# Buffalo Lake

Marquette County, Wisconsin

DRAFT

# Comprehensive Lake Management Plan

**January 2006**

Sponsored by:

DRAFT

**Buffalo Lake**
**Protection & Rehabilitation District**

&

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Lake Management Planning

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All of these people assisted in every facet of this project including; grant writing, the lake fair, goal development, creation of the implementation plan, and reviewing of this document. Special thanks go to Ms. Colleen Huber for extraordinary efforts during this project.

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# SUMMARY

Buffalo Lake is a shallow, eutrophic system and as a result it supports a great deal of aquatic plant growth. Phosphorus load modeling based upon land use indicates the nutrients that fuel the plant productivity come from the lake's large watershed and even with dramatic changes in the watershed, the nutrient levels would be sufficient to sustain the lake's eutrophic state. Unfortunately, the aquatic plant surveys documented that the lake contains a very high frequency of exotics, specifically Eurasian water milfoil and curly-leaf pondweed, in fact over 70% of the sample plots contained exotic plant species. Comparing the 2004 aquatic plant survey results with results from a survey completed in the early 1980's indicates that the presence of the exotics has significantly reduced the floristic quality of the lake. The decreased floristic quality represents degradation in habitat value for fish and wildlife and an overall decrease in the health of the lake.

Problems with lake itself were not the only concern of this project, another was to increase the capacity of the district to manage the lake by improving communication between the district and its members and by increasing the membership's understanding of their lake. At the beginning of this project, the district's only method of communication was their annual meeting. As a result of this project, the district has held a very informative lake fair, created a website, completed two membership surveys, sent out multiple mailings, and created a seasonal district newsletter.

An implementation plan has been created to not only guide the district's management of the lake, but also to assure that the communication structure that has been created during this project does not breakdown. The vision statement developed to guide the management of the lake is as follows:

> *The Buffalo Lake Protection & Rehabilitation District envisions that, through a cooperative effort, the future of Buffalo Lake is a lake with the natural aesthetics and water quality that maintains exceptional fish and wildlife habitat while providing a variety of recreational opportunities.*

The plan was designed to meet the following goals through implementable management actions:

- Goal 1: Maintain water quality (clear state)
- Goal 2: Reduce invasive plants and increase important native plants
- Goal 3: Enhance recreational opportunities
- Goal 4: Improve natural aesthetics
- Goal 5: Encourage cooperation and communication between agencies and municipalities
- Goal 6: Elected Commissioners work to meet the goals and need of the Buffalo Lake P&R District (added by District Board)

# RESULTS & DISCUSSION

## Water Quality

Judging the quality of lake water can be difficult because lakes display problems in many different ways. However, focusing on specific aspects or parameters that are important to lake ecology, comparing those values to similar lakes within the same region, and historical data from the study 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 within this document:

**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.

**Chlorophyll-*a*** is the pigment in plants that is used during *photosynthesis*. Chlorophyll-*a* concentrations are directly related to the abundance of free-floating algae in the lake. Chlorophyll-*a* values increase during algal blooms.

**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 understand. Furthermore, measuring Secchi disk transparency over long periods of time is one of the best methods of monitoring the health of a lake. 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 interrelated. 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, 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 trophic progression. To solve this problem, the parameters described above can be used in an index that will specify a lake's trophic state more clearly and provide a means for which to track it over time.

The complete results of these three parameters and the other chemical data that were collected at Buffalo Lake 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. They divided the state's lakes into five regions each having lakes of similar nature or apparent characteristics. Marquette County lakes are included within the study's Central Region (Figure 1) and are among 44 lakes randomly picked from the region that were analyzed for water clarity (Secchi disk), chlorophyll-*a*, and total phosphorus. These data along with data corresponding to statewide impoundment means, historical, current, and average data from Buffalo Lake are displayed in Figures 2-4. Please note that the data in these graphs represent concentrations and depths taken only during the growing season (April-October) or summer months (June-August) in the deepest location in the lake (Figure 1). Furthermore, the phosphorus and chlorophyll-a data represent only surface samples. Surface samples are used because they represent the depths at which algae grow and depths at which phosphorus levels are not greatly influenced by phosphorus being released from bottom sediments.


**Figure 1. Location of Buffalo Lake within the regions utilized by Lillie and Mason (1983).**

Summer and growing season phosphorus levels in Buffalo Lake have fluctuated since the 1970's ranging from over 200 μg/L to less than 100 μg/L (Figure 2). All of these concentrations would be considered quite high and as a result, they would be considered poor to even very poor using the Apparent Water Quality Index developed by Lillie and Mason (1983) using the same dataset of lake water quality as described above. These values are especially high when compared to other impoundments in Wisconsin and the lakes of Lillie and Mason's Central Region.

**Nitrogen to phosphorus ratios** indicate if algal growth within a lake is limited by nitrogen or phosphorus. If the ratio is greater than 15:1, the lake is considered phosphorus limited; if it is 10:1 or less, it is considered nitrogen limited. Ratios in between these values indicate that the lake likely fluctuates between nitrogen and phosphorus limitation. The ratios are related to the normal nitrogen to phosphorus ratio found in most algae.

During 2004 and likely during most other years, Buffalo Lake was phosphorus limited as indicated by a nitrogen to phosphorus ratio of 16.3:1. As a result, the high phosphorus values that occurred during the growing season fueled high algal biomass as indicated by the high chlorophyll-*a* values (Figure 3). Much like the total phosphorus values, the chlorophyll-*a* values are high compared to other impoundments in the state and the lakes of the region. They also fluctuate from year to year, but most often occur in the fair to poor range, especially concerning the growing season values. The majority of the time, the growing season mean is higher than the summer mean within the same year due to spring algae blooms. In a mixed impoundment, like Buffalo Lake, we would expect seasonal phosphorus values of surface waters to be the highest during the summer. Figure 4 indicates that this is indeed the case during 2004. It also shows that chlorophyll-*a*, which we would expect to increase with total phosphorus levels, in actuality does just the opposite. Although many factors impact the chlorophyll and phosphorus relationship, a primary factor of algal limitation in Buffalo Lake during the summer is likely the lake's abundant macrophyte population. The macrophytes reduce algal abundance directly and indirectly. They directly affect the algae by competing for nutrients and reducing light availability through shading. They indirectly affect algae by providing cover to zooplankton that graze upon algae and keep their growth in check. Without the plants, the zooplankton populations would diminish as they would be fed upon by small fish and fish fry. As a result, algal populations would increase.

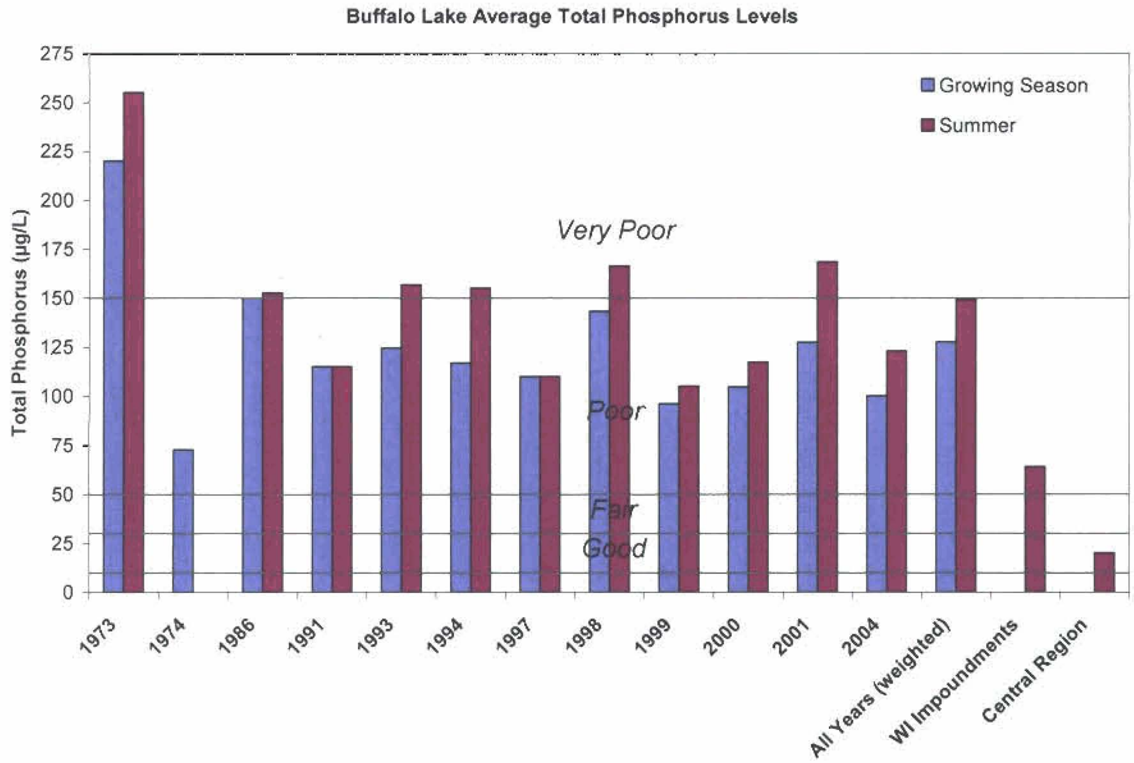



**Figure 2. Buffalo Lake total phosphorus concentrations.** Growing season means include values recorded April – May and summer means include values recorded June - August. Apparent water quality index ratings and state and regional means after Lillie & Mason (1983).

Although chlorophyll-*a* values are lower as a result of the macrophytes in the lake, current and historic (Figure 3) values are still considered poor to fair. Buffalo Lake chlorophyll-*a* values are lower than mean values for Wisconsin impoundments, but higher than mean values for the ecoregion. In the end, these higher algal abundances are responsible for the poor Secchi disk clarities that have been recorded in the lake over the past two decades (Figure 5). During many years, the Buffalo Lake clarity is comparable with other Wisconsin impoundments, but much less than other lakes and impoundments in the central region.

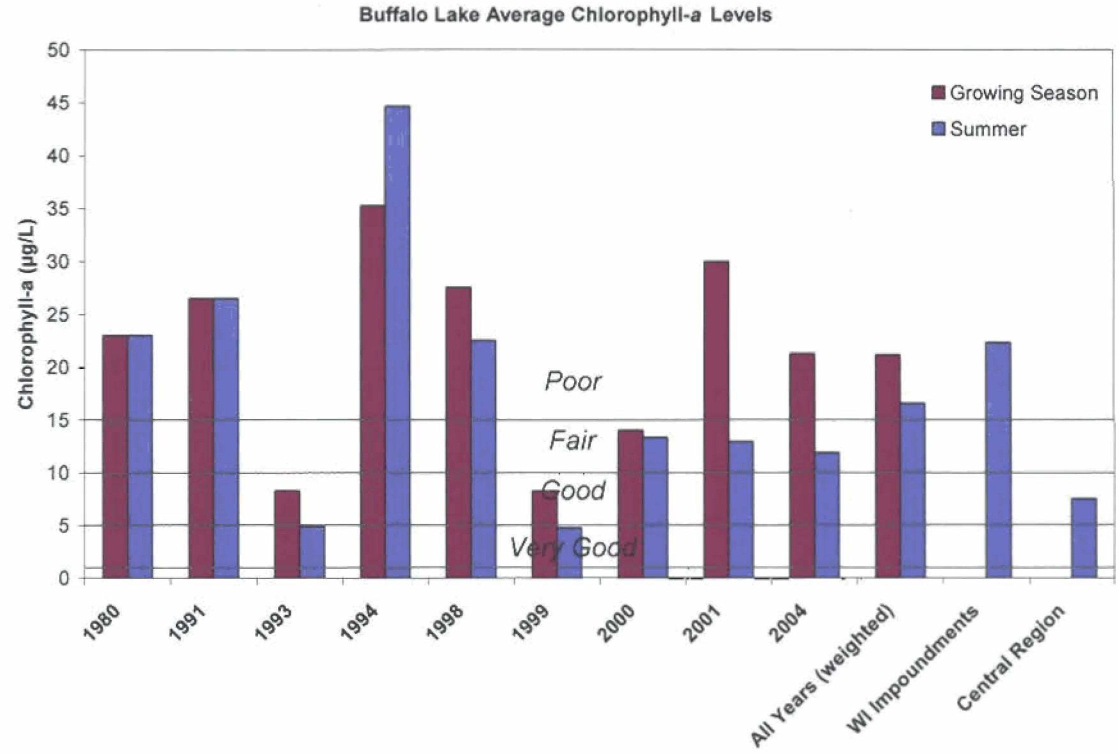



**Figure 3. Buffalo Lake chlorophyll-*a* concentrations.** Growing season means include values recorded April – May and summer means include values recorded June - August. Apparent water quality index ratings and state and regional means after Lillie and Mason (1983).

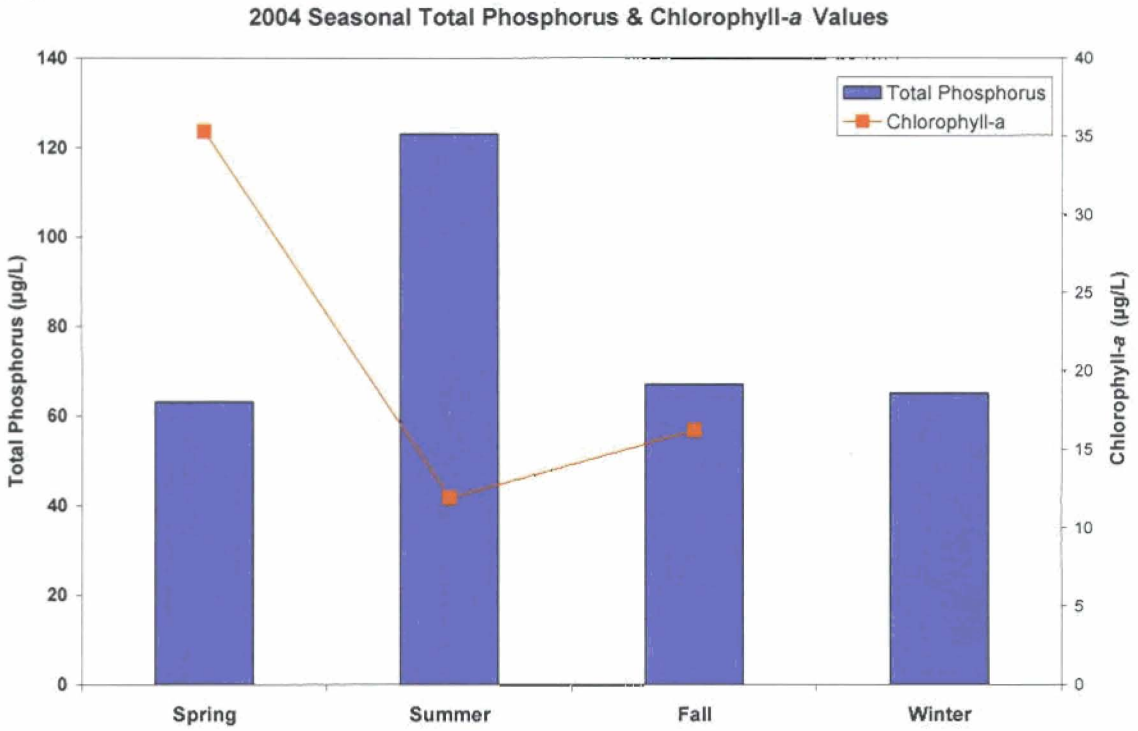



**Figure 4. 2004 seasonal Buffalo Lake total phosphorus and chlorophyll-*a* concentrations.**.

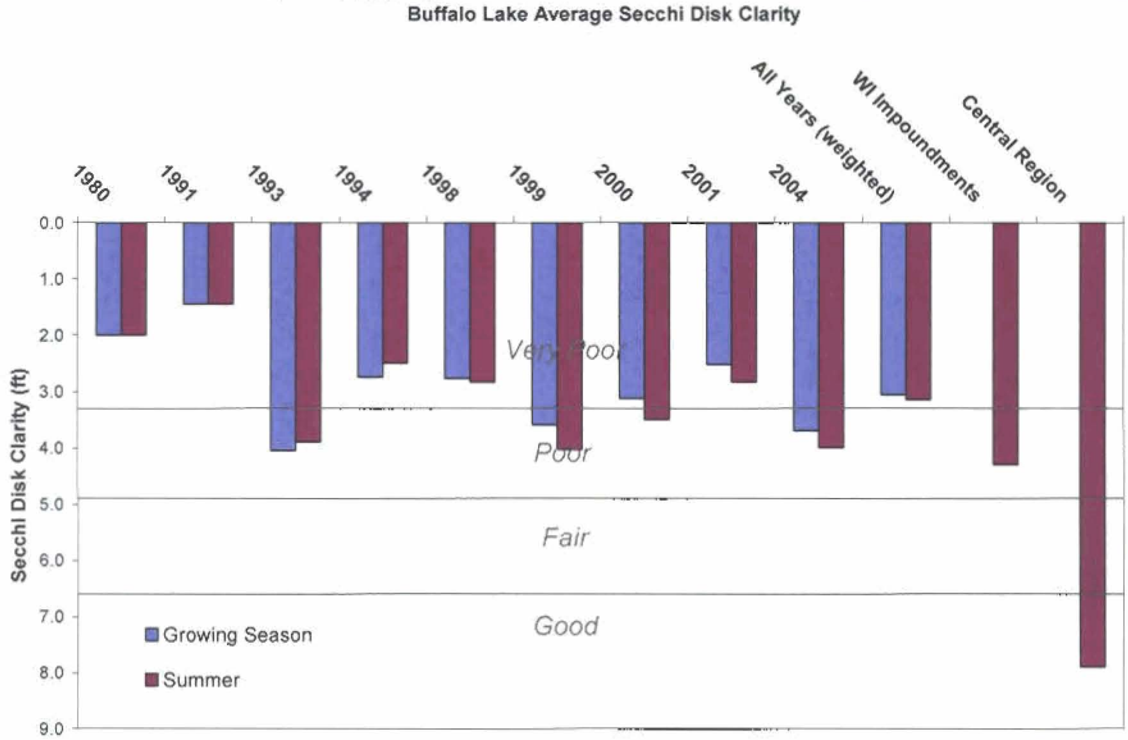



**Figure 5. Buffalo Lake Secchi disk clarity values.** Growing season means include values recorded April – May and summer means include values recorded June - August. Apparent water quality index ratings and state and regional means after Lillie & Mason (1983).

