

**2004 SUMMARY REPORT  
of  
LAKE FARMINGTON**

**Lake County, Illinois**

*Prepared by the*

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## EXECUTIVE SUMMARY

Lake Farmington is a private lake located in the Village of Kildeer (Ela Township) and is part of the Buffalo Creek drainage of the Des Plaines River watershed. Lake Farmington's watershed is approximately 98 acres, and has a watershed to lake ratio of 12:1. Lake Farmington encompasses approximately 8.4 acres and has a shoreline length of 0.66 miles. The current maximum depth was determined to be 6.8 feet, as measured in May 2004.

Lake Farmington's water quality is very poor compared to other lakes in Lake County. Water clarity, as measured by Secchi disk transparency readings, averaged 1.62 feet for the season, which is 47% below the county median of 3.08 feet. High concentrations of solids and nutrients were also found in the lake. The 2004 seasonal average TSS concentration was 21.2 mg/L, which is nearly three times the county median of 7.9 mg/L. The average total phosphorus (TP) concentration was 0.185 mg/L, which is also nearly three times higher than the county median of 0.063 mg/L. TP concentrations above 0.03 mg/L are considered sufficient enough to cause nuisance algae blooms. The sources of these nutrients are probably both internal and external.

Lake Farmington's average concentrations of total dissolved solids (TDS) and conductivity readings were also higher than the county medians. The 2004 average for TDS was 1035 mg/L, which is 127% higher than the county median for near surface samples of 454 mg/L. Similarly, the 2004 average conductivity reading was 2.033 milliSiemens/cm, which is 151% higher than the county median for near surface samples of 0.8105 milliSiemens/cm. The cause for these high TDS concentrations and conductivity readings in Lake Farmington is input from solids washed into the lake from storm events in the watershed. The seasonal average for chlorides in Lake Farmington in 2004 was 527 mg/L, which exceeds the IEPA standard of 500 mg/L. Once values exceed this standard (as in Lake Farmington) the water body is deemed to be impaired, thus negatively impacting aquatic life. The large retail site to the south of the lake is likely a significant source of chlorides from road salts used in winter road deicing.

Only four aquatic plant species and several emergent shoreline plants were found the lake. In addition, the aquatic plants that were present were found in small numbers. Curlyleaf pondweed, an exotic, was the most common species being found in 32% of all sites.

The entire shoreline of Lake Farmington was classified as developed. Lawn and buffer habitats were the most common shoreline types consisting of 40% and 23% of the shoreline, respectively. Beach (14%), riprap (10%), shrub (10%) and seawall (3%) made up the remaining shoreline. The majority (2,687 feet or 78%) of the shoreline was classified as slightly eroding, however no moderate or severe erosion was found.

Several exotics were found growing along the shoreline, including buckthorn, purple loosestrife, multiflora rose, and reed canary grass. Removal or control of these exotic species is recommended.

## **LAKE IDENTIFICATION AND LOCATION**

Lake Farmington (T43N, R10E, Section 34) is a private lake located east of U.S. Highway 12 and north of Long Grove Road in the village of Kildeer (Ela Township). It is part of the Buffalo Creek drainage of the Des Plaines River watershed. Lake Farmington's watershed is approximately 98 acres, and has a watershed to lake ratio of 12:1 (Figure 1). There is one main inlet to the lake, a stormwater culvert located along the southern shoreline. This culvert drains a detention pond on the south side of Long Grove Road. This pond detains stormwater from the retail center along Highway 12, along with some water from ditches on both sides of the highway. A small culvert located at the lake's western end, drains a small residential area. Some overall flow also enters the lake from a small grass swale at the north-central section of the lake. The outlet is a concrete spillway dam eastern end of the lake. Water leaves the lake and enters a tributary of Buffalo Creek, eventually flowing into the Des Plaines River.

Lake Farmington encompasses approximately 8.4 acres and has a shoreline length of 0.66 miles. Historically, the maximum depth was reported to be nine feet. However, the current maximum depth was determined to be 6.8 feet, as measured in May 2004, when water levels were considered high due to heavy spring rains. Since no bathymetric (depth contour) map of Lake Farmington is known to exist, the volume of the lake was estimated based on data from lakes with known depths and volumes. Mean depth was obtained by multiplying the maximum depth by 0.5. Volume was obtained by multiplying the mean depth by the lake surface area. Based on these calculations, Lake Farmington has an estimated mean depth of 3.4 feet and an estimated volume of 29 acre-feet. Lake elevation is approximately 766 feet above sea level.

## **BRIEF HISTORY OF LAKE FARMINGTON**

Lake Farmington was created by the excavation of a depression/wetland area in approximately 1960 when development around the lake began. Figure 2 shows a 1939 aerial photograph of the area, prior to the lake's creation.

## **SUMMARY OF CURRENT AND HISTORICAL LAKE USES**

Lake Farmington is used primarily for the aesthetic enjoyment of the residents. There are currently 16 private homes around the lake. The Lake Farmington Homeowners Association manages the lake informally. The lake has no public access. No motors are permitted on the lake, however canoes and paddleboats are allowed.

The lake is treated with aquatic herbicides and algicides on an annual basis. Details of these treatments will be addressed in the **Aquatic Plant Assessment** section of this report.

Figure 1. Watershed.

Figure 2. 1939 aerial

The composition of land uses within a lake's watershed often influences its water quality. The major land use in the Lake Farmington watershed (based on 2000 land use maps) is single family (33.6%), followed by retail/commercial (22.2%), government and institutional (13.1%), transportation (12.4%), water (10.8%), forest and grassland (5.2%), and wetlands (2.7%; Figure 3). Based on the land uses in the watershed and the estimated volume of Lake Farmington, the approximate retention time of the lake is 0.26 years or 95 days. Implications of the land uses in the watershed and the retention time of the lake will be addressed in the **Water Quality Assessment** section below.

## LIMNOLOGICAL DATA – WATER QUALITY

Water samples were collected monthly from May - September at the deep-hole location in the lake (Figure 4). See Appendix B for water sampling methods.

Lake Farmington's water quality is very poor compared to other lakes in Lake County (Table 1 in Appendix A). Most of the water quality parameters measured were above the median (where 50% of the lakes are above and below this value) of other lakes that we have monitored. Several important findings were noted.

Water clarity, as measured by Secchi disk transparency readings, averaged 1.62 feet for the season, which is 47% below the county median of 3.08 feet. The deepest reading was recorded in June (2.43 feet) and shallowest recorded in September (1.05 feet). The poor clarity over the season can be attributed, in part, to the high concentrations of total suspended solid (TSS), which increased as the season progressed (Figure 5). As a general rule, water clarity decreases as TSS increases.

The 2004 seasonal average TSS concentration was 21.2 mg/L, which is nearly three times the county median of 7.9 mg/L. In order to determine if the TSS was primarily organic or inorganic, we calculated the non-volatile suspended solids (NVSS) concentration, which indicates the inorganic portion in TSS. The average NVSS was 85% of the average TSS for the season indicating the TSS consisted primarily of inorganic substances, such as sediment. The sediment in the samples may be coming from several sources, both external and internal. Although Lake Farmington's watershed is relatively small, a significant portion (approximately 81%) is comprised of land uses with high amounts of impervious surfaces. These land uses may be contributing sediment and other inorganic substances to the lake from stormwater. Internally, the sediment is likely coming from the carp (*Cyprinus carpio*) activity that resuspends lake bottom sediment into the water column. Carp activity is exacerbated by the shallow nature of the lake. Also, as water levels decreased (reducing the lake's water volume), the TSS concentrations increased.

While inorganic material such as sediment is the main contributor in TSS concentrations, organic material such as algae is also a problem on Lake Farmington. Algae blooms were common throughout the season and the lake was treated with algicides several times in 2004. The degree of organic material present in the lake is supported by the average total

Figure 3. Land uses.

Figure 4. Sample Location

Figure 5. TSS and Secchi

volatile solid (TVS) concentration of 168 mg/L, which is 27% higher than the county median of 132 mg/L. TVS is a measurement of the organic substances, such as algae. To track future water quality trends, it is recommended that the lake become enrolled in the Volunteer Lake Monitoring Program (VMLP), which trains a volunteer to measure the Secchi disk readings on a bimonthly basis from April to October. For more information see **Objective II: Illinois Volunteer Lake Monitoring Program.**

Total phosphorus (TP) concentrations in Lake Farmington were also very high. The 2004 average TP concentration was 0.185 mg/L, which is nearly three times higher than the county median of 0.063 mg/L. Values above 0.03 mg/L are considered sufficient enough to cause nuisance algae blooms. The TP concentrations increased as the season progressed, primarily due to the drop in water levels over the season, which concentrated the TP into a small volume. The sources of TP are probably similar to TSS; external sources from stormwater and internal sources from sediment resuspension. TP is often attached to sediment particles, so managing the TSS sources will help in TP management.

Examination of a water sample taken on August 16, 2004 found that the dominant algae were *Anabaena* and *Oscillatoria*, which are blue-green algae. Blue-green algae are indicative of a degraded system and often grow into nuisance populations, particularly in late-summer. Frequently they can produce strong odors and are aesthetically displeasing. Management of the algae problems in the lake is a difficult one. The most common technique is spraying the algae with an algicide. However, repeated treatments are usually needed and address the problem (algae) and not the source (high TP). In Lake Farmington, the lake was treated with Cutrine-Plus®, a common algicide, on at least three occasions in 2004. Dredging is often suggested as one of the most effective techniques of improving a shallow, nutrient-rich lake. However, the costs of dredging (usually in the hundreds of thousands of dollars) are generally prohibitive to most lake associations. More information on algae management can be found in **Objective III: Nuisance Algae Management Options.** One threat to the lake is probably fertilizer (which is often high in phosphorus) applied to the lawns in the watershed. It is recommended that homeowners use a no-phosphorus fertilizer on their lawns. The management of the stormwater entering the lake should also be considered as this stormwater likely contains nutrients, sediment, and pollutants. The removal of the exotic carp in the lake will also assist in reducing the sediment resuspension. Currently, the most effective technique is total fish removal using a fish poison. More information on this can be found in **Objective IV: Controlling Excessive Numbers of Carp.**

Another nutrient, total Kjeldahl nitrogen (TKN) was also high. The 2004 seasonal average concentration for TKN, which is a measurement of the organic nitrogen in the water, was 1.87 mg/L, which is 53% higher than the county median of 1.22 mg/L. This nutrient followed a similar pattern as TSS and TP concentrations, increasing as the season progressed and as the water levels declined. Similar to TP, TKN may also be attached to sediments entering the lake or being internally resuspended.

