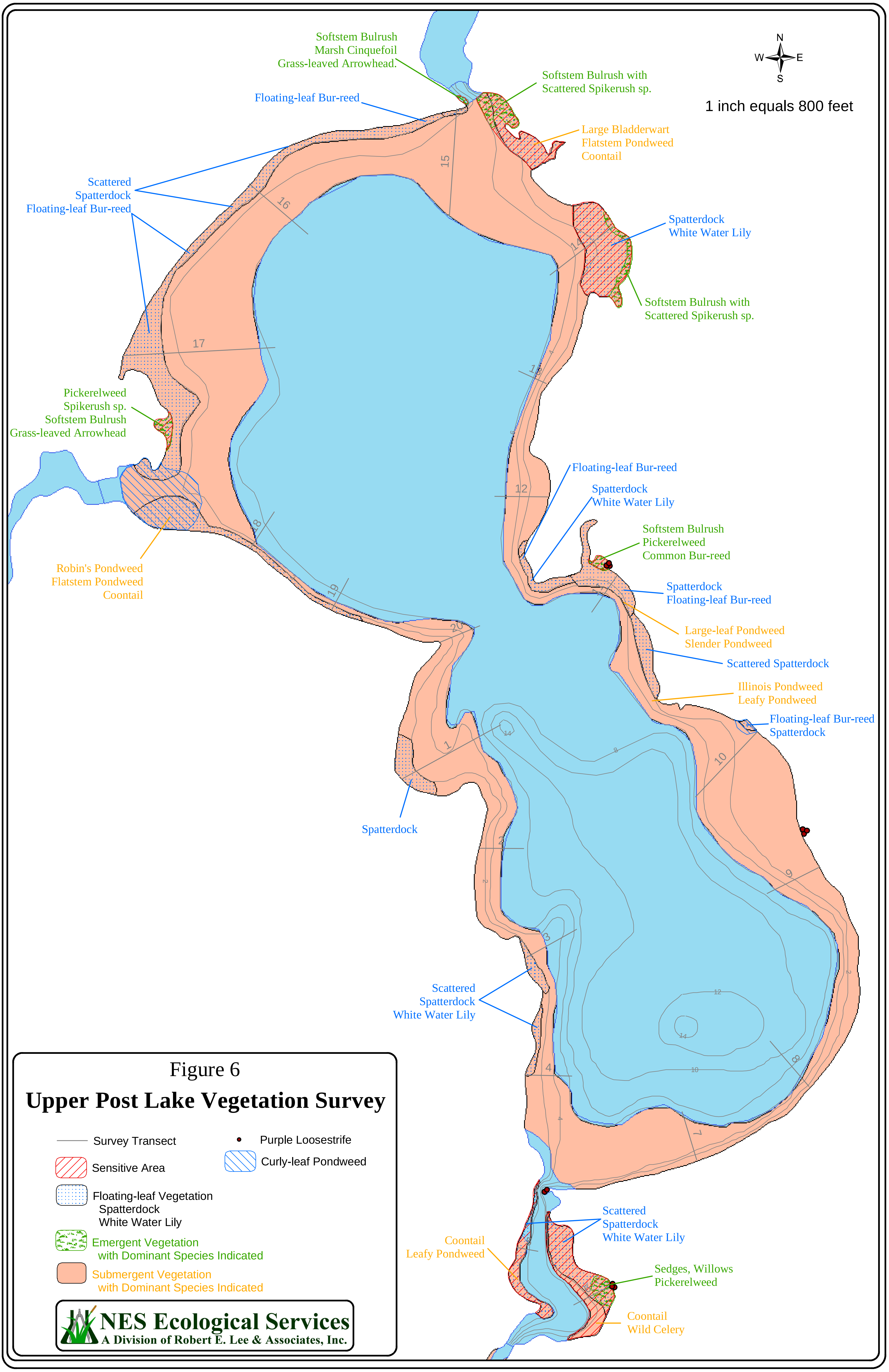


Figure 6

Upper Post Lake Vegetation Survey

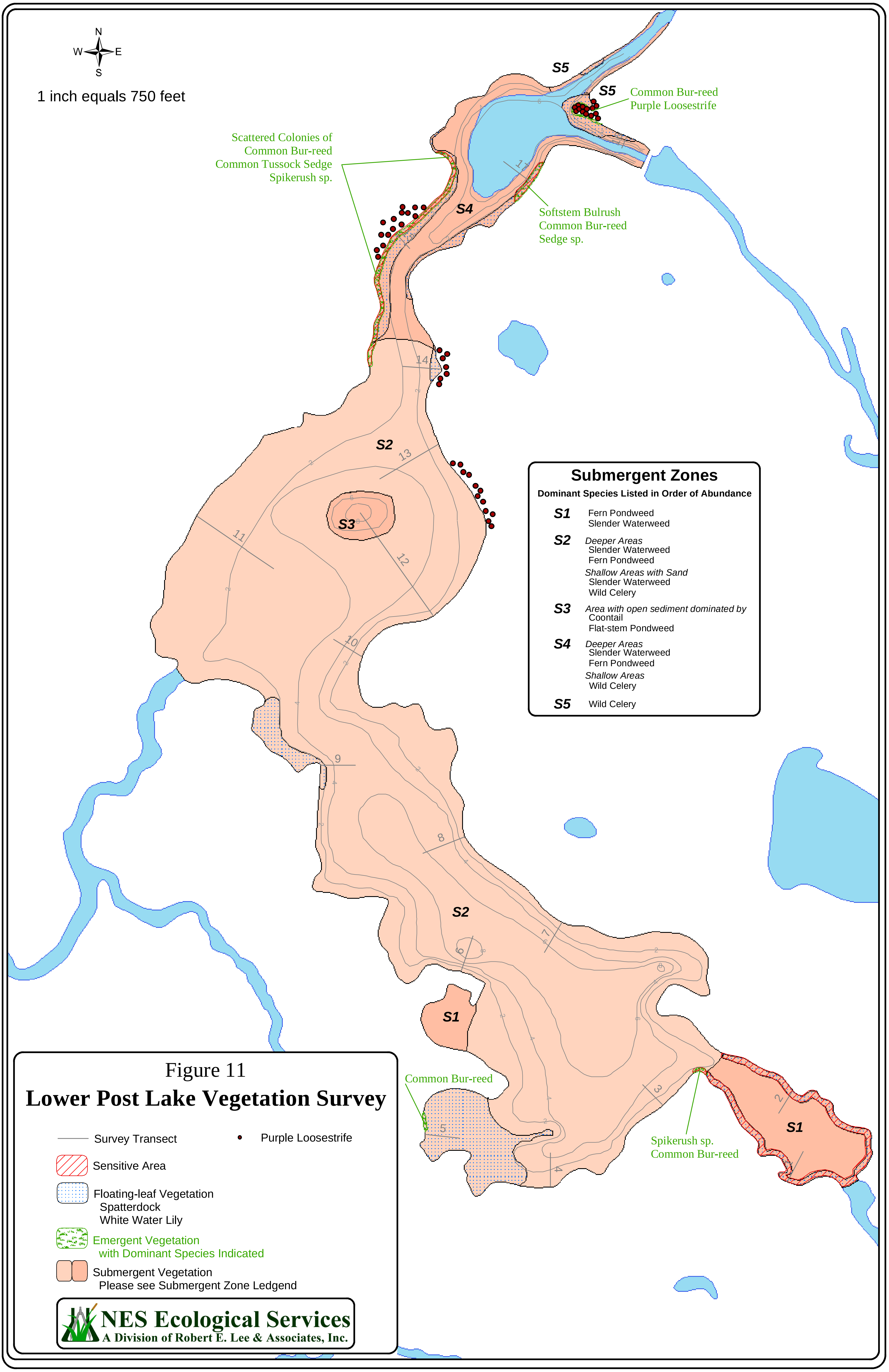
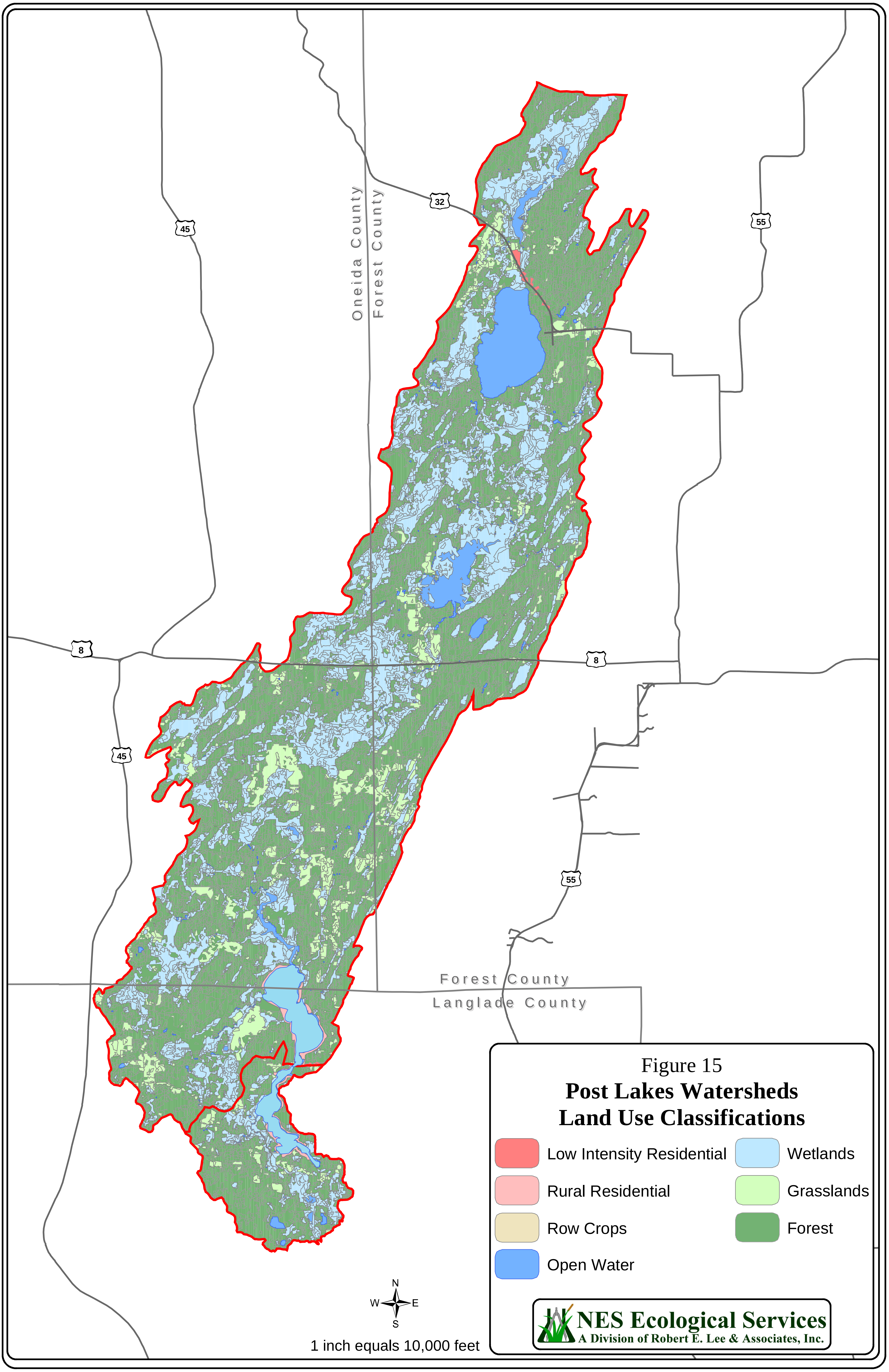


Figure 11

Lower Post Lake Vegetation Survey


32
45
55
8
8
45
55
Oneida County
Forest County
Forest County
Langlade County
N
W
E
S
1 inch equals 10,000 feet
Figure 15
Post Lakes Watersheds
Land Use Classifications
Low Intensity Residential
Rural Residential
Row Crops
Open Water
Wetlands
Grasslands
Forest
NES Ecological Services
A Division of Robert E. Lee & Associates, Inc.

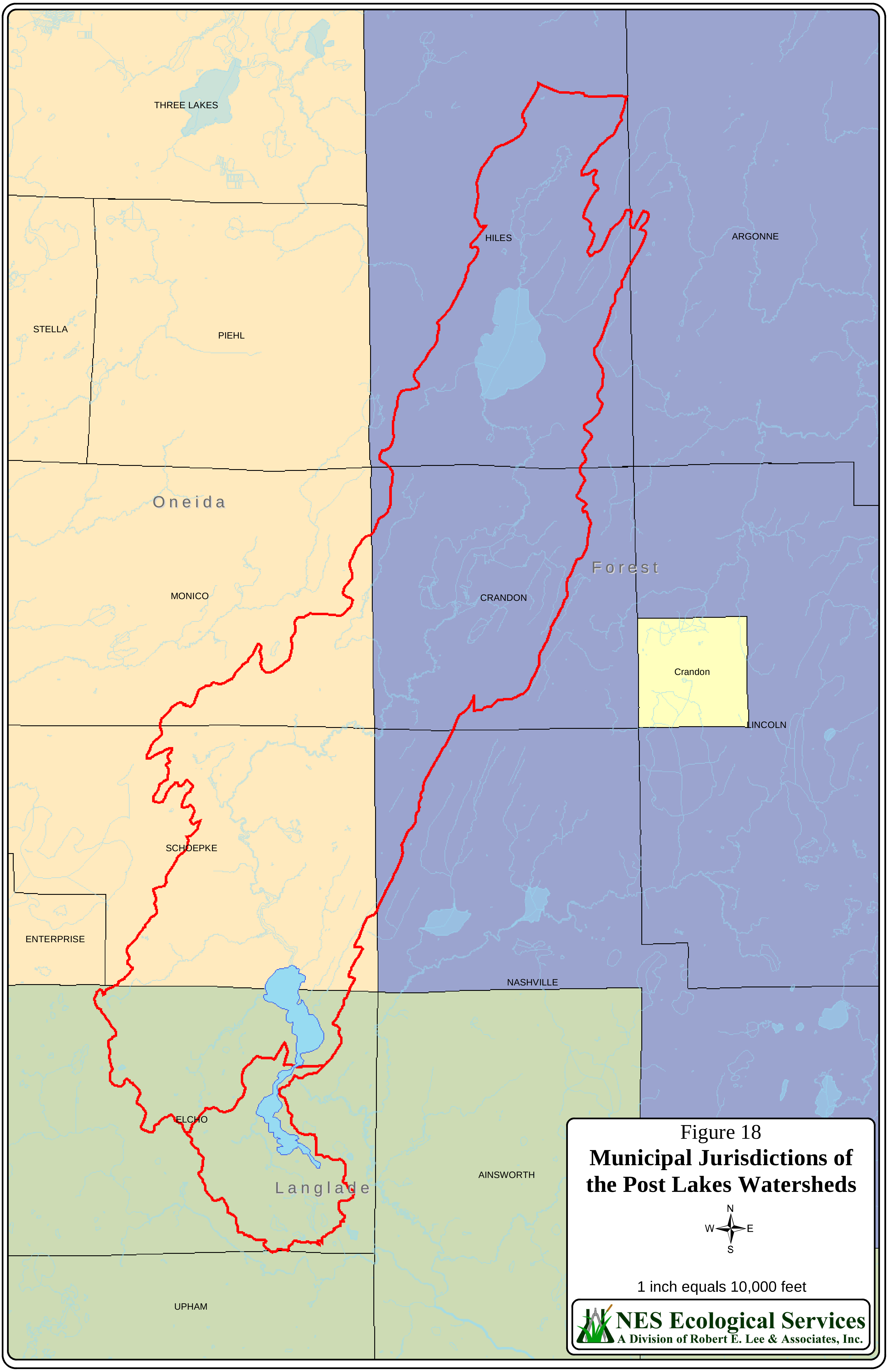


Figure 18
Municipal Jurisdictions of the Post Lakes Watersheds

A

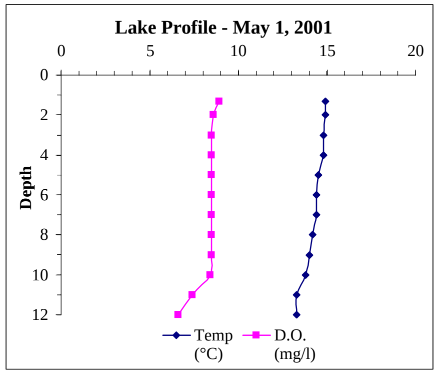
APPENDIX A

Water Quality Dataset Collected During 2001 & 2002

Upper Post Lake

Date:	**05-01-01**	**Max Depth (ft):**	14.0
Time:	10:40	**UPostS Depth (ft):**	3.0
Weather:	100% cloud cover, 60°F.	**UPostB Depth (ft):**	9.0
Ent:	TAH **Verf:**	**Secchi Depth (ft):**	3.7

