2002 SUMMARY REPORT
of
McGREAL LAKE

Lake County, Illinois

Prepared by the

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EXECUTIVE SUMMARY

McGreal Lake, located in unincorporated Antioch Township, just north of North Avenue and west of Deep Lake Road, is a small, manmade lake. McGreal Lake is a two-lobed lake with a surface area of 24.5 acres and estimated mean and maximum depths of 4.6 and 9.2 feet, respectively. The lake receives water from a small creek that drains residential and agricultural areas and other nonpoint sources. The lake is used for fishing and aesthetics by approximately five residents around the lake.

Water quality parameters, such as nutrients, suspended solids, oxygen, temperature and water clarity were measured and the plant community was assessed each month from May-September 2002. McGreal Lake was thermally stratified from June-August. Average total phosphorus (TP) concentrations in both the epilimnion and hypolimnion were well above the county medians. Hypolimnetic concentrations were three times as high as the epilimnetic concentrations, indicating very nutrient enriched lake sediment. The primary source of phosphorus to McGreal Lake appears to be release from decomposing curly leaf pondweed. The decomposing plant material also resulted in increased total suspended solids (TSS) concentrations and decreased Secchi depths as the summer progressed. The Phosphorus Trophic State Index (TSIp) of McGreal Lake was 64.7, indicating eutrophic conditions and placing it 68th out of 103 on the ranking of Lake County lakes since 1998.

McGreal Lake had a relatively diverse plant community, although it was dominated by curly leaf pondweed, Eurasian watermilfoil and coontail. Ten other native species were also present. Curly leaf pondweed (CLPW) and EWM are exotic species and CLPW contributed to high TP and TSS concentrations. However, without the presence of some plants in McGreal Lake, dense algae blooms would have dominated, water clarity would have been very poor and native plants may have been completely absent from the lake. The milfoil weevil, *Euhrychiopsis lecontei*, was observed on the Eurasian watermilfoil (EWM) during 2002. Weevil-induced damage was observed and the insect species was found in high densities. The presence of *E. lecontei* is encouraging and, in future years, the weevil population could begin to naturally decrease the density of EWM without the use of chemicals or harvesting.

The shoreline along McGreal Lake was dominated by buffer and shrub, and was exhibiting erosion along 25% of the lake. As a result of the domination of buffer and shrub shoreline types, a large number of bird and waterfowl species, including the Illinois state endangered black tern, and the Illinois state threatened sandhill crane and pied bill grebe were observed on the lake. Wetland, buffer and shrub shorelines should be maintained as much as possible, and manicured lawns should be discouraged. Buckthorn and reed canary grass, as well as several other exotic plant species were present along 86% of the shoreline of McGreal Lake and steps to eliminate these plants should be carried out before they completely take over these areas.

LAKE IDENTIFICATION AND LOCATION

McGreal Lake is located in unincorporated Antioch Township, just south of North Avenue and west of Deep Lake Road (T 46N, R 21E, S 4, 9). McGreal Lake is a two-lobed lake with a surface area of 24.5 acres with estimated mean and maximum depths of 4.6 feet and 9.2 feet, respectively. It has an estimated volume of 112.7 acre-feet and a shoreline length of 1.0 mile. McGreal Lake receives water from a small creek which drains residential and agricultural areas around the lake, and other nonpoint sources. Water exits the lake through a large pipe on the southwest shore into a creek which flows through a farm field and eventually ends up in Little Silver Lake. McGreal Lake is located in the Sequoit Creek sub basin of the Fox River Watershed.

BRIEF HISTORY OF MCGREAL LAKE

McGreal Lake began as a wetland and then became a 15-acre spring-fed lake (making up the eastern lobe by damming a low-lying area in 1955). Approximately 40 years ago, a dam was placed across the south end of the wetland, creating the two-lobed 24- acre lake present today. Art McGreal, the original owner of McGreal Lake, began building a home on the lake at the same time the second dam was installed. Currently, there are six individuals who own part of the bottom of McGreal Lake. However, there is no lake management association and all lake issues are addressed by each individual lake owner.

SUMMARY OF CURRENT AND HISTORICAL LAKE USES

Access to McGreal Lake is limited to homeowners and their guests who have access to the lake via their property. No motors are permitted and only 6 fisherman may be on the lake at any given time. Currently, none of the homeowners use the lake for fishing, but some have visitors who enjoy fishing, swimming and boating on the lake. An area along the western shoreline and around the peninsula separating the two lobes was dredged approximately 25 years ago, but no other management activities have taken place in the recent past. Currently, the biggest management concerns on McGreal Lake include excessive curly leaf pondweed growth and possible nutrient pollution entering the lake via the inlet creek.

LIMNOLOGICAL DATA – WATER QUALITY

Water samples collected from McGreal Lake were analyzed for a variety of water quality parameters (See Appendix B for methodology). Samples were collected at 3 and 6 foot depths from the deep hole location in the lake (Figure 1). McGreal Lake was thermally stratified from June-August. Thermal stratification occurs when a lake divides into an upper, warm water layer (epilimnion) and a lower, cold water layer (hypolimnion). When stratified, the epilimnetic and hypolimnetic waters do not mix, and the

hypolimnion typically becomes anoxic (dissolved oxygen=0 mg/l) by mid-summer. This phenomenon is a natural occurrence in deep lakes and is not necessarily a bad thing if enough of the lake volume remains oxygenated. During most of the summer, stratification in McGreal Lake was strongest at a depth of approximately 5-8 feet, and hypoxia (DO<1.0 mg/l) began to occur between 5-7 feet, depending on the month (Appendix C). However, since a current bathymetric map does not exist for McGreal Lake, it is impossible to know what volume of the lake lies below 5-7 feet and how much of the lake volume was experiencing hypoxia. The sharp decrease in surface water DO concentration in July likely occurred as a result of the decomposition of a massive amount of curly leaf pondweed throughout the end of June and early July. The decomposition of these plants was very likely stripping the water of DO as a result of high BOD (biological oxygen demand). A high BOD means that regardless of the amount of oxygen present, the demand for that oxygen by living organisms (especially bacteria that decompose organic matter such as plants) is very high, and a decrease in DO may occur for a period of time. Photosynthesis does not occur during the night to replace oxygen being taken up by respiration, and oxygen levels often decline overnight and into the early morning before rebounding by mid-morning with the sun. This is especially true in nutrient enriched lakes, such as McGreal Lake, with large amounts of algae and plant matter and a high BOD. DO concentrations recovered in the epilimnion in August before dropping again in September during an early fall turnover. This same pattern of a decrease in DO and an increase in other parameters was also seen in 1992 and 1993. Although there is no data regarding plant growth for those two years, it is likely that the current plant community is not significantly different than it was 10 years ago and that the decomposition of a high density of curly leaf pondweed occurred in July of 1992 and 1993. Hypolimnetic DO concentrations were below 5.0 mg/l in June and very near 0 mg/l in July and August, which (as mentioned above) is typical for a stratified, nutrient-enriched lake.

Phosphorus is a nutrient that can enter lakes through runoff or be released from lake sediment, and high levels of phosphorus typically trigger algal blooms or produce high plant density. The average near surface total phosphorus (TP) concentration in McGreal Lake was 0.091 mg/l, while the average hypolimnetic concentration was 0.233 mg/l (Table 1, Appendix A). These were much higher than the Lake County median epilimnetic phosphorus concentration of 0.056 mg/l and median hypolimnetic concentration of 0.170 mg/l. TP concentrations were positively correlated with rainfall amounts the previous month, and external sources such as non-point runoff from the cattle farm and nearby residential areas may be contributing some phosphorus to the lake. There was concern from a lake resident that the septic system of a neighbor along North Avenue was contributing raw effluent into the creek draining a grass swale along North Avenue and that empties into the lake. Lake Management Unit (LMU) staff investigated the request on three occasions. On June 6, 2002, a water sample was collected for testing of fecal coliform (FC) bacteria from the drainage swale and came back very low for FC (110 colonies FC/100 ml). On October 2, 2002, a water sample was collected and tested for FC and TP. The FC concentration was much higher than in June (1100 colonies FC/100 ml) and TP was relatively high (0.123 mg/l). Although these levels were well below what would be detected if raw septic effluent was discharging into the swale, LMU staff re-visited the area on October 24, 2002 to determine the source of water in the swale and inspect the septic field of the neighbor along North Avenue Visual inspection of the area around the house revealed no apparent septic failure, and the septic field does not drain into the swale. However, numerous lawns east of this property to Deep Lake Road, along with North Avenue, do drain into the swale. Water running over these impervious surfaces and over potentially fertilized lawns could easily provide the amount of FC and TP detected in the October 2, 2002 sample. Although a water sample was not collected on October 24, 2002, it was determined that the septic system of the neighbor along North Avenue was not contributing TP to the grass swale and that the sources of phosphorus to the swale included lawns to the east and runoff from Deep Lake Road and North Avenue The lake resident with the original complaint intends to collect water samples from the swale during the next rain or snow melt to be tested for FC and the LMU will review that data once it is available. At this time, the data collected during the above mentioned investigation and during the water quality study over the course of the summer may indicate that internal sources are providing more phosphorus than external sources.

TP increased almost three-fold from May (0.024 mg/l) to June, when the average TP concentration was (0.070 mg/l). One possible source of this large increase is the extremely high pH (10.11) measured in June (Table 1, Appendix A). pH is a measure of the hydrogen ion activity [H^+]in the water column and indicates whether the lake is acidic (pH<7), basic (pH>7) or neutral (pH=7). If a lake is acidic, the water will contain more H^+ ions and if a lake is basic, the water will contain more hydroxide ions (OH^-). The acidity of a lake can have an effect many things, including productivity. Lakes that are more basic typically have higher phosphorus concentrations and are more productive. One reason for this is that the sediment of basic lakes typically contains more phosphorus. The release of this phosphorus can result in a higher density of algae, which then contributes to increasing the pH of the lake further through photosynthesis, and the cycle continues. Another reason that extremely basic lakes (pH>10.0) contain more phosphorus in the water column is that a chemical reaction between OH^-, phosphate (PO_4) and iron (Fe) ions results in the release of soluble phosphate into the water column. This reaction occurs in oxygenated, often shallow water and the phosphorus can be easily taken up by algae upon release.