High nutrient concentrations are usually indicative of water quality problems. Algae need light and nutrients, most importantly carbon, nitrogen (N) and phosphorus (P), to

grow. Light and carbon are not normally in short supply (limiting). This means that nutrients (N&P) are usually the limiting factors in algal growth. Nitrogen, as well as carbon, naturally occur in high concentrations and come from a variety of sources (soil, air, etc.) that are more difficult to control than sources of phosphorus. To compare the availability of these nutrients, a ratio of total nitrogen to total phosphorus is used (TN: TP). Ratios < 10:1 indicate nitrogen is limiting. Ratios of >15:1 indicate phosphorus is limiting. Ratios >10:1, <15:1 indicate that there is enough of both nutrients for excessive algal growth. The average ratio between total nitrogen and total phosphorus for Lake Farmington in 2004 was 10:1, indicating a slightly nitrogen-limited system. In September the lake was nitrogen-limited (6:1). Lakes that are phosphorus-limited may be easier to manage, since controlling phosphorus is more feasible than controlling nitrogen or carbon, which are both ubiquitous in the environment.

Lake Farmington's average concentrations of total dissolved solids (TDS) and conductivity readings were also higher than the county medians. These two parameters correlate since the higher the concentrations of TDS in the water, the higher the conductivity readings. The 2004 average for TDS was 1035 mg/L, which is 127% higher than the county median for near surface samples of 454 mg/L. Similarly, the 2004 average conductivity reading was 2.033 milliSiemens/cm, which is 151% higher than the county median for near surface samples of 0.8105 milliSiemens/cm. The cause for these high TDS concentrations and conductivity readings in Lake Farmington is the input from solids washed into the lake from storm events in the watershed. One of the most common dissolved solids is road salt used in winter road deicing. Because of the high conductivity readings, one additional parameter, chlorides, was analyzed. Chloride concentrations help determine road salt presence since most road salt is sodium chloride, calcium chloride, potassium chloride, magnesium chloride or ferrocyanide salts. The seasonal average for chlorides in Lake Farmington in 2004 was 527 mg/L. The IEPA standard for chloride is 500 mg/L. Once values exceed this standard (as in Lake Farmington) the water body is deemed to be impaired, thus negatively impacting aquatic life. Since 2001, only two lakes (IMC Lake in Libertyville and Stone Quarry Lake in Lincolnshire) of 19 lakes sampled have had chloride concentrations above 500 mg/L. The May concentration in Lake Farmington of 653 mg/L is the 4<sup>th</sup> highest concentration that we have recorded in an inland lake. The apparent source of the road salt is from the commercial complex at the intersection of Long Grove Road and U.S. Highway 12 (Rand Road) as well as the other roads within the watershed. As mentioned previously, the stormwater from this commercial complex drains into a detention pond (approximately 350 feet south of the lake) before entering the lake. The impacts of road salt are a concern throughout the county and it appears that the road salt is compounding in many of the lakes. Some lakes in the county have seen a doubling of conductivity readings in the past 5-10 years. In a study by Environment Canada (equivalent to our USEPA), it was estimated that 5% of aquatic species such as fish, zooplankton and benthic invertebrates would be affected at chloride concentrations of about 210 mg/l. Additionally, shifts in algae populations in lakes were associated with chloride concentrations as low as 12 mg/l. Thus, the aquatic life in Lake Farmington is likely being negatively impacted. Alternatives to road salt should be assessed.

Due to the shallow nature of the lake, Lake Farmington did not stratify throughout the summer. The lake began to weakly stratify during the May sampling date with a thermocline established at approximately five feet and again weakly in July at approximately three feet. No stratification was seen during June, August, or September. The impact of this phenomenon is probably minimal since the lake is very shallow and anoxic conditions (<1mg/L of dissolved oxygen (DO)) only occurred at the bottom (below six feet) of the lake in May and June. Additional nutrients may be released from the sediment under anoxic conditions. The exact impact on the lake is unknown since a detailed bathymetric map with volumetric calculations is unavailable. With the exception of the small anoxic zones in May and June, DO concentrations in Lake Farmington were oxidic (>1 mg/L) and relatively stable during the season. Some fish species may become stressed when DO concentrations fall below 5 mg/L, however all 2004 surface readings in Lake Farmington were above 5 mg/L. Because of the small volume of the lake, DO concentrations may fluctuate and care should be exercised when herbicide and algicide treatments occur. DO concentrations should be taken prior to any herbicide or algicide treatments.

Water levels on Lake Farmington steadily dropped during the season. The maximum one-month change occurred between May and June when the lake level dropped by 1.75 inches. The maximum change over the season (May to August) was a 3.89-inch decrease. Significant changes in water levels may have a negative impact on water quality. For example, in Lake Farmington several parameters (i.e., TP, TKN, and TSS) increased as the water level decreased. This is likely the result of lower water levels and lack of water leaving the lake (water was flowing over the spillway only in May and June), which caused the nutrients to become more concentrated in the lake in July through September.

Rain events probably contribute additional sediment or nutrients (like phosphorus) to the lake, which may have influenced the water sample results. Rain occurred within 48 hours prior to water sampling in May (1.07 inches), June (0.27 inches), and August (0.01 inches) as recorded at the Lake County Stormwater Management Commission rain gage in Buffalo Grove. The heavy rains that occurred in Lake County in May and June 2004 had an impact on many lakes, including Lake Farmington. Large amounts of stormwater entered the lake in May and June during these rains bringing with it nutrients, pollutants, and sediment. While negative impacts from large amounts of stormwater may appear obvious, the potential positive impacts are not as obvious. However, a lake such as Lake Farmington may benefit by receiving large amounts of water by maintaining a flow over the spillway and essentially “flushing” the lake. In May and June, when water was flowing over the spillway, the concentrations of TSS, TKN, and TP were lower than when there was no flow over the spillway. In addition, Secchi disk transparency readings were highest in May and June. Thus, the main concern with the stormwater entering the lake is a question of quality rather quantity. The nutrient loads and flow rates from the stormwater entering the lake should be assessed, with particular attention to the stormwater from the retail detention pond.

Based on data collected in 2004, standard classification indices compiled by the Illinois Environmental Protection Agency (IEPA) were used to determine the current condition

of Lake Farmington. A general overall index that is commonly used is called a trophic state index or TSI. The TSI index classifies the lake into one of four categories: oligotrophic (nutrient-poor, biologically unproductive), mesotrophic (intermediate nutrient availability and biological productivity), eutrophic (nutrient-rich, highly productive), or hypereutrophic (extremely nutrient-rich productive). This index can be calculated using total phosphorus values obtained at or near the surface. The TSI<sub>p</sub> for Lake Farmington in 2004 classified it as a hypereutrophic lake (TSI<sub>p</sub> = 79.4). Eutrophic lakes are the most common types of lakes throughout the lower Midwest, and they are particularly common among manmade lakes. See Table 2 in Appendix A for a ranking of average TSI<sub>p</sub> values for Lake County lakes (Lake Farmington is currently #141 of 161). This ranking is only a relative assessment of the lakes in the county. The current rank of a lake is dependent upon many factors including lake origin, water source, nutrient loads, and morphometric features (volume, depth, substrate, etc.). Thus, a small shallow manmade lake with high nutrient loads could not expect to achieve a high ranking even with intensive management.

For Lake Farmington, we calculated the IEPA impairment indices and found that the aquatic life impairment index was classified as a partial degree of support for all aquatic organisms in the lake based on the high trophic state (hypereutrophic) and the lack of aquatic plants in the lake. Similarly, the swimming index indicated only a partial degree of support, based on the poor water clarity. The recreation use index impairment was classified as a degree of nonsupport due to the high trophic state and the high concentrations of NVSS. The overall use index for the lake was partial support.

## **LIMNOLOGICAL DATA – AQUATIC PLANT ASSESSMENT**

Aquatic plant species presence and distribution in Lake Farmington were assessed monthly from May through September 2004 (see Appendix B for methods). Only four aquatic plant species and several emergent shoreline plants were found (see Table 3, below). In addition, the aquatic plants that were present were found in small numbers. Terrestrial shoreline plants were also noted, but not quantified.

Curlyleaf pondweed, an exotic, was the most common species being found in 32% of all sites. It was found in May, just after an herbicide treatment of Aquathol-K® (endothall) of which curlyleaf was the target species. Some curlyleaf began to come back during the summer as it was seen in July through September, but in very small numbers. The remaining three species were found four or less times during the season.

Similar to the Secchi disk transparency readings, the 1% light levels (the point where plant photosynthesis ceases) declined as the summer progressed. The 1% level penetrated down to four feet in May and June but only to three feet in July and two feet in August and September. This decline in light penetration during the season was the result of the algae blooms which were occurring at the time of sampling as well as the increasing concentrations of TSS during these months. Although no bathymetric map of Lake Farmington exists, depth soundings throughout the season indicate that most of the lake is less than five feet deep. Thus, the potential aquatic plant coverage along the lake bottom

unknown, however due to the previously mentioned herbicide treatment and the poor clarity the plant coverage was determined to be 1%. The Illinois Department of Natural Resources (IDNR) recommends 25-40% aquatic plant coverage to maintain ideal gamefish habitat conditions. Beneficial native plants (both submersed and emergent) are present in the lake and should be encouraged to expand to enhance habitats for fish and other wildlife and well as improve water quality.

Within the past 10 years, aquatic plants have dominated the lake. The current minimal aquatic plant composition in the lake may be due to an ecological shift from a plant-dominated lake to an algae-dominated lake. This shift may have resulted from the significant herbicide treatments that occurred when aquatic plants were common in the lake or from the high concentrations of TSS entering the lake and sediment resuspension from carp activity that diminished light penetration into the water. Once this shift occurred, the light penetration was likely reduced significantly to a point where the only areas of the lake receiving light levels conducive to plant growth were less than two or three feet. If water clarity improved, the potential aquatic plant coverage along the lake bottom is near 100%. Thus, an active management plan for Lake Farmington should be implemented if this occurs. The challenge is to address the desires of the homeowners of the lake, while managing for the lake's overall ecological health. It is recommended that some native aquatic plants be allowed to grow and expand, while controlling those that become invasive and interfere with the aesthetic qualities of the lake. This may be achieved by spot treating areas of the lake where problematic plants are occurring. Healthy plant populations in the lake may result in cost savings due to the need for less herbicides and algicides. Native aquatic plants infrequently grow to nuisance levels (with the exception of coontail) and will compete with algae for available nutrients, as well as stabilize lake bottom sediment. Removal of carp from the lake will also aid in water quality improvement.

Floristic quality index (FQI; Swink and Wilhelm 1994) is an assessment tool designed to evaluate the closeness that the flora of an area is 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. Each aquatic plant in a lake is assigned a number between 1 and 10 (10 indicating the plant species most sensitive to disturbance). This is done for every floating and submersed plant species found in the lake. These numbers are averaged and multiplied by the square root of the number of species present to calculate an FQI. 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 counted in the FQI calculations for Lake County lakes. In 2004, Lake Farmington had a FQI of 8.5. The median FQI of lakes that we have studied from 2000-2004 is 12.1.