Depth (ft)	Temp (°C)	D.O. (mg/l)	pH	Sp. Cond (µS/cm)
1.3	14.9	8.9	7.8	70
2.0	14.9	8.6	7.7	71
3.0	14.8	8.5	7.7	71
4.0	14.8	8.5	7.7	71
5.0	14.5	8.5	7.7	71
6.0	14.4	8.5	7.7	71
7.0	14.4	8.5	7.7	71
8.0	14.2	8.5	7.7	71
9.0	14.0	8.5	7.7	71
10.0	13.8	8.4	7.7	71
11.0	13.3	7.4	7.6	72
12.0	13.3	6.6	7.5	74



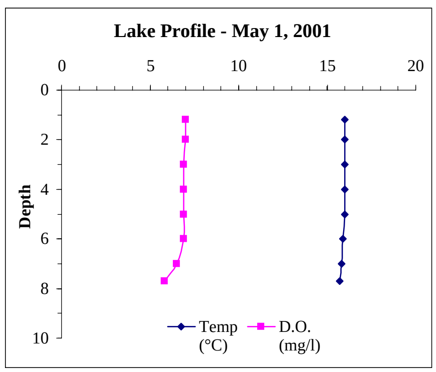
Parameter	UPostS	UPostB
Total P (mg/l)	0.029	0.024
Dissolved P (mg/l)	ND	0.002
Chl a (µg/l)	13	
TKN (mg/l)	0.400	0.600
NO_4+NO_3-N (mg/l)	0.041	0.041
NH_3-N (mg/l)	ND	0.022
Total N (mg/l)	0.441	0.641
Lab Cond. (µS/cm)	77	77
Lab pH	7.58	7.49
Alkal (mg/l $CaCO_3$)	29	29
Total Susp Sol (mg/l)	3	4
Calcium (mg/l)	8.9	8.5

Notes: After sampling Upper and Lower Post Lakes, we took a tour of the lakes with Marlin Kastenschmidt and Lori Regni. Some of the lake actually has a decent amount of buffer zone on it because of steep slopes.

Lower Post Lake

Date:	**05-01-01**	**Max Depth (ft):**	9.2
Time:	11:55	**LPostS Depth (ft):**	3.0
Weather:	100% cloud cover, 62°F	**LPostB Depth (ft):**	4.0
Ent:	TAH **Verf:**	**Secchi Depth (ft):**	6.0

Depth (ft)	Temp (°C)	D.O. (mg/l)	pH	Sp. Cond (µS/cm)
1.2	16.0	7.0	7.7	121
2.0	16.0	7.0	7.7	121
3.0	16.0	6.9	7.7	122
4.0	16.0	6.9	7.6	121
5.0	16.0	6.9	7.6	122
6.0	15.9	6.9	7.6	122
7.0	15.8	6.5	7.6	122
7.7	15.7	5.8	7.2	127



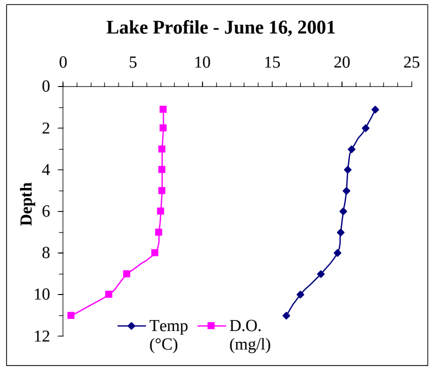
Parameter	LPostS	LPostB
Total P (mg/l)	0.030	0.032
Dissolved P (mg/l)	0.002	0.002
Chl a (µg/l)	11	
TKN (mg/l)	0.560	0.620
NO_4+NO_3-N (mg/l)	0.046	0.051
NH_3-N (mg/l)	ND	0.023
Total N (mg/l)	0.606	0.671
Lab Cond. (µS/cm)	130	129
Lab pH	7.66	7.75
Alkal (mg/l $CaCO_3$)	56	56
Total Susp Sol (mg/l)	2	2
Calcium (mg/l)	16	16

Notes: Below 8' eratic reading were received through Hydrolab because of plant mass near bottom.

Upper Post Lake

Date: 06-16-01 | **Max Depth (ft):** 12.1
Time: 12:30 | **UPostS Depth (ft):** 3.0
Weather: Clear 78°F. | **UPostB Depth (ft):** 9.0
Ent: TAH **Verf:** | **Secchi Depth (ft):** 4.0

Depth (ft)	Temp (°C)	D.O. (mg/l)	pH	Sp. Cond (µS/cm)
1.1	22.4	7.2	7.5	92
2.0	21.7	7.2	7.5	91
3.0	20.7	7.1	7.5	90
4.0	20.4	7.1	7.5	90
5.0	20.3	7.1	7.5	90
6.0	20.1	7.0	7.5	90
7.0	19.9	6.9	7.4	90
8.0	19.7	6.6	7.4	90
9.0	18.5	4.6	7.3	91
10.0	17.0	3.3	7.2	93
11.0	16.0	0.6	7.1	100



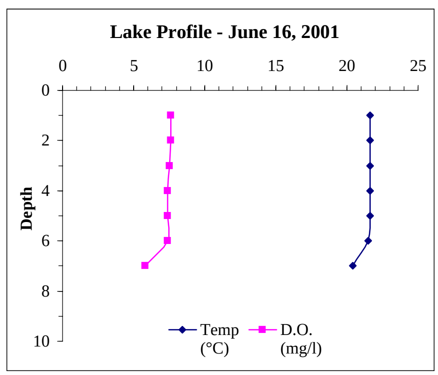
Parameter	UPostS	UPostB
Total P (mg/l)	0.030	0.025
Dissolved P (mg/l)		
Chl a (µg/l)	4	
TKN (mg/l)		
NO_4+NO_3-N (mg/l)		
NH_3-N (mg/l)		
Total N (mg/l)		
Lab Cond. (µS/cm)		
Lab pH		
Alkal (mg/l $CaCO_3$)		
Total Susp Sol (mg/l)		
Calcium (mg/l)		

Notes:

Lower Post Lake

Date: 06-16-01 | **Max Depth (ft):** 9.0
Time: 13:36 | **LPostS Depth (ft):** 3.0
Weather: 80% Cloud cover, 76°F. | **LPostB Depth (ft):** 6.0
Ent: TAH **Verf:** | **Secchi Depth (ft):** 7.3

Depth (ft)	Temp (°C)	D.O. (mg/l)	pH	Sp. Cond (µS/cm)
1.0	21.6	7.6	7.9	121
2.0	21.6	7.6	7.9	121
3.0	21.6	7.5	7.9	121
4.0	21.6	7.4	8.0	121
5.0	21.6	7.4	8.0	122
6.0	21.5	7.4	8.0	121
7.0	20.4	5.8	7.6	127



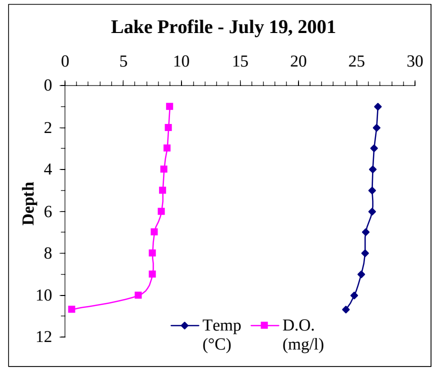
Parameter	LPostS	LPostB
Total P (mg/l)	0.026	0.026
Dissolved P (mg/l)		
Chl a (µg/l)	5	
TKN (mg/l)		
NO_4+NO_3-N (mg/l)		
NH_3-N (mg/l)		
Total N (mg/l)		
Lab Cond. (µS/cm)		
Lab pH		
Tot Alk (mg/l $CaCO_3$)		
Total Susp Sol (mg/l)		
Calcium (mg/l)		

Notes:

Upper Post Lake

Date:	**07-19-01**	**Max Depth (ft):**	11.8
Time:	15:50	**UPostS Depth (ft):**	3.0
Weather:	60% Cloud cover, breezy, 84°F	**UPostB Depth (ft):**	9.0
Ent:	TAH **Verf:**	**Secchi Depth (ft):**	2.3

Depth (ft)	Temp (°C)	D.O. (mg/l)	pH	Sp. Cond (µS/cm)
1.0	26.8	9.0	8.8	102
2.0	26.7	8.9	8.9	102
3.0	26.5	8.8	8.9	102
4.0	26.4	8.5	8.8	103
5.0	26.3	8.4	8.8	103
6.0	26.3	8.3	8.7	103
7.0	25.8	7.7	8.5	103
8.0	25.7	7.5	8.4	104
9.0	25.4	7.5	8.3	104
10.0	24.8	6.3	8.0	106
10.7	24.1	0.6	7.4	256



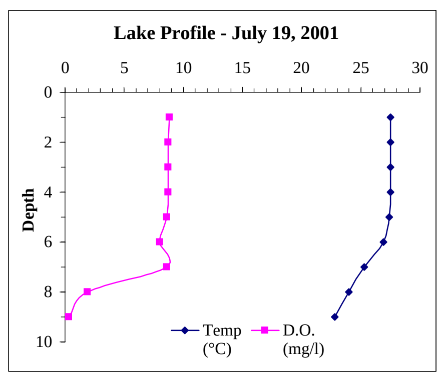
Parameter	UPostS	UPostB
Total P (mg/l)	0.040	0.040
Dissolved P (mg/l)	0.002	ND
Chl a (µg/l)	31	
TKN (mg/l)	1.190	0.940
NO_4+NO_3-N (mg/l)	ND	0.140
NH_3-N (mg/l)	ND	0.041
Total N (mg/l)	1.190	1.080
Lab Cond. (µS/cm)	106	108
Lab pH	8.44	7.9
Alkal (mg/l $CaCO_3$)	45	46
Total Susp Sol (mg/l)	6	5
Calcium (mg/l)	12.3	

Notes:

Lower Post Lake

Date:	**07-19-01**	**Max Depth (ft):**	10.8
Time:	14:45	**LPostS Depth (ft):**	3.0
Weather:	60% Cloud cover, breezy, 84°F.	**LPostB Depth (ft):**	6.0
Ent:	TAH **Verf:**	**Secchi Depth (ft):**	7.5

Depth (ft)	Temp (°C)	D.O. (mg/l)	pH	Sp. Cond (µS/cm)
1.0	27.5	8.8	8.8	121
2.0	27.5	8.7	8.8	121
3.0	27.5	8.7	8.9	121
4.0	27.5	8.7	8.9	121
5.0	27.4	8.6	8.8	121
6.0	26.9	8.0	8.7	119
7.0	25.3	8.6	8.7	119
8.0	24.0	1.9	7.8	128
9.0	22.8	0.3	7.3	196



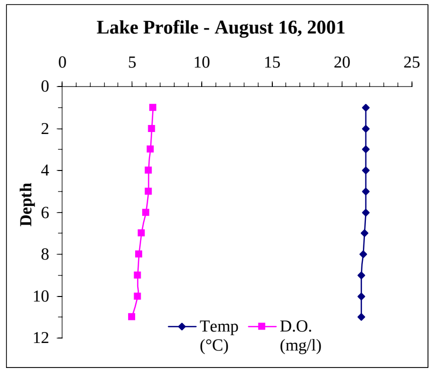
Parameter	LPostS	LPostB
Total P (mg/l)	0.028	0.030
Dissolved P (mg/l)	0.003	0.002
Chl a (µg/l)	*	
TKN (mg/l)	0.570	0.580
NO_4+NO_3-N (mg/l)	ND	ND
NH_3-N (mg/l)	ND	ND
Total N (mg/l)	0.570	0.580
Lab Cond. (µS/cm)	123	122
Lab pH	8.79	8.69
Tot Alk (mg/l $CaCO_3$)	55	55
Total Susp Sol (mg/l)	<2.5	ND
Calcium (mg/l)	13.9	

Notes: Chl a was analyzed on the LPostS sample because it was not marked on the lab sheet.

Upper Post Lake

Date:	**08-16-01**		**Max Depth (ft):**	11.9
Time:	13:00		**UPostS Depth (ft):**	3.0
Weather:	100% Cloud Cover 71° F Fairly Calm		**UPostB Depth (ft):**	9.0
Ent:	TAH	**Verf:**	**Secchi Depth (ft):**	3.1

Depth (ft)	Temp (°C)	D.O. (mg/l)	pH	Sp. Cond (µS/cm)
1.0	21.7	6.5	7.9	117
2.0	21.7	6.4	7.9	117
3.0	21.7	6.3	7.9	117
4.0	21.7	6.2	7.8	117
5.0	21.7	6.2	7.8	117
6.0	21.7	6.0	7.7	118
7.0	21.6	5.7	7.7	118
8.0	21.5	5.5	7.6	118
9.0	21.4	5.4	7.6	117
10.0	21.4	5.4	7.6	118
11.0	21.4	5.0	7.5	118



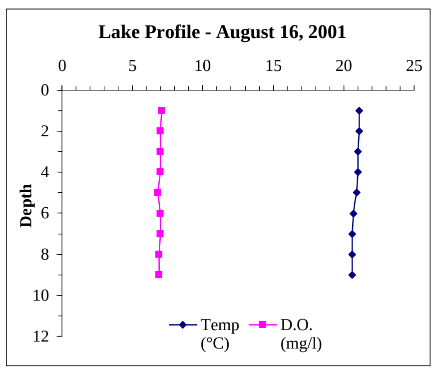
Parameter	UPostS	UPostB
Total P (mg/l)	0.049	0.043
Dissolved P (mg/l)		
Chl a (µg/l)	20	
TKN (mg/l)		
NO_4+NO_3-N (mg/l)		
NH_3-N (mg/l)		
Total N (mg/l)		
Lab Cond. (µS/cm)		
Lab pH		
Alkal (mg/l $CaCO_3$)		
Total Susp Sol (mg/l)		
Calcium (mg/l)		

Notes:

Lower Post Lake

Date:	**08-16-01**		**Max Depth (ft):**	10.8
Time:	14:25		**LPostS Depth (ft):**	3.0
Weather:	100% Cloud Cover 71° F Fairly Calm		**LPostB Depth (ft):**	7.0
Ent:	TAH	**Verf:**	**Secchi Depth (ft):**	9.4

Depth (ft)	Temp (°C)	D.O. (mg/l)	pH	Sp. Cond (µS/cm)
1.0	21.1	7.1	8.1	120
2.0	21.1	7.0	8.1	120
3.0	21.0	7.0	8.1	120
4.0	21.0	7.0	8.1	120
5.0	20.9	6.8	8.1	119
6.0	20.7	7.0	8.1	120
7.0	20.6	7.0	8.2	120
8.0	20.6	6.9	8.1	120
9.0	20.6	6.9	8.1	120