The hypolimnetic phosphorus concentration was over twice as high as the epilimnetic concentration. This is expected in a stratified lake. During stratification, oxygen is depleted (or nearly depleted) in the hypolimnion, triggering chemical reactions at the sediment surface. These reactions result in the release of phosphorus from the sediment into the water column and is known as internal phosphorus loading. Since the hypolimnion is thermally isolated from the epilimnion during the summer, phosphorus builds up and is isolated from the near surface water until fall turnover. The hypolimnetic average phosphorus concentration was 0.233 mg/l, a high average that indicates that the sediment of McGreal Lake has a large store of phosphorus, built up from years of decomposing plant material falling back to the sediment surface and from different sources of phosphorus rich water entering the lake in the past. This phosphorus that had been released and trapped in the hypolimnion all summer was distributed into the entire water column during fall turnover in September and served as another secondary source of TP to the surface water. The average hypolimnetic TP concentration has increased dramatically since 1992 and 1993 (Table 2, Appendix A). It appears that stratification during those two years was much weaker than in 2002, and phosphorus did not build up as much in the hypolimnion. The lake also has 10 more years of decomposed organic matter imbedded in the sediment than it did during those studies. This may be contributing to the dramatic decrease in DO in the hypolimnion.

The primary internal source of phosphorus to the epilimnion of McGreal Lake is probably decomposing plant material. Curly leaf pondweed dominated the plant community in May and June, covering much of the surface area of the east half of lake. Like many aquatic plants, the life cycle of curly leaf pondweed is affected and somewhat controlled by water temperature. This species thrives when water temperatures are relatively cool, and is typically one of the first plants to appear in a lake in the spring. However, its life cycle is driven by water temperature increases and, as the summer progresses, curly leaf pondweed will typically die off by late June or early July. Rooted aquatic plants such as curly leaf pondweed take up their nutrients from the sediment and store these nutrients in plant tissue. When these plants die and begin to decompose, the stored nutrients are released into the water column. This internal recycling of phosphorus from the sediment to the water column provides a readily available source of phosphorus for algae and may contribute to planktonic algae blooms each summer. This helps explain the large pulse of phosphorus observed in both the epilimnion and hypolimnion in July. In the epilimnion, TP concentration doubled from 0.070 mg/l in June to 0.159 mg/l in July. Additionally, the concentration of soluble reactive phosphorus (SRP) (a form of phosphorus that is soluble in water and more readily available for uptake and utilization by algae) increased from 0.015 mg/l to 0.065 mg/l, a huge increase for a variable that does not typically occur above a concentration of 0.005 mg/l. A pulse of phosphorus was also observed in July 1992 and July 1993, indicating a regularity associated with this event, and further suggesting that the death and decomposition of curly leaf pondweed occurring around this time every year is a source of phosphorus to McGreal Lake (Table 2, Appendix A). Also at this time of year, it appears that nitrogen levels decreased substantially relative to phosphorus levels. When this occurs, the lake becomes nitrogen limited and algae are not able to utilize the phosphorus in the water until nitrogen levels increase again. As a result, both SRP and TP concentrations in the water column increase, and a pulse of phosphorus is detected. Nitrogen limitation, therefore, also appears to be a primary source of phosphorus in the water column.

Total suspended solids (TSS) is a measure of the amount of suspended material, such as algae or sediment, in the water column. High TSS values are typically correlated with poor water clarity and can be detrimental to many aspects of the lake ecosystem such as the plant and fish communities. A large amount of material in the water column can inhibit successful predation by sight-feeding fish, such as bass and pike, or settle out and smother fish eggs. High turbidity caused by sediment or algae can shade out native aquatic plants, resulting in their reduction or disappearance from the littoral zone. TSS concentrations in the epilimnion of McGreal Lake were low in May and June, but increased by almost five-fold to 5.5 mg/l in July and remained above 5.0 mg/l through early September. Despite this increase, the average TSS concentration in McGreal Lake (3.9 mg/l) was much lower than the county median of 6.0 mg/l (Table 1, Appendix A). The increase in TSS in the water column in July most likely originated from decomposing plant matter. This was most certainly the case for the near bottom water sample collected in July (TSS = 33.0 mg/l). When the water sampler (Van Dorn) was brought to the surface, it contained large chunks of decomposing plant material that had been collecting near the lake bottom.

A strong relationship existed between TP and TSS concentrations (Figure 2). Additionally, total volatile solids (TVS, a measure of organic matter, such as algae or plant material, in the water column) concentrations were also strongly correlated with TSS concentrations (Figure 3). The primary source of phosphorus to the lake is decomposing plant matter. As the plant matter decomposed, it caused an increase in TSS.   Some of the TSS was also made up of planktonic algae. In this way, TP and TSS would also be related, but in the reverse manner. An increase in TP would result in increased algae density, which would increase TSS in the lake. The average TSS concentration has increased since 1993 but was lower in 2002 than it was in 1992. Although the average concentrations fluctuate between years, the TSS concentrations increased dramatically in July of all three years (Table 2, Appendix A). As with the increase in TP and the decrease in DO, the consistent timing of these increases indicates that the decomposition of curly leaf pondweed is to blame.

It is likely that the algae blooms would have been denser and the TSS concentration would have been much higher without the presence of plants in the lake. Although curly leaf pondweed is an exotic species and contributed to the high TSS concentration in July, without the presence of that plant, as well as native plant species, to stabilize sediment and compete with planktonic algae for resources, the high TP concentration in June may have resulted in an algae bloom in the lake.

The large number of plants and the relatively low TSS concentrations in 2002 resulted in relatively high water clarity throughout the summer. This was illustrated by higher than average Secchi depth measurements that coincided with low TSS concentrations (Figure 4). Average Secchi depth (water clarity) on McGreal Lake was higher than the County median (3.81 feet). Secchi depth reached a maximum of the lake bottom (8.9 feet) in June before decreasing dramatically in July and reaching a low of 2.79 feet in August. The average Secchi depth measurement in 2002 was slightly higher than in 1993. However, without yearly data, it cannot be concluded that water clarity is actually improving. The initiation of the Volunteer Lake Monitoring Program (VLMP) in McGreal Lake is highly recommended. This is a volunteer program in which a lakeshore homeowner measures Secchi depth each month in order to create a historical record of lake water quality. As mentioned above, algae density and TSS concentrations may have been much higher (and Secchi depths much lower) were it not for the presence of a high density of plants.

Typically, lakes are either phosphorus (P) or nitrogen (N) limited. This means that one of these nutrients is in short supply relative to the other and that any addition of phosphorus or nitrogen to the lake might result in an increase of plant or algal growth. Other resources necessary for plant and algae growth include light or carbon, but these are typically not limiting. Most lakes in Lake County are phosphorus limited, but to compare the availability of nitrogen and phosphorus, a ratio of total nitrogen to total phosphorus (TN:TP) is used. Ratios less than or equal to 10:1 indicate nitrogen is limiting. Ratios greater than or equal to 15:1 indicate that phosphorus is limiting. Ratios greater than 10:1, but less than 15:1 indicate that there are enough of both nutrients to facilitate excess algal or plant growth. McGreal Lake had an average TN:TP ratio of 14:1. This indicates that there was enough nitrogen and phosphorus to promote algae growth during certain months (as was observed in 2002). Because both N and P are already at high concentrations, additional inputs of nitrogen or phosphorus to the lake would not likely have any observable impact in the form of more plants or algae until the inputs reached a very high level. This is common in nutrient-enriched lakes, where high phosphorus levels have reached the point where either very large increases or very large decreases in phosphorus would be necessary to trigger changes in algae density. On the other hand, less enriched lakes are often more sensitive to increases or decreases in phosphorus. As a result of relatively lower nitrogen concentrations in 1992 as compared to 2002, the average TN:TP ratio in 1992 was 10:1, and as a result of relatively lower phosphorus concentrations in 1993 as compared to 2002, the average TN:TP ratio in 1993 was 16:1. These changes can have an impact on the growth of algae during each summer and the differences are likely the result of activities in the watershed and differences in rainfall between the three years.

Nitrogen (N) can come from a variety of external sources, including rain, fertilizer, the atmosphere and other non-point sources, and can be virtually impossible to control. The amount of N in the water column can have a direct effect on algae density through uptake by the algae cells. Additionally, the amount of N available in the water column can also have an indirect effect on algae density by affecting the uptake of phosphorus (P) as well. If the amount of available N is inadequate, the algae will not grow. If algae is not growing, it will take up and utilize neither N nor P from the water. As the algae in the water dies, soluble reactive phosphorus (SRP) will be released from those cells, resulting in a build-up of unused P in the water. This appeared to be what was happening, in part, in McGreal Lake during the summer of 2002. In May, the N:P ratio was 39:1 (phosphorus limited) and SRP was non-detectable. In June, the P concentration had increased and the N:P ratio was 14:1 (neither N nor P limited). SRP was just above the detection limit in June. In July, P concentrations increased dramatically due to continued release from plant decomposition, while N concentrations only increased slightly. The N:P ratio in July was 7:1 (nitrogen limited). Without an adequate source of N, algae were not able to utilize P for growth. This may have contributed to the dramatic increase in the TP and SRP concentrations as the unused P built up in the water column in July. By August, some of the blue-green algae may have begun to fix atmospheric nitrogen (converting it to a usable form), driving up the N:P ratio to 12:1 and enabling the algae to utilize available P in the water column. As a result, TP and SRP levels decreased in

August and September (SRP was, once again, below the detection level) (Table 1, Appendix A).