**Table 3. Aquatic and shoreline plants on Lake Farmington, May - September 2004.**

Aquatic Plants

Small Duckweed  
Water Smartweed  
Curlyleaf Pondweed<sup>#</sup>  
Flatstem Pondweed

*Lemna minor*  
*Polygonum amphibium*  
*Potamogeton crispus*  
*Potamogeton zosteriformis*

Shoreline Plants

Silver Maple  
Alder  
Prairie Dogbane  
Common Milkweed  
Sedge  
Bull Thistle<sup>#</sup>  
Dogwood  
Slender Spikerush  
Daisy Fleabane  
Ash  
Jewelweed  
Black Walnut  
Honeysuckle<sup>#</sup>  
Purple Loosestrife<sup>#</sup>  
White Sweet Clover<sup>#</sup>  
Virginia Creeper  
Reed Canary Grass<sup>#</sup>  
Pickerelweed  
Cottonwood  
Black Cherry  
Bur Oak  
Common Buckthorn<sup>#</sup>  
Multiflora Rose<sup>#</sup>  
Blackberry  
Curled Dock<sup>#</sup>  
Willow  
Softstem Bulrush  
River Bulrush  
Bittersweet Nightshade<sup>#</sup>  
Narrow-Leaved Cattail  
Cattail  
Viburnum  
Wild Grape

*Acer saccharinum*  
*Alnus* sp.  
*Apocynum cannabinum*  
*Asclepias syriaca*  
*Carex* sp.  
*Cirsium vulgare*  
*Cornus* sp.  
*Eleocharis acicularis*  
*Erigeron annuus*  
*Fraxinus* sp.  
*Impatiens pallida*  
*Juglans nigra*  
*Lonicera* sp.  
*Lythrum salicaria*  
*Melilotus alba*  
*Parthenocissus quinquefolia*  
*Phalaris arundinacea*  
*Pontederia cordata*  
*Populus deltoides*  
*Prunus serotina*  
*Quercus macrocarpa*  
*Rhamnus cathartica*  
*Rosa multiflora*  
*Rubus* sp.  
*Rumex crispus*  
*Salix* sp.  
*Scirpus validus*  
*Scirpus fluviatilis*  
*Solanum dulcamara*  
*Typha angustifolia*  
*Typha* sp.  
*Viburnum* sp.  
*Vitis* sp.

<sup>#</sup> Exotic species

## LIMNOLOGICAL DATA – SHORELINE ASSESSMENT

A shoreline assessment was conducted in July 2004 to determine the condition of the lake shoreline (see Appendix B for methods). Of particular interest was the condition of the shoreline at the water/land interface.

The entire shoreline of Lake Farmington was classified as developed. Lawn and buffer habitats were the most common shoreline types consisting of 40% and 23% of the shoreline, respectively (Figure 7). Beach (14%), riprap (10%), shrub (10%) and seawall (3%) made up the remaining shoreline. Buffer habitat, which is a strip of unmowed vegetation preferably consisting of native plants located at the water's edge should be established around the lake, particularly where manicured lawns are located. This habitat can help filter the nutrients and pollutants from the surrounding watershed before they enter the lake, as well as providing habitat that is favored by many wildlife species, but not favored by residential Canada geese.

The shoreline was assessed for the degrees and types of shoreline erosion. The majority (2,687 feet or 78%) of the shoreline was classified as slightly eroding, however no moderate or severe erosion was found (Figure 8). The slightly eroded areas should be monitored for future degradation. Eroded shorelines can contribute sediment into the lake and have negative impacts to water quality.

Several exotic plants were found growing along the shoreline, including buckthorn, purple loosestrife, multiflora rose, and reed canary grass. Similar to aquatic exotics, these terrestrial exotics are detrimental to the native plant ecosystems around the lake. Removal or control of exotic species is recommended. More information can be found in **Objective V: Eliminate or Control Exotic Species.**

## LIMNOLOGICAL DATA – WILDLIFE ASSESSMENT

Good numbers of wildlife, particularly birds, were noted on and around Lake Farmington. See Appendix B for methods. Several of the species listed in Table 5 (below) were seen during spring or fall migration and were assumed not to be nesting around the lake.

Habitat around Lake Farmington was poor to fair, due mostly to the presence of residential homes and lawns. Additional habitat may be created around the lake, such as erecting birdhouses or allowing brush and trees that have falling into the water remain. More information can be found in **Objective VI: Enhance Wildlife Habitat Conditions.**

Figure 7. Shoreline types

Figure 8. Erosion

One wildlife problem that was identified was the large numbers of resident Canada geese that were seen throughout the season. Resident geese contribute large amounts of feces to the surrounding landscape that eventually washes into the lake, which can exacerbate the nutrient problems in the lake, leading to excessive algae blooms. Controlling resident geese can be difficult and in some cases permits are required by the IDNR. Growing buffer strips around the lake will help discourage geese from using lawns and allowing the lake to completely freeze in the winter will potentially encourage geese to move away from the lake. More information can be found in **Objective VII: Canada Goose Management**.

During the season we observed a juvenile yellow-crowned night heron using the area around Lake Farmington. This species is listed as an endangered species in the state of Illinois. It is unknown if this bird fledged from a nest in the area or if it was using the area seasonally. We also observed a pair of great horned owls around the lake on three different occasions, suggesting a possible nest nearby.

We did not conduct any fish surveys in 2004.

**Table 5. Wildlife species observed on Lake Farmington, April – September 2004.**

Birds

Double-crested Cormorant	<i>Phalacrocorax auritus</i>
Canada Goose	<i>Branta canadensis</i>
Mallard	<i>Anas platyrhynchos</i>
Great Egret	<i>Casmerodius albus</i>
Great Blue Heron	<i>Ardea herodias</i>
Green Heron	<i>Butorides striatus</i>
Yellow-crowned Night Heron*	<i>Nyctanassa violacea</i>
Cooper's Hawk	<i>Accipiter cooperii</i>
Red-tailed Hawk	<i>Buteo jamaicensis</i>
Mourning Dove	<i>Zenaida macroura</i>
Great Horned Owl	<i>Bubo virginianus</i>
Common Flicker	<i>Colaptes auratus</i>
Downy Woodpecker	<i>Picoides pubescens</i>
Eastern Phoebe	<i>Sayornis phoebe</i>
Eastern Pewee	<i>Contopus virens</i>
Barn Swallow	<i>Hirundo rustica</i>
Tree Swallow	<i>Iridoprocne bicolor</i>
Chimney Swift	<i>Chaetura pelagica</i>
American Crow	<i>Corvus brachyrhynchos</i>
Blue Jay	<i>Cyanocitta cristata</i>
Black-capped Chickadee	<i>Poecile atricapillus</i>
White-breasted Nuthatch	<i>Sitta carolinensis</i>
House Wren	<i>Troglodytes aedon</i>
Catbird	<i>Dumetella carolinensis</i>
American Robin	<i>Turdus migratorius</i>

**Table 5. Wildlife species observed on Lake Farmington, April – September 2004  
(cont'd).**

Cedar Waxwing	<i>Bombycilla cedrorum</i>
Tennessee Warbler	<i>Vermivora peregrina</i>
Red-winged Blackbird	<i>Agelaius phoeniceus</i>
Common Grackle	<i>Quiscalus quiscula</i>
Starling	<i>Sturnus vulgaris</i>
Northern Oriole	<i>Icterus galbula</i>
House Sparrow	<i>Passer domesticus</i>
Northern Cardinal	<i>Cardinalis cardinalis</i>
American Goldfinch	<i>Carduelis tristis</i>
Chipping Sparrow	<i>Spizella passerina</i>
Song Sparrow	<i>Melospiza melodia</i>

Mammals

Eastern Chipmunk	<i>Tamias striatus</i>
Gray Squirrel	<i>Sciurus carolinensis</i>

Amphibians

Bull Frog	<i>Rana catesbeiana</i>
Green Frog	<i>Rana clamitans melanota</i>

Reptiles

Painted Turtle	<i>Chrysemys picta</i>
Snapping Turtle	<i>Chelydra serpentina</i>

Insects

Cicadas	Cicadidae
Dragonfly	Anisoptera
Damselfly	Zygoptera

\*Endangered in Illinois

+Threatened in Illinois

## EXISTING LAKE QUALITY PROBLEMS

- *Lack of a Quality Bathymetric Map*

A bathymetric (depth contour) map is an essential tool for effective lake management since it provides critical information on the morphometric features of the lake (i.e., acreage, depth, volume, etc.). This information is particularly important when intensive management techniques (i.e., aeration, chemical treatments for plant or algae control, dredging, fish stocking, etc.) are part of the lake's overall management plan. Currently, no bathymetric map of Lake Farmington exists.

- *Poor Water Clarity and High Concentrations of Total Suspended Solids (TSS) and Total Phosphorus (TP)*

Lake Farmington had a Secchi disk transparency reading of 1.62 feet, which is 47% lower than the county median. Correlated with clarity was the seasonal average for TSS of 21.2 mg/l, which is nearly three times higher than the county median. The majority of the TSS is in inorganic forms, such as sediment. The sediment source is probably from stormwater inputs and from sediment resuspension due to carp activity. The 2004 seasonal average for TP in Lake Farmington is 0.185 mg/L, which is also nearly three times higher than the county median. Some of the TP is probably attached to the sediment found in the water column.

- *High Concentrations of Total Dissolved Solids (TDS) and Chlorides and High Conductivity Readings*

The average concentrations of TDS in Lake Farmington were 127% above the county median. The average chloride concentration was 527 mg/L, which is above the IEPA standard of 500 mg/L. The chloride is in concentrations that may significantly impair aquatic life. The May chloride concentration of 653 mg/L was the 4<sup>th</sup> highest ever recorded in an inland lake in the county that we have monitored. Similarly, the average conductivity reading was also very high, 151% above the county median. The main cause of these problems is probably road salt used in winter road deicing. Alternatives to common road salt should be assessed.

- *Limited Aquatic Vegetation*

Only four species of aquatic plants were found in Lake Farmington. None of the species were found in abundance. The minimal aquatic plant populations contributed to the poor water quality and allowed for an increase in algae blooms. Beneficial native plants (both submersed and emergent) should be encouraged to expand to enhance habitats for fish and other wildlife and as well as improve water quality. A balanced aquatic plant management plan could address the aesthetic needs of the homeowners and the overall ecological health of the lake.

- *Invasive Shoreline Plant Species*

Numerous exotic plant species (i.e., purple loosestrife, multiflora rose, buckthorn, and reed canary grass) were found on the shores of Lake Farmington. These species are particularly problematic as they outcompete native plants and offer little value in terms of shoreline stabilization or wildlife habitat. These exotic plants should be removed and replaced with native shoreline plants.

- *Canada Geese*

Numerous resident Canada geese were observed throughout the season on lawns surrounding the lake. Geese can be problematic since they contribute large amounts of feces to the surrounding landscape that eventually washes into the lake, which can exacerbate the nutrients problems in the lake, leading to excessive algae blooms. Growing buffer habitat along the shoreline and allowing the lake to completely freeze during the winter will aid in the management of this bird around the lake.