## *Buffalo Lake Trophic State*

Figure 6 displays the Wisconsin Trophic State Index (WTSI) (Lillie, et al. 1993) values calculated from average surface levels of chlorophyll-*a*, total phosphorus, and Secchi disk transparencies measured during the summer months in Buffalo Lake. The WTSI is based upon the widely used Carlson Trophic State Index (TSI) (Carlson 1977), but is specific to Wisconsin lakes. In essence, a trophic state index is a mathematical procedure that assigns an index number that corresponds to a lake's trophic state based upon three common lake parameters; chlorophyll-*a*, Secchi disk transparency, and total phosphorus. The WTSI is used extensively by the WDNR and is reported along with lake data collected by Self-Help Volunteers.

The trophic state of lake is related to its level of primary production (plant production). In deep lakes that have only a portion of their bottom substrates available to macrophyte growth, known as a littoral zone, measuring algal production through chlorophyll-*a* levels is an excellent way to determine the lake's trophic state. Furthermore, in lakes such as these, the relationship between phosphorus, chlorophyll-*a*, and clarity are significant and therefore allow any of the parameters to be used to accurately judge the lake's trophic state. However, in lakes where a large portion of their bottom is available to plant growth, or in Buffalo Lake's case, all of the lake bottom, the use of these values often underestimates the lake's true trophic state. This is the case because the measurement of these parameters do not account for macrophyte production, their use of phosphorus, or their affect on water clarity. In the end, this means that the values displayed in Figure 6 indicate a past and present trophic levels lower than actually occur within the lake. Unfortunately, there currently is no simple method for determining the trophic state of a lake that encompasses its macrophyte production. In the end, we must accept the fact that the trophic state of Buffalo Lake is actually higher than the strongly eutrophic nature that is displayed in Figure 6.

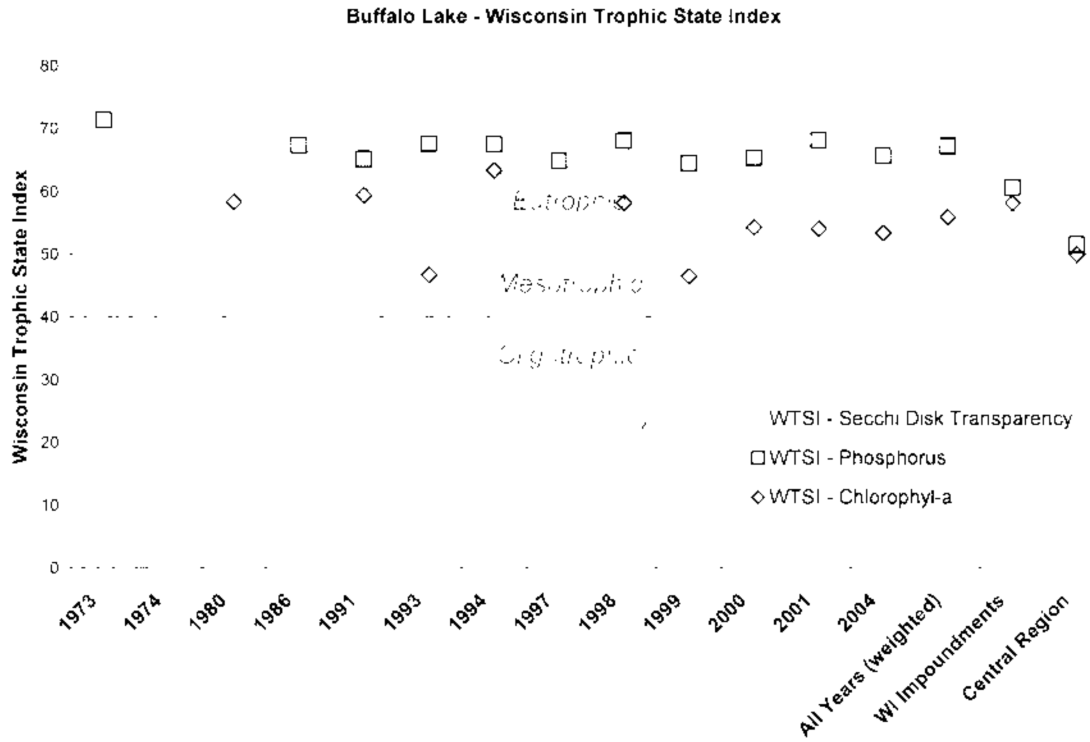



**Figure 6. Wisconsin Trophic State Index results for Buffalo Lake.** Calculations based upon Lillie, et al. (1993).

## Watershed Assessment

Buffalo Lake's watershed (drainage basin) is approximately 26,000 acres (roughly 40.6 $mi^2$), yielding a watershed to lake area ratio of approximately 118:1. This is a very high ratio and lakes with higher ratios tend to have greater phosphorus concentrations relative to lakes with lower ratios. This is because there is more land delivering (loading) sediments and nutrients to the lake through its tributary. The actual amount of pollutants (nutrients, sediment, toxins, etc.) depends greatly on how the land within the watershed is used. Vegetated areas, such as forests, grasslands, and meadows, allow the water to infiltrate into the ground and do not produce much 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 covers leads to increased pollutant loading; which, in turn, can lead to nuisance algal blooms, increased sedimentation, and/or overabundant macrophyte populations.

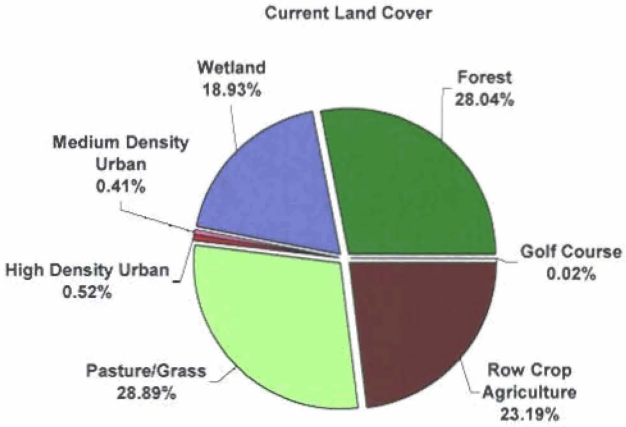



**Figure 7. Buffalo Lake watershed land cover types.** WISCLAND data.

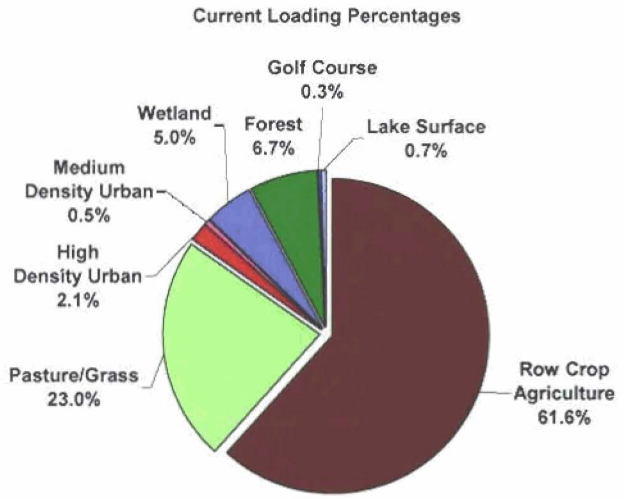



**Figure 8. Buffalo Lake watershed phosphorus loading by land cover type.** WiLMS data.

Land cover data from the Wisconsin Initiative for Statewide Cooperation on Landscape Analysis and Data (WISCLAND) for the Buffalo Lake watershed are displayed on Map 2. Much of the watershed's acreage is currently in a vegetated state, either pasture/grass or forested, while less than a quarter is in row crops (Figure 7). Modeling of these land cover types along with their respective acreages using the Wisconsin Lake Modeling Suite (WiLMS) indicates that approximately 87,000 lbs of phosphorus enters Buffalo Lake from its watershed annually. Further modeling through WiLMS indicates that the predicted load would result in a growing season phosphorus concentration of approximately 98 μg/L. The estimated concentration corresponds well to mean growing season phosphorus concentrations over the past 5 years (107 μg/L), indicating that the model portrays the system relatively well.

As described above, the WTSI analysis indicates that Buffalo Lake is eutrophic and has been that way for decades. The trophic state of some lakes can be altered by reducing phosphorus loads entering the lake from its watershed. The reductions are realized by implementing best management practices (BMPs) within the lake's watershed. BMPs include many techniques, such as: vegetated buffers along agricultural drainageways, terracing, crop rotation, manure spreading plans, etc. However, in lakes with very large watersheds, like Buffalo Lake, major changes in land cover may lead to reduced loadings, but not necessarily to a reduction in the trophic nature of the lake. Changes to the watershed of Buffalo Lake can be demonstrated through modeling in WiLMS.

Table 1 lists the WiLMS modeling results based upon the current watershed and two scenarios. The first scenario represents the Buffalo Lake watershed with the land covers responsible for the highest loading rates, row crops and golf course, converted to forest. The second scenario represents the entire watershed converted to forest.

**Table 1. Buffalo Lake watershed phosphorus loading scenarios.** Watershed loadings and growing season concentrations modeled with WiLMS.

| Scenario | Percent Forest Cover | Phosphorus Load (lbs) | Mean Growing Season Phosphorus (μg/L) |
|---|---|---|---|
| **Current** | 28 | 87,000 | 100 |
| **Partial Forest Conversion** | 51 | 38,000 | 52 |
| **Full Forest Conversion** | 100 | 21,500 | 32 |

With the changes in the watershed, there are obvious drops in both the phosphorus loads to the lake and the resulting phosphorus concentrations that occur within the lake. Unfortunately, due to the size of the watershed, these lower phosphorus concentrations are not enough to decrease the trophic state of the lake significantly (Figure 9). In fact, even with implementing a unrealistic watershed restoration that involves converting the entire watershed to forestlands, the lake would still be considered highly eutrophic and would likely exhibit the high levels of plant biomass that currently exist within the lake.

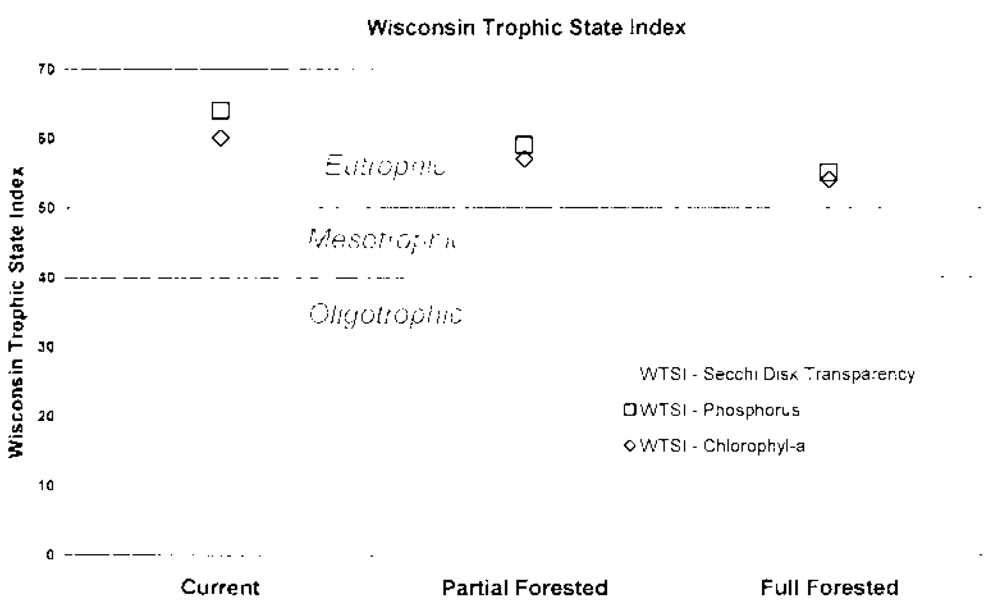



**Figure 9. Wisconsin Trophic State Index results for Buffalo Lake watershed using different land cover scenarios.** Calculations based upon Lillie, et al. (1993) using WiLMS data.

## Aquatic Plants and the Lake Ecosystem

Although some 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 and 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 *Z. palustris*) both serve as excellent food sources for ducks and geese. Emergent stands of vegetation provide necessary spawning habitat for fish such as northern pike (*Esox lucius*) and yellow perch (*Perca flavescens*) In addition, many of the insects that are eaten by young fish rely heavily on aquatic plants and the *periphyton* attached to them as their primary food source. The plants also provide cover for feeder fish and *zooplankton*, stabilizing the predator-prey relationships within the system. Furthermore, rooted aquatic plants prevent shoreline erosion and the resuspension of sediments and nutrients by absorbing wave energy and locking sediments within their root masses. In areas were plants do not exist, waves can resuspend bottom sediments decreasing water clarity and increasing plant nutrient levels that may lead to algae blooms. Lake plants also produce oxygen through photosynthesis and use nutrients that may otherwise be used by *phytoplankton*, which helps to minimize nuisance algal blooms.

Under certain conditions, a few species 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 and curly-leaf pondweed 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. At these levels they can also disrupt water quality by altering nutrient levels, dissolved oxygen content, and pH.

When plant abundance negatively affects the lake ecosystem and limits the use of the resource, plant management and control 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. No aquatic plant management plan should only contain methods to control plants, they should also contain methods on how to protect and possibly enhance the important plant communities within the lake. Unfortunately, the latter is often neglected and the ecosystem suffers as a result.

## Introduction to 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 native 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, the herbivorous grass carp (*Ctenopharyngodon idella*) is illegal in Wisconsin and rotovation, a process by which the lake bottom is tilled, is not an accepted practice. Unfortunately, there are no "silver bullets" 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.

**Please note:** Even though all of these techniques may not be applicable to Buffalo Lake, it is still important for lake users to have a basic understanding of all the techniques so they can better understand why particular methods are or are not applicable in their lake. The techniques applicable to Buffalo Lake are located in the management section.

### Permits

The signing of the 2001-2003 State Budget by Gov. McCallum enacted many aquatic plant management regulations. The rules for the regulations have been set forth by the WDNR as NR 107 and 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 wide and any piers, boatlifts, swim rafts, and other recreational and water use devices are located within that length. Furthermore, installation of aquatic plants, even natives, requires approval from the WDNR. It is important to note that local permits and U.S. Army Corps of Engineers regulations may also apply. 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 and dead, fallen timbers 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. Many homeowners significantly decrease the number of trees and shrubs along the water's edge in an effort to increase their view of the lake. However, this has been shown to locally increase water temperatures, and decrease infiltration rates of potentially harmful nutrients and pollutants. 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. Simply not mowing within the buffer zone does wonders to restore some the shoreland's natural function.

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 is 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 extensive grading requirements, removal of shoreland stabilization (e.g., rip-rap, seawall), and protective measures used to guard 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 $4,200.

- 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.
  - The property owner would maintain the site for weed control and watering.

### *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 before they become well established.

## 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 removed, rather the plants are cut similar to mowing a lawn; however Wisconsin law states that all plant fragments must be removed. One manual cutting technique involves throwing a specialized "V" shaped cutter into the plant bed and retrieving it with a rope. The raking method entails the use of a two-sided straight blade on a telescoping pole that is swiped back and forth at the base of the undesired 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 re-rooting 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 15$^{th}$.

### *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 colonization on top of the screen.

### *Cost*

Material costs range between $.20 and $1.25 per square-foot. Installation cost can vary largely, but may roughly cost $750 to have 1,000 square feet of bottom screen installed. Maintenance costs can also vary, but an estimate for a waterfront lot are about $120 each year.

### *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 and in deep water.
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.
Not practical in large-scale situations.

## 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 and coontail.
Allows some loose sediments to consolidate.
May enhance growth of desirable emergent species.
Other work, like dock and pier repair 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.
Has the potential to upset the lake ecosystem and have significant affects 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*).
Permitting process requires an environmental assessment that may take months to prepare.
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 6 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 especially 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.
Removal of plant biomass can improve the oxygen balance in the litoral zone.
Harvested plant materials produce excellent compost.

### *Disadvantages*

Initial costs and maintenance 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 if applied at the right time of the year.

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®, Avast!®) Broad spectrum, systemic herbicide that is effective on most submersed and emergent macrophytes. It is also effective on duckweed and at low concentrations has been shown to selectively remove Eurasian water-milfoil. Fluridone slowly kills macrophytes over a 30-90 day period and is only applicable in whole lake treatments or in bays and backwaters were dilution can be controlled. Required length of contact time makes this chemical inapplicable for use in flowages and impoundments. 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*).. Glyphosate is also marketed under the name Roundup®; this formulation is not permited for use near aquatic environments because of its harmful effects on fish, amphibians, and other aquatic organisms.

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

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

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

### *Advantages*

Herbicides are easily applied in restricted areas, like around docks and boatlifts.
If certain chemicals are applied at the correct dosages and at the right time of year, 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 $400 to $1000 per acre depending on the chemical used, who applies it, permitting procedures, and the size of the treatment area.

## Biological Controls

There are many insects, fish and pathogens within the United States that are used as biological controls for aquatic macrophytes. For instance, the herbivorous grass carp has been used for years in many states to control aquatic plants with some success and some failures. However, it is illegal to possess grass carp within Wisconsin because their use can create problems worse than the plants that they were used to control. 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, it is assumed that Wisconsin's climate is a bit harsh for these two invasive plants, so there is no need for 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 for 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 $1.20/weevil and they are usually stocked in lots of 1000 or more.