Phosphorus levels can also be used to indicate the trophic state (productivity level) of a lake. The Trophic State Index (TSI) uses phosphorus, chlorophyll *a* (algae biomass) and Secchi depth to classify and compare lake trophic states using just one value. The TSI is set up so that an increase in phosphorus concentration is related to an increase in algal biomass and a corresponding decrease in Secchi depth. High TSI values indicate eutrophic (TSI=50-69) to hypereutrophic (TSI ≥70) lake conditions, typically characterized by high nutrient concentrations, high algal biomass, low DO levels, a rough fish population, and low water clarity. McGreal Lake had an average phosphorus TSI (TSIp) value of 69.2, indicating highly eutrophic conditions. This means that the lake is a highly enriched system with relatively poor water quality. The lake ranked 68th out of 103 lakes studied in Lake County. Although this is a poor ranking, it is not unusual for a man-made lake in Lake County. Most man-made lakes in this region fall into the eutrophic and hypereutrophic categories, while many of the glacial lakes and old borrow pits rank higher (Table 3, Appendix A).

Most of the water quality parameters just discussed can be used to analyze the water quality of McGreal Lake based on use impairment indices established by the Illinois Environmental Protection Agency (IEPA). According to this index, McGreal Lake provides *Full* support of aquatic life and *Partial* support of swimming and recreational activities (such as boating) as a result of a high percent plant coverage and high nutrient concentrations. The lake provides *Partial* overall use.

LIMNOLOGICAL DATA – AQUATIC PLANT ASSESSMENT

Aquatic plant surveys were conducted every month for the duration of the study (See Appendix B for methodology). Shoreline plants of interest were also recorded. However, no quantitative surveys were made of these shoreline plant species and these data are purely observational. Light level was measured at one-foot intervals from the water surface to the lake bottom. When light intensity falls below 1% of the level at the water surface, plants are no longer able to grow. Using this information, along with a bathymetric map, it can be determined how much of the lake has the potential to support aquatic plant growth. Based on 1% light level, McGreal Lake could have supported plants over approximately 95% of the lake, and plants were observed growing over approximately 90% of the surface area during 2002 (Appendix C). The inability of aquatic plants to grow in all areas as determined by percent light level may be explained by the presence of poor substrate (rocky and sandy) in several parts of the lake, including the northern end of the peninsula.

Curly leaf pondweed, Eurasian watermilfoil (EWM) (both exotic species) and coontail dominated the plant community in McGreal Lake during the summer of 2002 (Table 5). Curly leaf pondweed dominated in May and June, after which it naturally died off and was replaced by coontail in July. Coontail and EWM dominated almost equally in

August and coontail dominated again in September. Twelve other plant species (all native) were present thoughout the summer, but were not observed in high abundance except for sago pondweed (Table 4 & 5). Curly leaf pondweed dominated at a time when water clarity was relatively high. However, after the curly leaf died and began to decompose, water clarity dropped significantly as a result of algae blooms, and EWM and coontail were able to take over the plant community due to their floating capabilities Unlike many of the native plants, EWM and coontail were able to successfully compete with algae for light because of their growth patterns. EWM is an exotic plant that quickly grows to the water surface and forms a dense canopy. Coontail is a native submersed plant that does not necessarily root, but floats. It gains its nutrients from the water column. Because of their ability to grow at the water surface, EWM and coontail can outcompete lower growing rooted native vegetation that may be shaded out.

Eurasian watermilfoil was one of the dominant plants in the lake, occurring at 45% of the plant sampling sites throughout the summer. This exotic plant species may have invaded McGreal Lake as early as the 1970's and it has come to dominate a large part of the lake's plant community. In 2002, the milfoil weevil (*Euhrychiopsis lecontei*) was observed in the lake during plant sampling. *E. lecontei* is a native insect that has shown some success as a biological control for Eurasian watermilfoil (EWM). When present in large enough numbers, it can cause significant damage to milfoil beds. The weevil was found in relatively high densities and a large amount of weevil-induced damage was observed on the plants. The presence of *E. lecontei* is encouraging and, in future years, the weevil population could begin to naturally decrease the density of EWM without the use of other plant management techniques.

Of the 31 emergent plant and trees species observed along the shoreline of McGreal Lake, eight are invasive species that do not provide ideal wildlife habitat and have the potential to dominate the emergent plant community (Table 4).

FQI (Floristic Quality Index) is a rapid assessment tool designed to evaluate the closeness of the flora of an area to that of undisturbed conditions. It can be used to: 1) identify natural areas, 2) compare the quality of different sites or different locations within a single site, 3) monitor long-term floristic trends, and 4) monitor habitat restoration efforts (Nichols, 1999). Each floating or submersed aquatic plant is assigned a number between 1 and 10 (10 indicating the plant species most sensitive to disturbance). An FQI is calculated by multiplying the average of these numbers by the square root of the number of these plant species found in the lake. A high FQI number indicates that there are a large number of sensitive, high quality plant species present in the lake. Non-native species were also included in the FQI calculations for Lake County lakes. The average FQI for 2000-2002 Lake County lakes is 14.9. McGreal Lake had an FQI of 20.2, well above the county average. Although the plant community was dominated by only three species, this high FQI reflects the fact that there were a large number of plant species and relatively high plant diversity in McGreal Lake throughout the summer.

Table 4. Aquatic and shoreline plants on McGreal Lake, May-September 2002.

Aquatic Plants	
Chara	*Chara* sp.
Coontail	*Ceratophyllum demersum*
Elodea	*Elodea canadensis*
Duckweed	*Lemna minor*
*Eurasian Watermilfoil	*Myriophyllum spicatum*
Northern Watermilfoil	*Myriophyllum sibericum*
*Curlyleaf Pondweed	*Potamogeton crispus*
Small Pondweed	*Potamogeton pusillis*
Flatstem Pondweed	Potamogeton zosterifomis
White Water Crowsfoot	*Ranunculus longirostris*
Widgeon Grass	*Ruppia maritima*
Sago Pondweed	*Potamogeton pectinatus*
Horned Pondweed	*Zannichellia palustris*
Shoreline Plants	
*Ragweed	*Ambrosia bidentata*
Marsh Milkweed	*Asclepaias incaruta*
Common Milkweed	*Asclepaias syriaca*
*Bull Thistle	*Cirsium vulgare*
*Queen Anne's Lace	*Daucus carota*
Water Spikerush	*Eleocharis elongata*
Joe-Pye Weed	*Eupatorium maculatum*
Hawkweed	*Hieracium* sp.
*Honeysuckle	*Lonicera* sp.
*White Sweet Clover	*Melilotus alba*
Virginia Creeper	*Parthenocissus quinquefolia*
*Reed Canary Grass	*Phalaris arundinacea*
Common Plantain	*Plantago major*
Swamp Smartweed	*Polygonum coccineum*
*Multiflora Rose	*Rosa multiflora*
Softstem Bulrush	*Scirpus validus*
Rigid Goldenrod	*Solidago rigida*
Common Cattail	*Typha latifolia*
Blue Vervain	*Verbena hastate*
Summer Grape	*Vitis aestivalis*
Trees/Shrubs	
Box Elder	*Acer negundo*
Silver Maple	*Acer saccharinum*
Hickory	*Carya* sp.
Dogwood	*Cornaceae* sp.
Ash	*Oleaceae* sp.

*Exotic plant or tree species

Table 4. Aquatic and shoreline plants on McGreal Lake, May-September 2002 (cont'd).

Wild Black Cherry	*Prunus serotina*
*Common Buckthorn	*Rhamnus cathartica*
Black Locust	*Robinia pseudoacacia*
Willow	*Salix* sp.
Elderberry	*Sambucus* sp.
American Elm	*Ulmus Americana*

*Exotic plant or tree species

LIMNOLOGICAL DATA – SHORELINE ASSESSMENT

A shoreline assessment was conducted at McGreal Lake on August 5, 2002. The shoreline was assessed for a variety of criteria (See Appendix B for methods), and based on this assessment, several important generalizations could be made. Approximately 54% of McGreal Lake's shoreline is developed. The developed shoreline is almost completely dominated by buffer (90.2%), while manicured lawn makes up the remainder (9.8%). The undeveloped shoreline consists of shrub (25.9%), wetland (17.6%) and woodland (2.1%) (Figure 5). Wetland, shrub and buffer are very desirable shoreline types, providing wildlife habitat and, typically, protecting the shore from excessive erosion. As a result of the dominance of buffered shoreline, 76% of McGreal Lake's shoreline exhibited no erosion. Slight erosion was occurring on 20% of the shoreline (primarily along manicured lawn) and moderate erosion was occurring on 4.1% of the shoreline (along manicured lawn and buffer) (Figure 6). Manicured lawn is considered undesirable because it provides a poor shoreline-water interface due to the poor root structure of turf grasses. These grasses are incapable of stabilizing the shoreline and typically lead to erosion. Normally, buffer is an ideal shoreline type because it prevents shoreline erosion, as well as provides wildlife habitat. However, if this type of shoreline is not properly maintained and exotic plant or tree species such as buckthorn are allowed to colonize, buffered shorelines can succumb to erosion as well. The erosion occurring along the manicured lawn and buffered shore should be addressed, while efforts should be made to ensure that well-maintained buffer, shrub and wetland dominated shorelines remain intact.

Dramatic water level fluctuation can increase shoreline erosion, especially if the fluctuations occur over short periods of time. The water level in McGreal Lake did not vary by more than 0.4 feet between May and September. Erosion occurs when water levels drop and newly exposed soil, which may not support emergent plant growth, is subjected to wave action. At this time, there does not appear to be a problem with significant lake level fluctuations in McGreal Lake.

Although relatively little erosion was occurring around McGreal Lake, invasive plant species, including reed canary grass, bull thistle, multiflora rose and buckthorn were present along 85.9% of the shoreline. These plants are extremely invasive and exclude native plants from the areas they inhabit. Buckthorn provides very poor shoreline stabilization and may lead to increasing erosion problems in the future. Reed canary grass inhabits mostly wetland areas and can easily outcompete native plants. Additionally, they do not provide the quality wildlife habitat or shoreline stabilization that native plants provide. The relative density of reed canary grass was high along the wetland areas of McGreal Lake and steps to eliminate this and other plants should be carried out before they take over these areas.