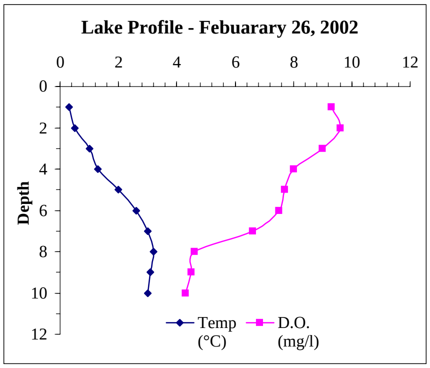
Parameter	LPostS	LPostB
Total P (mg/l)	0.020	0.016
Dissolved P (mg/l)		
Chl a (µg/l)	2.1	
TKN (mg/l)		
NO_4+NO_3-N (mg/l)		
NH_3-N (mg/l)		
Total N (mg/l)		
Lab Cond. (µS/cm)		
Lab pH		
Tot Alk (mg/l $CaCO_3$)		
Total Susp Sol (mg/l)		
Calcium (mg/l)		

Notes:

Upper Post Lake

Date:	**02-26-02**	**Max Depth (ft):**	11.5
Time:	11:50	**UPostS Depth (ft):**	3.0
Weather:	19º F Very windy, snow, overcast	**UPostB Depth (ft):**	9.0
Ent:	TAH **Verf:**	**Secchi Depth (ft):**	4.0

Depth (ft)	Temp (°C)	D.O. (mg/l)	pH	Sp. Cond (µS/cm)
1.0	0.3	9.3	7.3	143
2.0	0.5	9.6	7.3	142
3.0	1.0	9.0	7.3	140
4.0	1.3	8.0	7.3	140
5.0	2.0	7.7	7.2	136
6.0	2.6	7.5	7.2	134
7.0	3.0	6.6	7.2	135
8.0	3.2	4.6	7.2	138
9.0	3.1	4.5	7.1	150
10.0	3.0	4.3	7.1	163



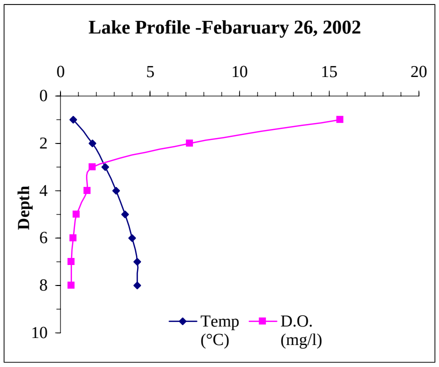
Parameter	UPostS	UPostB
Total P (mg/l)	0.014	0.011
Dissolved P (mg/l)		
Chl a (µg/l)		
TKN (mg/l)		
NO_4+NO_3-N (mg/l)		
NH_3-N (mg/l)		
Total N (mg/l)		
Lab Cond. (µS/cm)		
Lab pH		
Alkal (mg/l $CaCO_3$)		
Total Susp Sol (mg/l)		
Calcium (mg/l)		

Notes: The lower layer of Upper Post Lake is likely affected by the water entering the lake from the Wolf River.

Lower Post Lake

Date:	**02-26-02**	**Max Depth (ft):**	10.2
Time:	10:24	**LPostS Depth (ft):**	3.0
Weather:	18º F very windy, light snow, overcast.	**LPostB Depth (ft):**	7.0
Ent:	TAH **Verf:**	**Secchi Depth (ft):**	2.5

Depth (ft)	Temp (°C)	D.O. (mg/l)	pH	Sp. Cond (µS/cm)
1.0	0.7	15.6	7.8	136
2.0	1.8	7.2	7.3	161
3.0	2.5	1.8	7.2	165
4.0	3.1	1.5	7.2	168
5.0	3.6	0.9	7.1	169
6.0	4.0	0.7	7.1	172
7.0	4.3	0.6	7.0	178
8.0	4.3	0.6	6.9	186



Parameter	LPostS	LPostB
Total P (mg/l)	0.023	0.028
Dissolved P (mg/l)		
Chl a (µg/l)		
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		
Tot Alk (mg/l $CaCO_3$)		
Total Susp Sol (mg/l)		
Calcium (mg/l)		

Notes: Plants were very abundant at 8 feet. Made it difficult to sample LPOSTB

B

APPENDIX B

Comprehensive Aquatic Vegetation Survey Data

Transect	Depth Range	Substrate	Species	Common Name	Aerial Cover	Max Veg Z	Daubenmire Cover	Acronym
1	1	Sand	Potentilla palustris	Marsh Cinquefoil	1	5	1	POTPA
1	1	Sand	Sagittaria latifolia	Common arrowhead, broad-leaf arrowhead, duck potato, wapato	1	5	1	SAGLA
1	2	Sand	Chara sp.	Muskgrasses, stoneworts	1	5.5	1	CHASP
1	2	Sand	Lemna trisulca	Forked duckweed, ivy-leaf, star duckweed	1	5.5	1	LEMTR
1	2	Sand	Myriophyllum sibiricum	Northern water milfoil, spiked water milfoil	5	5	2	MYRSI
1	2	Sand	Spirodela polyrhiza	Great duckweed, large duckweed	1	5	1	SPIPO
1	3	DetritalMuck	Lemna minor	Small duckweed, water lentil, lesser duckweed	30	5	3	LEMMI
1	3	DetritalMuck	Potamogeton richardsonii	Clasping-leaf pondweed	5	6	2	POTRI
1	4	Muck	Nitella sp.	Stoneworts	40	6	3	NITSP
1	4	Muck	Potamogeton crispus	Curly-leaf pondweed	10	6	2	POTCR
1	4	Muck	Potamogeton pectinatus	Sago pondweed	1	6	1	POTPE
2	1	Sand w/Cobble	Potamogeton foliosus	Leafy pondweed	10	6.5	2	POTFO
2	1	Sand w/Cobble	Potamogeton illinoensis	Illinois pondweed	1	6	1	POTIL
2	2	Sand	Elodea canadensis	Common waterweed	5	6	2	ELOCA
2	2	Sand	Nymphaea odorata	White water lily, fragrant water lily	20	5.5	2	NYMOD
2	2	Sand	Potamogeton robbinsii	Fern pondweed, Robins pondweed	40	5	3	POTRO
2	3	Sand	Potamogeton zosteriformis	Flat-stem pondweed	5	5.5	2	POTZO
2	4	Muck	Nuphar variegata	Spatterdock, bullhead pond lily	50	5.5	4	NUPVA
2	4	Muck	Sparganium fluctuans	Floating-leaf bur-reed	5	5.5	2	SPAFL
2	4	Muck	Utricularia vulgaris	Common bladderwort, great bladderwort	1	5.5	1	UTRVU
3	1	Rocky Sand	Elodea nuttallii	Slender waterweed	5	6	2	ELONU
3	2	Sand w/Cobble	Ceratophyllum demersum	Coontail, hornwort	30	5.5	3	CERDE
3	3	Sand w/Cobble	Vallisneria americana	Wild celery, eel-grass, tape-grass	30	6	3	VALAM
3	4	Muck	Ceratophyllum demersum	Coontail, hornwort	1	7	1	CERDE
4	1	Sand w/Cobble	Ceratophyllum demersum	Coontail, hornwort	5	7	2	CERDE
4	2	Sand	Ceratophyllum demersum	Coontail, hornwort	30	5	3	CERDE
4	3	Sand	Ceratophyllum demersum	Coontail, hornwort	5	5	2	CERDE
4	4	Sand	Ceratophyllum demersum	Coontail, hornwort	10	5	2	CERDE
5	1	Sand w/Cobble	Ceratophyllum demersum	Coontail, hornwort	30	5	3	CERDE
5	2	Sand w/Cobble	Ceratophyllum demersum	Coontail, hornwort	1	6	1	CERDE
5	3	Muck	Ceratophyllum demersum	Coontail, hornwort	1	6	1	CERDE
5	4	Mucky Sand	Ceratophyllum demersum	Coontail, hornwort	25	6	3	CERDE
6	1	Muck	Ceratophyllum demersum	Coontail, hornwort	1	6.5	1	CERDE
6	1	Muck	Ceratophyllum demersum	Coontail, hornwort	5	6.5	2	CERDE
6	1	Muck	Ceratophyllum demersum	Coontail, hornwort	1	6	1	CERDE
6	1	Muck	Ceratophyllum demersum	Coontail, hornwort	10	6	2	CERDE
6	1	Muck	Ceratophyllum demersum	Coontail, hornwort	40	6	3	CERDE
6	1	Muck	Ceratophyllum demersum	Coontail, hornwort	1	6	1	CERDE
6	1	Muck	Ceratophyllum demersum	Coontail, hornwort	1	6	1	CERDE
6	1	Muck	Ceratophyllum demersum	Coontail, hornwort	1	6	1	CERDE
6	1	Muck	Ceratophyllum demersum	Coontail, hornwort	40	6	3	CERDE
6	2	Muck	Ceratophyllum demersum	Coontail, hornwort	1	5.5	1	CERDE
6	2	Muck	Chara sp.	Muskgrasses, stoneworts	1	6	1	CHASP
6	2	Muck	Elodea canadensis	Common waterweed	10	5	2	ELOCA
6	2	Muck	Elodea canadensis	Common waterweed	5	5	2	ELOCA
6	2	Muck	Elodea canadensis	Common waterweed	1	6	1	ELOCA
6	2	Muck	Elodea canadensis	Common waterweed	1	6	1	ELOCA
6	3	Muck	Elodea canadensis	Common waterweed	1	6	1	ELOCA
6	3	Muck	Elodea nuttallii	Slender waterweed	20	6	2	ELONU
6	3	Muck	Elodea nuttallii	Slender waterweed	1	6	1	ELONU
6	3	Muck	Elodea nuttallii	Slender waterweed	5	5	2	ELONU
6	3	Muck	Elodea nuttallii	Slender waterweed	5	6	2	ELONU
6	4	Muck	Elodea nuttallii	Slender waterweed	1	6	1	ELONU
6	4	Muck	Elodea nuttallii	Slender waterweed	1	5	1	ELONU
7	1	Sandy Rock	Elodea nuttallii	Slender waterweed	20	5	2	ELONU
7	2	Sand w/Cobble	Elodea nuttallii	Slender waterweed	5	5	2	ELONU
7	3	Sand	Elodea nuttallii	Slender waterweed	1	6	1	ELONU
7	4	Sand	Elodea nuttallii	Slender waterweed	20	6	2	ELONU
7	4	Sand	Elodea nuttallii	Slender waterweed	1	6	1	ELONU
7	4	Sand	Elodea nuttallii	Slender waterweed	1	6	1	ELONU
8	1	Sandy Rock	Elodea nuttallii	Slender waterweed	30	6.5	3	ELONU
8	2	Sand w/Cobble	Elodea nuttallii	Slender waterweed	5	6.5	2	ELONU
8	2	Sand w/Cobble	Elodea nuttallii	Slender waterweed	1	6.5	1	ELONU
8	3	Sand	Elodea nuttallii	Slender waterweed	1	6	1	ELONU
8	3	Sand	Lemna trisulca	Forked duckweed, ivy-leaf, star duckweed	1	5	1	LEMTR
8	3	Sand	NO VEG	NO VEG		4	0	NO VEG
8	4	Sandy Muck	NO VEG	NO VEG		4	0	NO VEG
8	4	Sandy Muck	NO VEG	NO VEG		4	0	NO VEG
8	4	Sandy Muck	NO VEG	NO VEG		4	0	NO VEG
9	1	Sand w/Cobble	NO VEG	NO VEG		2	0	NO VEG
9	1	Sand w/Cobble	NO VEG	NO VEG		2	0	NO VEG
9	2	Sand	NO VEG	NO VEG		2	0	NO VEG
9	2	Sand	NO VEG	NO VEG		6	0	NO VEG
9	3	Sand	NO VEG	NO VEG		5	0	NO VEG
9	3	Sand	NO VEG	NO VEG		6	0	NO VEG