## Analysis of Current Aquatic Plant Data

Aquatic plants are an important element in every healthy lake. Changes in lake ecosystems are often first seen in the lake's plant community. Whether these changes are positive, like variable water levels or negative, like increased shoreland development or the introduction of an exotic species, the plant community will respond. Plant communities respond in a variety of ways; there may be a loss of one or more species, certain life forms, such as emergents or floating-leaf communities may disappear from certain areas of the lake, or there may be a shift in plant dominance between species. With periodic monitoring and proper analysis, these changes are relatively easy to detect and provide very useful information for management decisions.

As described in more detail in the methods section, a comprehensive aquatic plant survey was completed on Buffalo Lake during August 23-27 and September 1, 2004. The survey produces a great deal of information about the aquatic vegetation of the lake (Appendix B). These data are analyzed and presented in numerous ways; each is discussed in more detail below.

### Primer on Data Analysis & Data Interpretation

**Species List**

The species list is simply a list of all of the species that were found within the lake, both exotic and native. The list also contains the life-form of each plant found, its scientific name, and its coefficient of conservatism. The latter is discussed in more detail below. Changes in this list over time, whether it is differences in total species present, gains and loses of individual species, or changes in life-forms that are present, can be an early indicator of changes in the health of the lake ecosystem.

**Frequency of Occurrence**

Frequency of occurrence describes how often a certain species is found within a lake. Obviously, all of the plants cannot be counted in a lake, so samples are collected from pre-determined areas. In the case of Buffalo Lake, plant samples were collected from plots laid out on a grid that covered the entire lake. Using the data collected from these plots, an estimate of occurrence of each plant species can be determined. In this section, relative frequency of occurrence is used to describe how often each species occurred in the plots that contained vegetation. These values are presented in percentages and if all of the values were added up, they would equal 100%. For example, if water lily had a relative frequency of 0.1 and we described that value as a percentage, it would mean that water lily made up 10% of the population.

In the end, this analysis indicates the species that dominate the plant community within the lake. Shifts in dominant plants over time may indicate disturbances in the ecosystem. For instance, low water levels over several years may increase the occurrence of emergent species while decreasing the occurrence of floating-leaf species. Introductions of invasive exotic species may result in major shifts as they crowd out native plants within the system.

### Species Diversity

Species diversity is probably the most misused value in ecology because it is often confused with species richness. Species richness is simply the number of species found within a system or community. Although these values are related, they are far from the same because diversity also takes into account how evenly the species occur within the system. A lake with 25 species may not be more diverse than a lake with 10 if the first lake is highly dominated by one or two species and the second lake has a more even distribution.

A lake with high species diversity is much more stable than a lake with a low diversity. This is analogous to diverse financial portfolio in that a diverse lake plant community can withstand environmental fluctuations much like a diverse portfolio can handle economic fluctuations. For example, a lake with a diverse plant community is much better suited to compete against exotic infestation than a lake with a lower diversity.

### Floristic Quality Assessment

Floristic Quality Assessment (FQA) is used to evaluate the closeness of a lake's aquatic plant community to that of an undisturbed, or pristine, lake. The higher the floristic quality, the closer a lake is to an undisturbed system. FQA is an excellent tool for comparing individual lakes and the same lake over time. In this section, the floristic quality of Buffalo Lake will be compared to lakes in the same ecoregion and in the state.

**Ecoregions are areas related by similar climate, physiography, hydrology, vegetation and wildlife potential. Comparing ecosystems in the same ecoregion is sounder than comparing systems within manmade boundaries such as counties, towns, or states.**

The floristic quality of a lake is calculated using its species richness and average species conservatism. As mentioned above, species richness is simply the number of species that occur in the lake, for this analysis, only native species are utilized. Average species conservatism utilizes the coefficient of conservatism values for each of those species in its calculation. A species coefficient of conservatism value indicates that species likelihood of being found in an undisturbed (pristine) system. The values range from one to ten. Species that are normally found in disturbed systems have lower coefficients, while species frequently found in pristine systems have higher values. For example, cattail, an invasive native species, has a value of 1, while common hard and softstem bulrush have values of 5, and Oakes pondweed, a sensitive and rare species, has a value of 10. On their own, the species richness and average conservatism values for a lake are useful in assessing a lake's plant community; however, the best assessment of the lake's plant community health is determined when the two values are used to calculate the lake's floristic quality.

### Community Mapping

A key component of the aquatic plant survey is the creation of an aquatic plant community map. The map represents a snapshot of the important plant communities in the lake as they existed in during the survey and is valuable in the development of the management plan and in comparisons with surveys completed in the future. A mapped community can consist of submergent, floating-leaf, or emergent plants, or a combination of these life-forms. Examples of submergent plants include wild celery and pondweeds; while emergents include cattails, bulrushes, and arrowheads, and floating-leaf species include white and yellow pond lilies. Emergents and floating-leaf communities lend themselves well to mapping because there are distinct boundaries between communities. Submergent species are often mixed throughout large areas of the lake and are seldom visible from the surface; therefore, mapping of submergent communities is more difficult and often impossible. For Buffalo Lake in particular, the entire lake bottom is available to and used by macrophytes. The only areas that did not have plant growth were the areas that have seen decades of harvesting, especially the area over the main channel (Photos 1 and 2). As a result, the ability to map communities on Buffalo Lake is very limited.

**Photo 1. Buffalo Lake during vegetation survey facing north towards railroad trestle** Photo taken September 1, 2004.

**Photo 2. Buffalo Lake during vegetation survey facing north from center navigation lane just west of the dam** Photo taken September 1, 2004.

## Exotic Plants

Because of their tendency to upset the natural balance of an aquatic ecosystem, exotic species are paid particular attention to during the aquatic plant surveys. Two exotics, curly-leaf pondweed and Eurasian water milfoil are the primary targets of this extra attention.

Eurasian water-milfoil is an invasive species, native to Europe, Asia and North Africa, that has spread to most Wisconsin counties (Figure 10). Eurasian water-milfoil is unique in that its primary mode of propagation is not by seed. It actually spreads by shoot fragmentation, which has supported its transport between lakes via boats and other equipment. In addition to its propagation method, Eurasian water-milfoil has two other competitive advantages over native aquatic plants, 1) it starts growing very early in the spring when water temperatures are too cold for most native plants to grow, and 2) once its stems reach the water surface, it does not stop growing like most native plants, instead it continues to grow along the surface creating a canopy that blocks light from reaching native plants. Eurasian water-milfoil can create dense stands and dominate submergent communities, reducing important natural habitat for fish and other wildlife, and impeding recreational activities such as swimming, fishing, and boating.

Curly-leaf pondweed is a European exotic first discovered in Wisconsin in the early 1900's that has an unconventional lifecycle giving it a competitive advantage over our native plants. Curly –leaf pondweed begins growing almost immediately after ice-out and by mid-June is at peak biomass. While it is growing, each plant produces many turions (asexual reproductive shoots) along its stem. By mid-July most of the plants have senesced, or died-back, leaving the turions in the sediment. The turions lie dormant until fall when they germinate to produce winter foliage, which thrives under the winter snow and ice. It remains in this state until spring foliage is produced in early May, giving the plant a significant jump on native vegetation. Like Eurasian water-milfoil, curly-leaf pondweed can become so abundant that it hampers recreational activities within the lake. Furthermore, its mid-summer die back can cause algal blooms spurred from the nutrients released during the plant's decomposition.

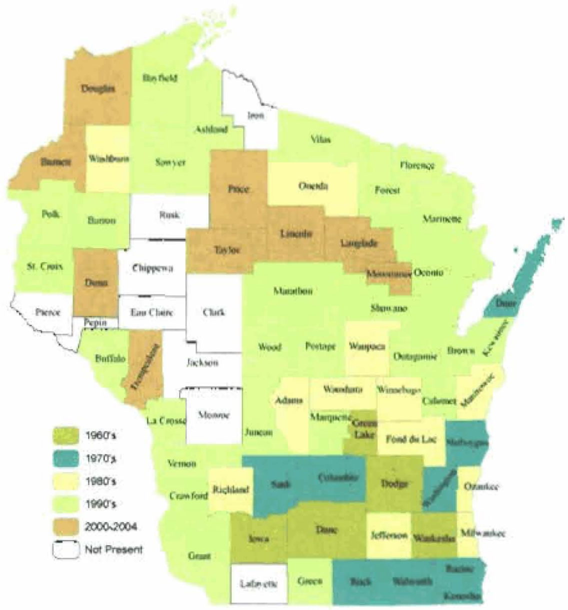



**Figure 10. Spread of Eurasian water milfoil throughout Wisconsin counties.** WDNR Data 2004 mapped by Onterra.

### Buffalo Lake Aquatic Vegetation

During the survey completed in August and September 2004 (Map 3), 19 aquatic plant species were identified in Buffalo Lake (Table 2). Two of the species were exotic, Eurasian water milfoil and curly-leaf pondweed. The lake was highly dominated by coontail, Eurasian water milfoil, small duckweed, and common watermeal (Figure 11). White water lily was also abundant over much of the lake, especially near and upstream of the causeway. Many other species were found on an infrequent basis. The uneven distribution of occurrence displayed in Figure 11 results in a moderate diversity of 0.84 for Buffalo Lake.

Four aquatic plant studies have been completed on Buffalo Lake since the early 1980's. Although each of these studies were completed by different surveyors and a variety of techniques were used to collect the data, the use of Nichols' (1999) Floristic Quality Assessment (FQA) is still applicable to compare the results between the studies (Figure 12). The full species lists from all four studies with explanations of how the results were interpreted and used are contained Appendix C.

The FQA of the four plant inventories indicate two trends:

1. With one survey being an exception, the native species richness within Buffalo Lake has not changed significantly over the past two decades; however the species makeup has (see Appendix C).
2. The expansion of non-native species has likely degraded the floristic quality of the lake.

Of the two points above, the most significant is the latter because it depicts a change in the Buffalo Lake plant community. Considering Eurasian water milfoil was not found during the

1982 survey and it was the second most frequent occurrence during the 2004 survey, it is likely that the expansion of that plant's presence is responsible for the dramatic decreases seen in average species conservatism and floristic quality within Buffalo Lake. Curly-leaf pondweed, which was found in all four surveys, has likely played a role in the degradation of the native community also. Furthermore, the extent of degradation could worsen because the two plants with the highest average conservatism values, long-leaf pondweed and wild rice (Map 3), were each only found in one location. If these two plants were to disappear from the lake, the average conservatism would drop to 4.7 and the floristic quality to 20.5. These are substantial changes that could realistically occur and truly indicate the profound affect that the Eurasian water milfoil and curly-leaf pondweed have had on Buffalo Lake's aquatic plant community.

Overall the aquatic plant community of Buffalo Lake is likely not what it once was, or what it could be. Considering that nearly 71% of the plots that were sampled contained exotics, it is not difficult to understand why. A fertile system like Buffalo Lake will always support an abundance of plants; it is unfortunate that most of the plants that it is currently supporting happen to be non-native and invasive plants that provide less habitat-value than natives.

**Table 2. Aquatic plants occurring in Buffalo Lake during 2004 survey.** Naming following Wisconsin State Herbarium. Coefficient of Conservatism (Nichols 1999).

| | Scientific Name | Common Name | Coefficient of Conservatism (C) |
|---|---|---|---|
| Emergent | *Iris versicolor** | Northern blue flag | 5 |
| | *Tyhpa latifolia** | Broad-leaved cattail | 1 |
| | *Zizania palustris** | Northern Wild rice | 8 |
| | *Sagittaria latifolia** | Common arrowhead | 3 |
| | *Schonoeplectus tabernaemontani* [1*] | Softstem bulrush | 4 |
| Floating-leaf | *Lemna minor* | Small duckweed | 5 |
| | *Wolffia columbiana* | Common watermeal | 5 |
| | *Nymphaea odorata* | White water lily | 6 |
| | *Nuphar variegata* | Spatterdock | 6 |
| | *Nelumbo lutea* | American lotus | 8 |
| | *Polygonum amphibium** | Water smartweed | 5 |
| Submergent | *Ceratophyllum demersum* | Coontail | 3 |
| | *Vallisneria americana* | Wild celery | 6 |
| | *Elodea canadensis* | Common waterweed | 3 |
| | *Potamogeton zosteriformis* | Flat-stem pondweed | 6 |
| | *Spirodela polyrhiza* | Great duckweed | 5 |
| | *Potamogeton nodosus* | Long-leaf pondweed | 7 |
| | *Stuckenia pectinata* [2*] | Sago pondweed | 3 |
| | *Heteranthera dubia* [3*] | Water stargrass | 6 |
| | *Myriophyllum spicatum* | Eurasian water milfoil | Invasive |
| | *Potamogeton crispus* | Curly-leaf pondweed | Invasive |

* = Incidental Species (found outside of plots)

[1]Formally known as *Scirpus validus*.

[2]Formally known as *Potamogeton pectinatus*.

[3]Formally known as *Zosterella dubia*.

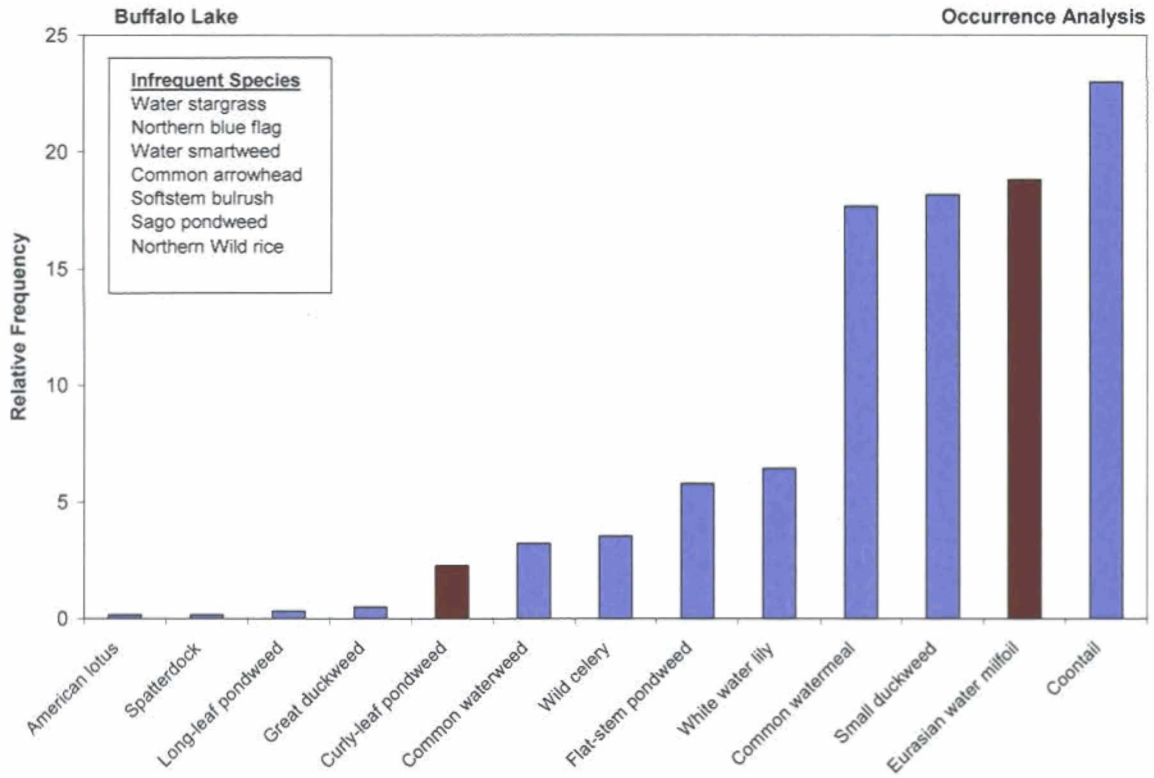



**Figure 11. Buffalo Lake aquatic plant occurrence analysis of 2004 survey data.** Exotic species indicated with red.

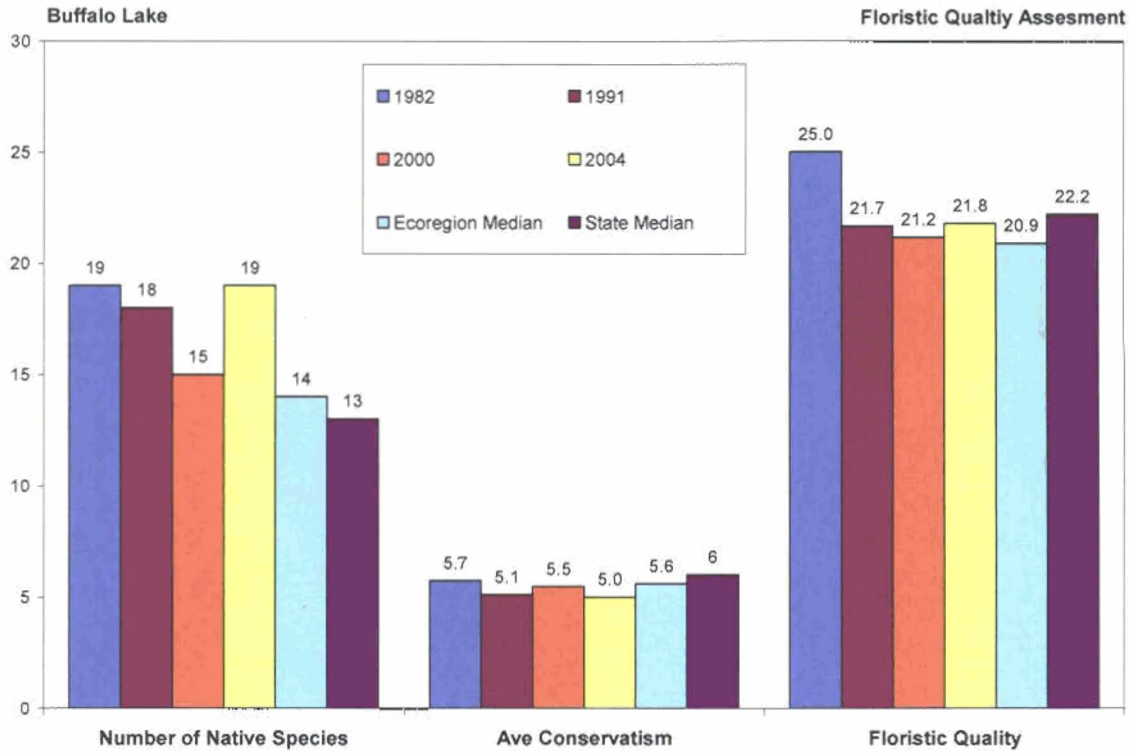



**Figure 12. Floristic Quality Assessment using data from four aquatic plant surveys completed on Buffalo Lake.** Analysis following Nichols 1999.