## **POTENTIAL OBJECTIVES FOR THE LAKE FARMINGTON MANAGEMENT PLAN**

- I. Create a Bathymetric Map Including a Morphometric Table
- II. Illinois Volunteer Lake Monitoring Program
- III. Nuisance Algae Management Options
- IV. Shoreline Erosion Control
- V. Eliminate or Control Exotic Plant Species
- VI. Enhance Wildlife Habitat Conditions
- VII. Canada Goose Management

## **Objective I: Create a Bathymetric Map Including a Morphometric Table**

A bathymetric map (depth contour) map is an essential tool for effective lake management since it provides critical information about the physical features of the lake, such as depth, surface area, volume, etc. This information is particularly important when intensive management techniques (i.e., chemical treatments for plant or algae control, dredging, fish stocking, etc.) are part of the lake's overall management plan. Some bathymetric maps for lakes in Lake County do exist, but they are frequently old, outdated and do not accurately represent the current features of the lake. Maps can be created by agencies like the Lake County Health Department - Lakes Management Unit or other companies. Costs vary, but can range 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, approximately 165 lakes (out of 3,041 lakes in Illinois) are sampled by approximately 300 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.

Currently the number of volunteers in the six county northeast Illinois region has reached its limit with regard to how many volunteers NIPC can handle. New lakes wishing to be part of the VLMP will be taken on and trained by the Lake County Health Department Lakes Management Unit (LMU). If you would like to be placed on this training list or would simply like more information, contact the Lakes Management Unit Local Coordinator:

LMU Local Coordinator:  
Mary Colwell  
Lake County Health Department  
3010 Grand Ave.  
Waukegan, IL 60085  
(847) 377-8009

VLMP Regional Coordinator:  
Holly Hudson  
Northeast Illinois Planning Commission  
222 S. Riverside Plaza, Suite 1800  
Chicago, IL 60606  
(312) 454-0400

### **Objective III: Nuisance Algae Management Options**

The growth of nuisance or excessive algae can cause a number of problems. Excessive algal growth can cause decreases in water clarity and light penetration. This can lead to several major problems such as loss of aquatic plants, decline in fishery health, and interference with recreational activities. Health hazards, such as swimmer's itch and other skin irritations have been linked to nuisance algae growth. Normally, excessive/nuisance algae growth is a sign of larger problems such excessive nutrients and/or lack of aquatic plants. Some treatment methods, such as copper sulfate, are only quick remedies to the problem. Solving the problem of nuisance algal growth involves treating the factors that cause the growth not the algae itself. Long-term solutions typically include an integrated approach such as alum treatments, revegetation with aquatic plants, and limiting external sources of nutrients. Interestingly enough, these long-term management strategies are seldom used, typically because of their high initial costs. Instead, the cheap, quick fix of using copper sulfate, though temporary, is much more widely used. However, the costs of continually applying copper sulfate over years, even decades, can eventually far exceed the costs of a slower acting, eventually more effective, integrated approach.

As with aquatic plant management techniques, algae management practices have both positive and negative characteristics. If used properly, they can 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 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 (beaches, boat ramps, etc.), habitat maintenance/restoration issues, and nutrient levels. For an algal management plan to achieve long term success, follow up is critical. The management of the lake's algae problem does not end once the blooms and/or mats have been reduced/eliminated. It is critical to continually monitor problematic areas for regrowth and treat as necessary. An association or property owner should not always expect immediate results. A quick fix of the algal problem may not always be in the best interest of the lake. Sometimes the best solutions take several seasons to properly address the problem. The management options covered below are commonly used techniques and those that are coming into wider acceptance, and have been used in Lake County. There are other algae management options that are not covered below as they are not very effective, unproven, unfounded, or are too experimental to be widely used.

#### **Option 1: No Action**

With a no action management plan nothing would be done to control the nuisance algae regardless of type and extent. Nuisance algae, planktonic and/or filamentous, could continue to grow until epidemic proportions are reached. Growth limitations of the algae and the characteristics of the lake itself (light penetration, nutrient levels.) will dictate the extent of growth. Unlike aquatic plants, algae are not normally bound by physical factors such as substrate type. The areas in which filamentous and thick surface planktonic blooms (scum) occur can be affected by wind and wave action if strong enough. However, under normal conditions, with no action, both filamentous and planktonic algal

blooms can spread to cover 100% of the 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 nuisance algae management. The first, and most obvious, is that there is no cost. However, if an active management plan for algae control were eventually needed, the cost would be substantially higher than if the no action plan had been followed in the first place. Another benefit of this option would be the lack of environmental manipulation. Under the no action option, chemicals or introduction of any organisms would not take place. Use of the lake would continue as normal unless blooms worsened. In this case, activities such as swimming might have to be suspended due to an increase in health risks. Other problems such as strong odors (blue-green algae) might also increase in frequency.

### ***Cons***

Under the no action option, if nuisance algae becomes wide spread and able to reach epidemic proportions, there will be many negative impacts on the lake. The fishery of the lake may become stunted due to lack of quality forage fish habitat and reduced predation. This will cause an explosion in the small fish population and with food resources not increasing, growth of fish will be reduced. Fish kills can result from toxins released by some species such as some blue-green algae. Blue-green algae can also produce toxins that are harmful to other algae. This allows blue-green algae to quickly dominate a body of water. Decreased dissolved oxygen levels, due to high biological oxygen demand from the excessive algae growth, will also have negative impacts on the aquatic life. Wildlife populations will also be negatively impacted by dense growths of algae. Birds and waterfowl will have difficulty finding quality plants for food or in locating prey within the turbid green waters. Additionally, some species, such as blue-green algae, are poor sources of food for zooplankton and fish.

Water quality could also be negatively impacted with the implementation of a no action option. Decomposition of organic matter and release of nutrients upon algal death is a probable outcome. Large nutrient release with algae die back could lead to lake-wide increases of internal nutrient load. This could in turn, could increase the frequency or severity of other blooms. In addition, decomposition of massive amounts of algae, filamentous and planktonic, will lead to a depletion of dissolved oxygen in the lake. This can cause fish stress, and eventually, if 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 ecological impacts, many physical lake uses will be negatively impacted. Boating could be nearly impossible without becoming entangled in thick mats of filamentous algae. Swimming could also become increasingly difficult and unsafe due to thick mats and reduction in visibility by planktonic

blooms. Fishing could become more and more exasperating due in part to the thick mats and stunted fish populations. In addition, the aesthetics of the lake will also decline due to large areas of the lake covered by large green mats and/or blooms of algae and the odors that may develop, such as with large blue-green blooms. The combination of above events could cause property values on the lake to suffer. Property values on lakes with algae problems have been shown to decrease by as much as 15-20%.

### *Costs*

No cost will be incurred by implementing the no action management option.

### **Option 2: Algicides**

Algicides are a quick and inexpensive way to temporarily treat nuisance algae. Copper sulfate ( $\text{CuSO}_4$ ) and chelated copper products are the two main algicides in use. These two compounds are sold by a variety of brand names by a number of different companies. There is also a non-copper based algicide on the market called GreenClean™ from BIOsafe Systems, which contains the active ingredient sodium carbonate peroxyhydrate. Regardless of active ingredient, they all work the same and act as contact killers. This means that the product has to come into contact with the algae to be effective. Algicides come in two forms, granular and liquid. Granular herbicides are spread by hand or machine over an effected area. They can also be placed in a porous bag (such as a burlap sack) and dragged through the water in order to dissolve and disperse the product. Granular algicides are mainly used on filamentous algae where they are spread over the mats. As the granules dissolve, they kill the algae. Liquid algicides, which are much more widely used, are mixed with a known amount of water to achieve a known concentration. The mixture is then sprayed onto/into the water. Liquid algicides are used on both filamentous and planktonic algae. Liquid algaecides are often mixed with herbicides and applied together to save on time and money. The effectiveness of some herbicides is enhanced when mixed with an algicide. When applying an algicide it is imperative that the label is completely read and followed. If too much of the lake is treated at any one time an oxygen crash may occur. This may cause fish kills due to decomposition of treated algae. Additionally, treatments should never be made when blooms/mats are at their fullest extent. It is best to divide the lake into at least two sections depending on the size of the lake. Larger lakes will need to be divided into more sections. Then treat the lake one section at a time allowing at least two weeks between treatments. Furthermore, application of algicides should never be done in extremely hot weather (>90°F) or when DO concentrations are low. This will help lessen the likelihood of an oxygen crash and resulting fish kills. When possible, treatments should be made as early in the season as possible when temperature and D.O. concentrations are adequate. It is best to treat in spring or when the blooms/mats starts to appear there by killing the algae before they become a problem.

Using algicides is part of the annual management of Lake Farmington. The current treatment program is working effectively. Care should be taken that treatments do not dramatically reduce the DO concentrations in the lake. Prior to any algicide treatments, DO concentrations should be tested.

### ***Pros***

When used properly, algicides can be a powerful tool in management of nuisance algae growth. A properly implemented plan can often provide season long control with minimal applications. Another benefit of using algicides is their low costs. The fisheries and waterfowl populations of the lake would greatly benefit due to a decrease in nuisance algal blooms. By reducing the algae, clarity would increase. This in turn would allow the native aquatic plants to return to the lake. Newly established stands of plants would 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*) and sago pondweed (*Potamogeton pectinatus*). Additionally, copper products, at proper dosages, are selective in the sense that they do not affect aquatic vascular plants and wildlife.

By implementing a good management plan, usage opportunities for the lake would increase. Activities such as boating and swimming would improve due to the removal of thick blooms and/or mats of algae. Health risks associated with excessive algae growth (toxins, reduced visibility, etc.) The quality of fishing may recover due to improved habitat and feeding opportunities. In addition to increased usage opportunities, overall aesthetics of the lake would improve, potentially increasing property values.

### ***Cons***

The most obvious drawback of using algicides is the input of chemicals into the lake. Even though the United States Environmental Protection Agency (USEPA) approved these chemicals for use, human error and overuse can make them unsafe and bring about undesired outcomes. By continually killing particular algal species, lake managers may unknowingly be creating a larger problem. As the algae are continuously exposed to copper, some species are becoming more and more tolerant. This results in the use of higher concentrations in order to achieve adequate control, which can be unhealthy for the lake. In other instances, by eliminating one type of algae, lake managers are finding that other species that are even more problematic are filling the empty gap. These species that fill the gap can often be more difficult to control due to an inherent resistance to copper products. Additionally, excessive use of copper products can lead to a build up of copper in lake sediment. This can cause problems for activities such as dredging. Due to a large amount of copper in the sediment, special permits and disposal methods would have to be utilized.