Transect	Depth Range	Substrate	Species	Common Name	Aerial Cover	Max Veg Z	Daubenmire Cover	Acronym
9	4	Sand	NO VEG	NO VEG		6	0	NO VEG
10	1	Sand w/Cobble	NO VEG	NO VEG		6	0	NO VEG
10	1	Sand w/Cobble	NO VEG	NO VEG		5.5	0	NO VEG
10	1	Sand w/Cobble	NO VEG	NO VEG		3.5	0	NO VEG
10	1	Sand w/Cobble	NO VEG	NO VEG		3.5	0	NO VEG
10	2	Mucky Sand	NO VEG	NO VEG		6	0	NO VEG
10	2	Mucky Sand	Nuphar variegata	Spatterdock, bullhead pond lily	30	7	3	NUPVA
10	2	Mucky Sand	Nuphar variegata	Spatterdock, bullhead pond lily	40	7	3	NUPVA
10	2	Mucky Sand	Nuphar variegata	Spatterdock, bullhead pond lily	1	5	1	NUPVA
10	2	Mucky Sand	Nuphar variegata	Spatterdock, bullhead pond lily	40	6.5	3	NUPVA
10	3	Mucky Sand	Nuphar variegata	Spatterdock, bullhead pond lily	5	6	2	NUPVA
10	3	Mucky Sand	Nuphar variegata	Spatterdock, bullhead pond lily	40	6	3	NUPVA
10	4	Muck	Nuphar variegata	Spatterdock, bullhead pond lily	30	6	3	NUPVA
10	4	Muck	Nymphaea odorata	White water lily, fragrant water lily	1	7	1	NYMOD
10	4	Muck	Nymphaea odorata	White water lily, fragrant water lily	1	2	1	NYMOD
10	4	Muck	Nymphaea odorata	White water lily, fragrant water lily	1	5	1	NYMOD
11	1	Sand	Nymphaea odorata	White water lily, fragrant water lily	15	5.5	2	NYMOD
11	2	Sand	Potamogeton amplifolius	Large-leaf pondweed, bass weed, musky weed	5	5	2	POTAM
11	2	Sand	Potamogeton crispus	Curly-leaf pondweed	1	6	1	POTCR
11	2	Sand	Potamogeton foliosus	Leafy pondweed	1	6	1	POTFO
11	3	Sandy Muck	Potamogeton foliosus	Leafy pondweed	1	6	1	POTFO
11	3	Sandy Muck	Potamogeton foliosus	Leafy pondweed	1	6	1	POTFO
11	3	Sandy Muck	Potamogeton illinoensis	Illinois pondweed	1	7	1	POTIL
11	3	Sandy Muck	Potamogeton illinoensis	Illinois pondweed	10	6	2	POTIL
11	3	Sandy Muck	Potamogeton illinoensis	Illinois pondweed	1	6	1	POTIL
11	4	Muck	Potamogeton pectinatus	Sago pondweed	1	6	1	POTPE
11	4	Muck	Potamogeton pectinatus	Sago pondweed	5	6	2	POTPE
12	1	Rocky Sand	Potamogeton robbinsii	Fern pondweed, Robins pondweed	5	7	2	POTRO
12	2	Rocky Sand	Potamogeton robbinsii	Fern pondweed, Robins pondweed	10	5	2	POTRO
12	3	Sand	Potamogeton zosteriformis	Flat-stem pondweed	1	6.5	1	POTZO
12	3	Sand	Potamogeton zosteriformis	Flat-stem pondweed	1	6	1	POTZO
12	4	Sandy Muck	Potamogeton zosteriformis	Flat-stem pondweed	20	6	2	POTZO
13	1	Sandy Rock	Potamogeton zosteriformis	Flat-stem pondweed	1	6	1	POTZO
13	2	Sandy Rock	Potamogeton zosteriformis	Flat-stem pondweed	1	6	1	POTZO
13	3	Sand	Sparganium fluctuans	Floating-leaf bur-reed	1	6	1	SPAFL
13	3	Sand	Sparganium fluctuans	Floating-leaf bur-reed	1	6	1	SPAFL
13	3	Sand	Sparganium fluctuans	Floating-leaf bur-reed	5	6	2	SPAFL
13	4	Mucky Sand	Sparganium fluctuans	Floating-leaf bur-reed	10	5.5	2	SPAFL
13	4	Mucky Sand	Utricularia vulgaris	Common bladderwort, great bladderwort	5	6	2	UTRVU
14	1	Muck	Utricularia vulgaris	Common bladderwort, great bladderwort	40	6	3	UTRVU
14	2	Muck	Utricularia vulgaris	Common bladderwort, great bladderwort	20	6	2	UTRVU
14	2	Muck	Utricularia vulgaris	Common bladderwort, great bladderwort	1	6	1	UTRVU
14	2	Muck	Utricularia vulgaris	Common bladderwort, great bladderwort	1	5.5	1	UTRVU
14	2	Muck	Vallisneria americana	Wild celery, eel-grass, tape-grass	5	7	2	VALAM
14	3	Muck	Vallisneria americana	Wild celery, eel-grass, tape-grass	40	7	3	VALAM
14	3	Muck	Vallisneria americana	Wild celery, eel-grass, tape-grass	25	7	3	VALAM
14	3	Muck	Vallisneria americana	Wild celery, eel-grass, tape-grass	1	7	1	VALAM
14	3	Muck	Vallisneria americana	Wild celery, eel-grass, tape-grass	40	6	3	VALAM
14	3	Muck	Vallisneria americana	Wild celery, eel-grass, tape-grass	30	6	3	VALAM
14	4	Sandy Muck	Vallisneria americana	Wild celery, eel-grass, tape-grass	20	6	2	VALAM
14	4	Sandy Muck	Vallisneria americana	Wild celery, eel-grass, tape-grass	1	6	1	VALAM
14	4	Sandy Muck	Vallisneria americana	Wild celery, eel-grass, tape-grass	30	4	3	VALAM
15	1	Sandy Rock	Vallisneria americana	Wild celery, eel-grass, tape-grass	30	4	3	VALAM
15	1	Sandy Rock	Vallisneria americana	Wild celery, eel-grass, tape-grass	60	4	4	VALAM
15	1	Sandy Rock	Vallisneria americana	Wild celery, eel-grass, tape-grass	60	4	4	VALAM
15	1	Sandy Rock	Vallisneria americana	Wild celery, eel-grass, tape-grass	1	5	1	VALAM
15	2	Sand	Vallisneria americana	Wild celery, eel-grass, tape-grass	20	5	2	VALAM
15	2	Sand	Vallisneria americana	Wild celery, eel-grass, tape-grass	10	5	2	VALAM
15	3	Sand	Vallisneria americana	Wild celery, eel-grass, tape-grass	10	5	2	VALAM
15	3	Sand	Vallisneria americana	Wild celery, eel-grass, tape-grass	10	6	2	VALAM
15	4	Mucky Sand	Vallisneria americana	Wild celery, eel-grass, tape-grass	30	6	3	VALAM
15	4	Mucky Sand	Vallisneria americana	Wild celery, eel-grass, tape-grass	30	6	3	VALAM
15	4	Mucky Sand	Vallisneria americana	Wild celery, eel-grass, tape-grass	50	6	4	VALAM
16	1	Sand	Vallisneria americana	Wild celery, eel-grass, tape-grass	40	6	3	VALAM
16	1	Sand	Vallisneria americana	Wild celery, eel-grass, tape-grass	25	6	3	VALAM
16	1	Sand	Vallisneria americana	Wild celery, eel-grass, tape-grass	30	5	3	VALAM
16	2	Sand	Vallisneria americana	Wild celery, eel-grass, tape-grass	65	5	4	VALAM
16	2	Sand	Vallisneria americana	Wild celery, eel-grass, tape-grass	30	5	3	VALAM
16	2	Sand	Vallisneria americana	Wild celery, eel-grass, tape-grass	10	6	2	VALAM
16	2	Sand	Vallisneria americana	Wild celery, eel-grass, tape-grass	40	6	3	VALAM
16	3	Mucky Sand	Vallisneria americana	Wild celery, eel-grass, tape-grass	75	6	5	VALAM
16	3	Mucky Sand	Vallisneria americana	Wild celery, eel-grass, tape-grass	5	6	2	VALAM
16	4	Muck	Vallisneria americana	Wild celery, eel-grass, tape-grass	40	6.5	3	VALAM
16	4	Muck	Vallisneria americana	Wild celery, eel-grass, tape-grass	60	6.5	4	VALAM
17	1	Muck	Vallisneria americana	Wild celery, eel-grass, tape-grass	60	6.5	4	VALAM

Transect	Depth Range	Substrate	Species	Common Name	Aerial Cover	Max Veg Z	Daubenmire Cover	Acronym
17	2	Muck	Vallisneria americana	Wild celery, eel-grass, tape-grass	30	6	3	VALAM
17	2	Muck	Vallisneria americana	Wild celery, eel-grass, tape-grass	50	6	4	VALAM
17	2	Muck	Vallisneria americana	Wild celery, eel-grass, tape-grass	15	6	2	VALAM
17	2	Muck	Vallisneria americana	Wild celery, eel-grass, tape-grass	40	6	3	VALAM
17	3	Muck	Vallisneria americana	Wild celery, eel-grass, tape-grass	30	6	3	VALAM
17	3	Muck	Vallisneria americana	Wild celery, eel-grass, tape-grass	20	6	2	VALAM
17	4	Muck	Vallisneria americana	Wild celery, eel-grass, tape-grass	1	6	1	VALAM
18	1	Sand w/Cobble	Vallisneria americana	Wild celery, eel-grass, tape-grass	30	6	3	VALAM
18	1	Sand w/Cobble	Vallisneria americana	Wild celery, eel-grass, tape-grass	25	6	3	VALAM
18	1	Sand w/Cobble	Vallisneria americana	Wild celery, eel-grass, tape-grass	70	6	4	VALAM
18	2	Mucky Sand	Vallisneria americana	Wild celery, eel-grass, tape-grass	80	6	5	VALAM
18	2	Mucky Sand	Vallisneria americana	Wild celery, eel-grass, tape-grass	60	6	4	VALAM
18	2	Mucky Sand	Vallisneria americana	Wild celery, eel-grass, tape-grass	1	6	1	VALAM
18	3	Muck	Vallisneria americana	Wild celery, eel-grass, tape-grass	40	6	3	VALAM
18	3	Muck	Vallisneria americana	Wild celery, eel-grass, tape-grass	30	6	3	VALAM
18	3	Muck	Vallisneria americana	Wild celery, eel-grass, tape-grass	20	6	2	VALAM
18	4	Muck	Vallisneria americana	Wild celery, eel-grass, tape-grass	15	5.5	2	VALAM
18	4	Muck	Vallisneria americana	Wild celery, eel-grass, tape-grass	20	5.5	2	VALAM
19	1	Sand w/Cobble	Vallisneria americana	Wild celery, eel-grass, tape-grass	30	5.5	3	VALAM
19	2	Sand w/Cobble	Vallisneria americana	Wild celery, eel-grass, tape-grass	25	5.5	3	VALAM
19	3	Sand	Vallisneria americana	Wild celery, eel-grass, tape-grass	25	5.5	3	VALAM
19	4	Sand	Vallisneria americana	Wild celery, eel-grass, tape-grass	1	5.5	1	VALAM
20	1	Sand w/Cobble	Vallisneria americana	Wild celery, eel-grass, tape-grass	70	3.5	4	VALAM
20	2	Sand	Vallisneria americana	Wild celery, eel-grass, tape-grass	30	3.5	3	VALAM
20	3	Sand	Vallisneria americana	Wild celery, eel-grass, tape-grass	10	6	2	VALAM
20	4	Mucky Sand	Vallisneria americana	Wild celery, eel-grass, tape-grass	30	6	3	VALAM

Transect	Depth Range	Substrate	Species	Common Name	Aerial Cover	Max Veg Z	Daubenmire Cover	Notes	Acronym
1	1	Bog	NO VEG	NO VEG		Complete	0		NO VEG
1	2	Muck	Nuphar variegata	Spatterdock, bullhead pond lily	90	Complete	5		NUPVA
1	2	Muck	Nymphaea odorata	White water lily, fragrant water lily	10	Complete	2		NYMOD
1	2	Muck	Lemna trisulca	Forked duckweed, ivy-leaf, star duckweed	5	Complete	2		LEMTR
1	2	Muck	Potamogeton robbinsii	Fern pondweed, Robins pondweed	30	Complete	3		POTRO
1	2	Muck	Elodea canadensis	Common waterweed	25	Complete	3		ELOCA
1	2	Muck	Ceratophyllum demersum	Coontail, hornwort	10	Complete	2		CERDE
1	2	Muck	Elodea nuttallii	Slender waterweed	15	Complete	2		ELONU
1	3	Muck	Nuphar variegata	Spatterdock, bullhead pond lily	50	Complete	4		NUPVA
1	3	Muck	Elodea canadensis	Common waterweed	25	Complete	3		ELOCA
1	3	Muck	Elodea nuttallii	Slender waterweed	20	Complete	2		ELONU
1	3	Muck	Ceratophyllum demersum	Coontail, hornwort	5	Complete	2		CERDE
1	3	Muck	Potamogeton robbinsii	Fern pondweed, Robins pondweed	5	Complete	2		POTRO
1	4	Muck	Elodea nuttallii	Slender waterweed	60	Complete	4		ELONU
1	4	Muck	Potamogeton robbinsii	Fern pondweed, Robins pondweed	50	Complete	4		POTRO
1	4	Muck	Elodea canadensis	Common waterweed	1	Complete	1		ELOCA
2	1	Mucky Sand	Lemna trisulca	Forked duckweed, ivy-leaf, star duckweed	95	Complete	6		LEMTR
2	1	Mucky Sand	Potamogeton robbinsii	Fern pondweed, Robins pondweed	5	Complete	2		POTRO
2	1	Mucky Sand	Elodea nuttallii	Slender waterweed	5	Complete	2		ELONU
2	1	Mucky Sand	Ceratophyllum demersum	Coontail, hornwort	1	Complete	1		CERDE
2	1	Mucky Sand	Nuphar variegata	Spatterdock, bullhead pond lily	5	Complete	2		NUPVA
2	1	Mucky Sand	Nymphaea odorata	White water lily, fragrant water lily	1	Complete	1		NYMOD
2	2	Mucky Sand	Nymphaea odorata	White water lily, fragrant water lily	1	Complete	1		NYMOD
2	2	Mucky Sand	Nuphar variegata	Spatterdock, bullhead pond lily	25	Complete	3		NUPVA
2	2	Mucky Sand	Lemna trisulca	Forked duckweed, ivy-leaf, star duckweed	40	Complete	3		LEMTR
2	2	Mucky Sand	Elodea canadensis	Common waterweed	10	Complete	2		ELOCA
2	2	Mucky Sand	Elodea nuttallii	Slender waterweed	10	Complete	2		ELONU
2	2	Mucky Sand	Potamogeton robbinsii	Fern pondweed, Robins pondweed	5	Complete	2		POTRO
2	2	Mucky Sand	Potamogeton robbinsii	Fern pondweed, Robins pondweed	1	Complete	1		POTRO
2	2	Mucky Sand	Ceratophyllum demersum	Coontail, hornwort	1	Complete	1		CERDE
2	3	Muck	Potamogeton robbinsii	Fern pondweed, Robins pondweed	80	Complete	5		POTRO
2	3	Muck	Elodea canadensis	Common waterweed	10	Complete	2		ELOCA
2	3	Muck	Potamogeton pectinatus	Sago pondweed	1	Complete	1		POTPE
2	3	Muck	Elodea nuttallii	Slender waterweed	1	Complete	1		ELONU
2	3	Muck	Ceratophyllum demersum	Coontail, hornwort	1	Complete	1		CERDE
2	4	Muck	Potamogeton robbinsii	Fern pondweed, Robins pondweed	75	Complete	5		POTRO
2	4	Muck	Ceratophyllum demersum	Coontail, hornwort	5	Complete	2		CERDE
2	4	Muck	Elodea canadensis	Common waterweed	1	Complete	1		ELOCA
2	4	Muck	Elodea nuttallii	Slender waterweed	5	Complete	2		ELONU
3	1	Pebbly Sand	Vallisneria americana	Wild celery, eel-grass, tape-grass	10	Complete	2		VALAM
3	1	Pebbly Sand	Eleocharis acicularis	Needle spikerush, hairgrass	5	Complete	2		ELEAC
3	1	Pebbly Sand	Nymphaea odorata	White water lily, fragrant water lily	1	Complete	1		NYMOD
3	1	Pebbly Sand	Elodea nuttallii	Slender waterweed	25	Complete	3		ELONU
3	1	Pebbly Sand	Ceratophyllum demersum	Coontail, hornwort	5	Complete	2		CERDE
3	2	Sand	Vallisneria americana	Wild celery, eel-grass, tape-grass	50	Complete	4		VALAM
3	2	Sand	Elodea nuttallii	Slender waterweed	25	Complete	3		ELONU
3	2	Sand	Elodea canadensis	Common waterweed	1	Complete	1		ELOCA
3	2	Sand	Potamogeton robbinsii	Fern pondweed, Robins pondweed	1	Complete	1		POTRO
3	3	Sand	Elodea nuttallii	Slender waterweed	75	Complete	5		ELONU
3	3	Sand	Potamogeton zosteriformis	Flat-stem pondweed	1	Complete	1		POTZO
3	3	Sand	Potamogeton robbinsii	Fern pondweed, Robins pondweed	1	Complete	1		POTRO
3	3	Sand	Elodea canadensis	Common waterweed	10	Complete	2		ELOCA
3	3	Sand	Ceratophyllum demersum	Coontail, hornwort	5	Complete	2		CERDE
3	4	Sand	Potamogeton robbinsii	Fern pondweed, Robins pondweed	85	Complete	5		POTRO
3	4	Sand	Ceratophyllum demersum	Coontail, hornwort	1	Complete	1		CERDE
3	4	Sand	Elodea nuttallii	Slender waterweed	40	Complete	3		ELONU
3	4	Sand	Elodea canadensis	Common waterweed	1	Complete	1		ELOCA
4	1	Rocky Sand	Vallisneria americana	Wild celery, eel-grass, tape-grass	10	Complete	2		VALAM
4	1	Rocky Sand	Elodea nuttallii	Slender waterweed	30	Complete	3		ELONU
4	1	Rocky Sand	Elodea canadensis	Common waterweed	15	Complete	2		ELOCA
4	2	Sand	Ceratophyllum demersum	Coontail, hornwort	1	Complete	1		CERDE
4	2	Sand	Elodea canadensis	Common waterweed	10	Complete	2		ELOCA
4	2	Sand	Elodea nuttallii	Slender waterweed	80	Complete	5		ELONU
4	2	Sand	Lemna trisulca	Forked duckweed, ivy-leaf, star duckweed	5	Complete	2		LEMTR
4	2	Sand	Potamogeton robbinsii	Fern pondweed, Robins pondweed	20	Complete	2		POTRO
4	3	Muck	Elodea nuttallii	Slender waterweed	90	Complete	5		ELONU
4	3	Muck	Potamogeton robbinsii	Fern pondweed, Robins pondweed	5	Complete	2		POTRO
4	3	Muck	Elodea canadensis	Common waterweed	1	Complete	1		ELOCA
4	3	Muck	Elodea nuttallii	Slender waterweed	50	Complete	4		ELONU
4	4	Muck	Potamogeton illinoensis	Illinois pondweed	1	Complete	1		POTIL
4	4	Muck	Potamogeton robbinsii	Fern pondweed, Robins pondweed	75	Complete	5		POTRO
4	4	Muck	Elodea canadensis	Common waterweed	5	Complete	2		ELOCA
4	4	Muck	Elodea nuttallii	Slender waterweed	50	Complete	4		ELONU
5	1	Rocky Sand	Sparganium eurycarpum	Common bur-reed	1	Complete	1		SPAEU
5	1	Rocky Sand	Nuphar variegata	Spatterdock, bullhead pond lily	20	Complete	2		NUPVA