LIMNOLOGICAL DATA – WILDLIFE ASSESSMENT

No recent fish surveys have been conducted on McGreal Lake. Historically, the Illinois Department of Natural Resources (IDNR) reported finding breeder largemouth bass and mixed panfish, which had been stocked at various times. The lake was also known to contain largemouth bass, bluegill and green sunfish. Panfish were reported to be overly abundant and periodic winter kills were reported due to the high density of coontail and Eurasian watermilfoil. It is highly recommended that a fish survey is scheduled for 2003.

Wildlife observations were made on a monthly basis during water quality and plant sampling activities (See Appendix B for methodology). Because wildlife habitat in the form of wetland, shrub and buffered areas was abundant around McGreal Lake, a large number of wildlife species, including several Illinois state threatened and endangered species, were observed (Table 6). Although McGreal Lake does not provide an abundance of recreational opportunities for its lakeshore residents due to algae blooms and high plant density, it is a quality lake area in that it provides habitat for a diverse collection of plants and animals. It is, therefore, very important that the wetland, shrub and buffer areas around the lake be maintained to provide the appropriate habitat for birds and other animals that can be enjoyed by lake users for many years to come.

Table 6. Wildlife species observed at McGreal Lake, May-September 2002.

<u>*Birds*</u>	
Pied-billed Grebe+	*Podilymbus podiceps*
Mute Swan	*Cygnus olor*
Canada Goose	*Branta canadensis*
Mallards	*Anas platyrhnchos*
Wood Duck	*Aix sponsa*
Blue-winged Teal	*Anas discors*
Black Tern*	*Chlidonias niger*
Great Egret	*Casmerodius albus*
Great Blue Heron	*Ardea herodias*
Green Heron	*Butorides striatus*
Sandhill Crane+	*Grus canadensis*
Killdeer	*Charadius vociferus*
Spotted Sandpiper	*Actitis macularia*
Solitary Sandpiper	*Tringa solitaria*
Red-tailed Hawk	*Buteo jamaicensis*
Mourning Dove	*Zenaida macroura*
Belted Kingfisher	*Megaceryle alcyon*
Common Flicker	*Colaptes auratus*
Red-bellied Woodpecker	*Melanerpes carolinus*
Downy Woodpecker	*Picoides pubescens*
Eastern Kingbird	*Tyrannus verticalis*
Willow Flycatcher	*Empidonax trailii*
Barn Swallow	*Hirundo rustica*
Rough-winged Swallow	*Stelgidopteryx ruficollis*
American Crow	*Corvus brachyrhynchos*
Blue Jay	*Cyanocitta cristata*
Black-Capped Chickadee	*Poecile atricapillus*
White-Breasted Nuthatch	*Sitta carolinensis*
House Wren	*Troglodytes aedon*
Catbird	*Dumetella carolinensis*
American Robin	*Turdus migratorius*
Waterthrush	*Seiurus* sp.
Warbling Vireo	*Vireo gilvus*
Yellow Warbler	*Dendroica petechia*
Common Yellowthroat	*Geothlypis trichas*
Red-winged Blackbird	*Agelaius phoeniceus*
Common Grackle	*Quiscalus quiscula*
Northern Cardinal	*Cardinalis cardinalis*
American Goldfinch	*Carduelis tristis*

*Endangered in Illinois
+Threatened in Illinois

Table 6. Wildlife species observed at McGreal Lake, May-September 2002 (cont'd).

Indigo Bunting	*Passerina cyanea*
Chipping Sparrow	*Spizella passerina*
Song Sparrow	*Melospiza melodia*
Mammals	
Muskrat	*Ondatra zibethicus*
Amphibians	
Bull Frog	*Rana catesbeiana*
Green Frog	*Rana clamitans melanota*
Reptiles	
Painted Turtle	*Chrysemys picta*
Snapping Turtle	*Chelydra serpentina*
Insects	
Milfoil Weevil	*Euhryciopsis leconteii*
Mourning Cloak Butterfly	*Nymphalis antiopa*
Eastern Tiger Swallowtail Butterfly	*Papilio glaucus*
Common Sulfur Butterfly	*Colias philodice*
Monarch Butterfly	*Danaus plexippus*

EXISTING LAKE QUALITY PROBLEMS

- *Lack of Participation in the Volunteer Lake Monitoring Program (VLMP)*

  In 1981, the Illinois Volunteer Lake Monitoring Program (VLMP) was established by the Illinois Environmental Protection agency (Illinois EPA) to gather fundamental information on Illinois inland lakes, and to provide an educational program for citizens. Annually, 150-200 lakes (out of 3,041 lakes in Illinois) are sampled by approximately 250 citizen volunteers. The volunteers are primarily lake shore residents, lake owners/managers, members of environmental groups, public water supply personnel, and citizens with interest in a particular lake. The establishment of a VLMP on McGreal Lake would provide valuable historical data and enable lake managers to create baseline information and then track the improvement or decline of lake water quality over time.

- *Lack of a Quality Bathymetric Map*

  A bathymetric (depth contour) map is an essential tool in effective lake management, especially if the long term lake management plan includes intensive treatments, such as fish stocking, dredging, chemical application or alum application. No bathymetric map currently exists for McGreal Lake. Morphometric data obtained in the creation of a bathymetric map is necessary for calculation of equations for correct application of many types of treatments.

- *High Nutrient Levels*

  Mild algae blooms occurred on McGreal Lake throughout the summer, but did not dominate the lake due to a high density of aquatic plants. The blooms largely consisted of planktonic algae and were caused by high phosphorus levels. It was determined that phosphorus is primarily originating from internal sources (high pH, destratification during fall overturn and decomposition of plant material). The presence of organic detritus and algae led to a decrease in water clarity, a decrease in light penetration, and an increase in TSS over the course of the summer. Since decomposition of a large density of plant matter is the primary source of TP and SRP to McGreal Lake, it is recommended that management of specific plant species be addressed in order to potentially remove this plant material from the lake.

- *Excessive Aquatic Vegetation*

  One key to a healthy lake is a healthy aquatic plant community. McGreal Lake is plagued by nuisance densities of several plant species. Curly leaf pondweed dominated the plant community in May and June, while Eurasian water milfoil (EWM) and coontail dominated the plant community throughout the remainder of the summer. Although these plant species may be providing some benefits to the lake by competing with algae and stabilizing lake sediment, high TP and TSS levels and low Secchi depths occur when they begin to decompose. They may also be negatively impacting the fish community.

- *Invasive Shoreline Plant Species*

  Numerous exotic plant species have been introduced into our local ecosystems. Some of these plants are aggressive, quickly out-competing native vegetation and flourishing in an environment where few natural predators exist. The outcome is a loss of plant and animal diversity. Buckthorn is an aggressive shrub species that grows along lake shorelines as well as most upland habitats. It shades out other plants and is quick to become established on disturbed soils. Reed canary grass is typically found along wetland areas and can quickly dominate all other plant species. Buckthorn and reed canary grass (along with several other exotic species) are present along 86% of the McGreal Lake shoreline, and attempts should be made to control their spread.

- *Shoreline Erosion*

  Approximately 25% of the shoreline along McGreal Lake was exhibiting slight to moderate erosion that was mostly concentrated along areas of manicured lawn. As mentioned above, manicured lawn provides poor shoreline stabilization due to its shallow root structure and it is not uncommon to see significant erosion along this type of shoreline. Buffered shoreline is much more desirable than manicured lawn and should replace lawn wherever possible. Shrubby areas can provide excellent wildlife habitat and, if maintained properly, erosion control. However, if the slope is steep or if these areas are not maintained, erosion can occur on both shrubby and buffered shorelines.

POTENTIAL OBJECTIVES FOR THE MCGREAL LAKE MANAGEMENT PLAN

I. Create a Bathymetric Map, Including a Morphometric Table
II. Participate in the Volunteer Lake Monitoring Program
III. Establish Aquatic Plant Management Techniques
IV. Eliminate or Control Invasive Species
V. Control Shoreline Erosion

Objective I: Create a Bathymetric Map, Including a Morphometric Table

A bathymetric (depth contour) map is an essential tool in effective lake management since it provides information on the morphometric features of the lake, such as depth, surface area, volume, etc. The knowledge of this morphometric information would be necessary if lake management treatments such as herbicide application, fish stocking, dredging, alum application or aeration were part of the overall lake management plan. McGreal Lake does not currently have a bathymetric map. Maps can be created by the Lake County Health Department – Lake Management Unit or other agencies for costs that vary from $3,000-$10,000, depending on lake size.

Objective II: Participate in the Volunteer Lake Monitoring Program

In 1981, the Illinois Volunteer Lake Monitoring Program (VLMP) was established by the Illinois Environmental Protection agency (Illinois EPA) to gather fundamental information on Illinois inland lakes, and to provide an educational program for citizens. Annually, 150-200 lakes (out of 3,041 lakes in Illinois) are sampled by approximately 250 citizen volunteers. The volunteers are primarily lake shore residents, lake owners/managers, members of environmental groups, public water supply personnel, and citizens with interest in a particular lake.

The VLMP relies on volunteers to gather a variety of information on their chosen lake. The primary measurement is Secchi disk transparency or Secchi depth. Analysis of the Secchi disk measurement provides an indication of the general water quality condition of the lake, as well as the amount of usable habitat available for fish and other aquatic life.

Microscopic plants and animals, water color, and suspended sediments are factors that interfere with light penetration through the water column and lessen the Secchi disk depth. As a rule, one to three times the Secchi depth is considered the lighted or euphotic zone of the lake. In this region of the lake there is enough light to allow plants to survive and produce oxygen. Water below the lighted zone can be expected to have little or no dissolved oxygen. Other observations such as water color, suspended algae and sediment, aquatic plants, and odor are also recorded. The sampling season is May through October with volunteer measurements taken twice a month. After volunteers have completed one year of the basic monitoring program, they are qualified to participate in the Expanded Monitoring Program. In the expanded program, selected volunteers are trained to collect water samples that are shipped to the Illinois EPA laboratory for analysis of total and volatile suspended solids, total phosphorus, nitrate-nitrite nitrogen and ammonia-nitrogen. Other parameters that are part of the expanded program include dissolved oxygen, temperature, and zebra mussel monitoring. Additionally, chlorophyll *a* monitoring has been added to the regiment of selected lakes. These water quality parameters are routinely measured by lake scientists to help determine the general health of the lake ecosystem.