# STAKEHOLDER PARTICIPATION

Stakeholder participation was utilized in three forms throughout the course of this project; first through the efforts of the district's steering committee, second through educational presentations and articles, and third through stakeholder surveys. Each of these is discussed in more detail below. Unless otherwise stated, all materials referenced below are contained in Appendix D.

The district board created an ad hoc steering committee to work with Mr. Tim Hoyman of Onterra, the firm hired to complete the ecological studies and assist in the development of this plan. The first meeting of the steering committee was held on June 5, 2004 and included a brief introduction to the project and the process that would be used to create the management plan. Between June 2004 and December 2005, the committee met a total of 12 times, with 6 of those meetings being with Mr. Hoyman, and the remaining 6 being work meetings where the group completed a specific task. During these meetings, the group designed the surveys described below, planned a successful lake fair, formed the goals that were accepted by the district membership in August 2005, and created the management actions that make up the Implementation Plan. The group also acted as a sounding board or focus group for the district as a whole. Overall, it was the work of the steering committee that made this project a success.

Stakeholder education is an important part of every environmental planning exercise. If stakeholders do not understand the value of the ecosystem they are managing, they will not strive to protect or enhance it. Steering committee discussions led to the conclusion that there was a great deal of misinformation pertaining to the lake's condition, its history, and its management; meaning that stakeholder education was even more important for project success. However, before any educational initiative could begin, the committee understood that the district's communication structure needed to be enhanced because at that time it relied on occasional mailing and its annual meeting to get the word out. The communication problem was later verified during the first survey when only 28% of the district members indicated that they were adequately informed about district events and news (Appendix E).

From the first meeting the steering committee knew that they wanted to create two permanent forms of communication; a district website and a seasonal newsletter. However, the committee also knew that the district members desired news concerning the new management project that was starting and rumors that a water level drawdown was to occur that fall; therefore, the steering committee, with Mr. Hoyman's assistance, created a one-page information flyer that was sent to each district property and published in the local paper.

The website (www.buffalolakedistrict.org) was accessible by May 2005 and has steadily grown in content since its inception. At this time, it contains a number of useful links and contacts, meeting announcement and minutes, and a posting of presentations and newsletters. The first newsletter was published during the fall of 2004 with others following during the spring, summer, and fall of 2005. Each of the newsletters contained an educational article concerning the lake and/or the progress of the project. The first edition contained an article summarizing a presentation reporting the preliminary findings of the aquatic plant surveys at the lake, which was given to the steering committee by Mr. Hoyman. The second announced the lake fair that was planned for the following spring and an updated schedule for the completion of the management plan. The third contained a summary of the very successful lake fair (details below). The fourth edition contained numerous articles about the lake, a presentation of the goals that were set for the management plan, an article describing the aquatic plant herbicide, Fluridone, and why it is not practical for use in Buffalo Lake, and an article discussing clear and turbid state dynamics of shallow lakes. Much like the website, the newsletter has increased in content as each issue was published.

The most ambitious educational event in the project was by far the Buffalo Lake Fair, held on May 14, 2005 at the Montello High School. Over 200 district members and non-members visited the nine informational booths set up by the district, the WDNR, and Marquette County. Mr. Hoyman presented the study results and his recommendations for the management of the lake using two methods. The first was a 40" x 72" poster diagramming the causes and effects of the Buffalo Lake ecosystem; the second was a detailed presentation he made as the fair's keynote address. Mr. Hoyman answered many questions while attending his booth and following his presentation.

The fair was considered a resounding success based upon comments received during the fair, by its incredible attendance, and by the positive comments related through the surveys that were returned by district members following the event. As with all of the educational initiatives, the work of the steering committee was responsible for the fair's success.

Two surveys were disbursed and their results compiled (Appendix E) as a part of this project. The first survey was sent out to district members during the summer of 2004. It contained three categories of questions: 1) those pertaining to biographical and lake use information, 2) those designed to gather data concerning the member's perception of the quality of the lake and how it should be managed, and 3) questions about the type and condition of the property's septic system. The form also provided an area for comments. The first category shed light on the make up the district membership and helped determine the experience they had on the lake and how the district would be able to maximize the effectiveness of their communications. The second set, along with the comments provided insight as to how much the district members understood about the ecology of their lake, and how they believed it could be managed. This understanding became the basis of much the educational initiative. The third category was beyond the scope of this project, but may be useful in further studies.

The interpretation of survey results is always difficult and often confusing. In general, the comments and the information provided by the second category of questions indicates that many of the people that own property around the lake are dissatisfied with its condition or believe it to be only fair. They also indicate that many of the residents believe that the lake can be better. Some believe that there is a "silver bullet" that will make the lake free of "weeds" and algae and create a lake better for swimming, boating, and fishing. This mythical "silver bullet" would come in the form of a chemical herbicide, dredging, and/or increased harvesting. Throughout the course of the project, attempts were made to dispel these myths and to increase the realistic understanding of the lake and what it can be.

The second survey was sent out to district members following the lake fair and included questions aimed at: assessing the effectiveness of the new educational and communication efforts, collecting biographical information, and determining the effectiveness of the lake fair. In general, the results indicate that the efforts of the steering committee have not gone to waste as the membership is now adequately informed about district happenings and most people feel that they have a better understanding of the lake. Unfortunately, the results indicated that some people still believe that there is a "silver bullet" that will make everything better at the lake.

# CONCLUSIONS

Buffalo Lake is a shallow system with a very large watershed. Systems such as this are always eutrophic and exhibit their high rates of productivity in one of two ways: by having dense stands of vascular plants (macrophytes) or by having waters murky with algae. As described in the watershed section, even an unrealistic improvement to the watershed, like entirely reforesting it, would not be enough to bring Buffalo Lake out of its eutrophic state. This does not mean that work to improve the watershed would not be good for the lake. Reductions in nutrient loadings from the watershed may help to reduce the suitability of the lake for non-native species such as Eurasian water milfoil and curly-leaf pondweed; however, those improvements would not lead to substantial decreases in plant productivity. In other words, the lake would still support an incredible amount of plant biomass. In fact, the area has always supported a great deal of plant biomass. Before the white man fully settled the area and began plowing for agriculture, Jolliet and Marquette explored the Fox River and as they approached the Portage area, Marquette entered in his journal "We knew, too, that the point of the compass we were to hold to reach it [the Wisconsin River] was the west-southwest, but the way is so cut up by marshes and little lakes, that it is easy to go astray, especially as the river leading to it is so covered with wild oats, that you can hardly discover the channel." (Gard et al. 1973) The wild oats Marquette describes are what we now call wild rice and the abundance he refers to is an indication of how fertile the area was well before the dam was added to Buffalo Lake

As described in the article titled "Turbid or Clear State…Which is it?" within the Buffalo Lake Fall Newsletter (November 2005) (Appendix D), the macrophytes in Buffalo Lake not only provide valuable fish and wildlife habitat, they are the key to keeping the lake in its current "clear state". If the macrophytes were to disappear, the lake would enter a "turbid state" and be dominated by algae. The turbidity would also be increased because the macrophytes would not be there to hold the lake's loose sediments in place and make them susceptible to resuspension from boat or wind-driven waves. Shoreline erosion would also increase leading to greater nutrient loads and turbidity. Once a lake enters a turbid state, it is very difficult to bring it back to the clear state.

It is clear the macrophytes are very important to the health of Buffalo Lake and that over or mis-management of them could lead to disastrous results. The problem with Buffalo Lake is not that it has a lot of plants – it is always going to be fertile and as a result, have many plants, whether they are in the form of algae or macrophytes. The problem with the lake is that it has too many plants of the wrong type. The aquatic plant survey completed during the summer of 2004 involved the sampling over 165 plots distributed through out the lake (Map 3). Nearly 71% of those plots contained Eurasian water milfoil, curly-leaf pondweed, or both. Furthermore, comparisons between the 2004 data and data collected when Eurasian water milfoil was believed not to occur in the lake indicates that it has had a significant impact on the lake's floristic quality. In other words, the spread of Eurasian water milfoil throughout the lake has degraded the aquatic plant community and as a result, has also degraded the health of the lake and its ecosystem.

The obvious solution to the plant problem is: get rid of the exotic plants. In fact, many of the comments received as a part of the survey conducted at the beginning of the project included thoughts such as these. Unfortunately, that is much easier said than done. First off, eradicating Eurasian water milfoil and/or curly-leaf pondweed from any lake, with the exception of a pioneer infestation, is beyond our current technology. Control and reduction, however, are possibilities.

According to the two surveys along with comments and questions related to Tim Hoyman and the steering committee during the project, it is clear that four techniques come to the forefront of the minds of many district members: harvesting, herbicides (chemicals), dredging, and water level drawdown. Each of these is discussed in a general fashion at the beginning of the aquatic plant section, below is a more specific discussion as each pertains to Buffalo Lake.

## Harvesting

Harvesting has been used on Buffalo Lake to alleviate nuisance aquatic plant problems for decades. In 2004, the district spent $81,900 clearing 300 acres to open parts of the lake for navigation (Map 4). The truth of the matter is the harvesting operations do a decent job of clearing a path for navigation, but do virtually nothing to stop the growth or spread of either exotic species. In fact, the harvesting has probably done much to spread both species around the lake and will likely continue to do so. Considering both exotics are so widespread, an increase in their abundance would likely go unnoticed for many years, maybe even a decade or more; in the end the increase in exotics would mean a further decrease in natives and a further degradation in floristic quality. Harvesting has its place in Buffalo Lake, and likely always will, but it will do nothing except provide short-term relief from nuisance plant levels.

## Herbicides

Chemical herbicides are described in more detail within the aquatic plant section. In general, herbicides are broken into two categories: systemic and contact. Contact herbicides only affected the part of the plant they contact and do not kill the root; therefore, the plants are able to regrow. Systemic herbicides affect the entire plant, including the root. If the entire plant is affected and dies, it obviously will not regrow. The systemic herbicide, 2,4-D (Navigate® and Aquacleen®) is effective against Eurasian water milfoil, while the contact herbicide, endothal (Aquathol® and Hydrothol®) is effective against curly-leaf pondweed and inconsistently against Eurasian water milfoil. A second systemic herbicide, fluridone (Sonar®) has also been shown to be effective against Eurasian water milfoil and some studies have been shown it to have an effect on curly-leaf pondweed. It is very important to note that the term "effective" should not be confused with or even associated with the term "eradicate" because in virtually every lake where any of these chemicals have been used, the target plant comes back. In the end, only two types of success can be realized through the use of herbicides, either some varying level of short-term control or like harvesting, nuisance relief. In either case, repeat treatments are required.

Fluridone has been the topic of many discussions among lake users and managers for the past year. Much of the information being passed around about this herbicide is inaccurate. Many people believe (or hope) that it is the answer to their Eurasian water milfoil problems. The truth is that it is not. Studies have shown that at low levels, fluridone is selective against Eurasian water milfoil and may knock it back for one or more years. Other studies have shown that even though it is considered selective, it still has an impact on non-target, native species. One of the biggest drawbacks of fluridone is that in order for it to be effective, it needs to be kept in contact with the target species at a specified dose rate for 60 or more days. Basically, this makes it applicable to only whole-lake treatments or in areas that can be physically separated from the rest of the lake. The downfall also makes the use of this chemical in Buffalo Lake a moot point. During a normal year, the water in Buffalo Lake is changed every 12-18 days. The cost of keeping the fluridone at its target concentration for 60+ days in a flowing system the size of

Buffalo Lake would likely run into the tens of millions of dollars. Then, it would likely need to be repeated in a couple of years.

As mentioned above, the contact herbicide, endothal is effective against curly-leaf pondweed and Eurasian water milfoil. Unfortunately, it is also effective against all of the native plants in the lake because it is not selective unless it is used at low concentrations very early in the year before the natives start to grow.

Studies completed by the U.S. Army Corps of Engineers have shown that curly-leaf pondweed abundances can be reduced if endothal is applied at the proper dose to curly-leaf pondweed colonies before they produce turions (asexual reproductive structures) and if those treatments are repeated annually for three to five years. Curly-leaf pondweed is an annual, so repeated treatment over the same area essentially depreciates the existing seed stock of the plant to the point that it is brought under control. Unfortunately, this kind of treatment scheme would be incredibly costly for Buffalo Lake because much of the lake's volume would need to be repeatedly treated over the course of three to five years to see a decrease in occurrence. For example, Buffalo Lake's volume is approximately 10,180 acre-feet (approximately 3.3 billion gallons), if only 10% of the volume were treated at the average cost (from 2005) of $130/ac-ft, the first year's treatment would cost approximately $132,000. Five years worth of treatments would cost over $660,000. That is for only 10% of the lake being treated, in reality much more of the lake would need to be treated to see an actual reduction. Obviously, the use of endothal to significantly reduce curly-leaf pondweed occurrence in Buffalo Lake is not a feasible option.

Because it is a contact herbicide, endothal is only useful for the temporary control of Eurasian water milfoil. In fact, multiple treatments may be required in one year to keep the plant under control. Treatments later in the year have devastating effects on native populations. Finally, the costs of the treatments would be similar to those shown above for curly-leaf pondweed, so in the end, the use of endothal to reduce the occurrence of Eurasian water milfoil is not applicable in Buffalo Lake.

2,4-D has been used to successfully and selectively control Eurasian water milfoil on many lakes in Wisconsin; however, in all of these cases, treatments need to be repeated to maintain control. Furthermore, its use may have even been successful at eradicating pioneer colonies from some lakes, although these cases are not officially documented. Unfortunately, Eurasian water milfoil has been found to occur in very high densities over much of Buffalo Lake, so achieving and maintaining control on a whole-lake basis would be tremendously expensive. For example, if 55% of the lake's shoreline were to be treated from shore to 100 feet out (approximately 13% of the lake's total surface area), it would cost approximately $140,000, at the average cost of $475/acre. Plus, there is no guarantee that the treatment would work and it would surely need to be repeated. As with the other chemicals, the use of 2,4-D to significantly decrease the abundance of Eurasian water milfoil is not feasible primarily because the plant is disbursed throughout the majority of the lake.

Without a substantial decrease in exotic abundances through a different technique or through a natural phenomenon, the use of herbicides in Buffalo Lake is only applicable for short-term nuisance relief on a property-by-property basis. It is beyond the scope of responsibility and the financial ability of the district to facilitate multiple chemical treatments within the district boundaries; therefore, it is the responsibility of individual property owners or groups of property owners, to complete such treatments. However, it must be stated here, that the WDNR has made it clear that chemical treatments will only be permitted on a case-by-case basis if the target plant or plants are non-native or in cases of extreme nuisance levels of native plants.

**Dredging**

Dredging, also known as lake deepening, is not an applicable method of plant control on Buffalo Lake. The common belief that deepening portions of the lake would reduce plant growth by limiting the amount of light available to the plants is essentially correct; however, it is far from practical. For example, if we were to remove 1% of Buffalo Lake's surface area from the photic zone (the maximum depth at which plants will grow in a lake) we would need to deepen approximately 22 acres to a depth greater than 9.25 feet. The value of 9.25 is an estimate of the depth of the photic zone of Buffalo Lake. It was determined by multiplying the average growing season Secchi disk clarity (3.7 feet in 2004) by 2.5. In most lakes, the photic zone is between 2.5 and 3 times the Secchi disk clarity; therefore, we would need to deepen that area of the lake to at least 9.25 feet before we would even be at the edge of the photic zone. The average depth of Buffalo Lake is approximately 4.6 feet. Using the average depth, we would need to remove 4.65 feet of sediment (9.25-4.6=4.65) from 22 acres of the lake bottom which equals approximately 102 acre-feet of sediment. That equals about 165,000 $yd^3$ and at a conservative estimate of about \$2.50/$yd^3$ for dredging, that means the project would cost \$412,500.

An alternative rationale behind dredging states that by removing some of the sediments, you remove the plant with it. Again, the thought process is accurate, but in the end it is definitely not practical. Even if a foot of sediment could be removed, and that foot included all of the seeds that built up over the years, the nutrient-rich sediments that lie beneath would be prime for reinfestation by pioneering species like Eurasian water milfoil and curly-leaf pondweed. Basically, the same thing would happen if a foot of soil were removed on dry land. The first thing that would occupy the area would be weedy species such as thistles and dandelions. Even if removing a foot of sediment would expose hard sand, it would only be a matter of time before the area was covered with silt, which again would be a perfect area for exotics to take hold.

**Water Level Drawdown**

The biggest disadvantage of using a drawdown is the uncertainty of how well it will work. Each lake reacts differently to a drawdown, and to some extent, the same plant species may react differently in drawdowns performed at different lakes. The fact is that the science behind drawdowns is not completely clear.

Overall, studies have shown that drawdowns often benefit a lake by compacting sediments, decreasing Eurasian water milfoil abundances, and increasing native plant abundances. Valuable emergent plant communities are often enhanced due to sediment drying and compaction. Furthermore, fisheries are often benefited by increased predation of smaller fish during the drawdown which leads to better predator/prey relationships.