### ***Costs***

To calculate total cost it will be necessary to calculate surface acreage (SA) or acre-feet (AF) of the area(s) to be treated according to each lake's aquatic plant management plan. The chelated copper products (Clearigate<sup>®</sup>, Cutrine<sup>®</sup>, Captain<sup>®</sup>, K-Tea<sup>®</sup>, Komeen<sup>®</sup>) cost \$35-45 per gallon and are generally applied at 0.5-2.5 gallons per acre-foot depending on the product.

### **Option 3: Alum Treatment**

A possible remedy to excessive algal growth is to eliminate or greatly reduce the amount of phosphorus. This can be accomplished by using aluminum sulfate (alum). Alum does not directly kill algae as copper sulfate does. Instead, alum binds phosphorus making it unavailable, thus reducing algal growth. Alum binds water-borne phosphorus and forms a flocculent layer that settles on the bottom. This floc layer can then prevent sediment bound phosphorus from entering the water column. Phosphorus inactivation using alum has been in use for 25 years. However, cost and sometimes unreliable results deterred its wide spread use. Currently, alum is commonly being used in ponds and small lakes, and its use in larger lakes is increasing. Alum treatment typically lasts 1 to 20 years depending on various parameters. Lakes with low mean depth to surface area ratio benefit more quickly from alum applications, while lakes with high mean depth to surface area ration (thermally stratified lakes) will see more longevity from an alum application due to isolation of the flocculent layer. Lakes with small watersheds are also better candidates because external phosphorus sources can be limited. Alum treatments must be carefully planned and carried out by an experienced professional. If not properly done, there may be many detrimental side effects.

An alum treatment in Lake Farmington may be a viable option. Due to the relatively shallow nature of the lake, the costs of an alum treatment may outweigh the annual costs of algicide treatments. However, prior to assessing this option, a bathymetric map (with volume calculations) is needed.

#### ***Pros***

Phosphorus inactivation is a possible long-term solution for controlling nuisance algae and increasing water clarity. Alum treatments can last as long as 20 years. This makes alum more cost effective in the long-term compared to continual treatment with algaecides. Studies have shown reductions in phosphorus concentrations by 66% in spring and 68% in summer. Chlorophyll *a*, a measure of algal biomass, was reduced by 61%. Reduction in algal biomass caused an increase in dissolved oxygen and a 79% increase in Secchi disk readings. Effects of alum treatments can be seen in as little as a few days. The increase in clarity can have many positive effects on the lake's ecosystem. With increased clarity, plant populations could expand or reestablish. This in turn would improve fish habitat and provide improved food/habitat sources for other organisms. Recreational activities such as swimming and fishing would be improved due to increased water clarity and healthy plant populations. Typically, there is a slight invertebrate decline immediately following treatment but populations recover fully by the following year.

#### ***Cons***

There are several drawbacks to alum. External nutrient inputs must also be reduced or eliminated for alum to provide long-term effectiveness. With larger watersheds this could prove to be physically and financially impossible. Phosphorus inactivation may be shortened by excessive plant growth or motorboat traffic, which can disturb the flocculent layer and allow phosphorus to

be released. Also, lakes that are shallow, non-stratified, and wind blown typically do not achieve long term control due to disruption of the flocculent layer. If alum is not properly applied toxicity problems may occur. Typically aluminum toxicity occurs if pH is below 6 or above 9. Most of Lake County's lakes are in this safe range. However, at these pHs, special precautions must be taken when applying alum. By adding the incorrect amounts of alum, pH of the lake could drastically change. Due to these dangers, it is highly recommended that a lake management professional plans and administers the alum treatment.

### ***Costs***

Morphometric data is required to make proper calculations. No such data exists currently for Lake Farmington. A bathymetric map would need to be completed before an accurate calculation can be made. However, using the estimated volume of 29 acre-feet, an alum treatment in Lake Farmington may cost between \$4,564 and \$7,845.

### **Option 4: Revegetation With Native Aquatic Plants**

A healthy native plant population can reduce algal growth. Many lakes with long-standing algal problems have a very sparse plant population or none at all. This is due to reduction in light penetration brought about by years of excessive algal blooms and/or mats. Revegetation should only be done when existing nuisance algal blooms are under control using one of the above management options. If the lake has poor clarity due to excessive algal growth or turbidity, these problems must be addressed before a revegetation plan is undertaken. Without adequate light penetration, revegetation will not work. At maximum, planting depth light levels must be greater than 1-5% of the surface light levels for plant growth and photosynthesis. If aquatic herbicides are being used to control what vegetation does exist there use should be scaled back or abandoned all together. This will allow the vegetation to grow back, which will help in controlling the algae in addition to other positive impacts associated with a healthy plant population.

There are two methods by which reestablishment can be accomplished. The first is use of existing plant populations to revegetate other areas within the lake. Plants from one part of the lake are allowed to naturally expand into adjacent areas thereby filling the niche left by the nuisance algae. Another technique utilizing existing plants is to transplant vegetation from one area to another. The second method of reestablishment is to import native plants from an outside source. A variety of plants can be ordered from nurseries that specialize in native aquatic plants. These plants are available in several forms such as seeds, roots, and small plants. These two methods can be used in conjunction with one another in order to increase both quantity and biodiversity of plant populations. Additionally, plantings must be protected from herbivory by waterfowl and other wildlife. Simple cages made out of wooden or metal stakes and chicken wire are erected around planted areas for at least one season. The cages are removed once the plants are established and less vulnerable. If large-scale revegetation is needed it would be best to use a consultant to plan and conduct the restoration. Table 6 lists common, native plants that should be considered when developing a revegetation plan. Included in this list are emergent shoreline vegetation (rushes, cattails, etc) and submersed aquatic plants

(pondweeds, *Vallisneria*, etc). Prices, planting depths, and planting densities are included and vary depending on plant species.

### ***Pros***

By revegetating newly opened areas that were once infested with nuisance species, the lake will benefit in several ways. Once established, expanded native plant populations will help to control growth of nuisance algae by shading and competition for resources. This provides a more natural approach as compared to other management options. In addition, using established native plants to control excessive invasive plant growth is less expensive than other options. Expanded native plant populations will also help with sediment stabilization. This in turn will have a positive effect on water clarity by reducing suspended solids and nutrients that decrease clarity and cause excessive algal growth. Properly revegetating shallow water areas with plants such as cattails, bulrushes, and water lilies can help reduce wave action that can lead to shoreline erosion. Increases in desirable vegetation will increase the plant biodiversity and also provide better quality habitat and food sources for fish and other wildlife. Recreational uses of the lake such as fishing and boating will also improve due to the improvement in water quality and the suppression of weedy species.

### ***Cons***

There are few negative impacts to revegetating a lake. One possible drawback is the possibility of new vegetation expanding to nuisance levels and needing control. However, this is an unlikely outcome. Another drawback could be high costs if extensive revegetation is needed using imported plants. If a consultant were used costs would be substantially higher. Additional costs could be associated with constructing proper herbivory protection measures.

### ***Costs***

See Table 6 for plant pricing. Costs will be higher if a consultant/nursery is contracted for design and labor. Additional costs will include herbivory protection materials such as metal posts and protective wire mesh (chicken wire).

## **Objective IV: Controlling Excessive Numbers of Carp**

A frequent problem that plagues many of the lakes in the County is the presence of common carp (*Cyprinus carpio*). Common carp were first introduced into the United States from Europe in the early 1870's, and were first introduced into Illinois river systems in 1885 to improve commercial fishing. The carp eventually made their way into many inland lakes and are now so widespread that many people do not realize that they are not native to the U.S.

Carp prefer warm waters in lakes, streams, ponds, and sloughs that contain high levels of organic matter. This is indicative of many lakes in Lake County. Carp feed on insect larvae, crustaceans, mollusks, and even small fish by rooting through the sediment. Immature carp feed mainly on small crustaceans. Because their feeding habits cause a variety of water quality problems, carp are very undesirable in lakes. Rooting around for food causes resuspension of sediment and nutrients, which can both lead to increased turbidity. Additionally, spawning, which occurs near shore in shallow water, can occur from late April until June. The spawning activities of carp can be violent, further contributing to turbidity problems. Adult carp can lay between 100,000 –500,000 eggs, which hatch in 5-8 days. Initial growth is rapid with young growing 4 ¾" to 5" in the first year. Adults normally range in size from 1-10 lbs., with some as large as 60 lbs. Average carp lifespan is 7-10 years, but they may live up to 15 years.

There are several techniques to remove carp from a lake. However, rarely does any technique completely eradicate carp from a lake. Commonly, once a lake has carp, it has carp forever. However, it is up to the management entity to dictate how big the problem is allowed to become. Rotenone is the only reliable piscicide (fish poison) on the market at this time, but it kills all fish that it comes into contact with. Currently, there is a rotenone laced baiting system that can selectively remove carp. While the process is a step in the right direction, several factors still need to be worked out in order for it to be a viable alternative to the whole lake treatment. Until this baiting technique is further developed and produces consistent results, we do not recommend it at this time.

### **Option 1: No Action**

By following a no action management approach, nothing would be done to control the carp population of the lake. Populations will continue to expand and reach epidemic proportions if they do not already exist.

#### **Pros**

There are very few positive aspects to following a no action plan for excessive carp populations. The only real advantage would be the money saved by taking no action.

#### **Cons**

There are many negative aspects to a no action management plan for carp management. The feeding habits of carp cause most of the associated problems. As carp feed they root around in the lake sediment. This causes resuspension of

sediment and nutrients. Increased nutrient levels can lead to increased algal blooms, which, combined with resuspended sediment, lead to increased turbidity (reduced clarity). As a result there is a decrease in light penetration, negatively impacting aquatic plants. Additionally, the rooting action of the carp causes the direct disruption of aquatic plants. Loss of aquatic plants can further aggravate sediment and nutrient loads in the water column due to loss of sediment stabilization provided by the plants. Additionally, the fishery of the lake may decline and/or become stunted due to predation issues related to decreased water clarity and loss of habitat. Other wildlife, such as waterfowl, which commonly forage on aquatic plants and fish, would also be negatively impacted by the decrease in vegetation.

The loss of aquatic plants and an increase in algae will drastically impair recreational use of the lake. Swimming could be adversely affected due to the increased likelihood of algal blooms. Swimmers may become entangled in large mats of filamentous algae, and blooms of planktonic species, such as blue-green algae, can produce harmful toxins and noxious odors. Fishing would also be negatively affected due to the decreased health of the lake's fishery. The overall appearance of the lake would also suffer from an increase in unsightly algal blooms, having an unwanted effect on property values.

#### *Costs*

There is no cost associated with the no action option.