For more information about the VLMP contact the VLMP Regional Coordinator:

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Objective III: Establish Aquatic Plant Management Techniques

All aquatic plant management techniques have both positive and negative characteristics. If used properly, they can all be beneficial to a lake's well being. If misused or abused, they all share similar outcomes - negative impacts to the lake. Putting together a good aquatic plant management plan should not be rushed. Plans should consist of a realistic set of goals well thought out before implementation. The plan should be based on the management goals of the lake and involve usage issues, habitat maintenance/restoration, and limitations of the lake. For an aquatic plant management plan to achieve long term success, follow up is critical. A good aquatic plant management plan considers both the short and long-term needs of the lake. The management of the lake's vegetation does not end once the nuisance vegetation has been reduced/eliminated. It is critical to continually monitor problematic areas for regrowth and remove as necessary. An association or property owner should not always expect immediate results. A quick fix of the vegetation problems may not always be in the best interest of the lake. Sometimes the best solutions take several seasons to properly solve the problem. The management options covered below are commonly used techniques that are coming into wider acceptance and have been used in Lake County. There are other plant management options that are not covered below as they not are very effective, unreliable, or are too experimental to be widely used.

Option 1: No Action

If the lake is dominated by *native*, *non-invasive* species, the no action option could be ideal. Under these circumstances native plant populations could flourish and keep nuisance plants from becoming problematic. However, if a no action aquatic plant management plan in a lake with non-native, invasive species, nothing would be done to control the aquatic plant population of the lake regardless of the type and extent of the vegetation. Nuisance vegetation could continue to grow until epidemic proportions are reached. Growth limitations of the plant and the characteristics of the lake itself (light penetration, lake morphology, substrate type, etc.) will dictate the extent of infestation. Rooted plants, such as curly leaf pondweed (which dominated in May and June) and elodea, will be bound by physical factors such as substrate type and light availability. Plants such as Eurasian watermilfoil and coontail, (present in McGreal Lake) which can grow unrooted at the surface regardless of water depth, could grow to cover 100% of the water's surface. This could cause major inhibition of the lakes recreational uses and impact fish and other aquatic organisms adversely.

Pros

There are positive aspects associated with the no action option for plant management. The first, and most obvious, is that there is no cost. However, if an active management plan for vegetation control were eventually needed, the cost would be substantially higher than if the no action plan had not been followed in the first place. Another benefit of this option would be the lack of environmental manipulation. Under the no action option, no chemicals, mechanical alteration, or introduction of any organisms would take place. This is important since studies have shown that nuisance plants are more likely to invade disrupted areas. If the lake contains native, non-invasive plant species, expansion of the native plant population would increase the overall biodiversity and health of the lake. Habitat, breeding areas, and food source availability would greatly improve. Use of the lake would continue as normal and in some cases might improve (fishing) if native plants keep "weedy" plants under control.

An additional benefit of the no action option is the possible improvement in water quality. Turbidity could decrease and clarity should increase due to sediment stabilization by the plant's roots. Algal blooms could be reduced due to decreased resource availability and sediment stabilization. However, the occurrence of filamentous algae may increase/remain stable due to their surface growth habitat. The lake's fishery could improve due to habitat availability, which in turn would have numerous positive effects on the rest of the lake's ecosystem.

Cons
Under the no action option, if nuisance vegetation is dominant in the lake and were uninhibited and able to reach epidemic proportions, there will be many negative impacts on the lake. By their weedy nature, the nuisance plants would out-compete the more desirable native plants. This could eventually, drastically reduce or even eliminate the native plant population of the lake and reduce the lake's biodiversity. The fishery of the lake may become stunted due the to lack of quality forage fish habitat and reduced predation. Predation will decrease due to the difficulty of finding prey in the dense stands of vegetation. This will cause an explosion in the small fish population and with food resources not increasing, growth of fish will be reduced. Decreased dissolved oxygen levels, resulting from high biological oxygen demand from the excessive vegetation, will also have negative impacts on the aquatic life. Wildlife populations will be negatively impacted by these dense stands of vegetation. Birds and waterfowl will have difficulty finding quality plants for food or locating prey within the dense plant stands.

Water quality could also be negatively impacted with the implementation of the no action option. Deposition of large amounts of organic matter and release of nutrients upon the death of the massive stands of vegetation is a probable outcome of the no action option. These dead plants will contribute to the sediment load of the lake and could accelerate its filling in. The large nutrient release when the plants die back in the fall could lead to lake-wide algae blooms and an overall increase of the internal nutrient load. In addition, the decomposition of the massive amounts of vegetation will lead to a depletion of the lakes dissolved oxygen. This can cause fish stress, and eventually, if the stress is frequent or severe enough, fish kills. All of the impacts above could in turn have negative impacts on numerous aspects of the lake's ecosystem.

In addition to the ecological impacts, many physical uses of the lake will be negatively impacted. Boating could be nearly impossible without becoming entangled in thick stands of plants. Swimming could also become increasingly difficult due to thick vegetation that would develop at beaches. Fishing could become more and more exasperating due in part to the thick vegetation and also because of the stunted fish population. In addition, the aesthetics of the lake will also decline due to large areas of the lake covered by tangled mats of vegetation and the odors that will develop when they decay.

Costs
No cost will be incurred by implementing the no action management option. However, if in the future a management plan was initiated, costs might be significantly higher since a no action plan was originally followed.

Option 2: Aquatic Herbicides

Aquatic herbicides are the most common method to control nuisance vegetation/algae. When used properly, they can provide selective and reliable control. Products can not be licensed for use in aquatic situations unless there is less than a 1 in 1,000,000 chance of any negative effects on human health, wildlife, and the environment. Aquatic herbicides are not allowed to be environmentally persistent, bioaccumulate, or have any bioavailability. Prior to herbicide application, licensed applicators should evaluate the lake's vegetation and, along with the lake's management plan, choose the appropriate herbicide and treatment areas, and apply the herbicides during appropriate conditions (i.e., low wind speed, D.O. concentration, temperature).

There are two groups of herbicides: contact and systemic. Contact herbicides, like their name indicates, kill on contact. These herbicides affect only the above ground portion of the plant that they come into contact with and therefore do not kill the root system. An example of a contact herbicide is diquat. Systemic herbicides are taken up by the plant and disrupt cellular processes, which in turn cause plant death. These herbicides kill both the above ground portions of the plant as well as the root system. An example of a systemic herbicide is fluridone. Both types of herbicides are available in liquid or granular forms. Liquid forms are concentrated and need to be mixed into water to obtain the desired concentration. The solution is then sprayed on the water's surface or injected into the water in the treatment areas. Granular herbicides are broadcast in a known rate over the treatment area where they sink to the bottom. Some granular products slowly release the herbicide, which is then taken up by the plant. These are referred to as SRP formulations (Slow Release Pellet). Other granular herbicides come in crystal form and dissolve as they come in contact with water. This is typical of herbicides such as copper sulfate. Many herbicides come in both liquid and granular forms to fit the management needs of the lake. Herbicide applications can either be done as whole lake treatments or as more selective spot treatments. Multiple herbicides are often mixed and applied together. This is called a tank mix. This is done to save time, energy, and cost.

Aquatic herbicides are best used on actively growing plants to ensure optimal herbicide uptake. For this reason, herbicides are normally applied mid to late spring when water temperatures are above 60^0F. This is the time of year when the plants are most actively growing and before seed/vegetative propagule formation. Follow-up applications should be done as needed. When choosing an aquatic herbicide it is important to know what plants are present, which ones are problematic, which plants are beneficial, and how a particular herbicide will act upon these plants. The herbicide label is very important and should always be read before use. There may be more than one herbicide for a given plant. As with other management options, proper usage is the key to their effectiveness, benefits, and disadvantages.

Pros

When used properly, aquatic herbicides can be a powerful tool in management of excessive vegetation. Often, aquatic herbicide treatments can be more cost effective in the long run compared to other management techniques. A properly implemented plan can often provide season long control with minimal applications. Ecologically, herbicides can be a better management option than using mechanical harvesting or grass carp. When properly applied, aquatic herbicides may be selective for nuisance plants such as Eurasian watermilfoil but allow desirable plants such as American pondweed (*Potamogeton nodosus*) to remain. This removes the problematic vegetation and allows native and more desirable plants to remain and flourish with minimal manipulation.

The fisheries and waterfowl populations of the lake would benefit greatly due to an increase in quality habitat and food supply. Dense stands of plants would be thinned out and improve spawning habitat and food source availability for fish. Waterfowl population would greatly benefit from increases in quality food sources, such as large-leaf pondweed (*Potamogeton amplifolius*). Another environmental benefit of using aquatic herbicides over other management options is that they are organism specific. The metabolic pathways by which herbicides kill plants are plant specific which humans and other organisms do not carry out. Organisms such as fish, birds, mussels, and zooplankton are generally unaffected.

By implementing a good management plan with aquatic herbicides, usage opportunities of the lake would increase. Activities such as boating and swimming would improve due to the removal of dense stands of vegetation. The quality of fishing may improve because of improved habitat. In addition to increased usage opportunities, the overall aesthetics of the lake would improve, potentially increasing property values on the lake.

Cons

The most obvious drawback of using aquatic herbicides is the input of chemicals into the lake. Even though the United States Environmental Protection Agency (USEPA) approved these chemicals for use, human error can make them unsafe and bring about undesired outcomes. If not properly used, aquatic herbicides can remove too much vegetation from the lake. This could drastically alter biodiversity and ecological. Total or over-removal of plants can cause a variety of problems lake-wide. The fishery of the lake may decline and/or become stunted due to predation issues related to decreased water clarity. Other wildlife, such as waterfowl, which commonly forage on aquatic plants, would also be negatively impacted by the decrease in food supply.