Transect	Depth Range	Substrate	Species	Common Name	Aerial Cover	Max Veg Z	Daubenmire Cover	Notes	Acronym
5	1	Rocky Sand	Elodea canadensis	Common waterweed	50	Complete	4		ELOCA
5	1	Rocky Sand	Potamogeton robbinsii	Fern pondweed, Robins pondweed	5	Complete	2		POTRO
5	1	Rocky Sand	Elodea nuttallii	Slender waterweed	5	Complete	2		ELONU
5	2	Sandy Muck	Nuphar variegata	Spatterdock, bullhead pond lily	75	Complete	5		NUPVA
5	2	Sandy Muck	Nymphaea odorata	White water lily, fragrant water lily	5	Complete	2		NYMOD
5	2	Sandy Muck	Elodea canadensis	Common waterweed	70	Complete	4		ELOCA
5	2	Sandy Muck	Potamogeton robbinsii	Fern pondweed, Robins pondweed	1	Complete	1		POTRO
5	2	Sandy Muck	Elodea nuttallii	Slender waterweed	5	Complete	2		ELONU
5	2	Sandy Muck	Ceratophyllum demersum	Coontail, hornwort	1	Complete	1		CERDE
5	3	Muck	Elodea nuttallii	Slender waterweed	85	Complete	5		ELONU
5	3	Muck	Lemna trisulca	Forked duckweed, ivy-leaf, star duckweed	20	Complete	2		LEMTR
5	3	Muck	Nuphar variegata	Spatterdock, bullhead pond lily	5	Complete	2		NUPVA
5	3	Muck	Potamogeton illinoensis	Illinois pondweed	5	Complete	2		POTIL
5	3	Muck	Potamogeton robbinsii	Fern pondweed, Robins pondweed	10	Complete	2		POTRO
5	3	Muck	Elodea canadensis	Common waterweed	1	Complete	1		ELOCA
5	4	Muck	Ceratophyllum demersum	Coontail, hornwort	1	Complete	1		CERDE
5	4	Muck	Elodea nuttallii	Slender waterweed	70	Complete	4		ELONU
5	4	Muck	Lemna trisulca	Forked duckweed, ivy-leaf, star duckweed	1	Complete	1		LEMTR
5	4	Muck	Myriophyllum sibiricum	Northern water milfoil, spiked water milfoil	1	Complete	1		MYRSI
5	4	Muck	Potamogeton robbinsii	Fern pondweed, Robins pondweed	40	Complete	3		POTRO
5	4	Muck	Elodea canadensis	Common waterweed	1	Complete	1		ELOCA
6	1	Sand	Vallisneria americana	Wild celery, eel-grass, tape-grass	60	Complete	4		VALAM
6	1	Sand	Ceratophyllum demersum	Coontail, hornwort	1	Complete	1		CERDE
6	2	Sand	Vallisneria americana	Wild celery, eel-grass, tape-grass	10	Complete	2		VALAM
6	2	Sand	Potamogeton zosteriformis	Flat-stem pondweed	1	Complete	1		POTZO
6	2	Sand	Elodea nuttallii	Slender waterweed	40	Complete	3		ELONU
6	2	Sand	Lemna trisulca	Forked duckweed, ivy-leaf, star duckweed	15	Complete	2		LEMTR
6	2	Sand	Potamogeton robbinsii	Fern pondweed, Robins pondweed	10	Complete	2		POTRO
6	2	Sand	Ceratophyllum demersum	Coontail, hornwort	5	Complete	2		CERDE
6	2	Sand	Elodea canadensis	Common waterweed	1	Complete	1		ELOCA
6	3	Mucky Sand	Potamogeton zosteriformis	Flat-stem pondweed	1	Complete	1		POTZO
6	3	Mucky Sand	Elodea nuttallii	Slender waterweed	90	Complete	5		ELONU
6	3	Mucky Sand	Elodea canadensis	Common waterweed	1	Complete	1		ELOCA
6	3	Mucky Sand	Potamogeton robbinsii	Fern pondweed, Robins pondweed	10	Complete	2		POTRO
6	3	Mucky Sand	Ceratophyllum demersum	Coontail, hornwort	1	Complete	1		CERDE
6	4	Muck	Elodea nuttallii	Slender waterweed	60	Complete	4		ELONU
6	4	Muck	Potamogeton zosteriformis	Flat-stem pondweed	20	Complete	2		POTZO
6	4	Muck	Ceratophyllum demersum	Coontail, hornwort	30	Complete	3		CERDE
6	4	Muck	Potamogeton robbinsii	Fern pondweed, Robins pondweed	25	Complete	3		POTRO
7	1	Rocky Sand	NO VEG	NO VEG		Complete	0		NO VEG
7	2	Rocky Sand	Vallisneria americana	Wild celery, eel-grass, tape-grass	10	Complete	2		VALAM
7	2	Rocky Sand	Ceratophyllum demersum	Coontail, hornwort	1	Complete	1		CERDE
7	2	Rocky Sand	Elodea nuttallii	Slender waterweed	10	Complete	2		ELONU
7	3	Rocky Sand	Elodea nuttallii	Slender waterweed	40	Complete	3		ELONU
7	3	Rocky Sand	Potamogeton robbinsii	Fern pondweed, Robins pondweed	1	Complete	1		POTRO
7	3	Rocky Sand	Ceratophyllum demersum	Coontail, hornwort	5	Complete	2		CERDE
7	4	Muck	Ceratophyllum demersum	Coontail, hornwort	40	Complete	3		CERDE
7	4	Muck	Elodea nuttallii	Slender waterweed	40	Complete	3		ELONU
7	4	Muck	Potamogeton zosteriformis	Flat-stem pondweed	5	Complete	2		POTZO
7	4	Muck	Potamogeton robbinsii	Fern pondweed, Robins pondweed	10	Complete	2		POTRO
8	1	Rocky Sand	Ceratophyllum demersum	Coontail, hornwort	20	Complete	2		CERDE
8	1	Rocky Sand	Eleocharis acicularis	Needle spikerush, hairgrass	5	Complete	2		ELEAC
8	1	Rocky Sand	Vallisneria americana	Wild celery, eel-grass, tape-grass	10	Complete	2		VALAM
8	1	Rocky Sand	Elodea nuttallii	Slender waterweed	5	Complete	2		ELONU
8	2	Rocky Sand	Vallisneria americana	Wild celery, eel-grass, tape-grass	10	Complete	2		VALAM
8	2	Rocky Sand	Elodea nuttallii	Slender waterweed	1	Complete	1		ELONU
8	2	Rocky Sand	Ceratophyllum demersum	Coontail, hornwort	1	Complete	1		CERDE
8	3	Sandy Muck	Elodea nuttallii	Slender waterweed	50	Complete	4		ELONU
8	3	Sandy Muck	Ceratophyllum demersum	Coontail, hornwort	25	Complete	3		CERDE
8	3	Sandy Muck	Potamogeton zosteriformis	Flat-stem pondweed	5	Complete	2		POTZO
8	3	Sandy Muck	Myriophyllum sibiricum	Northern water milfoil, spiked water milfoil	1	Complete	1		MYRSI
8	3	Sandy Muck	Potamogeton robbinsii	Fern pondweed, Robins pondweed	20	Complete	2		POTRO
8	4	Sandy Muck	Elodea nuttallii	Slender waterweed	80	Complete	5		ELONU
8	4	Sandy Muck	Ceratophyllum demersum	Coontail, hornwort	10	Complete	2		CERDE
8	4	Sandy Muck	Potamogeton zosteriformis	Flat-stem pondweed	1	Complete	1		POTZO
8	4	Sandy Muck	Potamogeton robbinsii	Fern pondweed, Robins pondweed	10	Complete	2		POTRO
9	1	Rocky Sand	Vallisneria americana	Wild celery, eel-grass, tape-grass	10	Complete	2		VALAM
9	1	Rocky Sand	Eleocharis acicularis	Needle spikerush, hairgrass	1	Complete	1		ELEAC
9	2	Rocky Sand	Potamogeton zosteriformis	Flat-stem pondweed	1	Complete	1		POTZO
9	2	Rocky Sand	Elodea canadensis	Common waterweed	1	Complete	1		ELOCA
9	2	Rocky Sand	Vallisneria americana	Wild celery, eel-grass, tape-grass	75	Complete	5		VALAM
9	2	Rocky Sand	Elodea nuttallii	Slender waterweed	1	Complete	1		ELONU
9	3	Rocky Sand	Elodea nuttallii	Slender waterweed	90	Complete	5		ELONU
9	3	Rocky Sand	Vallisneria americana	Wild celery, eel-grass, tape-grass	1	Complete	1		VALAM
9	3	Rocky Sand	Elodea canadensis	Common waterweed	5	Complete	2		ELOCA

Transect	Depth Range	Substrate	Species	Common Name	Aerial Cover	Max Veg Z	Daubenmire Cover	Notes	Acronym
9	3	Rocky Sand	Ceratophyllum demersum	Coontail, hornwort	1	Complete	1		CERDE
9	3	Rocky Sand	Potamogeton robbinsii	Fern pondweed, Robins pondweed	1	Complete	1		POTRO
9	4	Muck	Elodea nuttallii	Slender waterweed	95	Complete	6		ELONU
9	4	Muck	Elodea canadensis	Common waterweed	1	Complete	1		ELOCA
9	4	Muck	Potamogeton robbinsii	Fern pondweed, Robins pondweed	1	Complete	1		POTRO
9	4	Muck	Ceratophyllum demersum	Coontail, hornwort	1	Complete	1		CERDE
10	1	Rocky Sand	Vallisneria americana	Wild celery, eel-grass, tape-grass	70	Complete	4		VALAM
10	1	Rocky Sand	Lemna trisulca	Forked duckweed, ivy-leaf, star duckweed	1	Complete	1		LEMTR
10	2	Sand	Potamogeton zosteriformis	Flat-stem pondweed	1	Complete	1		POTZO
10	2	Sand	Lemna trisulca	Forked duckweed, ivy-leaf, star duckweed	40	Complete	3		LEMTR
10	2	Sand	Elodea canadensis	Common waterweed	1	Complete	1		ELOCA
10	2	Sand	Elodea nuttallii	Slender waterweed	10	Complete	2		ELONU
10	2	Sand	Ceratophyllum demersum	Coontail, hornwort	1	Complete	1		CERDE
10	3	Sandy Muck	Potamogeton zosteriformis	Flat-stem pondweed	20	Complete	2		POTZO
10	3	Sandy Muck	Elodea nuttallii	Slender waterweed	70	Complete	4		ELONU
10	3	Sandy Muck	Potamogeton robbinsii	Fern pondweed, Robins pondweed	5	Complete	2		POTRO
10	3	Sandy Muck	Ceratophyllum demersum	Coontail, hornwort	1	Complete	1		CERDE
10	4	Muck	Lemna trisulca	Forked duckweed, ivy-leaf, star duckweed	70	Complete	4		LEMTR
10	4	Muck	Elodea nuttallii	Slender waterweed	30	Complete	3		ELONU
10	4	Muck	Potamogeton robbinsii	Fern pondweed, Robins pondweed	10	Complete	2		POTRO
10	4	Muck	Potamogeton zosteriformis	Flat-stem pondweed	5	Complete	2		POTZO
11	1	Bog	NO VEG	NO VEG		Complete	0		NO VEG
11	2	Muck	Potamogeton zosteriformis	Flat-stem pondweed	40	Complete	3		POTZO
11	2	Muck	Ceratophyllum demersum	Coontail, hornwort	40	Complete	3		CERDE
11	2	Muck	Elodea nuttallii	Slender waterweed	1	Complete	1		ELONU
11	2	Muck	Elodea canadensis	Common waterweed	5	Complete	2		ELOCA
11	2	Muck	Myriophyllum sibiricum	Northern water milfoil, spiked water milfoil	1	Complete	1		MYRSI
11	3	Muck	Potamogeton zosteriformis	Flat-stem pondweed	70	Complete	4		POTZO
11	3	Muck	Potamogeton robbinsii	Fern pondweed, Robins pondweed	40	Complete	3		POTRO
11	3	Muck	Elodea canadensis	Common waterweed	10	Complete	2		ELOCA
11	3	Muck	Ceratophyllum demersum	Coontail, hornwort	5	Complete	2		CERDE
11	3	Muck	Elodea nuttallii	Slender waterweed	1	Complete	1		ELONU
11	4	Muck	Potamogeton robbinsii	Fern pondweed, Robins pondweed	99	Complete	6		POTRO
11	4	Muck	Ceratophyllum demersum	Coontail, hornwort	1	Complete	1		CERDE
11	4	Muck	Potamogeton zosteriformis	Flat-stem pondweed	1	Complete	1		POTZO
11	4	Muck	Lemna trisulca	Forked duckweed, ivy-leaf, star duckweed	1	Complete	1		LEMTR
12	1	Rocky Sand	Potamogeton foliosus	Leafy pondweed	1	Complete	1		POTFO
12	1	Rocky Sand	Vallisneria americana	Wild celery, eel-grass, tape-grass	1	Complete	1		VALAM
12	2	Sand	Vallisneria americana	Wild celery, eel-grass, tape-grass	15	Complete	2		VALAM
12	2	Sand	Potamogeton richardsonii	Clasping-leaf pondweed	5	Complete	2		POTRI
12	2	Sand	Ceratophyllum demersum	Coontail, hornwort	30	Complete	3		CERDE
12	2	Sand	Elodea nuttallii	Slender waterweed	30	Complete	3		ELONU
12	2	Sand	Potamogeton zosteriformis	Flat-stem pondweed	10	Complete	2		POTZO
12	2	Sand	Potamogeton robbinsii	Fern pondweed, Robins pondweed	20	Complete	2		POTRO
12	3	Muck	Potamogeton robbinsii	Fern pondweed, Robins pondweed	70	Complete	4		POTRO
12	3	Muck	Ceratophyllum demersum	Coontail, hornwort	30	Complete	3		CERDE
12	3	Muck	Lemna trisulca	Forked duckweed, ivy-leaf, star duckweed	40	Complete	3		LEMTR
12	3	Muck	Potamogeton zosteriformis	Flat-stem pondweed	1	Complete	1		POTZO
12	4	Muck	Potamogeton robbinsii	Fern pondweed, Robins pondweed	70	Complete	4		POTRO
12	4	Muck	Ceratophyllum demersum	Coontail, hornwort	10	Complete	2		CERDE
12	4	Muck	Potamogeton richardsonii	Clasping-leaf pondweed	1	Complete	1		POTRI
12	4	Muck	Lemna trisulca	Forked duckweed, ivy-leaf, star duckweed	1	Complete	1		LEMTR
13	1	Sand w/Cobble	Vallisneria americana	Wild celery, eel-grass, tape-grass	30	Complete	3		VALAM
13	1	Sand w/Cobble	Eleocharis acicularis	Needle spikerush, hairgrass	5	Complete	2		ELEAC
13	2	Sand w/Cobble	Vallisneria americana	Wild celery, eel-grass, tape-grass	40	Complete	3		VALAM
13	2	Sand w/Cobble	Eleocharis acicularis	Needle spikerush, hairgrass	50	Complete	4		ELEAC
13	3	Sand	Elodea nuttallii	Slender waterweed	90	Complete	5		ELONU
13	3	Sand	Ceratophyllum demersum	Coontail, hornwort	1	Complete	1		CERDE
13	3	Sand	Lemna trisulca	Forked duckweed, ivy-leaf, star duckweed	1	Complete	1		LEMTR
13	3	Sand	Potamogeton robbinsii	Fern pondweed, Robins pondweed	1	Complete	1		POTRO
13	4	Muck	Elodea nuttallii	Slender waterweed	60	Complete	4		ELONU
13	4	Muck	Ceratophyllum demersum	Coontail, hornwort	20	Complete	2		CERDE
13	4	Muck	Potamogeton robbinsii	Fern pondweed, Robins pondweed	20	Complete	2		POTRO
13	4	Muck	Potamogeton zosteriformis	Flat-stem pondweed	10	Complete	2		POTZO
14	1	Bog	NO VEG	NO VEG		Complete	0		NO VEG
14	2	Muck	Spirodela polyrhiza	Great duckweed, large duckweed	20	Complete	2		SPIPO
14	2	Muck	Lemna minor	Small duckweed, water lentil, lesser duckweed	50	Complete	4		LEMMI
14	2	Muck	Wolffia columbiana	Common watermeal	15	Complete	2		WOLCO
14	2	Muck	Lemna trisulca	Forked duckweed, ivy-leaf, star duckweed	5	Complete	2		LEMTR
14	2	Muck	Ceratophyllum demersum	Coontail, hornwort	40	Complete	3		CERDE
14	2	Muck	Potamogeton robbinsii	Fern pondweed, Robins pondweed	10	Complete	2		POTRO
14	3	Muck	Potamogeton robbinsii	Fern pondweed, Robins pondweed	70	Complete	4		POTRO
14	3	Muck	Lemna trisulca	Forked duckweed, ivy-leaf, star duckweed	20	Complete	2		LEMTR
14	3	Muck	Potamogeton zosteriformis	Flat-stem pondweed	1	Complete	1		POTZO
14	3	Muck	Ceratophyllum demersum	Coontail, hornwort	20	Complete	2		CERDE