#### **Option 2: Rotenone**

Rotenone is a piscicide that is naturally derived from the stems and roots of several tropical plants. Rotenone is approved for use as a piscicide by the USEPA and has been used in the U.S. since the 1930's. It is biodegradable (breaks down into CO<sub>2</sub> and H<sub>2</sub>O) and there is no bioaccumulation. Because rotenone kills fish by chemically inhibiting the use of oxygen in biochemical pathways, adult fish are much more susceptible than fish eggs (carp eggs are 50 times more resistant). Other aquatic organisms are less sensitive to rotenone. However, some organisms are effected enough to reduce populations for several months. In the aquatic environment, fish come into contact with the rotenone by a different method than other organisms. With fish, the rotenone comes into direct contact with the exposed respiratory surfaces (gills), which is the route of entry. In other organisms this type of contact is minimal. More sensitive nonfish species include frogs and mollusks but these organisms typically recover to pretreatment levels within a few months. Rotenone has low mammalian and avian toxicity. For example, if a human consumed fish treated with normal concentrations of rotenone, approximately 8,816 lbs. of fish would need to be eaten at one sitting in order to produce toxic effects. Furthermore, due to its unstable nature, it is unlikely that the rotenone would still be active at the time of consumption. Additionally, warm-blooded mammals have natural enzymes that would break down the toxin before it had any effects.

Rotenone is available in 5% and 2.5% concentrations. Both concentrations are available as synergized formulations. The synergist (piperonal butoxide) is an additive that inhibits

fish detoxification of rotenone, making the rotenone more effective. Rotenone has varying levels of toxicity on different fish species. Some species of fish can detoxify rotenone quicker than it can build up in their systems. Unfortunately, concentrations to remove undesirable fish, such as carp, bullhead and green sunfish, are high enough to kill more desirable species such as bass, bluegill, crappie, walleye, and northern pike. Therefore, it is difficult to selectively remove undesirable fish while leaving desirable ones. Typically, rotenone is used at concentrations from 2 ppm (parts per million) – 12 ppm. For removal of undesirable fish (carp, bullhead and green sunfish) in lakes with alkalinities in the range found in Lake County, the target concentration should be 6 ppm. Sometimes concentrations will need to be increased based on high alkalinity and/or high turbidity. Rotenone is most effectively used when waters are cooling down (fall) not warming up (spring) and is most effective when water temperatures are <50°F. Under these conditions, rotenone is not as toxic as in warmer waters but it breaks down slower and provides a longer exposure time. If treatments are done in warmer weather they should be done before spawn or after hatch as fish eggs are highly tolerant to rotenone.

Rotenone rarely kills every fish (normally 99-100% effective). Some fish can escape removal and additional rotenone treatments need to occur about every 10 years. At this point in time, carp populations will have become reestablished due to reintroduction and reproduction by fish that were not removed during previous treatment. To ensure the best results, precautions can be taken to assure a higher longevity. These precautions include banning live bait fishing (minnows bought from bait stores can contain carp) and making sure every part of the lake is treated (i.e., cattails, inlets, and harbored shallow areas). Restocking of desirable fish species may occur about 30-50 days after treatment when the rotenone concentrations have dropped to sub-lethal levels. Since it is best to treat in the fall, restocking may not be possible until the following spring. To use rotenone in a body of water over 6 acres a *Permit to Remove Undesirable Fish* must be obtained from the Illinois Department of Natural Resources (IDNR), Natural Heritage Division, Endangered and Threatened Species Program. Furthermore, only an IDNR fisheries biologist licensed to apply aquatic pesticides can apply rotenone in the state of Illinois, as it is a restricted use pesticide.

### **Pros**

Rotenone is one of the only ways to effectively remove undesirable fish species. This allows for rehabilitation of the lake's fishery, which will allow for improvement of the aquatic plant community, and overall water quality. By removing carp, sediment will be left largely undisturbed. This will allow aquatic plants to grow and help further stabilize the sediment. As a result of decreased carp activity and increased aquatic plant coverage, fewer nutrients will be resuspended, greatly reducing the likelihood of nuisance algae blooms and associated dissolved oxygen problems. Additionally, reestablishment of aquatic plants will have other positive effects on lake health and water quality, increases in fish habitat and food source availability for wildlife such as waterfowl.

### **Cons**

In the process of removing carp with rotenone, other desirable fish species will also be removed. The fishery can be replenished with restocking and quality sport fishing normally returns within 2-3 years. Other aquatic organisms, such as mollusks, frogs, and invertebrates (insects, zooplankton, etc.), are also negatively impacted. However, this disruption is temporary and studies show that recovery occurs within a few months. Furthermore, the IDNR will not approve application of rotenone to waters known to contain threatened and endangered fish species. Another drawback to rotenone is the cost. Since the whole lake is treated and costs per gallon range from \$50.00 - \$75.00, total costs can quickly add up. This can be offset with lake draw down to reduce treatment volume. Unfortunately, draw down is not an option on all lakes.

### **Costs**

As with most intensive lake management techniques, a good bathymetric map is needed so that an accurate lake volume can be determined. To achieve a concentration of 6 ppm, which is the rate needed for most total rehabilitation projects (remove carp, bullhead and green sunfish), 2.022 gal/AF is required. Additional costs include preparation and clean-up after the treatment is completed as well as costs to restock the lake with beneficial fish.

## **Objective V: Eliminate or Control Exotic 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.

Purple loosestrife is responsible for the “sea of purple” seen along roadsides and in wetlands during summer. It can quickly dominate a wetland or shoreline. Due in part to an extensive root system, large seed production (estimates range from 100,000 to 2.7 million seeds per plant), and high seed germination rate, purple loosestrife spreads quickly. Buckthorn is an aggressive shrub species that grows along lake shorelines as well as most upland habitats. It shades out other plants, its roots exude a chemical that discourages other plant growth, and it is quick to become established on disturbed soils. Reed canary grass is an aggressive plant species that was introduced as a shoreline stabilizer. It is found on lakeshores, stream banks, marshes and exposed moist ground. Although it does serve to stabilize shorelines to some extent, it has low food value and does not provide winter habitat for wildlife. It is very successful in taking over disturbed areas and, 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 purple loosestrife, buckthorn, and reed canary grass are discussed below. However, these control measures can be similarly applied to other exotic species such as garlic mustard (*Alliaria officianalis*) or honeysuckle (*Lonicera* spp.) as well as some aggressive native species, such as box elder (*Acer negundo*).

The 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, but its removal early on is best. 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 whenever 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 affected.

### ***Costs***

Costs with this option are zeroing 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.

## **Option 2: Biological Control**

Biological control (bio-control) is a means of using natural relationships already in place to limit, stop, or reverse an exotic species' expansion. In most cases, insects that prey upon the exotic plants in its native ecosystem are imported. Since there is a danger of bringing another exotic species into the ecosystem, state and federal agencies require testing before any bio-control species are released or made available for purchase.

Recently two leaf beetles (*Galerucella pusilla* and *G. californiensis*) and two weevils, one a root-feeder (*Hylobius transversovittatus*) and one a flower-feeder (*Nanophyes marmoratus*) have offered some hope to control purple loosestrife by natural means. These insects feed on the leaves, roots, or flowers of purple loosestrife, eventually weakening and killing the plant or, in the case of the flower-feeder, prevent seeding. In large stands of loosestrife, the beetles and weevils naturally reproduce and in many locations, significantly reduce plant densities. The insects are host specific, meaning that

they will attack no other plant but purple loosestrife. Currently, the beetles have proven to be most effective and are available for purchase. There are no designated stocking rate recommendations, since using bio-control insects are seen as an inoculation and it may take 3-5 years for beetle populations to increase to levels that will cause significant damage. Depending on the size of the infested area, it may take 1,000 or more adult beetles per acre to cause significant damage.

### ***Pros***

Control of exotics by a natural mechanism is preferable to chemical treatments. Insects, being part of the same ecological system as the exotic plant (i.e., the beetles and weevils and the purple loosestrife) are more likely to provide long-term control. Chemical treatments are usually non-selective while bio-control measures target specific plant species. This technique is beneficial to the ecosystem since it preserves, even promotes, biodiversity. As the exotic plant dies back, native vegetation can reestablish the area.

### ***Cons***

Few exotics can be controlled using biological means. Currently, there are no bio-control techniques for plants such as buckthorn, reed canary grass, or a host of other exotics. One of the major disadvantages of using bio-control is the costs and labor associated with it.

Use of biological mechanisms to control plants such as purple loosestrife is still under debate. Similar to purple loosestrife, the beetles and weevils that control it are not native to North America. Due to the poor historical record of introducing non-native species, even to control other non-native species, this technique has its critics.

### ***Costs***

The New York Department of Natural Resources at Cornell University (email: [bb22@cornell.edu](mailto:bb22@cornell.edu), 607-255-5314, or visit the website: [www.invasiveplants.net](http://www.invasiveplants.net)) sells overwintering adult leaf beetles (which will lay eggs the year of release) for \$1 per beetle and new generation leaf beetles (which will lay eggs beginning the following year) at \$0.25 per beetle. The root beetles are sold for \$5 per beetle. Some beetles may be available for free by contacting the Illinois Natural History Survey (INHS; 217-333-6846). The INHS also conducts a workshop each spring at Volo Bog for individuals and groups interested in learning how to rear their own beetles.

### **Option 3: Control by Hand**

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 since regrowth is common. 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 4: 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 impractical (i.e., large expanses of a wetland or woodland), chemical treatments may not be an option because in order to chemically treat the area, a broadcast application would be needed. Because many of the herbicides 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 an herbicide-soaked device. Trees are normally treated by cutting off a ring of bark around the trunk (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®, Round-up™, Eagre™, or AquaPro™), are sold in 2.5 gallon jugs, and cost approximately \$200 and \$350, 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. A girdling tool costs about \$150.

## **Objective VI: Enhance Wildlife Habitat Conditions**

The key to increasing wildlife species in and around a lake can be summed up in one word: habitat. Wildlife need the same four things all living creatures need: food, water, shelter, and a place to raise their young. Since each wildlife species has specific habitat requirements, which fulfill these four basic needs, providing a variety of habitats will increase the chance that wildlife species may use an area. Groups of wildlife are often associated with the types of habitats they use. For example, grassland habitats may attract wildlife such as northern harriers, bobolinks, meadowlarks, meadow voles, and leopard frogs. Marsh habitats may attract yellow-headed blackbirds and sora rails, while manicured residential lawns attract house sparrows and gray squirrels. Thus, in order to attract a variety of wildlife, a mix of habitats are needed. In most cases quality is more important than quantity (i.e., five 0.1-acre plots of different habitats may not attract as many wildlife species than one 0.5 acre of one habitat type).

It is important to understand that the natural world is constantly changing. Habitats change or naturally succeed to other types of habitats. For example, grasses may be succeeded by shrub or shade intolerant tree species (e.g., willows, locust, and cottonwood). The point at which one habitat changes to another is rarely clear, since these changes usually occur over long periods of time, except in the case of dramatic events such as fire or flood.