Another problem associated with removing too much vegetation is the loss of sediment stabilization by plants, which can lead to increased turbidity and resuspension of nutrients. The increase in turbidity can cause a decrease in light penetration, which can further aggravate the aquatic plant community. The resuspension of nutrients will contribute to the overall nutrient load of the lake, which can lead to an increased frequency of noxious algal blooms. Furthermore, the removal of aquatic vegetation, which compete with algae for resources, can directly contribute to an increase in blooms.

After the initial removal, there is a possibility for regrowth of vegetation. Upon regrowth, weedy plants such as Eurasian watermilfoil and coontail quickly reestablish, form dense stands, and prevent the growth of desirable species. This causes a decrease in plant biodiversity. Additionally, these dense stands of nuisance vegetation can lead to an overpopulation of stunted fish due to a decrease in predation of forage species by predatory fish. This disruption in the fisheries can have negative impacts throughout the ecosystem from zooplankton to higher organisms such as waterfowl and other wildlife. Additionally, some herbicides have use restrictions regarding their use in relation to fish, swimming, irrigation, etc.

Over-removal, and possible regrowth of nuisance vegetation that may follow will drastically impair recreational use of the lake. Swimming could be adversely affected due to the likelihood of increased algal blooms. Swimmers may become entangled in large mats of filamentous algae. Blooms of planktonic species, such as blue-green algae, can produce harmful toxins as well produce noxious odors. If regrowth of nuisance vegetation were to occur, motors could become entangled making boating difficult. Fishing would also be negatively impacted due to the decreased health of the lake's fishery. The overall appearance of the lake would also suffer due to an increase in unsightly algal blooms and massive stands of vegetation.

Costs

Since curly leaf pondweed, EWM and coontail plants appear to be providing some sediment stabilization and competing with algae for resources, it would not be desirable to remove all the plants from the lake. Therefore, spot treatments of Aquathol K® are recommended late in the spring to treat curly leaf pondweed. Aquathol K® is a contact herbicide that affects only the plants with which it comes into contact and will cause rapid plant death and dieback within about a week. It is very short-lived in the environment and provides short-term control. However, since curly leaf pondweed does not persist through the summer, it is an effective herbicide in controlling curly leaf pondweed density early without the need for multiple treatments later in the summer. The early treatment of curly leaf pondweed will be beneficial in two ways: It will reduce the amount of plant material decomposing and releasing phosphorus into the water column and it will reduce the number of turions formed. Turions are structures released from the curly leaf pondweed plants that sink to the lake sediment, overwinter, and give rise to new plants in the spring. If the plants are consistently removed before turions are given the chance to form during the early summer, the density of curly leaf pondweed can eventually be reduced. For treatment of EWM and coontail, 2,4-D is a very effective systemic herbicide that is biologically dicot specific. This is very advantageous in aquatic plant management where EWM and coontail are dicots and many of the more beneficial plants are monocots. 2,4-D is available in liquid or granular form and is taken up very quickly by the plant. This reduces drift of the chemical to off-target areas. Currently, approximately 65% (15.9 acres) of the lake (primarily in the east arm) is covered with nuisance plants, while 35% of the lake is either unvegetated or supports native plant species. The LMU recommends that 30-40% of the east arm of the lake remain vegetated in order to provide fish habitat and sediment stabilization in that area. That means that 9.5-11 vegetated acres could be treated. At a cost of $150-173/gallon and a recommended rate of 1-2 gallons/acre foot (AF) for Aquathol K®, herbicide treatment of curly leaf pondweed would cost $2,850-$3,806. At a rate of $350-$425/surface acre (SA), treatment of 2,4-D would cost $3,325-$4,675, depending on the size of the treatment area and type of chemical form used.

Option 3: Mechanical Harvesting

Mechanical harvesting involves the cutting and removal of nuisance aquatic vegetation by large specialized boats with underwater cutting bars. Plants are cut below the water at a level that will restore use of the lake. Typically, problematic areas are harvested and other areas are left alone. However, some management plans call for more widespread harvesting, especially when nuisance plants such as Eurasian watermilfoil become dominant. The total removal or over removal (neither of which should never be the plan of any management entity) of plants by mechanical harvesting should never be attempted. To avoid complete or over removal, the management entity should have a harvesting plan that determines where and how much vegetation is to be removed.

Pros

Mechanical harvesting can be a selective means to reduce stands of nuisance vegetation in a lake. Typically, plants cut low enough to restore recreational use and limit or prevent regrowth. This practice normally improves habitat for fish and other aquatic organisms. Some plant species such as curlyleaf pondweed, if harvested at the right time, do not grow back to nuisance proportions after harvesting. Plant clippings are high in nutrients and can be used as fertilizer or compost. Additionally, use of the lake is uninterrupted while harvesting is occurring.

By removing large quantities of plant biomass the overall quality of the lake may improve in many ways. The decrease in vegetative biomass will reduce the dissolved oxygen (D.O.) demand on the lake. This will cause increased dissolved oxygen levels. Some nuisance vegetation such as coontail have extremely high oxygen demands. Dense stands of these plants can quickly deplete a lake of D.O. during certain periods of the day and can cause fish stress. Additionally, a decrease in plant density will improve the lake's fishery by creating better opportunities for predation, which is essential in creating a balanced fish population. By removing nuisance vegetation, recreational uses of the lake will improve. The quality of activities such as boating, swimming, and fishing would greatly improve. By removing dense stands of vegetation the possibility of entanglement will decrease thereby increasing opportunities for boating and swimming. Paths cut by the harvester will open fishing areas especially if networks of fish "cruising lanes" are created.

Cons

Once widespread, mechanical harvesting is becoming a less attractive management technique for a variety of reasons. Many applicators that regularly employed mechanical harvesting no longer use or even offer this service due to low public demand. In addition, high initial investment, extensive maintenance, and high operational costs have also led to decreased use. Since many applicators no longer offer harvesting services, a lake association would have to purchase and maintain their own harvester. Many associations do not even have the financial resources to cover the maintenance and operational cost involved with owning a harvester. Harvester costs can range from $50,000-$150,000. Beside the financial limitations there are also physical limitations. Mechanical harvesters cannot be used in less than 2-4 feet of water (depending on draft of the harvester) and cannot maneuver well in tight places. The harvested plant material must be disposed of properly to a place that can accommodate large quantities of plants and prevent any from washing back into the lake. Fish, mussels, turtles and other aquatic organisms are commonly caught in the harvester and injured or even removed from the lake in the harvesting process.

After the initial removal, there is a possibility for vegetation regrowth. Upon regrowth, weedy plants such as Eurasian watermilfoil and coontail quickly reestablish, form dense stands, and prevent the growth of desirable species. This causes a decrease in plant biodiversity. Additionally, these dense stands of nuisance vegetation may lead to an overpopulation of stunted fish due to a decrease in predation of forage species by predatory fish. This disruption in the fishery will have negative impacts throughout the ecosystem from zooplankton to higher organisms such as waterfowl.

If complete/over removal does occur several problems can result. One problem is the loss of sediment stabilization by plants, which can lead to increased turbidity and resuspension of nutrients. The increase in turbidity can cause a decrease in light penetration, which can further aggravate the aquatic plant community. The resuspension of nutrients will also contribute to overall nutrient load of the lake, which can lead to increased frequency of algal blooms. Furthermore, the removal of aquatic vegetation, which competes for resources with algae, can directly contribute to an increase in algal blooms. Removal of plants may lead to increased turbidity and decreased clarity. The fishery of the lake may decline and/or become stunted due changes in predation related to decreased water clarity. Other organisms, such as waterfowl, which commonly forage on native aquatic plants, would also be negatively impacted by the removal of these plants.

Another problem with mechanical harvesting, even if properly done, is that it can be a nonselective process. In the areas where harvesting is being conducted, one plant can not be removed and another left. All the plants are removed from that area. After the initial removal, regrowth of desirable plants does not typically occur in these harvested areas. Due to their weedy nature, plants such as Eurasian water milfoil, are able to grow more quickly than native plants and become more established in harvested areas. This will create a monoculture of nuisance vegetation. This causes an overall decrease in plant biodiversity, which can have detrimental effects to the entire ecosystem. Depending on the plant species, frequent harvesting might be required (typically 2-4 times per season). Along with this increased harvesting frequency come increased operational costs (labor, gas, maintenance, etc.). Nuisance plants such as coontail and Eurasian watermilfoil can spread by vegetative fragments that may escape collection during the harvesting process and spread to uninfested parts of the lake. In addition to the release of plant fragments, as the plants are cut, there is a possibility of plant associated nutrients being released into the lake. This could cause an increase is algal blooms whenever harvesting in conducted. Short-term turbidity may also be created by the harvester paddle wheels stirring up sediment in harvested area.

Cost

Depending on the type of the harvester (cutting width, payload capacity, hull material, HP of the motor, trailer options, etc) prices range from $50,000 to $150,000. Operational and maintenance cost typically range from $161.00-$445.00/acre.

Option 4: Water Milfoil Weevil

Euhrychiopsis lecontei (*E. lecontei*) is a biological control organism used to control Eurasian water milfoil (EWM). *E. lecontei* is a native weevil, which feeds exclusively on milfoil species. It was originally discovered while investigating declines of EWM in a Vermont lake in the early 1990s. It was discovered in northeastern Illinois lakes by 1995. Another weevil, *Phytobius leucogaster*, also feeds on EWM but does not cause as much damage as *E. lecontei*. Therefore, *E. lecontei* is stocked as a biocontrol and is commonly referred to as the Eurasian water milfoil weevil. Currently, the LCHD-Lakes Management Unit has documented weevils (*E. lecontei* and/or *P. leucogaster*) in 24 Lake County lakes. Many of these lakes have seen declines in EWM densities in recent years. It is highly likely that *E. lecontei* and/or *P. leucogaster* occurs in all lakes in Lake County that have excessive EWM growth.