Big Muskego Lake in Waukesha County was drawndown during 1995/1996, as a result of that drawdown, researchers found significant decreases in sediment moisture content and increases in sediment density (James et al. 2001). Both of these changes indicate significant sediment compaction. Montello Lake saw a definite decrease in Eurasian water milfoil, an increase in native plant abundance, and experienced an average sediment compaction of 6" following the drawdown performed in 2002/2003 (Aquatic Engineering, Inc. 2005).

Concerning a winter drawdown of Buffalo Lake, cost is not much of an issue because of the existing dam and lock structure. The majority of costs in conducting a winter drawdown would be associated with the studies used to determine the drawdown's success or failure along with the need and frequency of additional drawdowns.

Linda Hyatt, Dam Specialist with the WDNR, states that the locks would be useable to drawdown the lake as it was during the 1970's. Ms. Hyatt also stated that drawdown and refill rates would be determined by the Environmental Assessment (EA) that would be created by the WDNR. Regardless of the rates stated in the EA, Ms. Hyatt believes that fall and spring precipitation would ultimately determine the rates and the extent of the drawdown because the limited slope of the Fox River. Obviously the best time to complete the drawdown would be during a dry period, which unfortunately cannot be predicted.

David Bartz, Fisheries Biologist with the WDNR, believes that in the long-term, the fisheries of Buffalo Lake would benefit if a winter drawdown were completed. He believes this because the productive fishery of Buffalo Lake would quickly rebound from a minor fishkill that may occur during the drawdown. Furthermore, the expected increase in native plant abundances would benefit the fishery by increasing habitat value within the lake.

The timing of a winter drawdown is important to its success, as is the amount of precipitation (rain and snow) received during drawdown. The best conditions for a drawdown include very little snow and rain with very cold temperatures. These conditions ensure the greatest desiccation and freezing of the sediments and in turn the plants, their roots, and their reproductive structures (seeds, root crowns, turions, etc.). In general, winter drawdowns are conducted from September to the following April or May. During a normal year, Buffalo Lake would refill within a few weeks or a month. Most importantly, the controlling factor will always be the weather.

At this time, the primary focus has been a winter drawdown - and that is likely a good first step. However, it must be stated here, that additional soil compaction and native species enhancement would likely result if the drawdown were extended into, or carried through, the summer months. Furthermore, these benefits may be realized and better maintained if partial drawdowns were completed during the summer months to expose shallow areas and mud-flats. Completing the partial drawdowns would be considered more of a natural water level management scheme as opposed to the current management scheme of attempting to keep the lake at a constant level.

Goal 2 of this management plan is to reduce invasive plants and increase important native plants. Based upon the findings of the Montello and Big Muskego Lake drawdowns, it is expected that Buffalo Lake would see a marked decrease in Eurasian water milfoil, an increase in native plant abundance, and an added benefit of sediment compaction if a winter drawdown were completed. In other words, it is likely that completing a winter drawdown on Buffalo Lake would result in Goal 2 being met for some amount of time, but <u>not</u> indefinitely. A winter drawdown would not be a silver bullet, in order to maintain or even enhance those benefits, some sort of water level management would be needed in the future. Determining the frequency, magnitude, and need would be determined through the studies that would occur before and after the drawdown. Those studies would also shed light on the needs and extents of other management techniques, such as harvesting and herbicides.

Finally, when all of the results and conclusions are considered, it is clear that of all the methods described in this section, winter drawdown is the only one that provides a chance of reducing non-native species, while increasing important native species, as stated in Goal 2.

More information concerning a winter drawdown can be found within the implementation plan section.

# IMPLEMENTATION PLAN

A lake management plan is useless unless it is implemented. The implementation plan outlined here was created to meet the five management goals that were accepted by the district during the Annual Meeting in August 2005. Each of the goals is discussed below and a detailed list of management actions, complete with facilitator(s), timeframe, and action steps, as applicable, are listed to help the district meet each goal. The primary focus of the goals is to meet the following vision statement created by the steering committee concerning the management of Buffalo Lake:

> *The Buffalo Lake Protection & Rehabilitation District envisions that, through a cooperative effort, the future of Buffalo Lake is a lake with the natural aesthetics and water quality that maintains exceptional fish and wildlife habitat while providing a variety of recreational opportunities.*

## Goal 1: Maintain water quality (clear state)

Buffalo Lake is currently in a "Clear State" because the aquatic plants (native and exotic) are competing with algae for the large amount of phosphorus that is entering the lake from its very large watershed. Plus, the aquatic plants also provide cover to the microscopic critters (zooplankton) that graze on the algae. If the aquatic plants were not there, Buffalo Lake would be in a "Turbid State" and be dominated by algae. Lake Winnebago is an excellent example of a shallow lake like Buffalo Lake that is in a turbid state. We need to do everything that we can to keep the plants so Buffalo Lake remains in a clear state. Work in the watershed to reduce phosphorus loading to the lake will ultimately help to maintain the current water quality.

**Management Action:** *Initiate Volunteer Water Quality Monitoring Program*
**Cross-over Goals:** Goal 5
**Timeframe:** Summer 2006 in perpetuity
**Facilitator:** District Board to recruit volunteer(s).
**Description:** Over 1,000 volunteers are currently collecting data on Wisconsin Lakes as a part of the WDNR Self-Help Lake Monitoring Program. Volunteers are trained by WDNR staff to collect water clarity data using a Secchi disk. After one year of clarity monitoring, some volunteers start collecting water quality data. Spaces and equipment for water quality monitoring are limited, so the district may need to purchase equipment and pay for analysis at some point. Sampling for phosphorus, water clarity, and chlorophyll-*a* levels three to four times per year would be appropriate. An important aspect of this action would be the reporting of collected data at annual meetings, through the newsletter, and on the district website.

**Action Steps:**

1. Contact Mark Sesing, Lakes Coordinator, WDNR to enlist volunteer(s) as Self-Help Lake Monitor(s)
2. Monitor water clarity through first year.
3. Approach Mark Sesing about enlisting Self-Help Volunteer in advanced water quality collection program. If unable to proceed to advanced level as a part of the WDNR program, the district should investigate other monitoring programs at the district's expense.

**Management Action:** *Investigate Wetland Restorations*
**Cross-over Goals:** Goal 5
**Timeframe:** 2006
**Facilitator:** District Board to enlist volunteers / set up committee.
**Description:** The primary target of these restorations would be the muck farms that currently utilize portions of the Buffalo Lake Watershed. Funding may be available through federal agencies; however, standards for qualification are complicated and funds are limited. Potential sources of information on this topic include the Wisconsin Wetland Association, the State Department of Agriculture, and the Marquette County Land and Water Conservation Department. The Montello Lake P & R District may be an additional information source because they recently announced that 1000 acres of muck farm has been restored in their lake's watershed. Regardless of which source is contacted first, being prepared with accurate figures and realistic goals will help the source provide more useful information.

**Action Steps:**

1. Compile maps and figures pertaining to the acreage and distribution of muck farms in the Buffalo Lake watershed.
2. Contact the sources listed above to obtain information about programs available to restore existing agricultural areas back into wetlands.
3. Follow applicable program guidelines.

**Management Action:** *Private Septic System Education*
**Cross-over Goals:** Goal 5
**Timeframe:** 2006/2007
**Facilitator:** Communication Committee
**Description:** The purpose of this action is to increase awareness of lakeshore property owners concerning their septic system's impact on the lake and how maintaining a septic system properly can reduce these negative effects. This educational effort could be completed with a single article or a series of articles that would appear in the newsletter and on the website. These articles could be written using expert interviews and information taken from relevant websites and informational pamphlets/brochures available from county and state agencies. Specific to the county, an excellent source would be the county's Planning & Zoning Department.

**Action Steps:**

1. Refer to description above.

## Goal 2: Reduce invasive plants and increase important native plants

As described above, the aquatic plants are very important to the health of the lake. The problem is that many of them are exotics, primarily curly-leaf pondweed and Eurasian water-milfoil. Reducing the exotic plants while enhancing the natives will be the best thing for the lake because it will maintain the "Clear State" while increasing the fish and wildlife value of the lake. It will also increase aesthetics of the lake.

**Management Action:** *Winter Water Level Drawdown*
**Cross-over Goals:** Goal 1, Goal 3, & Goal 4
**Timeframe:** 2007/2008
**Facilitator:** District Board
**Description:** Although this is by far the most controversial management action, it is the district's best option for meeting this goal. Continued harvesting of Eurasian water milfoil and curly-leaf pondweed will do nothing to decrease their occurrence, in fact, it is likely sustaining or possibly spreading them. Wide-scale chemical treatments would be incredibly expensive, have limited results both in effectiveness and sustainability of results, and would not be permitted by the WDNR if native plants were to be impacted. A combination of harvesting, drawdown, and very limited, nuisance-level chemical applications would be the most successful. Specific to chemical applications; these would likely not be sponsored by the district, but would be on a property-to-property basis and would be initiated by the property owners themselves.

The science behind water level drawdown is not perfect by any means. Each lake and each type of plant reacts differently to drawdown. In general, Eurasian water milfoil occurrence is decreased for a year or more, while many native, especially emergents, respond well. Native response can be enhanced if the drawdown is extended in to the early summer. Curly-leaf pondweed response is variable. In a lake with a fishery as productive as Buffalo's any loss of fish due to the drawdown would be replaced quickly. Furthermore, increased native habitat would benefit the fishery greatly.

As with all aquatic plant management techniques, drawdown is not a silver bullet and its affects will not last forever. Normally, lakes that benefit from drawdown need to be treated again within a period of three to five years. Some, like Buffalo's neighbor, Lake Montello, may need to be lowered again in two years. The key is continued monitoring over the first few years to determine the frequency and success of drawdowns.

As alluded to above, drawdowns are complicated; however, if completed with care, they can have favorable results. The key is preparation and proper planning. There are many things that would need to be done prior to the drawdown:

**Environmental Assessment** The WDNR would complete an environmental assessment of the lake and surrounding area to determine the potential impacts the drawdown my have on the Buffalo Lake and related ecosystems. Ultimately, the environmental assessment would contain guidance on rate of drawdown and refill and the environmental monitoring that would be necessary to assure that other ecosystems are not being adversely impacted. For instance, the WDNR would likely require suspended solids monitoring downstream of the Buffalo Lake dam to assure that high levels of sediment were not being released to the Fox River and Lake Puckaway. If it were found that the sediment load was too high, the drawdown may need to be slowed or possibly halted to protect the other systems. The environmental assessment would also contain an alternatives analysis and guidance concerning the timing (length) and magnitude of the drawdown. It is important to understand that if the district decides to implement a drawdown, the environmental assessment would contain the specifics on how the drawdown should be completed.

**Curly-leaf Pondweed Survey** The response of curly-leaf pondweed to winter drawdowns is variable. Predicting its response is impossible until after the drawdown is completed. A curly-leaf pondweed survey has not been completed on Buffalo Lake during the plant's peak growth period in mid June; therefore, a survey should be completed the summer prior to the drawdown to collect data that could be compared to post-drawdown studies. This information would be useful in guiding decisions concerning future drawdowns.

**Fishery Study** WDNR personnel have confirmed that a fish study will be completed on Buffalo Lake during the fall of 2006 and spring of 2007. The results of that study will be compared with post-drawdown data to determine the impact on the Buffalo Lake fishery. Again, these data would be useful in making future drawdown determinations. As fish studies are very costly, it is not expected that the studies would be repeated as a part of each future drawdown.

**Dam Study and Hydrologic Study** A study of the dam and lake hydraulics would need to be completed prior to the drawdown to determine drawdown magnitude and methods for which it would be completed with the current dam, lochs, and spillway. This study would likely be competed by the WDNR.

**Action Steps:**

1. Refer to description above.

## Goal 3: Enhance recreational opportunities

This means the enhancement of all recreational activities – boating, fishing, swimming, and nature viewing. Recreational use is important on Wisconsin Lakes we have to do all we can to maintain it.

**Management Action:** *Formation of a Causeway Committee*
**Cross-over Goals:** Goal 4
**Timeframe:** 2006- 2007
**Facilitator:** District Board to create committee.
**Description:** This committee would be formed to complete the following tasks. Because the causeway is part of County Highway D, Marquette County would need to be involved with the committee and its actions.

***Initiate feasibility study***

There have been many negative comments made pertaining to the causeway and its' affect on that portion of the lake. Many of the problems reflected in the comments are believed to be the result of decreased flow through the culverts. An example being the excessive amount of plants that build up on both sides of the causeway on the south end. It is a common belief that this reduced flow is the result of blocked or crushed culverts. This study will determine if flows can be increased and if the increased flow would be a benefit to this area of the lake. This study would likely be completed by an engineering consulting firm.

***Facilitate periodic causeway cleanup***

At times, there is an incredible amount of trash that builds up on the causeway. This reduces aesthetics of the causeway and the lake. Part of this committee's responsibilities would be to recruit individuals who would be interested in periodically cleaning up the causeway. This could be accomplished by high school students, scouting troops and/or district members.

***Investigate methods to enhance safe causeway fishing***

There is an underlying concern regarding safety on the causeway. However, it offers many individuals shoreline fishing opportunities that are not available elsewhere. There may be ways to continue this opportunity and possibly enhance it and still ensure safety. Such as, making parking available off of the causeway, providing a walkway to one or multiple fishing piers, creating handicapped accessible fishing piers, reducing the speed limit on the causeway when fishing is taking place, posting signs which indicate dogs must be on a leash and parents must supervise their children.

**Action Steps:**

1. Contact Marquette County representative for guidance on who the district should speak with concerning the committee and its actions.
2. Refer to description above.

**Management Action:** *Creation of a Harvesting Committee*
**Cross-over Goals:**
**Timeframe:** 2006 - 2007
**Facilitator:** District Board to create committee.
**Description:** Responsibilities would include the creation of an annual harvesting budget, keeping track of the harvesting funds, and collecting and reporting harvesting data to the district. In addition, this committee would be tasked with investigating potential grants and/or funds that may be available for purchasing and/or maintaining harvesting equipment. A specific account should be earmarked for harvesting equipment. A member of the Buffalo Lake Association would be an active member of this committee. This committee would also look into fund raisers such as, brat fries, raffles, voluntary contributions, raised dues, etc. in order to keep this fund solvent.

**Action Steps:**

1. Refer to descriptions above.

## Goal 4: Improve natural aesthetics

People enjoy lake aesthetics. In fact, a study completed by the UW-Extension in the late 90's indicated that over 70% of Wisconsin lake-users enjoy lakes because of their natural beauty. Enhancing the aesthetics of Buffalo Lake will add to everyone's enjoyment of the lake.

**Management Action:** *Create Shoreland Restoration Demonstration Site*
**Cross-over Goals:** Goal 1 & Goal 2
**Timeframe:** 2007
**Facilitator:** District Board to recruit facilitator.
**Description:** Natural shorelands add to the aesthetics of the lake, reduce shoreland erosion, provide wildlife habitat and conceal shoreland structures. This action will demonstrate the process of shoreland restoration and the beauty of the end product. This will encourage other shoreland property owners to do the same. The WDNR Lake Protection Grant Program provides cost sharing funds for projects such as this on public and private properties. Toni Herkert, of the WDNR, has experience completing projects such as this and would be an excellent first contact. The Marquette County Land and Water Conservation Department (LWCD) may also have cost-share dollars available. A publicly owned site on the lake would receive priority over private sites for this demonstration because signage could be used and people would be able to visit the site. A logical portion of this action is to include an educational initiative concerning shoreland buffer zones, including the benefit of woodland management and no mow zones. The educational initiative could be completed through newsletter articles and the creation of a district brochure.

**Action Steps:**

1. Locate a suitable property.
2. Recruit the assistance of the WDNR, Marquette County LWCD or a consultant.
3. Create a preliminary plan.
4. Apply for Lake Protection Grant.
5. Complete project.

## Goal 5: Encourage cooperation and communication between agencies and municipalities

The Buffalo Lake P & R District should work to enhance cooperation and communication between itself and other governmental entities. By doing this we will enhance our efforts by utilizing the resources these entities posses. These resources include personnel, expertise, and funds.

**Management Action:** *Creation of District Communication/Education Committee*
**Cross-over Goals:** All other goals.
**Timeframe:** 2006
**Facilitator:** District Board to create
**Description:** This committee would be responsible for maintaining and enhancing the District's newsletter, web site, special mailings, and press releases. In addition, this committee would be charged with fulfilling the educational initiatives, not only outlined throughout this implementation plan, but also those that may arise in the future. An example of "in the future" would be the applicability and use of chemical treatments in our lake. Completing this action may require that the District Board set certain guidelines or standard procedures for determining what material will appear in the newsletter, special mailings, web site content, and press releases. The committee would also recruit speakers to present educational topics at the annual meetings and other events.
**Action Steps:**

1. District Board passes resolution to setup committee.
2. District Board recruits members.
3. Members take over responsibilities and initiatives.

**Management Action:** *Recruit Members to Actively Participate in the Wisconsin Association of Lakes*
**Cross-over Goals:** All other goals
**Timeframe:** 2006
**Facilitator:** District Board to create committee.
**Description:** The Wisconsin Association of Lakes (WAL) is an excellent resource for lake-related topics. WAL, along with the other members of the Wisconsin Lakes Partnership (WDNR and UW-Extension) host the annual Wisconsin Lakes Convention in Green Bay. WAL publishes "The Lake Connection" four times a year to bring its members and others up–to-date concerning lake-related issues, including educational topics, current events, and state and federal legislative issues that may affect lakes. Having three or more members involved with WAL by reading "The Lake Connection", attending its annual conference, and receiving its E-Newsletter would greatly increase the district's awareness of statewide lake-related issues. It would also increase communications between the district and other groups including, federal and state agencies, local governments, and other lake groups by exposing a core group of district members to these organizations during the lakes convention. One method to facilitate and sustain this involvement would be to have a group of three or four members be involved for two or three years at a time. The membership would be rotated so at least one or two people would be attending the conference multiple times. This would be opposed to having a different group of people involved

annually. Husband and wife teams would be a benefit because it would save the district money for lodging during the annual convention. These people could then be involved with the Communication/Education Committee in order to share what they have learned with the rest of the district.