Transect	Depth Range	Substrate	Species	Common Name	Aerial Cover	Max Veg Z	Daubenmire Cover	Notes	Acronym
14	4	Muck	Ceratophyllum demersum	Coontail, hornwort	40	Complete	3		CERDE
14	4	Muck	Potamogeton robbinsii	Fern pondweed, Robins pondweed	40	Complete	3		POTRO
14	4	Muck	Elodea canadensis	Common waterweed	10	Complete	2		ELOCA
14	4	Muck	Elodea nuttallii	Slender waterweed	10	Complete	2		ELONU
14	4	Muck	Lemna trisulca	Forked duckweed, ivy-leaf, star duckweed	5	Complete	2		LEMTR
15	1	Bog	NO VEG	NO VEG		Complete	0		NO VEG
15	2	Muck	Nuphar variegata	Spatterdock, bullhead pond lily	75	Complete	5		NUPVA
15	2	Muck	Nymphaea odorata	White water lily, fragrant water lily	10	Complete	2		NYMOD
15	2	Muck	Vallisneria americana	Wild celery, eel-grass, tape-grass	10	Complete	2		VALAM
15	2	Muck	Lemna trisulca	Forked duckweed, ivy-leaf, star duckweed	1	Complete	1		LEMTR
15	2	Muck	Ceratophyllum demersum	Coontail, hornwort	1	Complete	1		CERDE
15	3	Muck	Nuphar variegata	Spatterdock, bullhead pond lily	25	Complete	3		NUPVA
15	3	Muck	Vallisneria americana	Wild celery, eel-grass, tape-grass	50	Complete	4		VALAM
15	3	Muck	Potamogeton zosteriformis	Flat-stem pondweed	5	Complete	2		POTZO
15	3	Muck	Potamogeton robbinsii	Fern pondweed, Robins pondweed	5	Complete	2		POTRO
15	3	Muck	Ceratophyllum demersum	Coontail, hornwort	1	Complete	1		CERDE
15	3	Muck	Potamogeton richardsonii	Clasping-leaf pondweed	1	Complete	1		POTRI
15	3	Muck	Lemna trisulca	Forked duckweed, ivy-leaf, star duckweed	1	Complete	1		LEMTR
15	4	Muck	Ceratophyllum demersum	Coontail, hornwort	30	Complete	3		CERDE
15	4	Muck	Vallisneria americana	Wild celery, eel-grass, tape-grass	10	Complete	2		VALAM
15	4	Muck	Potamogeton zosteriformis	Flat-stem pondweed	10	Complete	2		POTZO
15	4	Muck	Potamogeton robbinsii	Fern pondweed, Robins pondweed	30	Complete	3		POTRO
15	4	Muck	Lemna trisulca	Forked duckweed, ivy-leaf, star duckweed	1	Complete	1		LEMTR
16	1	Rocky Sand	Vallisneria americana	Wild celery, eel-grass, tape-grass	10	5	2		VALAM
16	2	Rocky Sand	Vallisneria americana	Wild celery, eel-grass, tape-grass	5	5	2		VALAM
16	3	Muck	Vallisneria americana	Wild celery, eel-grass, tape-grass	40	5	3		VALAM
16	4	Muck	NO VEG	NO VEG		5	0		NO VEG
17	1	Rocky Sand	Vallisneria americana	Wild celery, eel-grass, tape-grass	20	7	2		VALAM
17	1	Rocky Sand	Ceratophyllum demersum	Coontail, hornwort	1	7	1		CERDE
17	1	Rocky Sand	Elodea nuttallii	Slender waterweed	1	7	1		ELONU
17	2	Rocky Sand	Ceratophyllum demersum	Coontail, hornwort	20	7	2		CERDE
17	2	Rocky Sand	Elodea canadensis	Common waterweed	10	7	2		ELOCA
17	2	Rocky Sand	Elodea nuttallii	Slender waterweed	20	7	2		ELONU
17	2	Rocky Sand	Vallisneria americana	Wild celery, eel-grass, tape-grass	5	7	2		VALAM
17	3	Muck	Ceratophyllum demersum	Coontail, hornwort	20	7	2		CERDE
17	3	Muck	Vallisneria americana	Wild celery, eel-grass, tape-grass	40	7	3		VALAM
17	3	Muck	Elodea nuttallii	Slender waterweed	1	7	1		ELONU
17	4	Muck	NO VEG	NO VEG		7	0		NO VEG

C

APPENDIX C

Lake Term Glossary

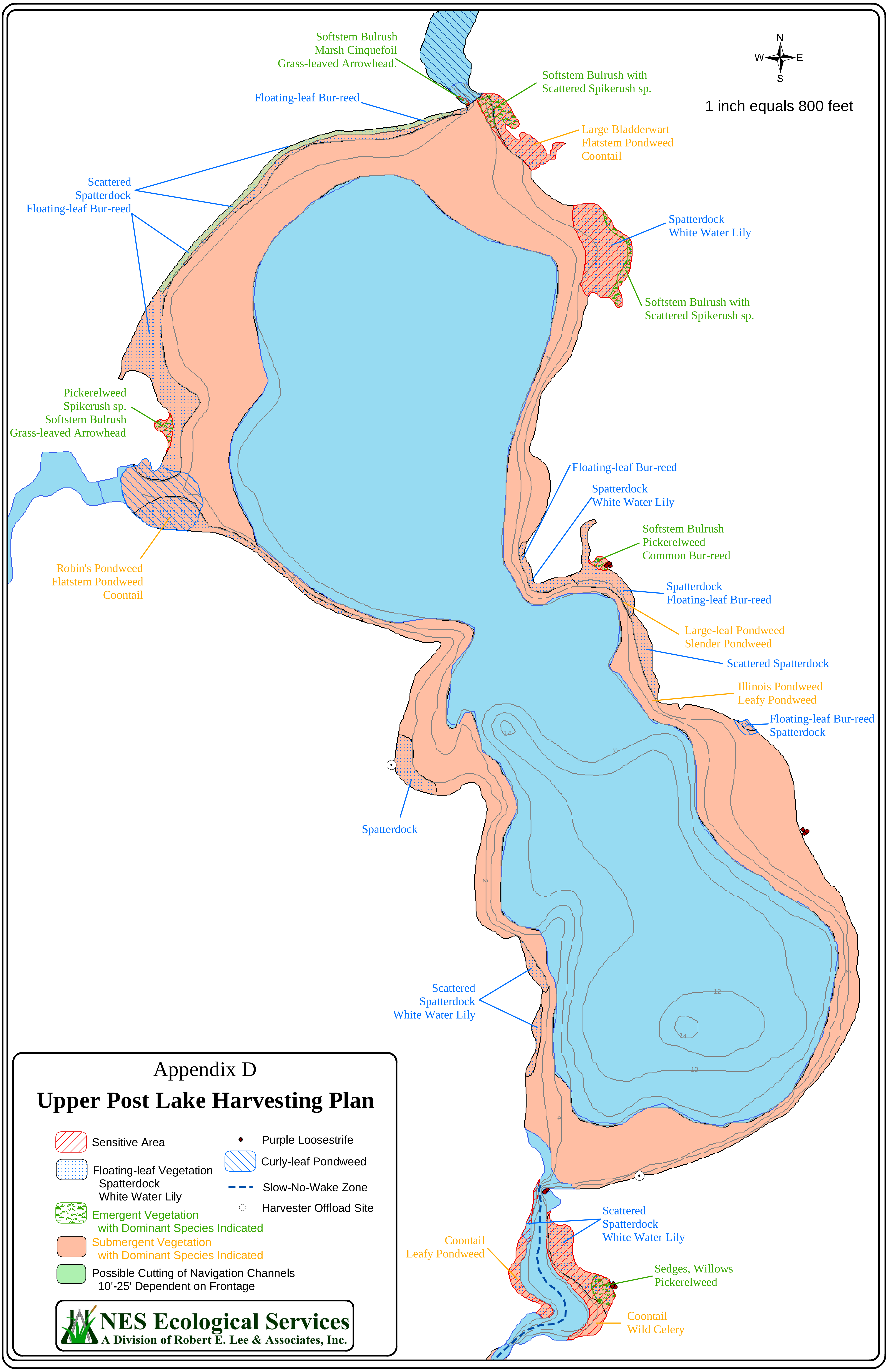
Algae	Microscopic plants that use sunlight as an energy source. Algae can be unicellular (Diatoms), filamentous (many green or blue-green species), colonies in a gelatinous mass (many blue-greens) or more complicated colonies like *Chara sp.*
Anthropogenic	An occurrence caused or produced by the action of humans.
Anoxic	Devoid of dissolved oxygen.
Benthic	Pertaining to a river bed or lake floor
Contact Herbicide	A plant specific pesticide which causes extensive cellular damage exclusively to the areas of the target which come in contact with the herbicide (Affects contacted area only)
Ecosystem	The interaction of a community of organisms with each other and with the characteristics that make up their environment (Aquatic ecosystem, Northern Boreal Forest)
Emergent	An aquatic plant having most of its vegetative parts above the water surface (Cattail, Common Arrowhead)
Epilimnion	The upper most layer of water within a stratified lake. During the summer, this layer holds the warmest water and during the winter it holds the coldest water. This layer continuously circulates.
Exotic	A non-native organism that has been introduced into an area (Purple Loosestrife, Eurasian Water Milfoil)
Floating-leaf	Plants rooted in the sediment or free-floating with leaves lying flat on the water surface (Duckweed, White Water Lilly)
Hypolimnion	The deepest layer of water within a stratified lake. In the winter it holds the warmest water and in the summer it holds the coldest water.
Interspecific	Between two or more distinct species.
Invasive	An organism which readily colonizes a disturbed area and tends to take it over by out-competing other plants. These can be native (Cattail) or exotic species (Purple Loosestrife).
Limiting Nutrient	The nutrient, usually phosphorus, which is in shortest supply and controls the growth rate of algae and macrophytes.
Littoral Zone	Pertaining to the shallow water zone of a lake that has sufficient light penetration to support macrophytes.
Macrophyte	A multicelled plant, usually with roots, stems, and leaves. A vascular plant (Cattail, Eurasian water-milfoil, pondweeds)
Median Value	A value in a set which has an equal number of observations above it and below it
Metalimnion	This is the layer between the epilimnion and the Hypolimnion that has the greatest range of temperature change with depth. The metalimnion contains the thermocline, but is not the same thing.
Native	An organism that is naturally occurring to an area (White Water Lilly, Northern Water-milfoil)

Nitrogen to Phosphorus Ratio	Results of this ratio indicate if algal growth within a lake is limited by nitrogen or phosphorus. If the ratio is greater than 16:1, the lake is considered phosphorus limited; if it is less than 16:1, it is considered nitrogen limited. The key ratio of 16:1 is related to the normal nitrogen to phosphorus ration found in most algae.
Non-Point Source Pollution	A source of pollution that comes from an indirect point of discharge (Overland flow)
Periphyton	A community of algae, and fragments of algae, which are attached to submerged objects such as plants and stones
Photosynthesis	The process in which chlorophyll producing organisms convert CO2 and water into sugar and oxygen, using sunlight as an energy source
Phytoplankton	Free-floating (not attached) algae.
Point Source Pollution	A source of pollution that comes from a direct point of discharge (Drain Tile Outfall)
Senesce	To complete a life cycle; to die off
Shoreland Buffer Zone	A buffer of native plants and habitat that occurs between the lake and developed property. The buffer zone serves to filter sediment and nutrients that wash off of a developed area before they reach the lake.
Species Diversity	An index that relates the number of species to their relative abundances. A community with many species with similar numbers (abundances) is more diverse than a community with the same number of species, but only a few of the species dominate the area with their abundances.
Species Richness	The total number of species occurring in a community
Submergent	An aquatic plant growing entirely under the water surface (Coontail, Large-leaf pondweed, Eurasian water-milfoil)
Systematic Herbicide	A plant specific pesticide which causes systematic cellular damage after coming in contact with the target. These herbicides spread through the entire plant.
Water Residence Time	The average amount of time water resides in a lake. Usually measured in years or days. A lake with a long residence time would have a slow flushing rate.
Zooplankton	Microscopic animals that are free-floating with in a water body. Many prey on algae and are an important food source for young fish.