Weevils are stocked in known quantities to achieve a density of 1-4 weevils per stem. As weevil populations expand, EWM populations may decline. After EWM declines, weevil populations decline and do not feed on any other aquatic plants. When EWM starts to grow again in the spring, the weevil populations respond by keeping the increasing milfoil under control before it becomes a problem. Once the weevil is established, EWM should no longer reach nuisance proportions and begins to become more sparse. Best results are achieved in lakes that have shallow EWM infestations in areas where it is undisturbed by recreational and management actives. Weevils need proper overwintering habitat such as leaf litter and mud, which are typically found on naturalized shorelines or shores with good buffer strips. Additionally, water temperatures need to be 68-70^{o}F for maximum weevil activity. For this reason, weevils are typically stocked in late spring/early summer. Currently only one company, EnviroScience Inc., has a stocking program (called the MiddFoil® process). The program includes evaluation of EWM densities, of current weevil populations (if any), stocking, monitoring, and restocking as needed. McGreal Lake already has a small population of *E. leconteii.* This indicates that conditions are right for the survival of these weevils in and around the lake and that the addition of more weevils via a stocking program would most likely be successful. However, since the weevils are already present, it may be unnecessary (given enough time) to stock more weevils and it may be financially worthwhile to see if the weevil population increases on its own.

Pros

The milfoil weevil can provide long-term control of EWM. Typically, by the end of June EWM stands are starting to decline due to weevil damage. In many situations, EWM beds might not reach the surface before weevil damage causes declines. *E. lecontei* is also a selective means to control EWM. Studies have shown that *E. lecontei* has a strong preference for EWM and the only other plant it possibly will feed on is northern water milfoil. Since milfoil weevils are found to naturally occur in several lakes in Lake County, weevil stocking would be an augmentation rather than an introduction, making it a more natural control option.

If control with milfoil weevils were successful, the quality of the lake may be improved. Native plants could then start to recolonize after water clarity problems were addressed. Fisheries of the lake would improve due to more balanced predation and higher quality habitat. Waterfowl would benefit due to increased food sources and availability of prey. Recreational activities such as fishing, swimming, and boating would be easier and more enjoyable with the removal of inhibiting stands of EWM.

Cons

Use of milfoil weevils does have some drawbacks. Control using the weevil has been inconsistent in many cases. EWM has been reduced one year, only to be unaffected the next. Reasons for these inconsistencies are under investigation. One possible explanation is lack of suitable overwintering habitat. The highly developed, manicured shorelines of many lakes in the county are not suitable habitat for weevil overwintering. Another possible explanation is cooler than normal summer water temperatures. Studies have shown that cooler water temperatures reduce weevil feeding and egg production.

Milfoil control using weevils may not work well on plants in deep water. Plants are able to compensate for weevil damage on upper portions of the plant by increasing growth on lower portions where weevil does not feed. Furthermore, weevils do not work well in areas where plants are continuously disturbed by activities such as powerboats and swimming, harvesting or herbicide use. In areas where weevils are to be stocked, activity should be reduced as much as possible. This may either limit the extent to which the weevils can be used or limit recreational use of the lake.

One of the most prohibitive aspects to weevil use is price. Typically weevils are stocked to achieve a density of 1-4 weevils per stem. This translates to 500-3000 weevils per acre. At a cost of $1 per weevil plus labor, a EWM management program using weevils can be expensive. Additionally, there is no guarantee that weevils will provide long-term control or even produce any results at all, and the insects will not have any effect on the curly leaf pondweed that dominates early in the summer and may be providing the largest source of TP to McGreal Lake.

Costs
EnviroScience, Inc.
3781 Darrow Road
Stow, Ohio 44224
1(800) 940-4025

Weevils are sold in units of 1000 bugs/unit and stocking rates must be at least 1 unit/stocked area. Normally there is a minimum purchase of 5-10 units. The cost of the weevils does not include the labor involved in initial surveys, stocking, and monitoring, which typically run an additional $3,500-$4,500.

Objective IV: Eliminate or Control Invasive Species

Numerous exotic plant species have been introduced into our local ecosystems. Some of these plants are aggressive, quickly out-competing native vegetation and flourishing in an environment where few natural predators exist. Plants such as purple loosestrife (*Lythrum salicaria*), buckthorn (*Rhamnus cathartica*), and reed canary grass (*Phalaris arundinacea*) are three examples. The outcome is a loss of plant and animal diversity. This section will address terrestrial shoreline exotic species.

Buckthorn is an aggressive shrub species that grows along lake shorelines as well as most upland habitats. It shades out other plants and is quick to become established on disturbed soils. Reed canary grass is an aggressive plant that if left unchecked will dominate an area, particularly a wetland or shoreline, in a short period of time. Since it begins growing early in the spring, it quickly out-competes native vegetation that begins growth later in the year. Control of buckthorn, and reed canary grass are discussed below. However, these control measures can be similarly applied to other exotic species such as garlic mustard (*Allilaria officianalis*) or honeysuckle (*Lonicera* spp.) as well as some aggressive native species, such as box elder (*Acer negundo*).

Presence of exotic species along a lakeshore is by no means a death sentence for the lake or other plant and animal life. If controlled, many exotic species can perform many of the original functions that they were brought here for. For example, reed canary grass was imported for its erosion control properties. It still contributes to this objective (offering better erosion control than commercial turfgrass), but needs to be isolated and kept in control. Many exotics are the result of garden or ornamental plants escaping into the wild. One isolated plant along a shoreline will probably not create a problem by itself. However, problems arise when plants are left to spread, many times to the point where treatment is difficult or cost prohibitive. A monitoring program should be established, problem areas identified, and control measures taken when appropriate. This is particularly important in remote areas of lake shorelines where the spread of exotic species may go unnoticed for some time.

Option 1: No Action

No control will likely result in the expansion of the exotic species and the decline of native species. This option is not recommended if possible.

Pros

There are few advantages with this option. Some of the reasons exotics were brought into this country are no longer used or have limited use. However, in some cases having an exotic species growing along a shoreline may actually be preferable if the alternative plant is commercial turfgrass. Since turfgrass has shallow roots and is prone to erosion along shorelines, exotics like reed canary grass or common reed (*Phragmites australis*) will control erosion more effectively. Native plants should take precedent over exotics when possible. A table in Appendix A lists several native plants that can be planted along shorelines.

Cons

Native plant and wildlife diversity will be lost as stands of exotic species expand. Exotic species are not under the same stresses (particularly diseases and predators) as native plants and thus can out-compete the natives for nutrients, space, and light. Few wildlife species use areas where exotic plants dominate. This happens because many wildlife species either have not adapted with the plants and do not view them as a food resource, the plants are not digestible to the animal, or their primary food supply (i.e.,, insects) are not attracted to the plants. The result is a monoculture of exotic plants with limited biodiversity.

Recreational activities, especially wildlife viewing, may be hampered by such monocultures. Access to lake shorelines may be impaired due to dense stands of non-native plants. Other recreational activities, such as swimming and boating, may not be effected.

Costs

Costs with this option are zero initially, however, when control is eventually needed, costs will be substantially more than if action was taken immediately. Additionally, the eventual loss of ecological diversity is difficult to calculate financially.

<u>Option 2: Control by Hand</u>

Controlling exotic plants by hand removal is most effective on small areas (< 1 acre) and if done prior to heavy infestation. Some exotics, such as purple loosestrife and reed canary grass, can be controlled to some degree by digging, cutting, or mowing if done early and often during the year. Digging may be required to ensure the entire root mass is removed. Spring or summer is the best time to cut or mow, since late summer and fall is when many of the plant seeds disperse. Proper disposal of excavated plants is important since seeds may persist and germinate even after several years. Once exotic plants are removed, the disturbed ground should be planted with native vegetation and closely monitored. Many exotic species, such as purple loosestrife, buckthorn, and garlic mustard are proficient at colonizing disturbed sites.

Pros

Removal of exotics by hand eliminates the need for chemical treatments. Costs are low if stands of plants are not too large already. Once removed, control is simple with yearly maintenance. Control or elimination of exotics preserves the ecosystem's biodiversity. This will have positive impacts on plant and wildlife presence as well as some recreational activities.

Cons

This option may be labor intensive or prohibitive if the exotic plant is already well established. Costs may be high if large numbers of people are needed to remove plants. Soil disturbance may introduce additional problems such as providing a seedbed for other non-native plants that quickly establish disturbed sites, or cause soil-laden run-off to flow into nearby lakes or streams. In addition, a well-established stand of an exotic like purple loosestrife or reed canary grass may require several years of intense removal to control or eliminate.

Costs
Cost for this option is primarily in tools, labor, and proper plant disposal.

Option 3: Herbicide Treatment
Chemical treatments can be effective at controlling exotic plant species. However, chemical treatment works best on individual plants or small areas already infested with the plant. In some areas where individual spot treatments are prohibitive or unpractical (i.e.,, large expanses of a wetland or woodland), chemical treatments may not be an option due to the fact that in order to chemically treat the area a broadcast application would be needed. Since many of the herbicides that are used are not selective, meaning they kill all plants they contact; this may be unacceptable if native plants are found in the proposed treatment area.

Herbicides are commonly used to control nuisance shoreline vegetation such as buckthorn and purple loosestrife. Herbicides are applied to green foliage or cut stems. Products are applied by either spraying or wicking (wiping) solution on plant surfaces. Spraying is used when large patches of undesirable vegetation are targeted. Herbicides are sprayed on growing foliage using a hand-held or backpack sprayer. Wicking is used when selected plants are to be removed from a group of plants. The herbicide solution is wiped on foliage, bark, or cut stems using a herbicide soaked device. Trees are normally treated by cutting a ring in the bark (called girdling). Herbicides are applied onto the ring at high concentrations. Other devices inject the herbicide through the bark. It is best to apply herbicides when plants are actively growing, such as in the late spring/early summer, but before formation of seed heads. Herbicides are often used in conjunction with other methods, such as cutting or mowing, to achieve the best results. Proper use of these products is critical to their success. Always read and follow label directions.

Pros
Herbicides provide a fast and effective way to control or eliminate nuisance vegetation. Unlike other control methods, herbicides kill the root of the plant, which prevents regrowth. If applied properly, herbicides can be selective. This allows for removal of selected plants within a mix of desirable and undesirable plants.