**Action Steps:**

1. Visit www.wisconsinlakes.org for more information.

**Management Action:** *Improve working relationships with municipal governments within the District and government agencies that can have a role in assisting the District achieve its vision.*

**Cross-over Goals:** All Goals
**Timeframe:** 2006
**Facilitator:** District Board
**Description:** The District is within the jurisdiction of several local governments and decisions on land use and transportation by these governments can impact Buffalo Lake. The District should develop a process to ensure the District is notified of issues so it can participate in the dialog leading to decisions which can affect the lake. The District should also make use of the local agencies whose missions are to preserve and protect local natural resources.
**Action Steps:**

1. Meet at least annually with the Towns of Montello and Packwaukee, and the City of Montello to discuss mutual goals and objectives of comprehensive plans and the lake management plan.
2. Discuss the potential for the District Secretary to be noticed on all public hearings by the County Board of Adjustment and Planning & Zoning Committee that affect land or property in the District.
3. Discuss the potential for the District Secretary to be noticed on all public hearings by the Towns of Montello and Packwaukee that affect land or property in the District.
4. Attempt to include appropriate County and WDNR staff on committees working on related goals and objectives.
5. Present proposal to District members at annual meeting in August, 2006 for vote.

## Goal 6: Elected Commissioners work to meet the goals and need of the Buffalo Lake P&R District

Buffalo Lake is 2500 acres and has over 770 property owners; in order to meet the needs and goals set by the district members, much time and organization is needed. To increase the capacity of the District Board, it has added the above stated goal and created the management action detailed below to meet that goal.

**Management Action:** Increase number of commissioners and re-write position descriptions.
**Cross-over Goals:** All Goals
**Timeframe:** 2006
**Facilitator:** District Board
**Description:** Five Commissioner Board

**Chair**: Chair district meetings. Oversee other commissioners. Chair harvesting committee. Attend district meetings.

**Assistant Chair**: Post all notices to website. Write and post articles to website if required. Chair communication/education committee. Attend district meetings.

**Treasurer**: Responsible for all out going money. Keep track and record expenditures. Furnish treasurer report at meetings. Chair audit/budget committee and Causeway committee. Attend district meetings.

**Assistant Treasurer**: Collect and deposit assessments, donations, grants, etc. in checking or savings accounts at the direction of the Treasurer. Keep district computer data base with latest names and address updated by coordinating with county and other means. Print out assessments, mailing labels and other data. Chair Water Quality Monitoring Program Committee. Attend district meetings.

**Secretary**: Post district/committee meeting notices in newspaper and at post office. Record minutes from district meetings. Write and send thank you letters/letters of explanation as required to district members. Write and monitor grants. Chair Wetland Restoration Committee. Attend district meetings.

**Action Steps:**

1. 3 commissioners plus two representatives review proposal and modify/adopt or reject plan.
2. Review present by-laws for possible changes/additions due to proposal.
3. Present proposal to District members at annual meeting in August, 2006 for vote.

## METHODS

This will be added in the final draft.

## LITERATURE CITED

Aquatic Engineering, Inc. 2005. 2004 Montello Lake Aquatic Plant Management Plan (Preliminary Draft).

Carlson, R.E. 1977 A trophic state index for lakes. Limnology and Oceanography 22: 361-369.

Gard, R.E., E. Reetz, and E.G. Mueller. 1973 The Trail of the Serpent. The Fox River Valley, Lore and Legend. Wisconsin House, LTD. Madison, WI.

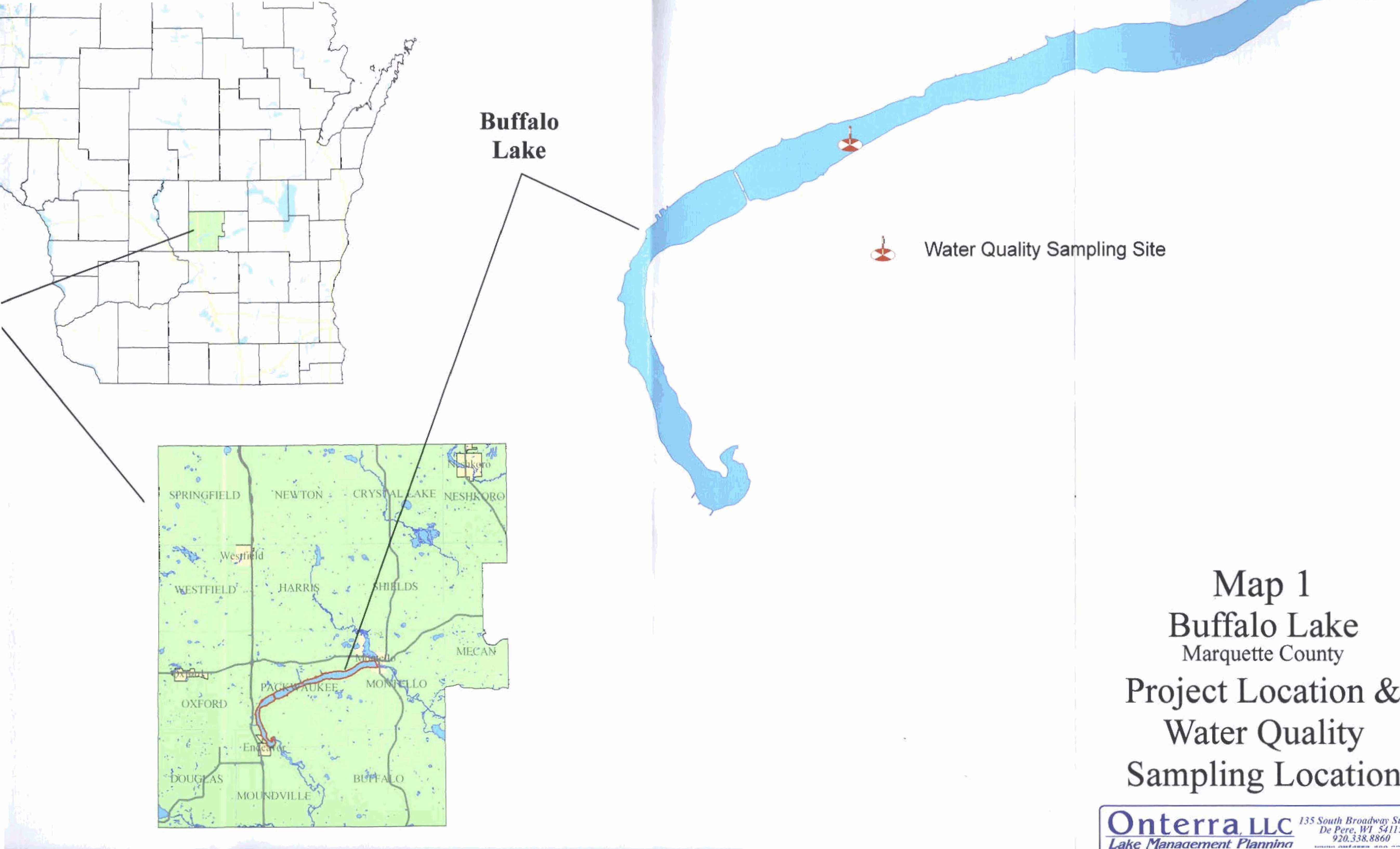
James, W.F., J.W. Barko, H.L. Eakin, and D.R. Helsel. 2001. Changes in sediment characteristics following drawdown of Big Muskego Lake, Wisconsin. Arch Hydrobiol. 151(3): 459-474.

Lillie, R.A., and J.W. Mason. 1983. Limnological characteristics of Wisconsin lakes. Technical Bulletin No. 138. Wisconsin Department of Natural Resources.

Lillie, R.A., S. Graham, and P. Rasmussen. 1993. Trophic state index equations and regional predictive equations for Wisconsin lakes. Research Management Findings 35. Wisconsin Department of Natural Resources.

Nichols, S.A. 1999. Floristic quality assessment of Wisconsin lake plant communities with example applications. Journal of Lake and Reservoir Management 15(2): 133-141

Omernick, J.M. and A.L. Gallant. 1988. Ecoregions of the Upper Midwest states. U.S. Environmental Protection Agency Report EPA/600/3-88/037. Corvallis, OR. 56p.


Buffalo Lake
SPRINGFIELD
NEWTON
CRYSTAL LAKE
NESHKORO
WESTFIELD
HARRIS
SHIELDS
MECAN
PACKWAUKEE
MONTELLO
OXFORD
DOUGLAS
MOUNDVILLE
BUFFALO
Westfield
Water Quality Sampling Site
Map 1
Buffalo Lake
Marquette County
Project Location &
Water Quality
Sampling Location
Onterra, LLC
Lake Management Planning
920.338.8860


# Buffalo Lak

Marquette County, Wisco

## Aquatic Plants

## Survey Plot Locat

Extent of large map shown in

## Legend

- Curly-leaf pondwe
- Eurasian water mil
- Eurasian water mil Curly-leaf pondwe
- Native Plants Only
- Not sampled (unre
- No Vegetation
- Small plant colony
- Boat Landing

A

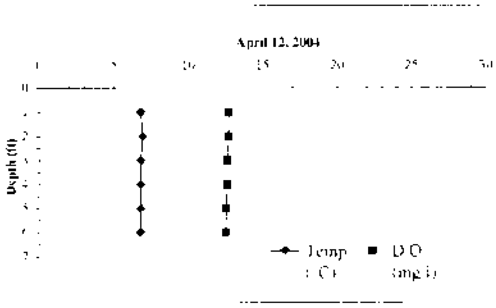
# APPENDIX A

2004 & 2005 Water Quality Data Set

## Buffalo Lake

**Date:** 04-12-04 **Max Depth (ft):** 6.7
**Time:** 10:21 **BUFS 5 Depth (ft):** 1.5
**Weather:** 38F Clear Breezy **BUFB 3 Depth (ft):** 5.5
**Ent:** TSN **Verf:** **Secchi Depth (ft):** 2.8

| Depth (ft) | Temp (°C) | D.O. (mg/l) | pH | Sp. Cond (µS/cm) |
|---|---|---|---|---|
| 1.0 | 6.8 | 12.7 | na | 395 |
| 2.0 | 6.9 | 12.7 | na | 394 |
| 3.0 | 6.8 | 12.6 | na | 395 |
| 4.0 | 6.8 | 12.6 | na | 393 |
| 5.0 | 6.8 | 12.5 | na | 394 |
| 6.0 | 6.8 | 12.5 | na | 393 |



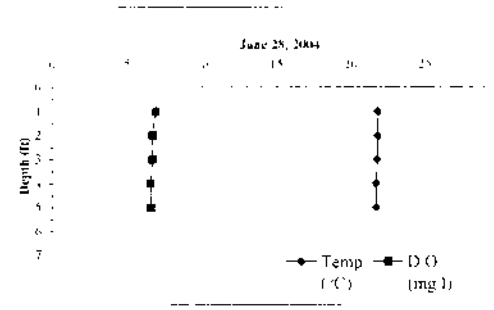

| Parameter | BUFS | BUFB |
|---|---|---|
| Total P (µg/L) | 63.000 | 64.000 |
| Dissolved P (µg/L) | ND | ND |
| Chl a (µg/L) | 35.30 | |
| TKN (µg/L) | 1020.00 | 1200.00 |
| NO4+NO3-N (µg/L) | 1130.000 | 1140.000 |
| NH3-N (µg/L) | 71.000 | 62.000 |
| Total N (µg/L) | 2150.00 | 2340.00 |
| Lab Cond (µS/cm) | 412 | 408 |
| Lab pH | 8.76 | 8.77 |
| Alkal (mg/l CaCO3) | 181 | 181 |
| Total Susp Sol (mg/l) | 5 | 7 |
| Calcium (mg/l) | 44.0 | |

Notes

## Buffalo Lake

**Date:** 06-28-04 **Max Depth (ft):** 5.7
**Time:** 15:27 **BUFS 5 Depth (ft):** 1.5
**Weather:** 63F, Windy Mostly Cloudy **BUFB 3 Depth (ft):** 4.5
**Ent:** TSN **Verf:** **Secchi Depth (ft):** 3.2

| Depth (ft) | Temp (°C) | D.O. (mg/l) | pH | Sp. Cond (µS/cm) |
|---|---|---|---|---|
| 1.0 | 21.8 | 6.9 | na | 349 |
| 2.0 | 21.8 | 6.7 | na | 348 |
| 3.0 | 21.8 | 6.7 | na | 348 |
| 4.0 | 21.7 | 6.6 | na | 349 |
| 5.0 | 21.7 | 6.6 | na | 347 |



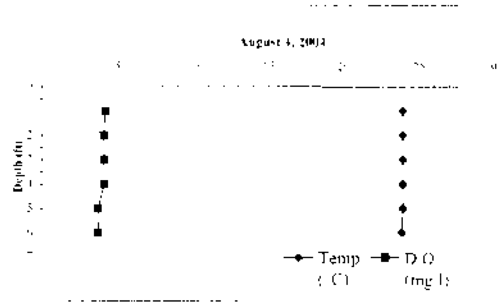

| Parameter | BUFS | BUFB |
|---|---|---|
| Total P (µg/L) | 119.000 | 114.000 |
| Dissolved P (µg/L) | | |
| Chl a (µg/L) | 16.30 | |
| TKN (µg/l) | | |
| NO4+NO3-N (µg/L) | | |
| NH3-N (µg/L) | | |
| Total N (µg/L) | | |
| Lab Cond (µS/cm) | | |
| Lab pH | | |
| Alkal (mg/l CaCO3) | | |
| Total Susp Sol (mg/l) | 5 | 7 |
| Calcium (mg/l) | | |

Notes

## Buffalo Lake

| | | | |
|---|---|---|---|
| **Date:** | **08-04-04** | **Max Depth (ft):** | 5.4 |
| **Time:** | 11:50 | **BUFS 5 Depth (ft):** | 1.5 |
| **Weather:** | 74F, Breezy, Partly Cloudy | **BUFB 3 Depth (ft):** | 4.5 |
| **Ent:** | TSN **Verf:** | **Secchi Depth (ft):** | 4.8 |

| Depth (ft) | Temp (°C) | D.O (mg/l) | pH | Sp. Cond (µS/cm) |
|---|---|---|---|---|
| 1.0 | 23.9 | 4.2 | na | 395 |
| 2.0 | 23.9 | 4.1 | na | 395 |
| 3.0 | 23.9 | 4.1 | na | 395 |
| 4.0 | 23.9 | 4.1 | na | 396 |
| 5.0 | 23.9 | 3.7 | na | 396 |
| 6.0 | 23.8 | 3.7 | na | 396 |



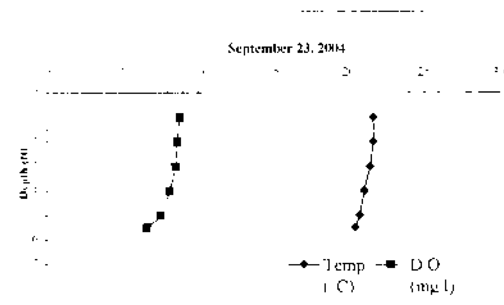

| Parameter | BUFS | BUFB |
|---|---|---|
| Total P (µg/L) | 127 | 118.000 |
| Dissolved P (µg/L) | | |
| Chl a (µg/L) | 7.46 | |
| TKN (µg/L) | 950 | 1210 |
| NO4+NO3-N (µg/L) | 149 | 148 |
| NH3-N (µg/L) | 74 | 273 |
| Total N (µg/L) | 1109.00 | 1358.00 |
| Lab Cond (µS/cm) | 392 | 390 |
| Lab pH | 8.09 | 8.09 |
| Alkal (mg/l CaCO3) | 182 | 182 |
| Total Susp Sol (mg/l) | 3 | 4 |
| Calcium (mg/l) | 42.3 | |

Notes: Chemistry Data was not sent to us. Used DNR website Data

## Buffalo Lake

| | | | |
|---|---|---|---|
| **Date:** | **09-23-04** | **Max Depth (ft):** | 5.8 |
| **Time:** | 13:17 | **BUFS 5 Depth (ft):** | 1.5 |
| **Weather:** | 82F, Breezy, Clear | **BUFB 3 Depth (ft):** | 4.5 |
| **Ent:** | TSN **Verf:** | **Secchi Depth (ft):** | 4.0 |

| Depth (ft) | Temp (°C) | D.O (mg/l) | pH | Sp. Cond (µS/cm) |
|---|---|---|---|---|
| 1.0 | 21.6 | 8.8 | na | 408 |
| 2.0 | 21.6 | 8.6 | na | 408 |
| 3.0 | 21.4 | 8.5 | na | 410 |
| 4.0 | 21.0 | 8.1 | na | 409 |
| 5.0 | 20.7 | 7.5 | na | 409 |
| 5.5 | 20.4 | 6.6 | na | 407 |



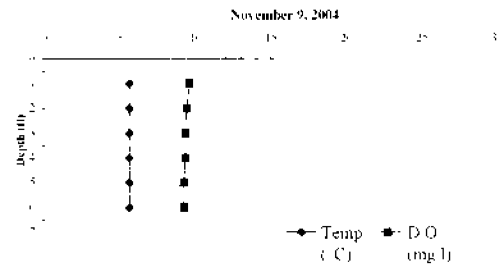

| Parameter | BUFS | BUFB |
|---|---|---|
| Total P (µg/L) | 92 | 64 |
| Dissolved P (µg/L) | | |
| Chl a (µg/L) | 26 | |
| TKN (µg/L) | | |
| NO4+NO3-N (µg/L) | | |
| NH3-N (µg/L) | | |
| Total N (µg/L) | | |
| Lab Cond (µS/cm) | | |
| Lab pH | | |
| Alkal (mg/l CaCO3) | | |
| Total Susp Sol (mg/l) | 6 | 6 |
| Calcium (mg/l) | | |