In all cases, the best wildlife habitats are ones consisting of native plants. Unfortunately, non-native plants dominate many of our lake shorelines. Many of them escaped from gardens and landscaped yards (i.e., purple loosestrife) while others were introduced at some point to solve a problem (i.e., reed canary grass for erosion control). Wildlife species prefer native plants for food, shelter, and raising their young. In fact, one study showed that plant and animal diversity was 500% higher along naturalized shorelines compared to shorelines with conventional lawns (University of Wisconsin – Extension, 1999).

### **Option 1: No Action**

This option means that the current land use activities will continue. No additional techniques will be implemented. Allowing a field to go fallow or not mowing a manicured lawn would be considered an action.

#### ***Pros***

Taking no action may maintain the current habitat conditions and wildlife species present, depending on environmental conditions and pending land use actions. If all things remain constant there will be little to no effect on lake water quality and other lake uses.

#### ***Cons***

If environmental conditions change or substantial land use actions occur (i.e., development) wildlife use of the area may change. For example, if a new housing

development with manicured lawns and roads is built next to an undeveloped property, there will probably be a change in wildlife present.

Conditions in the lake (i.e., siltation or nutrient loading) may also change the composition of aquatic plant and invertebrate communities and thus influence biodiversity. Siltation and nutrient loading will likely decrease water clarity, increase turbidity, increase algal growth (due to nutrient availability), and decrease habitat for fish and wildlife.

### ***Costs***

The financial cost of this option may be zero. However, due to continual loss of habitats many wildlife species have suffered drastic declines in recent years. The loss of habitat affects the overall health and biodiversity of the lake's ecosystems.

### **Option 2: Increase Habitat Cover**

This option can be incorporated with Option 3 (see below). One of the best ways to increase habitat cover is to leave a minimum 25-foot buffer between the edge of the water and any mowed grass. Allow native plants to grow or plant native vegetation along shorelines, including emergent vegetation such as cattails, rushes, and bulrushes (see the table in Appendix A for costs and seeding rates). This will provide cover from predators and provide nesting structure for many wildlife species and their prey. It is important to control or eliminate non-native plants such as buckthorn, purple loosestrife, garlic mustard, and reed canary grass, since these species outcompete native plants and provide little value for wildlife.

Occasionally high mowing (with the mower set at its highest setting) may have to be done for specific plants, particularly if the area is newly established, since competition from weedy and exotic species is highest in the first couple years. If mowing, do not mow the buffer strip until after July 15 of each year. This will allow nesting birds to complete their breeding cycle.

Brush piles make excellent wildlife habitat. They provide cover as well as food resources for many species. Brush piles are easy to create and will last for several years. They should be placed at least 10 feet away from the shoreline to prevent any debris from washing into the lake.

Trees that have fallen on the ground or into the water are beneficial by harboring food and providing cover for many wildlife species. In a lake, fallen trees provide excellent cover for fish, basking sites for turtles, and perches for herons and egrets.

Increasing habitat cover should not be limited to the terrestrial environment. Native aquatic vegetation, particularly along the shoreline, can provide cover for fish and other wildlife.

### ***Pros***

Increased cover will lead to increased use by wildlife. Since cover is one of the most important elements required by most species, providing cover will increase the chances of wildlife using the shoreline. Once cover is established, wildlife usually have little problem finding food, since many of the same plants that provide cover also supply the food the wildlife eat, either directly (seeds, fruit, roots, or leaves) or indirectly (prey attracted to the plants).

Additional benefits of leaving a buffer include: stabilizing shorelines, reducing runoff which may lead to better water quality, and deterring nuisance Canada geese. Shorelines with erosion problems can benefit from a buffer zone because native plants have deeper root structures and hold the soil more effectively than conventional turfgrass. Buffers also absorb much of the wave energy that batters the shoreline. Water quality may be improved by the filtering of nutrients, sediment, and pollutants in run-off. This has a “domino effect” since less run-off flowing into a lake means less nutrient availability for nuisance algae, and less sediment means less turbidity, which leads to better water quality. All this is beneficial for fish and wildlife, such as sight-feeders like bass and herons, as well as people who use the lake for recreation. Finally, a buffer strip along the shoreline can serve as a deterrent to Canada geese from using a shoreline. Canada geese like flat, open areas with a wide field of vision. Ideal habitat for them are areas that have short grass up to the edge of the lake. If a buffer is allowed to grow tall, geese may choose to move elsewhere.

### ***Cons***

There are few disadvantages to this option. However, if vegetation is allowed to grow, lake access and visibility may be limited. If this occurs, a small path can be made to the shoreline. Composition and density of aquatic and shoreline vegetation are important. If vegetation consists of non-native species such as or Eurasian water milfoil or purple loosestrife, or in excess amounts, undesirable conditions may result. A shoreline with excess exotic plant growth may result in a poor fishery (exhibited by stunted fish) and poor recreation opportunities (i.e., boating, swimming, or wildlife viewing).

### ***Costs***

The cost of this option would be minimal. The purchase of native plants can vary depending upon species and quantity. Based upon 100 feet of shoreline, a 25-foot buffer planted with a native forb and grass seed mix would cost between \$165-270 (2500 sq. ft. would require 2.5, 1000 sq. ft. seed mix packages at \$66-108 per package). This does not include labor that would be needed to prepare the site for planting and follow-up maintenance. This cost can be reduced or minimized if native plants are allowed to grow. However, additional time and labor may be needed to insure other exotic species, such as buckthorn, reed canary grass, and purple loosestrife, do not become established.

### **Option 3: Increase Natural Food Supply**

This can be accomplished in conjunction with Option 2. Habitats with a diversity of native plants will provide an ample food supply for wildlife. Food comes in a variety of forms, from seeds to leaves or roots to invertebrates that live on or are attracted to the plants. Plants found in the table in Appendix A should be planted or allowed to grow. In addition, encourage native aquatic vegetation, such as water lily (*Nuphar* spp. and *Nymphaea tuberosa*), sago pondweed (*Stuckenia pectinatus*), largeleaf pondweed (*Potamogeton amplifolius*), and wild celery (*Vallisneria americana*) to grow. Aquatic plants such as these are particularly important to waterfowl in the spring and fall, as they replenish energy reserves lost during migration.

Providing a natural food source in and around a lake starts with good water quality. Water quality is important to all life forms in a lake. If there is good water quality, the fishery benefits and subsequently so does the wildlife (and people) who prey on the fish. Insect populations in the area, including beneficial predatory insects, such as dragonflies, thrive in lakes with good water quality.

Dead or dying plant material can be a source of food for wildlife. A dead standing or fallen tree will harbor good populations of insects for woodpeckers, while a pile of brush may provide insects for several species of songbirds such as warblers and flycatchers.

Supplying natural foods artificially (i.e., birdfeeders, nectar feeders, corn cobs, etc.) will attract wildlife and in most cases does not harm the animals. However, “people food” such as bread should be avoided. Care should be given to maintain clean feeders and birdbaths to minimize disease outbreaks.

#### ***Pros***

Providing food for wildlife will increase the likelihood they will use the area. Providing wildlife with natural food sources has many benefits. Wildlife attracted to a lake can serve the lake and its residents well, since many wildlife species (i.e., many birds, bats, and other insects) are predators of nuisance insects such as mosquitoes, biting flies, and garden and yard pests (such as certain moths and beetles). Effective natural insect control eliminates the need for chemical treatments or use of electrical “bug zappers” that have limited effect on nuisance insects.

Migrating wildlife can be attracted with a natural food supply, primarily from seeds, but also from insects, aquatic plants or small fish. In fact, most migrating birds are dependent on food sources along their migration routes to replenish lost energy reserves. This may present an opportunity to view various species that would otherwise not be seen during the summer or winter.

#### ***Cons***

Feeding wildlife can have adverse consequences if populations become dependent on hand-outs or populations of wildlife exceed healthy numbers. This frequently happens when people feed waterfowl like Canada geese or mallard ducks.

Feeding these waterfowl can lead to a domestication of these animals. As a result, these birds do not migrate and can contribute to numerous problems, such as excess feces, which is both a nuisance to property owners and a significant contribution to the lake's nutrient load. Waterfowl feces are particularly high in phosphorus. Since phosphorus is generally the limiting factor for nuisance algae growth in many lakes in the Midwest, the addition of large amounts of this nutrient from waterfowl may exacerbate a lake's excessive algae problem. In addition, high populations of birds in an area can increase the risk of disease for not only the resident birds, but also wild bird populations that visit the area.

Finally, tall plants along the shoreline may limit lake access or visibility for property owners. If this occurs, a path leading to the lake could be created or shorter plants may be used in the viewing area.

#### ***Costs***

The costs of this option are minimal. The purchase of native plants and food and the time and labor required to plant and maintain would be the limit of the expense.

#### **Option 4: Increase Nest Availability**

Wildlife are attracted by habitats that serve as a place to raise their young. Habitats can vary from open grasslands to closed woodlands (similar to Options 2 and 3).

Standing dead or dying trees provide excellent habitat for a variety of wildlife species. Birds such as swallows, woodpeckers, and some waterfowl need dead trees to nest in. Generally, a cavity created and used by a woodpecker (e.g., red-headed or downy woodpecker, or common flicker) in one year, will in subsequent years be used by species like tree swallows or chickadees. Over time, older cavities may be large enough for waterfowl, like wood ducks, or mammals (e.g., flying squirrels) to use. Standing dead trees are also favored habitat for nesting wading birds, such as great blue herons, night herons, and double-crested cormorants, which build stick nests on limbs. For these birds, dead trees in groups or clumps are preferred as most herons and cormorants are colonial nesters.

In addition to allowing dead and dying trees to remain, erecting bird boxes will increase nesting sites for many bird species. Box sizes should vary to accommodate various species. Swallows, bluebirds, and other cavity nesting birds can be attracted to the area using small artificial nest boxes. Larger boxes will attract species such as wood ducks, flickers, and owls. A colony of purple martins can be attracted with a purple martin house, which has multiple cavity holes, placed in an open area near water.

Bat houses are also recommended for any area close to water. Bats are voracious predators of insects and are naturally attracted to bodies of water. They can be enticed into roosting in the area by the placement of bat boxes. Boxes should be constructed of rough non-treated lumber and placed >10 feet high in a sunny location.

### ***Pros***

Providing places where wildlife can rear their young has many benefits. Watching wildlife raise their young can be an excellent educational tool for both young and old.

The presence of certain wildlife species can help in controlling nuisance insects like mosquitoes, biting flies, and garden and yard pests. This eliminates the need for chemical treatments or electric “bug zappers” for pest control.

Various wildlife species populations have dramatically declined in recent years. Since, the overall health of ecosystems depend, in part, on the role of many of these species, providing sites for wildlife to raise their young will benefit not only the animals themselves, but the entire lake ecosystem.

### ***Cons***

Providing sites for wildlife to raise their young have few disadvantages. Safety precautions should be taken with leaving dead and dying trees due to the potential of falling limbs. Safety is also important when around wildlife with young, since many animals are protective of their young. Most actions by adult animals are simply threats and are rarely carried out as attacks.