D

APPENDIX D

Harvesting Plan Maps


Appendix D
Upper Post Lake Harvesting Plan
Sensitive Area
Purple Loosestrife
Floating-leaf Vegetation
Spatterdock
White Water Lily
Curly-leaf Pondweed
Slow-No-Wake Zone
Harvester Offload Site
Emergent Vegetation
with Dominant Species Indicated
Submergent Vegetation
with Dominant Species Indicated
Possible Cutting of Navigation Channels
10'-25' Dependent on Frontage
NES Ecological Services
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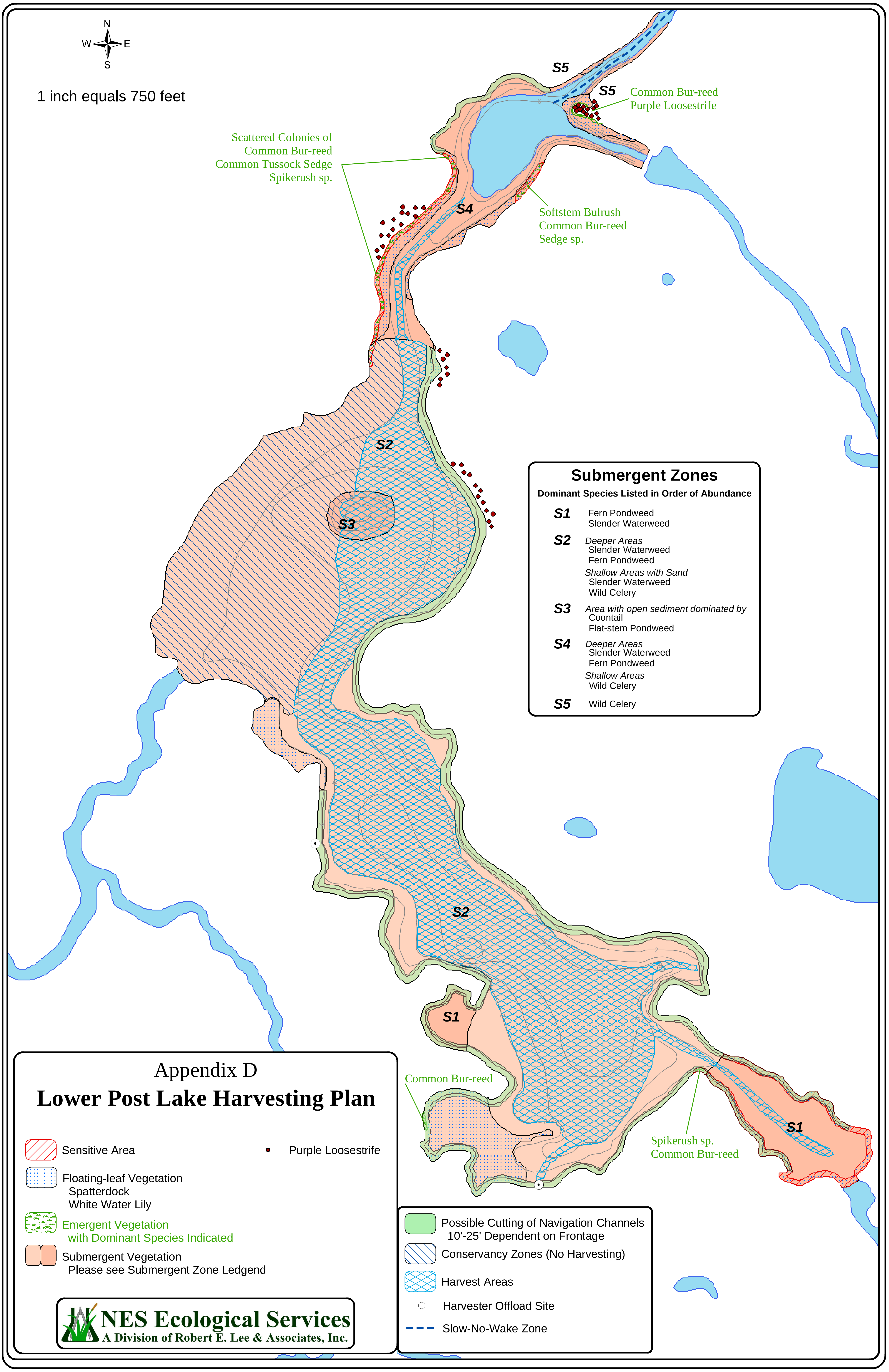
N
W
E
S
1 inch equals 800 feet
Softstem Bulrush
Marsh Cinquefoil
Grass-leaved Arrowhead.
Softstem Bulrush with
Scattered Spikerush sp.
Floating-leaf Bur-reed
Large Bladderwart
Flatstem Pondweed
Coontail
Scattered
Spatterdock
Floating-leaf Bur-reed
Spatterdock
White Water Lily
Softstem Bulrush with
Scattered Spikerush sp.
Pickerelweed
Spikerush sp.
Softstem Bulrush
Grass-leaved Arrowhead
Robin's Pondweed
Flatstem Pondweed
Coontail
Floating-leaf Bur-reed
Spatterdock
White Water Lily
Softstem Bulrush
Pickerelweed
Common Bur-reed
Spatterdock
Floating-leaf Bur-reed
Large-leaf Pondweed
Slender Pondweed
Scattered Spatterdock
Illinois Pondweed
Leafy Pondweed
Floating-leaf Bur-reed
Spatterdock
Spatterdock
Scattered
Spatterdock
White Water Lily
Scattered
Spatterdock
White Water Lily
Coontail
Leafy Pondweed
Sedges, Willows
Pickerelweed
Coontail
Wild Celery


N
W
E
S
1 inch equals 750 feet
S5
S5
Common Bur-reed
Purple Loosestrife
Scattered Colonies of
Common Bur-reed
Common Tussock Sedge
Spikerush sp.
S4
Softstem Bulrush
Common Bur-reed
Sedge sp.
S2
S3
S2
S1
S1
Common Bur-reed
Spikerush sp.
Common Bur-reed
Submergent Zones
Dominant Species Listed in Order of Abundance
S1 Fern Pondweed
Slender Waterweed
S2 Deeper Areas
Slender Waterweed
Fern Pondweed
Shallow Areas with Sand
Slender Waterweed
Wild Celery
S3 Area with open sediment dominated by
Coontail
Flat-stem Pondweed
S4 Deeper Areas
Slender Waterweed
Fern Pondweed
Shallow Areas
Wild Celery
S5 Wild Celery
Appendix D
Lower Post Lake Harvesting Plan
Sensitive Area
Purple Loosestrife
Floating-leaf Vegetation
Spatterdock
White Water Lily
Emergent Vegetation
with Dominant Species Indicated
Submergent Vegetation
Please see Submergent Zone Ledgend
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Possible Cutting of Navigation Channels
10'-25' Dependent on Frontage
Conservancy Zones (No Harvesting)
Harvest Areas
Harvester Offload Site
Slow-No-Wake Zone

E

APPENDIX E

Education Component Materials

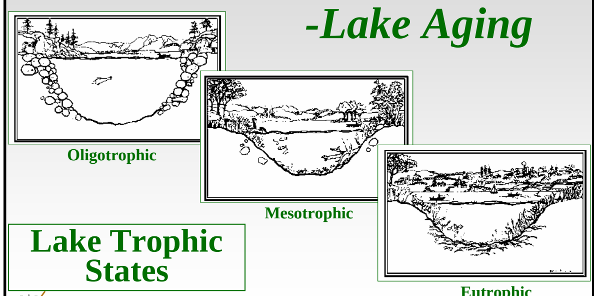
Presentation Outline

- Lake Ecology 101
- Comprehensive Management Plan Development
  - Major Components
  - Timeline

General Lake Ecology

Eutrophication

-Lake Aging



Lake Trophic States

Cultural Eutrophication

Accelerated eutrophication caused by human activity.

Non-Point Source Pollution

- *Lakeshore Property*
- *Agricultural*
- *Urban*

General Lake Ecology

Point Source Pollution

•Agricultural Drain Tiles

•Storm Sewers

•Treatment Plant Effluent

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General Lake Ecology

Internal Nutrient Loading

-May be significant source of phosphorus after external loads are minimized.

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General Lake Ecology

Conclusions

Consequences if Loadings are not Inventoried, Monitored, and Controlled

- Accelerated Eutrophication
- Loss of Recreation Value
- Degraded Aesthetics
- Lower Property Values

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Comprehensive Management Plan Development

- Public Education
- Watershed and Land Use
- Water Quality
- Aquatic Vegetation
- Management Plan & Report

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Comprehensive Lake Management Plan Development

Public Education

- Enhance Public Awareness of Project
- District's Goals and Objectives
- Provide Information to Ecologists about Lake and Watershed
- Lake Stewardship

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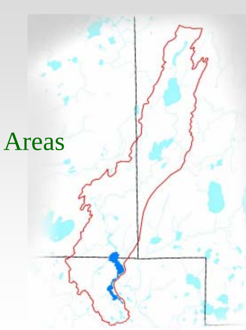
Comprehensive Lake Management Plan Development

Watershed and Land Use

- Watershed Delineation
- Environmentally Sensitive Areas
- Land Use
  - Field Verification
  - Phosphorus Modeling



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Water Quality Monitoring

- Transparency (Secchi Disk)
- Nutrients
  - Phosphorus
  - Nitrogen
- Algal Abundance (Chlorophyll *a*)
- Suspended Solids
- Miscellaneous

Comprehensive Lake Management Plan Development

Aquatic Vegetation Survey

- Species Present
- Relative Abundance
- Sensitive Areas
- Community and Dominant Species Map
- Floristic Quality Assessment

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Comprehensive Lake Management Plan Development

Lake Management Plan

- Methods
- Results
- Lake Management Alternatives
- Aquatic Plant Management

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Comprehensive Lake Management Plan Development

Schedule

	2001									2002			
Task	A	M	J	J	A	S	O	N	D	J	F	M	A
Kick-Off Meeting			■										
Lake Sample	■		■	■	■						■		
Aquatic Plant Survey				■									
Progress Report							■						
Data Analysis						■	■	■	■	■	■	■	■
Report Completed													■
Project Completion Meeting													■

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Thank You

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www.releeinc.com/NES

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Wisconsin Lakes Partnership

UW Extension

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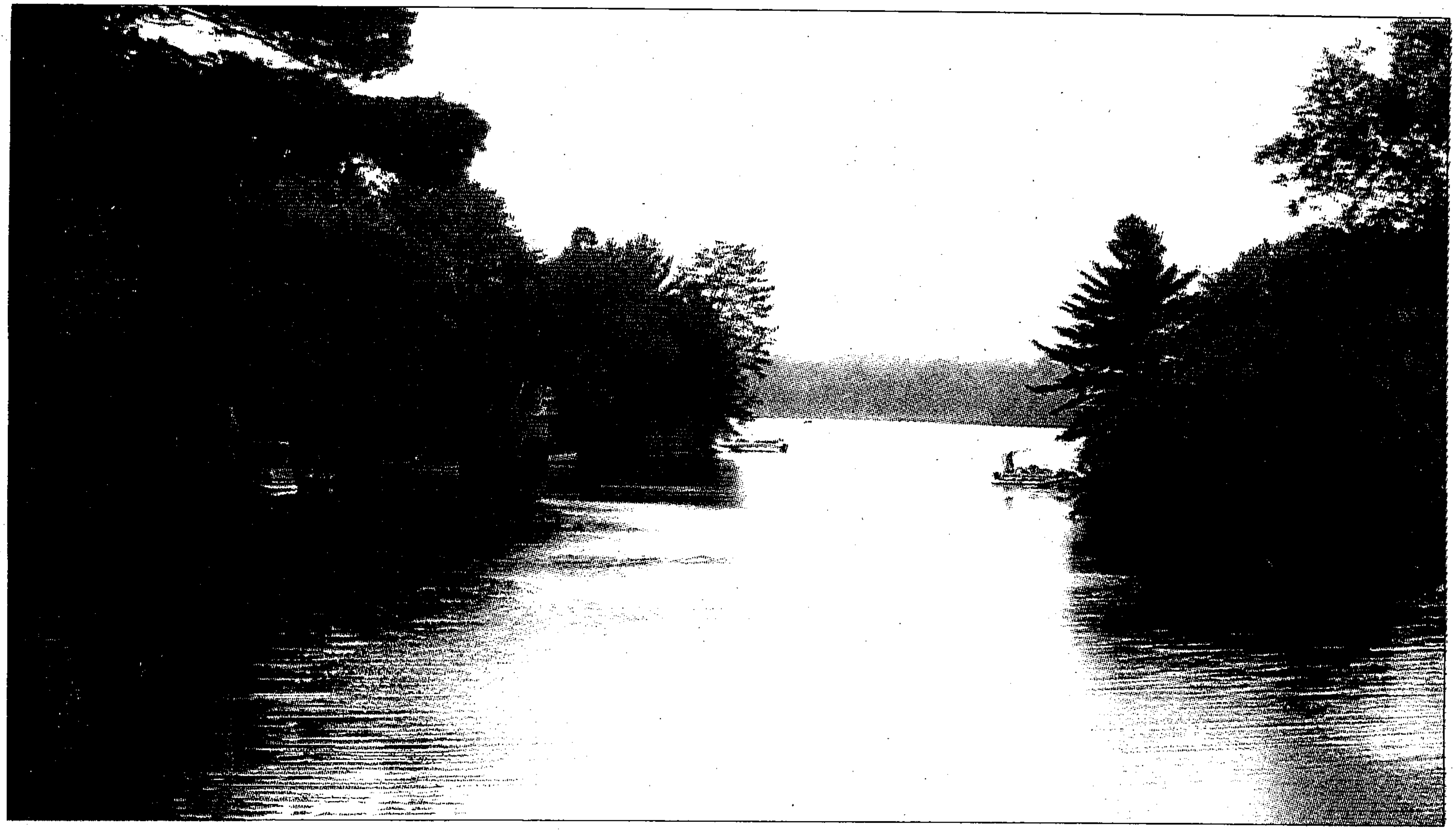
Antigo Daily Journal

VOL. 96 NO. 300 SATURDAY, SEPTEMBER 8, 2001 ANTIGO, WISCONSIN PRICE 50 CENTS



The channel connecting Upper and Lower Post Lakes was tranquil Thursday afternoon.

Post Lake wins grants for water studies

Upper and Lower Post Lakes, among the most popular bodies of water in Langlade County, are getting an infusion of state money for lake protection studies.

Lori Regni of the Post Lakes Protection and Rehabiltation District said that the district has received two Wisconsin Department of Natural Resources Lake Management grants totaling nearly $18,000.

The monies are a 75 percent match by the state that will be utilized to complete comprehensive lake management studies, including biological, chemical, and physical surveys in both Upper and Lower Post Lakes and their watersheds.

"NES Ecological Services of Green Bay will be completing the studies and will report their findings and recommendations to the Post Lakes Protection and Rehabilitation District in the spring of 2002," Regni said. "Thus far, water quality samples and aquatic vegetation data has been collected for both lakes."

Regni said that the lake management plans that will be developed through these studies, will be important tools in determining future protection, monitoring and restoration activities concerning both Upper and Lower Post Lakes.

Management activities may include work in the lake's watershed that will help reduce agricultural runoff that add plant nutrients and sediments to the lakes and restoration projects on the lake's shore that would provide natural wildlife habitat, minimize shoreline erosion, and buffer the lakes from the impacts of human activity," she said.

Recommendations will also include management alternatives used to enhance and control the aquatic plants in and around both lakes.

Post Lakes Comprehensive Management Plan Development Study
Progress Report to the Post Lakes Protection and Rehabilitation District

The following report is intended to inform the Post Lake Protection and Rehabilitation District (PLPRD) about the progress that has been made in completing the lake studies involved with the development of the Upper and Lower Post Lake Comprehensive Management Plans. It contains summaries of the tasks that have been completed and a listing of any available results. It must be stressed here that the data collection and analysis stages of the study are not complete; therefore, any conclusions and/or recommendations provided below must be considered as preliminary.

Public Education and Project Awareness

An important component in any lake management plan is public awareness and education. If a person is not informed as to the complexity and value of something, for instance, a lake ecosystem, they are not going to involve themselves in its protection. In keeping with these thoughts, Tim Hoyman from NES Ecological Services gave a presentation during a special meeting held on June 16, 2001 at the Elcho School. In general, his presentation covered a variety of topics concerning lake ecology and the development of the management plans for Upper and Lower Post Lakes. The educational section of Tim's presentation discussed the adverse affects of human activities on lake ecosystems and how they have lead to the accelerated aging of lakes. The natural aging of a lake is termed *eutrophication*, while the accelerated aging of a lake caused by human activities is termed *cultural eutrophication*. Cultural eutrophication is responsible for many of the problems that currently exist in many lakes. The over abundance of plant biomass that hampers powerboat navigation and recreational activities in Lower Post Lake is an example of these affects. Finally, Tim described the need to inventory, monitor, and control these affects in order to preserve and restore our lake ecosystems and how the development of a lake management plan is an important step in completing these tasks.