Notes: Chemistry Data was not sent to us. Used DNR website Data

## Buffalo Lake

| | | | |
|---|---|---|---|
| **Date:** | 11-09-04 | **Max Depth (ft):** | 7.0 |
| **Time:** | 12:00 | **BUFS S Depth (ft):** | 1.5 |
| **Weather:** | 40F, Windy, Clear | **BUFB 3 Depth (ft):** | 6.0 |
| **Ent:** | TSN **Verf:** | **Secchi Depth (ft):** | 3.7 |

| Depth (ft) | Temp (°C) | D.O. (mg/l) | pH | Sp. Cond (µS/cm) |
|---|---|---|---|---|
| 1.0 | 5.6 | 9.6 | na | 410 |
| 2.0 | 5.6 | 9.4 | na | 410 |
| 3.0 | 5.6 | 9.3 | na | 409 |
| 4.0 | 5.6 | 9.3 | na | 410 |
| 5.0 | 5.6 | 9.2 | na | 410 |
| 6.0 | 5.6 | 9.2 | na | 410 |
| | | | | |



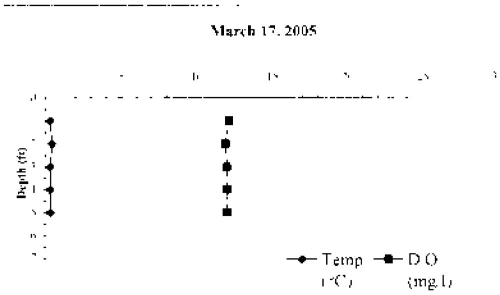

| Parameter | BUFS | BUFB |
|---|---|---|
| Total P (µg/L) | 42 | 45 |
| Dissolved P (µg/L) | | |
| Chl a (µg/L) | 5.38 | |
| TKN (µg/L) | | |
| NO4+NO3-N (µg/L) | | |
| NH3-N (µg/L) | | |
| Total N (µg/L) | | |
| Lab Cond (µS/cm) | | |
| Lab pH | | |
| Alkal (mg/l CaCO3) | | |
| Total Susp Sol (mg/l) | 4 | |
| Calcium (mg/l) | | |

Notes: Chemistry Data was not sent to us, used DNR website Data

## Buffalo Lake

| | | | |
|---|---|---|---|
| **Date:** | 03-17-05 | **Max Depth (ft):** | 5.5 |
| **Time:** | 11:2 | **BUFS S Depth (ft):** | 2.0 |
| **Weather:** | 28°F, ice depth - 0.5 feet, 75% Cloud | **BUFB 3 Depth (ft):** | 4.5 |
| **Ent.** | TSN **Verf:** | **Secchi Depth (ft):** | 4.7 |

| Depth (ft) | Temp (°C) | D.O. (mg/l) | pH | Sp. Cond (µS/cm) |
|---|---|---|---|---|
| 1.0 | 0.3 | 12.1 | 7.4 | 409 |
| 2.0 | 0.4 | 11.9 | 7.6 | 408 |
| 3.0 | 0.3 | 12.0 | 8.1 | 410 |
| 4.0 | 0.3 | 12.0 | 8.1 | 410 |
| 5.0 | 0.3 | 12.0 | 8.1 | 409 |
| | | | | |
| | | | | |




| Parameter | BUFS | BUFB |
|---|---|---|
| Total P (µg/L) | 65.000 | 62.000 |
| Dissolved P (µg/L) | | |
| Chl a (µg/L) | | |
| TKN (µg/L) | 650.00 | 710.00 |
| NO4+NO3-N (µg/L) | 1340.000 | 1350.000 |
| NH3-N (µg/L) | 93.000 | 69.000 |
| Total N (µg/L) | 1990.00 | 2060.00 |
| Lab Cond (µS/cm) | | |
| Lab pH | | |
| Alkal (mg/l CaCO3) | | |
| Total Susp Sol (mg/l) | 3 | 5 |
| Calcium (mg/l) | | |

Notes: 223 paces south of County Hwy C Boatramp

**Water Quality Data**

| 2004-2005 Parameter | Surface Count | Surface Mean | Bottom Count | Bottom Mean |
|---|---|---|---|---|
| Secchi Depth (feet) | 6 | 3.87 | | |
| Total P (µg/L) | 6 | 84.67 | 6 | 77.83 |
| Dissolved P (µg/L) | | | | |
| Chl a (µg/L) | 5 | 16.29 | | |
| TKN (µg/L) | 3 | 876.67 | 3 | 1040.00 |
| NO4+NO3-N (µg/L) | 3 | 873.00 | 3 | 879.33 |
| NH3-N (µg/L) | 3 | 79.33 | 3 | 134.67 |
| Total N (µg/L) | 3 | 1749.67 | 3 | 1919.33 |
| Lab Cond. (µS/cm) | 2 | 402.00 | 2 | 399.00 |
| Lab pH | 2 | 8.43 | 2 | 8.43 |
| Alka (mg/l CaCO3) | 2 | 181.50 | 2 | 181.50 |
| Total Susp Sol (mg/l) | 6 | 4.33 | 5 | 5.80 |
| Calcium (mg/l) | 2 | 43.15 | | |

**Morphological / Geographical Data**

| Parameter | Value |
|---|---|
| Acreage | 2210 |
| Volume (acre-feet) | 10180 |
| Perimeter (miles) | 24.9 |
| Shoreland Development | 3.78 |
| Maximum Depth (feet) | 8 |
| County | Marquette County |
| WBIC | 168000 |
| Lillie Mason Region(1983) | Central Region |
| Nichols Ecoregion(1999) | NCSE |

**Watershed Data**

| WILMS Class | Acreage | kg/yr | lbs/yr |
|---|---|---|---|
| Row Crop Agriculture | 60292 | 24400 | 53793 |
| Pasture/Grass | 75106 | 9119 | 20104 |
| High Density Urban (1/8 Ac) | 1358 | 824 | 1817 |
| Medium Density Urban (1/4 Ac) | 1068 | 216 | 476 |
| Wetlands | 49205 | 1991 | 4389 |
| Forest | 72908 | 2656 | 5855 |
| Golf Course | 58 | 106 | 234 |
| Lake Surface | 2210 | 268 | 591 |

**Wisconsin Trophic State Index (WTSI)**

| Year | TP | Chla | SD |
|---|---|---|---|
| 1973 | 71.27 | | |
| 1974 | | | |
| 1980 | | 58.28 | 57.14 |
| 1986 | 67.27 | | |
| 1991 | 65.07 | 59.34 | 71.77 |
| 1993 | 67.48 | 46.66 | 57.51 |
| 1994 | 67.40 | 63.25 | 63.92 |
| 1997 | 64.73 | | |
| 1998 | 67.95 | 58.12 | 62.11 |
| 1999 | 64.36 | 46.45 | 57.02 |
| 2000 | 65.23 | 54.19 | 59.07 |
| 2001 | 68.04 | 53.96 | 62.11 |
| 2004 | 65.60 | 53.32 | 57.14 |
| All Years (weighted) | 67.09 | 55.81 | 60.61 |
| WI Impoundments | 60.51 | 58.05 | 56.10 |
| Central Region | 51.45 | 49.68 | 47.33 |

| | Secchi (feet) | | | | Chlorophyll a (µg/L) | | | | Phosphorus (µg/L) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Growing Season | | Summer | | Growing Season | | Summer | | Growing Season | | Summer | |
| Year | Count | Mean | Count | Mean | Count | Mean | Count | Mean | Count | Mean | Count | Mean |
| 1973 | | | | | | | | | 4 | 220.00 | 2 | 255.00 |
| 1974 | | | | | | | | | 4 | 72.50 | | |
| 1980 | 1 | 2.0 | 1 | 2.0 | 1 | 23.00 | 1 | 23.00 | | | | |
| 1986 | | | | | | | | | 10 | 150.00 | 8 | 152.50 |
| 1991 | 2 | 1.5 | 2 | 1.5 | 2 | 26.50 | 2 | 26.50 | 2 | 115.00 | 2 | 115.00 |
| 1993 | 4 | 4.1 | 3 | 3.9 | 5 | 8.28 | 3 | 4.88 | 5 | 124.60 | 3 | 156.67 |
| 1994 | 4 | 2.5 | 2 | 2.5 | 5 | 35.26 | 2 | 44.65 | 5 | 116.80 | 2 | 155.00 |
| 1997 | | | | | | | | | 1 | 110.00 | 1 | 110.00 |
| 1998 | 4 | 2.6 | 3 | 2.8 | 4 | 27.55 | 3 | 22.53 | 4 | 143.25 | 3 | 166.33 |
| 1999 | 4 | 3.6 | 3 | 4.0 | 4 | 8.26 | 3 | 4.75 | 4 | 96.00 | 3 | 105.00 |
| 2000 | 4 | 3.1 | 3 | 3.5 | 4 | 14.00 | 3 | 13.33 | 4 | 104.75 | 3 | 117.33 |
| 2001 | 4 | 2.5 | 3 | 2.8 | 4 | 29.95 | 3 | 12.93 | 4 | 127.50 | 3 | 168.33 |
| 2004 | 4 | 3.7 | 2 | 4.0 | 4 | 21.27 | 2 | 11.88 | 4 | 100.25 | 2 | 123.00 |
| All Years (weighted) | | 3.1 | | 3.1 | | 21.14 | | 16.56 | | 127.53 | | 149.0 |
| WI Impoundments | | | | 4.3 | | | | 22.30 | | | | 64 |
| Central Region | | | | 7.9 | | | | 7.50 | | | | 20 |

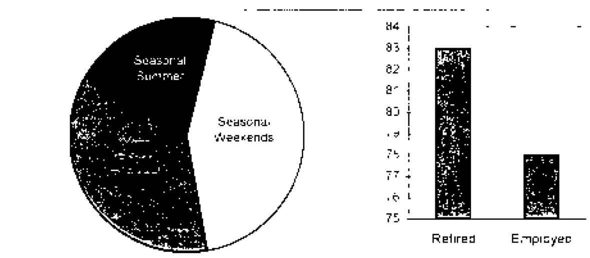
E

# APPENDIX E

Stakeholder Survey Results

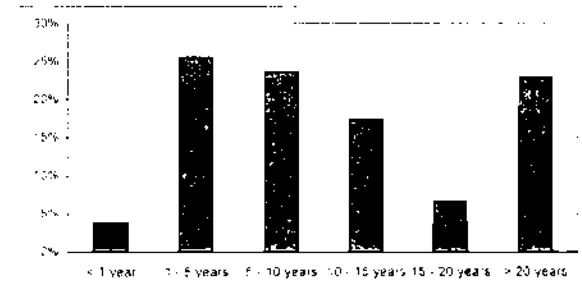
#1

| *Are you?* | |
|---|---|
| Year Round Resident | 97 |
| Seasonal Summer | 55 |
| Seasonal Weekends | 116 |
| **Total** | **268** |
| Retired | 83 |
| Employed | 78 |
| **Total** | **161** |



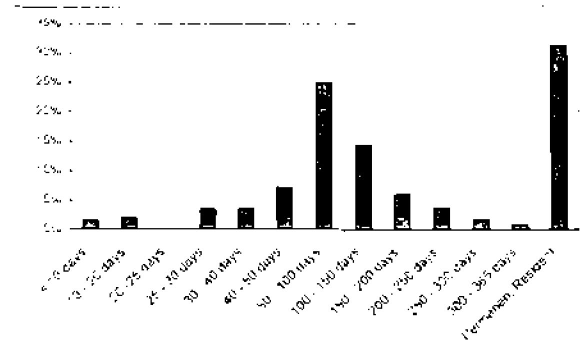

#2

| *How many years have you or your family owned property on the lake?* | |
|---|---|
| < 1 year | 10 |
| 1 - 5 years | 66 |
| 5 - 10 years | 61 |
| 10 - 15 years | 45 |
| 15 - 20 years | 17 |
| > 20 years | 59 |
| **Total** | **258** |



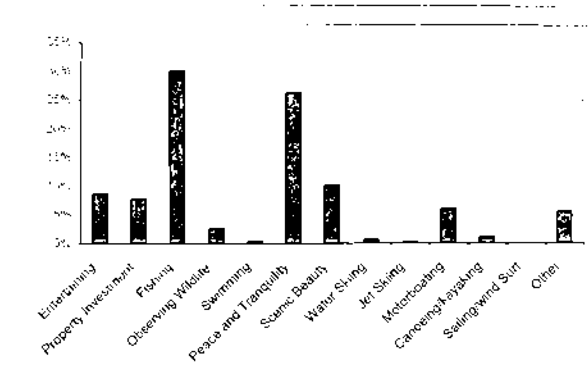

#3

| *About how many days during the year do you use your Buffalo Lake property?* | |
|---|---|
| < 10 days | 4 |
| 10 - 20 days | 5 |
| 20 -25 days | 0 |
| 25 - 30 days | 9 |
| 30 - 40 days | 9 |
| 40 - 50 days | 18 |
| 50 - 100 days | 63 |
| 100 - 150 days | 36 |
| 150 - 200 days | 11 |
| 200 - 250 days | 9 |
| 250 - 300 days | 4 |
| 300 - 365 days | 2 |
| Permanent Resident | 79 |
| | **253** |



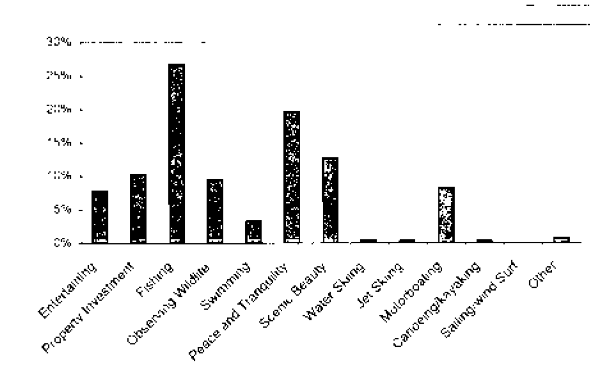
#4(1st)

| *What are the most important reasons why you own property on the Buffalo Lake?* | |
|---|---|
| Entertaining | 23 |
| Property Investment | 21 |
| Fishing | 80 |
| Observing Wildlife | 7 |
| Swimming | 1 |
| Peace and Tranquility | 75 |
| Scenic Beauty | 27 |
| Water Skiing | 2 |
| Jet Skiing | 1 |
| Motorboating | 16 |
| Canoeing/kayaking | 3 |
| Sailing/wind Surf | 0 |
| Other | 15 |
| **Total** | **266** |



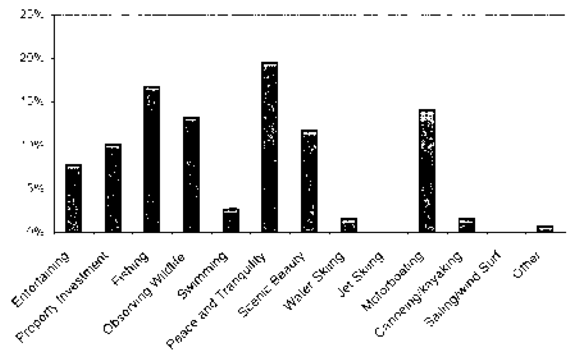

#4(2nd)

| *What are the most important reasons why you own property on the Buffalo Lake?* | |
|---|---|
| Entertaining | 19 |
| Property Investment | 25 |
| Fishing | 65 |
| Observing Wildlife | 23 |
| Swimming | 8 |
| Peace and Tranquility | 48 |
| Scenic Beauty | 31 |
| Water Skiing | 1 |
| Jet Skiing | 1 |
| Motorboating | 20 |
| Canoeing/kayaking | 1 |
| Sailing/wind Surf | 0 |
| Other | 2 |
| **Total** | **244** |



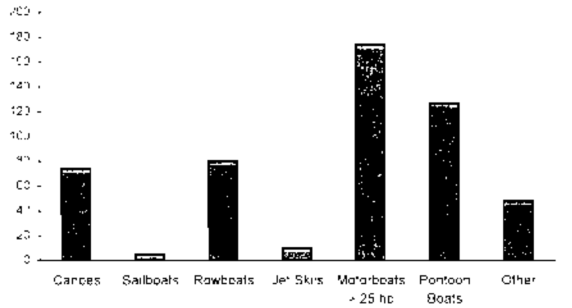
#4(3rd) *What are the most important reasons why you own property on the Buffalo Lake?*

| | |
|---|---|
| Entertaining | 20 |
| Property Investment | 26 |
| Fishing | 43 |
| Observing Wildlife | 34 |
| Swimming | 7 |
| Peace and Tranquility | 50 |
| Scenic Beauty | 30 |
| Water Skiing | 4 |
| Jet Skiing | 0 |
| Motorboating | 36 |
| Canoeing/kayaking | 4 |
| Sailing/wind Surf | 0 |
| Other | 2 |
| **Total** | **256** |



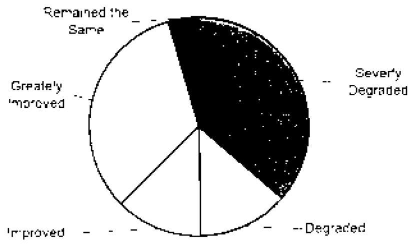

#5 *How many of the following watercraft are kept and used at your porperty?*

| | |
|---|---|
| Canoes | 74 |
| Sailboats | 5 |
| Rowboats | 80 |
| Jet Skis | 10 |
| Motorboats > 25 hp | 174 |
| Pontoon Boats | 127 |
| Other | 48 |



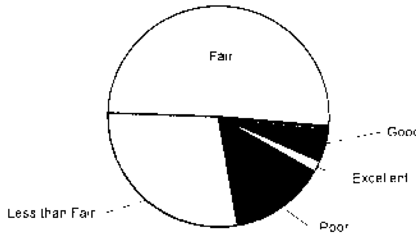

#9 *Has the water quality changed since you obtained your porperty?*

| | |
|---|---|
| Severly Degraded | 91 |
| Degraded | 34 |
| Improved | 32 |
| Greately Improved | 83 |
| Remained the Same | 11 |
| **Total** | **251** |