Cons
Since most herbicides are non-selective, they are not suitable for broadcast application. Thus, chemical treatment of large stands of exotic species may not be practical. Native species are likely to be killed inadvertently and replaced by other non-native species. Off target injury/death may result from the improper use of herbicides. If herbicides are applied in windy conditions, chemicals may drift onto desirable vegetation. Care must also be taken when wicking herbicides as

not to drip on to non-targeted vegetation such as native grasses and wildflowers. Another drawback to herbicide use relates to their ecological soundness and the public perception of them. Costs may also be prohibitive if plant stands are large. Depending on the device, cost of the application equipment can be high.

Costs

Two common herbicides, triclopyr (sold as Garlon ™) and glyphosate (sold as Rodeo® or Round-up™), cost approximately $100 and $65 per gallon, respectively. Only Rodeo® is approved for water use. A Hydrohatchet®, a hatchet that injects herbicide through the bark, is about $300.00. Another injecting device, E-Z Ject® is $450.00. Hand-held and backpack sprayers costs from $25-$45 and $80-150, respectively. Wicking devices are $30-40.

Objective V: Control Shoreline Erosion

Erosion is a potentially serious problem to lake shorelines and occurs as a result of wind, wave, or ice action or from overland rainwater runoff. While some erosion to shorelines is natural, human alteration of the environment can accelerate and exacerbate the problem. Erosion not only results in loss of shoreline, but negatively influences the lake's overall water quality by contributing nutrients, sediment, and pollutants into the water. This effect is felt throughout the food chain since poor water quality negatively affects everything from microbial life to sight feeding fish and birds to people who want to use the lake for recreational purposes. The resulting increased amount of sediment will over time begin to fill in the lake, decreasing overall lake depth and volume and potentially impairing various recreational uses.

Option 1: No Action

Pros

There are no short-term costs to this option. However, extended periods of erosion may result in substantially higher costs to repair the shoreline in the future.

Eroding banks on steep slopes can provide habitat for wildlife, particularly bird species (e.g. kingfishers and bank swallows) that need to burrow into exposed banks to nest. In addition, certain minerals and salts in the soils are exposed during the erosion process, which are utilized by various wildlife species.

Cons

Taking no action will most likely cause erosion to continue and subsequently may cause poor water quality due to high levels of sediment or nutrients entering a lake. This in turn may retard plant growth and provide additional nutrients for algal growth. A continual loss of shoreline is both aesthetically unpleasing and may potentially reduce property values. Since a shoreline is easier to protect than it is to rehabilitate, it is in the interest of the property owner to address the erosion issue immediately.

Costs

In the short-term, cost of this option is zero. However, long-term implications can be severe since prolonged erosion problems may be more costly to repair than if the problems were addressed earlier. As mentioned previously, long-term erosion may cause serious damage to shoreline property and in some cases lower property values.

Option 2: Create a Buffer Strip

Another effective method of controlling shoreline erosion is to create a buffer strip with existing or native vegetation. Native plants have deeper root systems than turfgrass and thus hold soil more effectively. Native plants also provide positive aesthetics and good wildlife habitat. Cost of creating a buffer strip is quite variable, depending on the current state of the vegetation and shoreline and whether vegetation is allowed to become established naturally or if the area needs to be graded and replanted. Allowing vegetation to naturally propagate the shoreline would be the most cost effective, depending on the severity of erosion and the composition of the current vegetation. Non-native plants or noxious weedy species may be present and should be controlled or eliminated.

Stabilizing the shoreline with vegetation is most effective on slopes no less than 2:1 to 3:1, horizontal to vertical, or flatter. Usually a buffer strip of at least 25 feet is recommended, however, wider strips (50 or even 100 feet) are recommended on steeper slopes or areas with severe erosion problems. Areas where erosion is severe or where slopes are greater than 3:1, additional erosion control techniques may have to be incorporated such as biologs, A-Jacks®, or rip-rap.

Buffer strips can be constructed in a variety of ways with various plant species. Generally, buffer strip vegetation consists of native terrestrial (land) species and emergent (at the land and water interface) species. Terrestrial vegetation such as native grasses and wildflowers can be used to create a buffer strip along lake shorelines. Table 7 (Appendix A) gives some examples, seeding rates and costs of grasses and seed mixes that can be used to create buffer strips. Native plants and seeds can be purchased at regional nurseries or from catalogs. When purchasing seed mixes, care should be taken that native plant seeds are used. Some commercial seed mixes contain non-native or weedy species or may contain annual wildflowers that will have to be reseeded every year. If purchasing plants from a nursery or if a licensed contractor is installing plants, inquire about any guarantees they may have on plant survival. Finally, new plants should be protected from herbivory (e.g., geese and muskrats) by placing a wire cage over the plants for at least one year.

A technique that is sometimes implemented along shorelines is the use of willow posts, or live stakes, which are harvested cuttings from live willows (*Salix* spp.). They can be planted along the shoreline along with a cover crop or native seed mix. The willows will resprout and begin establishing a deep root structure that secures the soil. If the shoreline is highly erodible, willow posts may have to be used in conjunction with another erosion control technique such as biologs, A-Jacks ®, or rip-rap.

Emergent vegetation, or those plants that grow in shallow water and wet areas, can be used to control erosion more naturally than seawalls or rip-rap. Native emergent vegetation can be either hand planted or allowed to become established on its own over time. Some plants, such as native cattails (*Typha* sp.), quickly spread and help stabilize shorelines, however they can be aggressive and may pose a problem later. Other species, such as those listed in a Table 7, Appendix A should be considered for native plantings.

Pros

Buffer strips can be one of the least expensive means to stabilize shorelines. If no permits or heavy equipment are needed (i.e., no significant earthmoving or filling is planned), the property owner can complete the work without the need of professional contractors. Once established (typically within 3 years), a buffer strip of native vegetation will require little maintenance and may actually reduce the overall maintenance of the property, since the buffer strip will not have to be continuously mowed, watered, or fertilized. Occasional high mowing (1-2 times per year) for specific plants or physically removing other weedy species may be needed.

The buffer strip will stabilize the soil with its deep root structure and help filter run-off from lawns and agricultural fields by trapping nutrients, pollutants, and sediment that would otherwise drain into the lake. This may have a positive impact on the lake's water quality since there will be less "food" for nuisance algae. Buffer strips can filter as much as 70-95% of sediment and 25-60% of nutrients and other pollutants from runoff.

Another benefit of a buffer strip is potential flood control protection. Buffer strips may slow the velocity of flood waters, thus preventing shoreline erosion. Native plants also can withstand fluctuating water levels more effectively than commercial turfgrass. Many plants can survive after being under water for several days, even weeks, while turfgrass is intolerant of wet conditions and usually dies after several days under water. This contributes to increased maintenance costs, since the turfgrass has to be either replanted or replaced with sod. Emergent vegetation can provide additional help in preserving shorelines and improving water quality by absorbing wave energy that might otherwise batter the shoreline. Calmer wave action will result in less shoreline erosion and resuspension of bottom sediment, which may result in potential improvements in water quality.

Many fish and wildlife species prefer the native shoreline vegetation habitat. This habitat is an asset to the lake's fishery since the emergent vegetation cover may be used for spawning, foraging, and hiding. Various wildlife species are even dependent upon shoreline vegetation for their existence. Certain birds, such as marsh wrens (*Cistothorus palustris*) and endangered yellow-headed blackbirds (*Xanthocephalus xanthocephalus*) nest exclusively in emergent vegetation like cattails and bulrushes. Hosts of other wildlife like waterfowl, rails, herons, mink, and frogs to mention just a few, benefit from healthy stands of shoreline vegetation. Dragonflies, damselflies, and other beneficial invertebrates can be found thriving in vegetation along the shoreline as well.

In addition to the benefits of increased fish and wildlife use, a buffer strip planted with a variety of native plants may provide a season long show of various colors from flowers, leaves, seeds, and stems. This is not only aesthetically pleasing to people, but also benefits wildlife and the overall health of the lake's ecosystem.

Cons
There are few disadvantages to native shoreline vegetation. Certain species (i.e., cattails) can be aggressive and may need to be controlled occasionally. If stands of shoreline vegetation become dense enough, access and visibility to the lake may be compromised to some degree. However, small paths could be cleared to provide lake access or smaller plants could be planted in these areas.

Costs
If minimal amount of site preparation is needed, costs can be approximately $10 per linear foot, plus labor. Cost of installing willow posts is approximately $15-20 per linear foot. The labor that is needed can be completed by the property owner in most cases, although consultants can be used to provide technical advice where needed. This cost will be higher if the area needs to be graded. If grading is necessary, appropriate permits and surveys are needed. If filling is required, additional costs will be incurred if compensatory storage is needed. The permitting process is costly, running as high as $1,000-2,000 depending on the types of permits needed.

Option 3: Install Biolog, Fiber Roll, or Straw Blanket with Plantings
These products are long cylinders of compacted synthetic or natural fibers wrapped in mesh. The rolls are staked into shallow water. Once established, a buffer strip of native plants can be planted along side or on top of the roll (depending if rolls are made of synthetic or natural fibers). They are most effective in areas where plantings alone are not effective due to already severe erosion. In areas of severe erosion, other techniques may need to be employed or incorporated with these products.

Pros
Biologs, fiber rolls, and straw blankets provide erosion control that secure the shoreline in the short-term and allow native plants to establish which will eventually provide long-term shoreline stabilization. They are most often made of bio-degradable materials, which break down by the time the natural vegetation becomes established (generally within 3 years). They provide additional strength to the shoreline, absorb wave energy, and effectively filter run-off from terrestrial sources. These factors help improve water quality in the lake by reducing the amount of nutrients available for algae growth and by reducing the sediment that flows into a lake.

Cons
These products may not be as effective on highly erodible shorelines or in areas with steep slopes, as wave action may be severe enough to displace or undercut these products. On steep shorelines grading may be necessary to obtain a 2:1 or 3:1 slope or additional erosion control products may be needed. If grading or filling is needed, the appropriate permits and surveys will have to be obtained.

Costs

Costs range from $25 to $35 per linear foot of shoreline, including plantings. This does not include the necessary permits and surveys, which may cost $1,000 – 2,000 depending on the type of earthmoving that is being done. Additional costs may be incurred if compensatory storage is needed.