Tim finished his presentation by describing how studies consisting of work both in the lakes and their watersheds will be used to develop management plans for each of the lakes. The plans are scheduled for completion in the spring of 2002 and will include complete descriptions of the study methods, results and conclusions along with management recommendations concerning the lakes and their watersheds with emphasis on the management of aquatic plants within each lake.

Watershed Definition and Existing Land Uses

A lake is a reflection of its watershed; therefore, defining the lake's drainage basin is an important step in developing a lake management plan. This step has been completed for both the Upper and Lower Post Lakes watersheds. The next step of quantifying the land uses in each drainage basin is well underway. Preliminary land use maps have been created using data from the Wisconsin Initiative for Statewide Cooperation on Landscape Analysis and Data (WISCLAND) project. These maps were created using geographical information services (GIS) technology and have been provided to volunteers from the PLPRD for field verification. Once the land use data is verified, we will use the information to model phosphorus loads entering the lakes. The modeling results will help determine what areas of each lake's watershed are contributing the highest amounts of phosphorus and should be targeted for priority attention as part of the lake's management plan.

Water Quality

To date, three (May 1, 2001, June 16, 2001, and July 19, 2001) water quality sampling trips have been made to the Post Lakes, of which, data for two of the trips have been received from the Wisconsin State Laboratory of Hygiene. Water quality samples will also be collected in August and October 2001, and

February 2002. These data will then be analyzed with data supplied by the PLPRD and the Wisconsin Department of Natural Resources for long and short-term trends. Furthermore, the data will also be used to determine each lake's trophic status and whether or not internal nutrient loading may be a significant source of phosphorus in either lake.

Aquatic Vegetation Survey

Aquatic plants are an essential element in all lake ecosystems and are comprised of two major classes: 1) macrophytes or vascular plants, such as pond lilies, coontail, elodea, wild celery, and cattails; and 2) free-floating and attached algae. Although both classes are important in the healthy functioning of a lake, macrophytes are of the most concern because they provide essential habitat and food for insects, fish, and other wildlife. In addition, they are the dominant plant class within Upper and Lower Post Lakes. While these plants are of great benefit to the system, they may grow to nuisance levels if sufficient light and nutrients are available, as sometimes is the case with Lower Post Lake and possibly portions of Upper Post Lake. For these reasons, both good and bad, a complete survey of macrophytic vegetation is a critical ingredient of any comprehensive lake management plan.

Macrophyte surveys were conducted on Upper and Lower Post Lakes July 16 –19, 2001. During our fieldwork, we found 28 different species on Upper Post and 26 on Lower Post. This is a slight increase in the number species compared to findings of similar studies conducted in 1976. Unfortunately, in addition to the previously discovered purple loosestrife (*Lythrum salicaria*) a second exotic plant species, curly-leaf pondweed (*Potamogeton crispus*) has been found in Upper Post Lake.

Curly-leaf pondweed is a European exotic first discovered in Wisconsin in the early 1900s that has an odd lifecycle allowing it to out compete our native plants. Curly-leaf pondweed starts to die back 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. This exotic plant can become so abundant it hampers navigation, fishing, and other recreational activities. It can also cause mid-summer algal blooms spurred from the nutrients released during the plant's decomposition after it dies off in July.

Two separate areas were found containing curly-leaf pondweed. One small patch near the southern most tributary entrance on the east side of the lake and another much larger patch at the mouth of Pollock Creek. Recent studies recommend the use of early-spring herbicide treatments to reduce turion production in curly-leaf pondweed. This method will likely to do the most to prevent the species from spreading throughout the lake and at this time, is the recommended course of action for next spring.

During our survey of Lower Post Lake, dense mats of slender waterweed (*Elodea nuttallii*) and fern pondweed (*Potamogeton robbinsii*) were observed. At that time, the plants had not reached the surface and as a result were not hampering recreational activities on most of the lake. However, if the plants continue to grow and reach the surface, navigation will definitely be a problem. If this occurs, as it has in the past, it is recommended that the PLPRD consider purchasing a weed harvester or contract with a third-party to have the weeds harvested. Harvesting would be the preferred method because it removes the plant biomass from the lake, as opposed to herbicides, which leave the plants in the lake to decay, ultimately adding nutrients to the sediment and open water. Winter drawdown is not recommended at this time, due to the potential adverse impacts it may have on the fisheries in both lakes and the and on the healthy plant community of Upper Post Lake. In addition, raising the water level is not recommended for two primary reasons: 1) shoreline erosion could increase on both lakes, and 2) the water level cannot be increased enough to sufficiently reduce light penetration and limit photosynthesis to hinder plant growth.

Post Lakes Protection & Rehabilitation District

Post Lakes Comprehensive Lake Management Plans
August 16, 2003

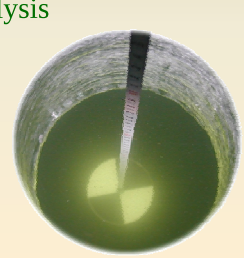
Timothy A. Hoyman, CLM
NES Ecological Services
A Division of Robert E. Lee & Associates, Inc.

Presentation Outline

- Project Objectives
- Study Results
- Management Recommendations

Project Objectives

- Data Collection and Analysis
  - Watershed
  - Aquatic Plants
  - Water Quality
- Develop Comprehensive Management Plans



Study Results

Water Quality

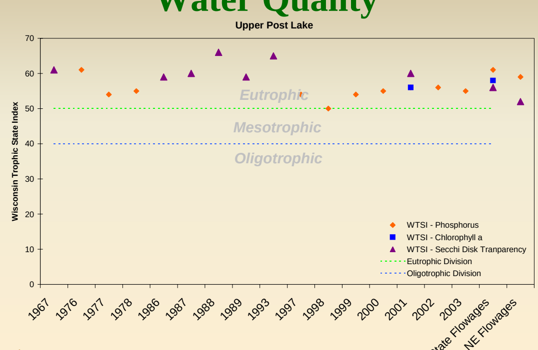
↑ Phosphorus (Limiting Plant Nutrient)

↑ Chlorophyll-*a* (Algal Abundance)

↓ Water Clarity (Secchi Disk)

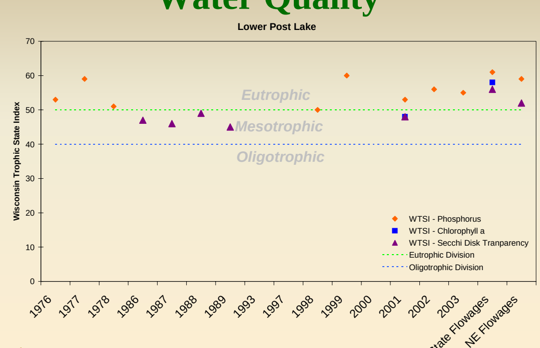
Study Results

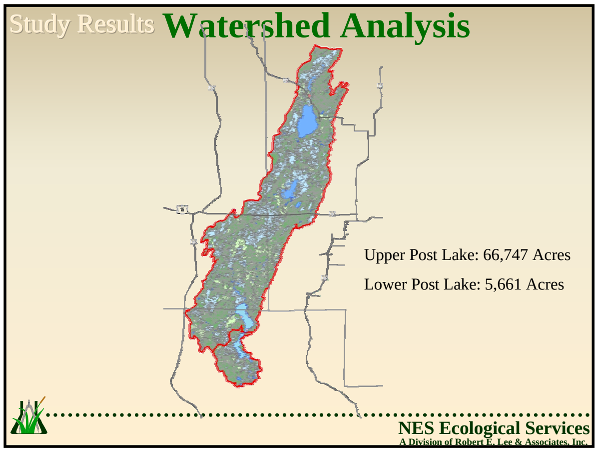
Water Quality



Study Results

Water Quality




Study Results
Watershed Analysis
Upper Post Lake: 66,747 Acres
Lower Post Lake: 5,661 Acres
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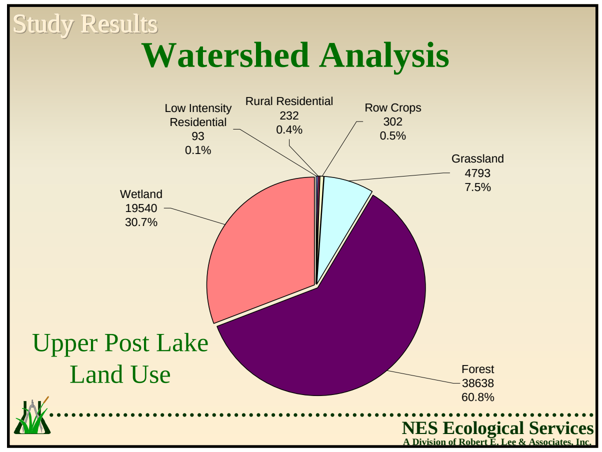
Study Results
Watershed Analysis
Low Intensity Residential 93 0.1%
Rural Residential 232 0.4%
Row Crops 302 0.5%
Grassland 4793 7.5%
Wetland 19540 30.7%
Forest 38638 60.8%
Upper Post Lake Land Use
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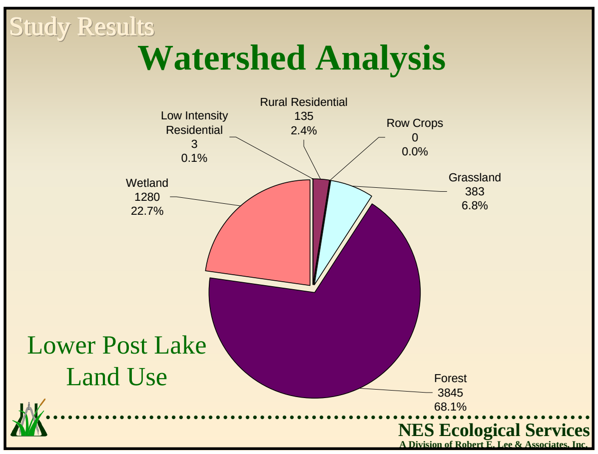
Study Results
Watershed Analysis
Low Intensity Residential 3 0.1%
Rural Residential 135 2.4%
Row Crops 0 0.0%
Grassland 383 6.8%
Wetland 1280 22.7%
Forest 3845 68.1%
Lower Post Lake Land Use
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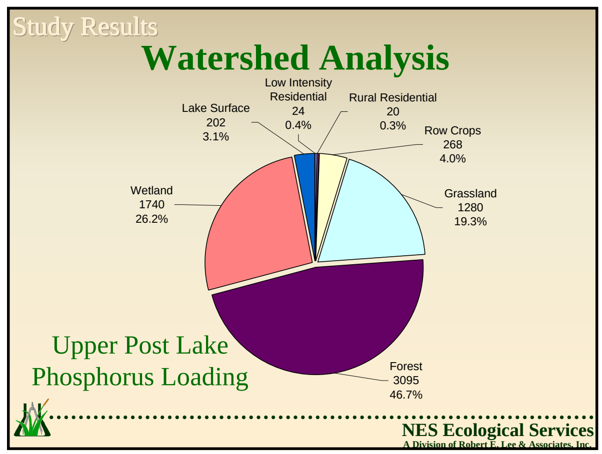
Study Results
Watershed Analysis
Low Intensity Residential 24 0.4%
Rural Residential 20 0.3%
Lake Surface 202 3.1%
Row Crops 268 4.0%
Grassland 1280 19.3%
Wetland 1740 26.2%
Forest 3095 46.7%
Upper Post Lake Phosphorus Loading
NES Ecological Services
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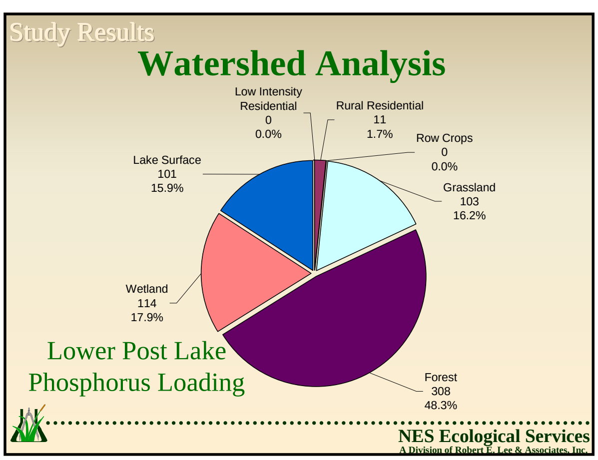
Study Results
Watershed Analysis
Low Intensity Residential 0 0.0%
Rural Residential 11 1.7%
Row Crops 0 0.0%
Lake Surface 101 15.9%
Grassland 103 16.2%
Wetland 114 17.9%
Forest 308 48.3%
Lower Post Lake Phosphorus Loading
NES Ecological Services
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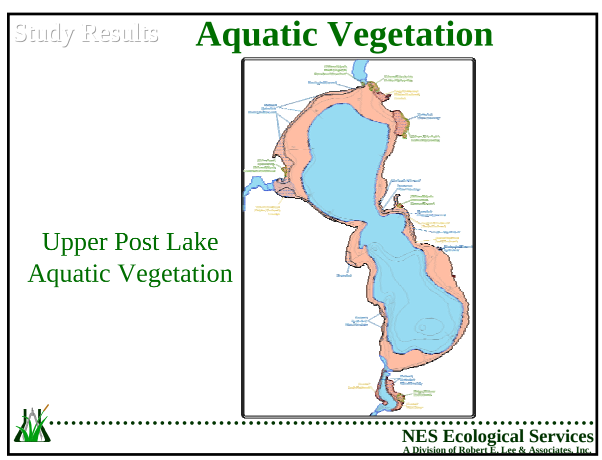
Study Results
Aquatic Vegetation
Upper Post Lake Aquatic Vegetation
NES Ecological Services
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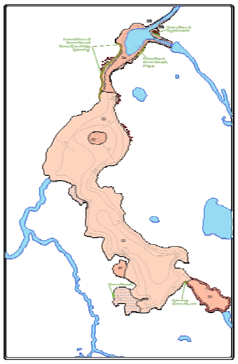
Study Results

Aquatic Vegetation

Lower Post Lake Aquatic Vegetation



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Recommendations

Water Quality

“A lake is a mirror of its watershed.”

Protect and Restore Water Quality by Reducing Phosphorus Loads

(Follow the watershed plan.)

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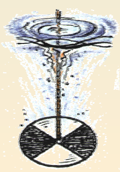
Recommendations

Water Quality

Monitoring

- Phosphorus, Chlorophyll-*a*, Secchi, Dissolved Oxygen
  - Minimum of every three years
  - Summer samples
- Self-Help Volunteer



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Recommendations

Watershed

Two Major Components

1. Tributary Watersheds
2. Shoreland Areas

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Recommendations

Watershed

- Protect Tributary Watershed’s Current State
  - Environmentally Sensitive Areas Ordinances
  - Limit Development and Conversion
  - Wetland Protection
  - Monitoring

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Recommendations

Watershed

- Shoreland Areas
  - Shoreland Zoning
  - Continue Septic System Testing and Replacement
  - Create Shoreland Buffer Zones
  - NO FERTILIZING!

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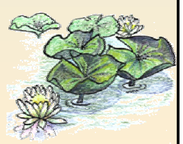
Recommendations

Aquatic Vegetation

Two Primary Concerns:

Exotics & Nuisance → Monitor & Manage

Native Species → Monitor, Protect, & Enhance



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Recommendations

Aquatic Vegetation

Exotics & Nuisance

- Continue Harvesting in Lower Post Lake
- Continue Purple Loosestrife Management Program
- Continue Curly-leaf Pondweed Monitoring and Treatments in Upper Post Lake (under the guidance of the WDNR)
- Periodic Monitoring (District and Pro's)

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Recommendations

Aquatic Vegetation

Native Species

- Shoreland Buffers
- Protect Existing Communities
    - Expansion of Slow-No-Wake Zones
- Emergent Species Enhancement
    - Trial Installations

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Thank You

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