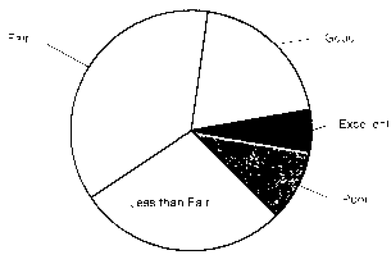

#10 *Your perception of the water quality within Buffalo Lake?*

| | |
|---|---|
| Poor | 36 |
| Less than Fair | 73 |
| Fair | 132 |
| Good | 14 |
| Excellent | 4 |
| **Total** | **259** |

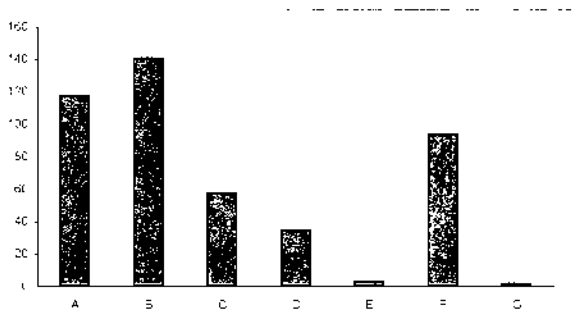



#11 *Your perception of the current fishing quality within Buffalo Lake?*

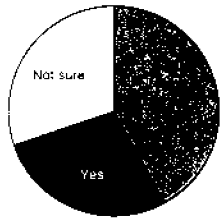
| | |
|---|---|
| Poor | 25 |
| Less than Fair | 71 |
| Fair | 93 |
| Good | 51 |
| Excellent | 14 |
| **Total** | **254** |



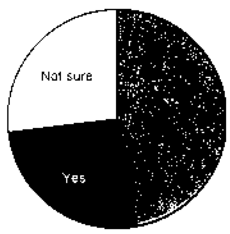
| #12 | *What do you consider to be the primary management objectives for Buffalo Lake?* | |
|---|---|---|
| | **A** - Providing water quality suitable for maintaining fish & other aquatic life | 118 |
| | **B** - Reducing the severity of nuisance plant growth | 141 |
| | **C** - Improving water quality conditions for suitable, full-body contact recreational use | 58 |
| | **D** - Improving wildlife habitat | 35 |
| | **E** - None of the above | 3 |
| | **F** - All of the above | 94 |
| | **G** - Other | 2 |



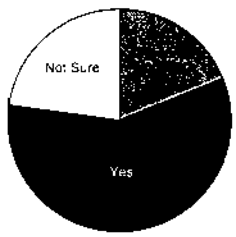

| #13 | *Have you been adequately informed of the issues facing Buffalo Lake?* | |
|---|---|---|
| | No | 109 |
| | Yes | 72 |
| | Not sure | 79 |
| | **Total** | **260** |



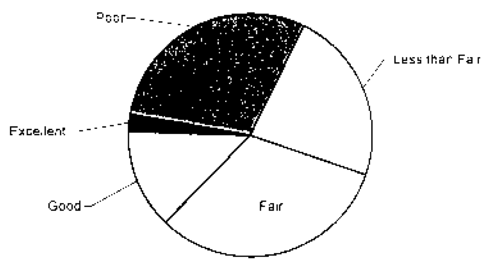

| #14 | *Do you favor a drawdown of the lake to control nuisance plant growth?* | |
|---|---|---|
| | No | 125 |
| | Yes | 68 |
| | Not sure | 71 |
| | **Total** | **264** |



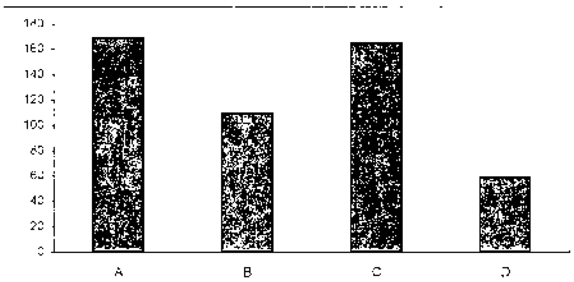

| #15 | *Has the quality of the lake affected you financially or your porperty value?* | |
|---|---|---|
| | No Affect | 49 |
| | Yes | 152 |
| | Not Sure | 59 |
| | **Total** | **260** |



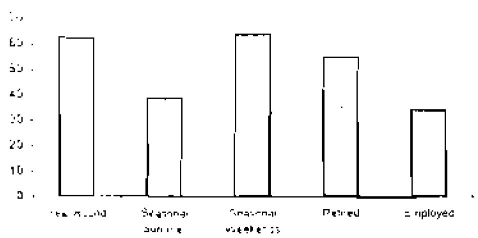

| #16 | *How would you rate the current plant harvesting efforts on Buffalo Lake?* | |
|---|---|---|
| | Poor | 76 |
| | Less than Fair | 60 |
| | Fair | 83 |
| | Good | 34 |
| | Excellent | 6 |
| | **Total** | **259** |



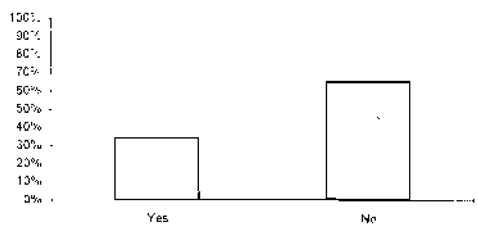

| #17 | *What other methods would you like to see utilized to control nuisance plant growth?* | |
|---|---|---|
| | **A** - Continued use of the mechanical aquatic plant harvesting | 169 |
| | **B** - Increased control by manual methods along the shoreline | 110 |
| | **C** - Use of aquatic herbicides (chemicals) on a lake-wide basis (guided by the District) | 165 |
| | **D** - Water level drawdown | 59 |



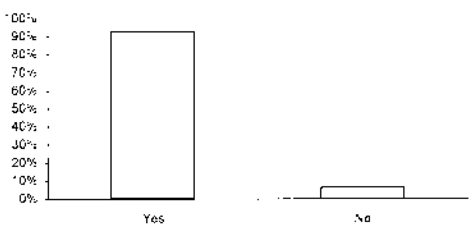
| | | Year Round | Seasonal Summer | Seasonal Weekends | Retired | Employed |
|---|---|---|---|---|---|---|
| #1 | Are You? | 53 | 39 | 64 | 55 | 34 |



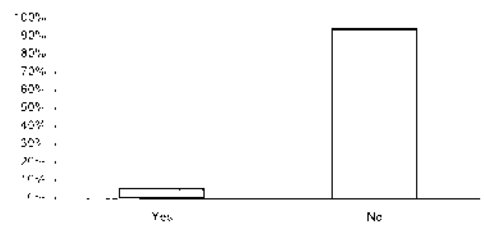

| | | Yes | No | Total |
|---|---|---|---|---|
| #2 | Did you attend the Lake Fair on Saturday, May 14th, 2005? | 56 | 106 | 162 |



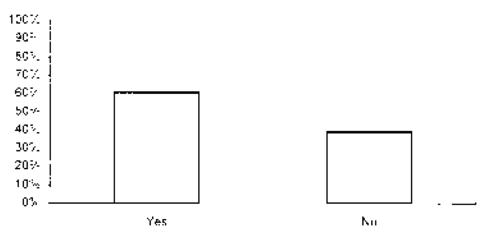

| | | Yes | No | Total |
|---|---|---|---|---|
| #3 | Did you receive notice of the date, time and location of the Lake Fair? | 151 | 11 | 162 |

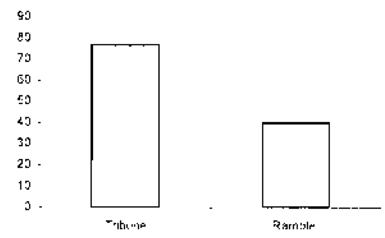


| #4 | | Yes | No | Total |
|---|---|---|---|---|
| | Did you hear the radio advertisements spreading the word about the Lake Fair? | 9 | 152 | 161 |

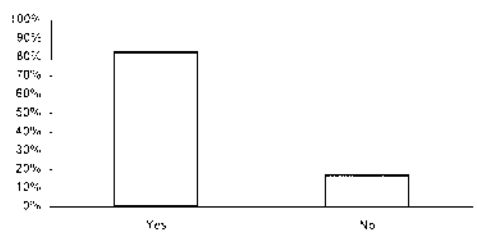



| #5 | | Yes | No | Total | Tribune | Rambler |
|---|---|---|---|---|---|---|
| | Did you read about the Lake Fair in the Marquette Tribune and/or Rural Rambler? | 98 | 53 | 151 | 77 | 40 |

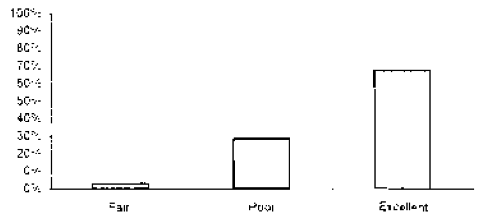


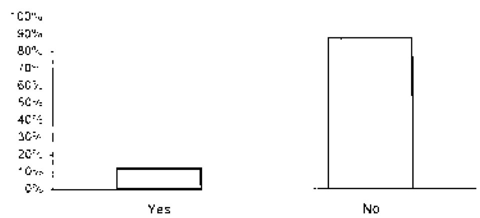

| #6 | | Yes | No | Total |
|---|---|---|---|---|
| | Did you read about the Lake Fair in the March 2005 Buffalo Lake Newsletter? | 134 | 28 | 162 |



| #7 | | Fair | Poor | Excellent | Total |
|---|---|---|---|---|---|
| | Please indicate the rating you would give on the effort made to promote the Lake Fair | 5 | 44 | 104 | 153 |

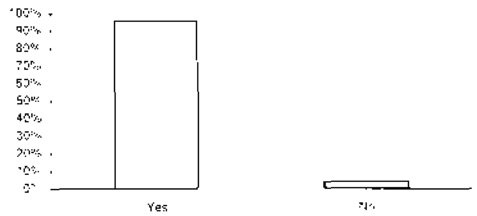



| #8 | | Yes | No | Total |
|---|---|---|---|---|
| | Is there something else we could have done to promote this event? | 18 | 129 | 147 |

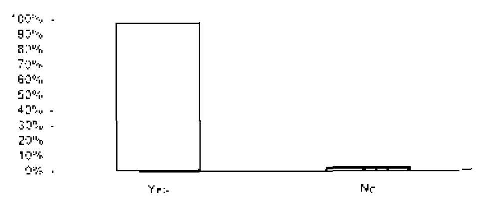



| #9 | | Yes | No | Total |
|---|---|---|---|---|
| | Did the booth representatives answer your questions? | 47 | 11 | 58 |

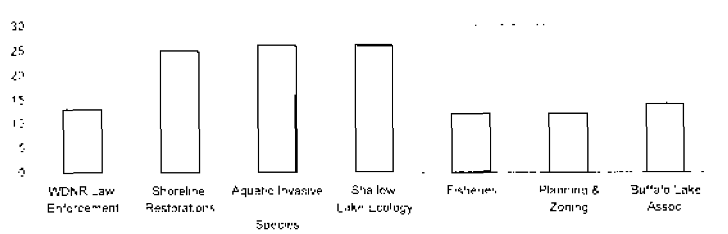
| | | Yes | No | Total |
|---|---|---|---|---|
| #10 | Was enough take-home information available at the booths? | 46 | 2 | 48 |



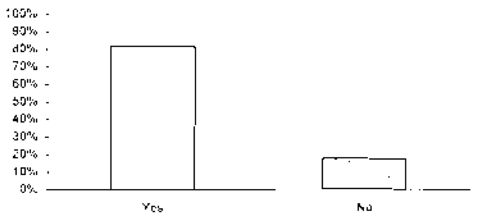

| | | Yes | No | Total |
|---|---|---|---|---|
| #11 | Was the information you obtained from the booths helpful? | 48 | 1 | 49 |



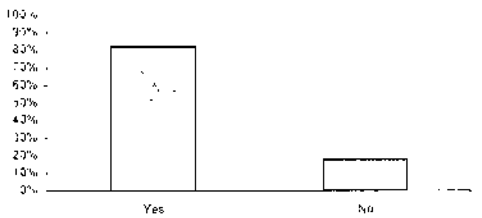

| | | WDNR Law Enforcement | Shoreline Restorations | Aquatic Invasive Species | Shallow Lake Ecology | Fisheries | Planning & Zoning | Buffalo Lake Assoc. |
|---|---|---|---|---|---|---|---|---|
| #12 | Which booth(s) provided you with the information you were most interested in? | 13 | 25 | 26 | 25 | 12 | 12 | 14 |



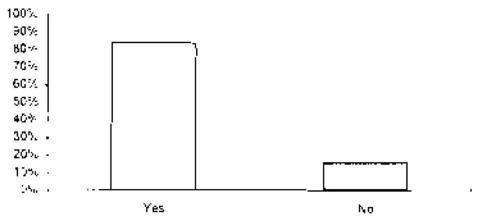
| | | Yes | No | Total |
|---|---|---|---|---|
| #13 | Were you able to attend the 2:00 p.m. Keynote Speaker presentation by Tim Hoyman? | 4[illegible] | 9 | 50 |



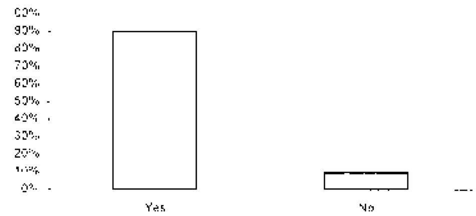

| | | Yes | No | Total |
|---|---|---|---|---|
| #14 | Were you able to hear Tim's presentation? | 37 | 8 | 45 |



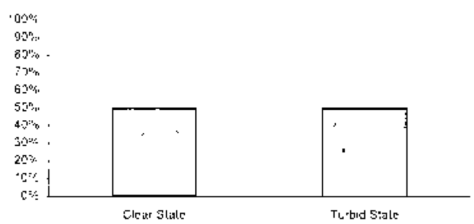

| | | Yes | No | Total |
|---|---|---|---|---|
| #15 | Did Tim clearly communicate his findings and conclusions? | 37 | 7 | 44 |



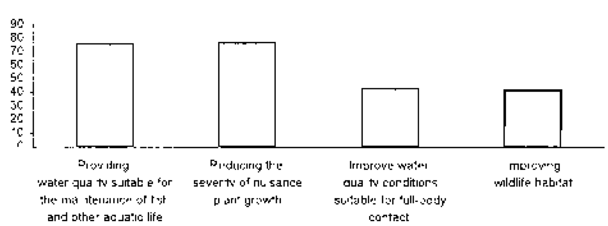
| | | Yes | No | Total |
|---|---|---|---|---|
| #16 | Did you find the material I'm covered to be organized in a fashion that assisted you in understanding the issues facing Buffalo Lake? | 37 | 4 | 41 |



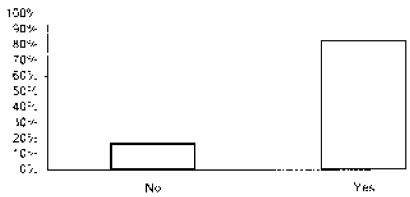

| | | Clear State | Turbid State | Total |
|---|---|---|---|---|
| #17 | Based on the information you received, what is the state of the water quality in Buffalo Lake? | 32 | 32 | 64 |



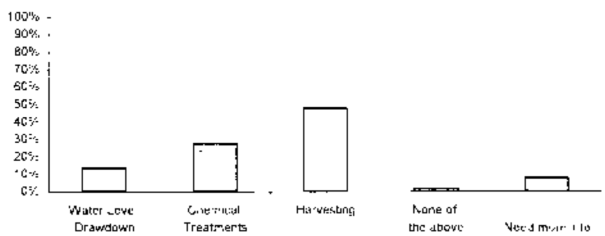

| | | Providing water quality suitable for the maintenance of fish and other aquatic life | Reducing the severity of nuisance plant growth | Improve water quality conditions suitable for full-body contact | Improving wildlife habitat |
|---|---|---|---|---|---|
| #18 | What do you consider to be primary management objective(s) for Buffalo Lake? | 76 | 77 | 43 | 42 |



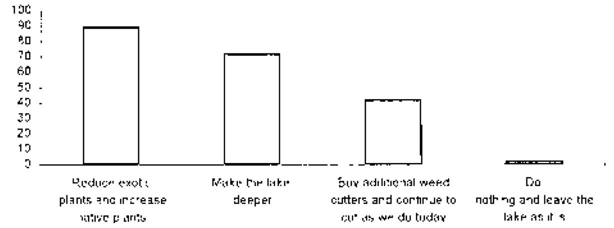
| | | No | Yes | Total |
|---|---|---|---|---|
| #19 | Do you feel you have been adequately informed of the issues facing Buffalo Lake? | 12 | 58 | 70 |




| | | Water Level Drawdown | Chemical Treatments | Harvesting | None of the above | Need more info | Total |
|---|---|---|---|---|---|---|---|
| #20 | Tim discussed the advantages and disadvantages of *harvesting*, *chemical treatments*, and *water level drawdown*, and. After listening to the descriptions, which method would you support? | 15 | 30 | 52 | 2 | 9 | 108 |



| | | Reduce exotic plants and increase native plants | Make the lake deeper | Buy additional weed cutters and continue to cut as we do today | Do nothing and leave the lake as it is |
|---|---|---|---|---|---|
| #21 | What do you feel the Primary Goal of the Comprehensive Lake Plan should be? | 89 | 72 | 42 | 2 |




| | | Yes | No | Partially | Total |
|---|---|---|---|---|---|
| #22 | Overall, did the Lake Fair help you to understand the issues facing Buffalo Lake and the choices we have in managing the lake? | 48 | 10 | 25 | 84 |