Parental wildlife may chase off other animals of its own species or even other species. This may limit the number of animals in the area for the duration of the breeding season.

### ***Costs***

The costs of leaving dead and dying trees are minimal. The costs of installing the bird and bat boxes vary. Bird boxes can range in price from \$10-100.00. Purple martin houses can cost \$50-150. Bat boxes range in price from \$15-50.00. These prices do not include mounting poles or installation.

## **Option 5: Limit Disturbance**

Since most species of wildlife are susceptible to human disturbance, any action to curtail disturbances will be beneficial. Limiting disturbance can include posting signs in areas of the lake where wildlife may live (e.g., nesting waterfowl), establish a “no wake” area, boat horsepower or speed limits, or establish restricted boating hours. These are examples of time and space zoning for lake usage. Enforcement and public education are needed if this option is to be successful. In some areas, off-duty law enforcement officers can be hired to patrol the lake.

### ***Pros***

Limiting disturbance will increase the chance that wildlife will use the lake, particularly for raising their young. Many wildlife species have suffered population declines due to loss of habitat and poor breeding success. This is due in part to their sensitivity to disturbance.

This option also can benefit the lake in other ways. Limited boat traffic may lead to less wave action to batter shorelines and cause erosion, which results in suspension of nutrients and sediment in the water column. Less nutrients and sediment in the water column may improve water quality by increasing water clarity and limiting nutrient availability for excessive plant or algae growth.

Recreation activities such as canoeing and paddleboating may be enhanced by the limited disturbance.

### ***Cons***

One of the strongest oppositions to this option would probably be from the powerboat users and water skiers. However, this problem may be solved if a significant portion of the daylight hours and the use of the middle part of the lake (assuming the lake is deep enough) are allowed for powerboating. For example, powerboating could be allowed between 9 AM and 6 PM within the boundaries established by “no wake” restricted area buoys.

### ***Costs***

The costs of this option include the purchase and placement of signs and public educational materials as well as enforcement. Off-duty law enforcement officers usually charge \$25/hour to enforce boating laws or local ordinances.

## **Objective VII: Canada Goose Management**

Canada geese (*Branta canadensis*) are migratory waterfowl common throughout North America. Geese in urban areas can be undesirable primarily due to the large amount of feces they leave behind. Recreational activities on lawns and parks are impeded due to goose feces. Large amounts of feces may end up in the water, either directly from geese on the water or rainwater runoff from lawns where feces have accumulated. Goose feces are high in organic phosphorus. High nutrient levels, particularly phosphorus, can contribute to excessive algae growth in lakes. This may inhibit other recreational activities such as boating or swimming, as well as create poor habitat for fish and wildlife, and possibly bad odors when the algae decays.

Geese become problematic for many reasons. They seek locations that have open water, adequate food supplies, and safety from predators. If these factors are present, geese may not migrate. Since geese exhibit a high level of site fidelity, they return to (or stay at) the same area each year. Thus, adults will likely come back to the same area year after year to nest. If conditions remain optimal, one pair of geese can quickly multiply causing additional problems. Increased development in Lake County has inadvertently created ideal habitat for goose populations. Manicured lawns mowed to the edge of lakes and detention ponds provide geese with open areas with ample food and security. Other conditions that encourage goose residency include open water during winter (primarily the result of aerators in lakes and ponds), mild winters, and people feeding birds with bread or similar human food.

Large populations of geese pose a potential disease threat both to resident and wild populations of waterfowl. This problem may be more serious in residential populations since these birds stay in one area for long periods of time are more likely to transmit any disease to neighboring groups of geese. There is no threat of disease transmission to humans or domestic dogs and cats since most of the diseases are specific to birds.

### **Option 1: No Action**

#### ***Pros***

This option has no costs, however, increasing numbers of geese will most likely exacerbate existing problems and probably create new ones, which in the future may cost more than if the problems are addressed immediately.

#### ***Cons***

If current conditions continue and no action is taken, numbers of Canada Geese and problems associated with them will likely increase. An increase of goose feces washed into a lake will increase the lake's nutrient load and eventually may have a detrimental impact on water quality through excessive algae growth. One study (Manny et al. 1975) documented that each goose excretes 0.072 lbs of feces per day. This may not seem like a significant amount, but if 100 geese are present (many lakes in the county can experience 1,000 or more at a time) that equates to over 7 lbs of feces per day! Algae blooms may negatively impact recreational

uses such as swimming, boating, and fishing. In addition, when algae dies, odor problems and depleted oxygen levels in the water occur. Increased numbers of geese may also result in overgrazed areas of grass.

### ***Costs***

There are a few short-term financial costs with this option. Costs of cleaning feces off lawns or piers are probably more psychological or physical than financial. Long-term costs may be more indirect, including increased nutrient deposition into lakes which may promote excessive algae and plants. Costs incurred may include money needed to control algae with algaecides.

### **Option 2: Removal**

Since Canada Geese are considered migratory waterfowl, both state and federal laws restrict taking or harassing geese. Under the federal Migratory Bird Treaty Act, it is illegal to kill or capture geese outside a legal hunting season or to harass their nests without a permit. If removal of problematic geese is warranted or if nest and egg destruction is an option, permits need to be obtained from the Illinois Department of Natural Resources (217- 782-6384) and the U.S. Fish and Wildlife Service (217-241-6700).

Hunting is one of the most effective techniques used in goose management. However, since many municipalities have ordinances prohibiting the discharge of firearms, reduction of goose numbers by hunting in urban areas (i.e., lakes, ponds, and parks) may not be an option. Hunting does occur on many lakes in the county, but certain regulations apply (e.g., 100 yard minimum distance from any residential property). Contact the Illinois Department of Natural Resources for dates and regulations regarding the waterfowl hunting seasons. Also, contact local and county law enforcement agencies regarding any ordinances concerning hunting within municipal boundaries.

Egg addling, or destroying the egg by shaking, piercing, or freezing, can be used to reduce or eliminate a successful clutch. Eggs should be returned to the nest so the hen goose does not re-lay another clutch. However, if no eggs hatch, she may still lay another clutch. Leaving one or two eggs unaltered and allowing them to hatch may prevent another clutch from being laid and reduces the total year's reproduction. Egg addling requires a state and federal permit.

The capture and relocation of geese is no longer a desirable option. First, relocated geese may return to the same location where they were captured. Second, there is a concern over potential disease transmission from relocated geese to other goose populations. Finally, since goose numbers in Illinois are already high there is no need to supplement other populations in the area.

### ***Pros***

Removing a significant portion of a problem goose population can have a positive effect on the overall health of a lake. Reduction of feces on lawns and parks is beneficial to recreation users of all types. Less feces in the water means less

phosphorus available for nuisance plant and algae growth. Thus, the overall water quality of the lake may be improved by this reduction in phosphorus.

### ***Cons***

If the habitat conditions still exist, more geese will likely replace any that were removed. Thus, money and time used removing geese may not be well spent unless there is a change in habitat conditions.

### ***Costs***

A Illinois residential waterfowl hunting license (including state and federal waterfowl stamps) is \$39.00 for the 2002-2004 hunting season. For depredation permits, there is a \$25 fee for the federal permit. Once the federal permit is issued the state permit can be obtained at no charge.

### **Option 3: Dispersal/Repellent Techniques**

Several techniques and products are on the market that claim to disperse or deter geese from using an area. These techniques can be divided into two categories: harassment and chemical. With both types of techniques it is important to implement any action early in the season, before geese establish territories and begin nesting. Once established, the dispersal/repellent techniques may be less effective and geese more difficult to coerce into leaving.

The goal with harassment techniques is to frighten geese from an area using sounds or objects. Various products are available that simulate natural predators (i.e., plastic hawks and owls) or otherwise make geese nervous (i.e., balloons, shiny tape, and flags). Other products emit noises, such as propane cannons, which can be set on a timer to go off at programmed intervals (e.g., every 20-30 seconds), or recorded goose distress calls which can be played back over a loudspeaker or tape player. Over time these techniques may be ineffective, since geese become acclimated to these devices. Most of these products are more effective when used in combination with other techniques.

Another technique that has become popular is using dogs or swans to harass geese. Dogs can be used primarily in the spring and fall to keep birds from using an area by herding or chasing geese away from a particular area. Any dogs used for this purpose should be well trained and under the owners control at all times. Professional trainers can be contracted to use their dogs for this purpose. Dogs should not be used during the summer when geese are unable to fly due to molting. Swans are used because they are naturally aggressive in defending their territory, including chasing other waterfowl away from their nesting area. Since wild swans cannot be used for this technique, non-native mute swans are used. However, mute swans are not as aggressive and in some case are permissive of geese. Again, using a combination of techniques would be most effective.

Chemical repellents can be used with some effectiveness. New products are continually coming out that claim to rid an area of nuisance geese. Several products (ReJeX-iT® and GooseChase™) are made from methyl-anthranilate, a natural occurring compound, and can be sprayed on areas where geese are feeding. The spray makes the grass distasteful

and forces geese to move elsewhere to feed. Another product, Flight Control™, works similarly, but has the additional benefit of absorbing ultra violet light making the grass appear as if it was not a food source. The sprays need to be reapplied every 14-30 days, depending upon weather conditions and mowing frequency.

### ***Pros***

With persistence, harassment and/or use of repellants can result in reduced or minimal usage of an area by geese. Fewer geese may mean less feces and cleaner yards and parks, which may increase recreational uses along shorelines. If large numbers of geese were once present, the reduction of fecal deposits into the lake may help minimize the amount of phosphorus entering the water. Less phosphorus in the water means less “food” available for plant and algae growth, which may have a positive effect of water quality. Finally, any areas overgrazed by geese may have a chance to recover.

### ***Cons***

The effectiveness of harassment techniques is reduced over time since geese will adapt to the devices. However, their effectiveness can be extended if the devices are moved to different locations periodically, or used in conjunction with other techniques.

Use of dogs can be time consuming, since the dog must be trained and taken care of. Dogs must also be used frequently in the beginning of the season to be effective at deterring geese. This requires time of the dog owner as well. Dogs (frequently herding dogs, like border collies) that are effective at harassing or herding geese are typically may not be the best pets for the average homeowner. They are bred as working dogs and consequently have high levels of energy that requires the owner’s attention.

Repelling or chasing away geese from an area only solves the goose problem for that area and most likely moves the geese (and the problem) to another area. As long as there is suitable habitat nearby, the geese will not wander very far.

### ***Costs***

Costs for the propane cannons are approximately \$660 (\$360 for the cannon, \$300 for a timer), not including the propane tank. The cost of ReJeX-iT® is \$80/gallon, GooseChase™ is \$95/gallon, and Flight Control™ costs \$200/gallon. One gallon covers one acre of turf using ReJeX-iT® and, GooseChase™, and two acres using Flight Control™.

### **Option 4: Exclusion**

Erecting a barrier to exclude geese is another option. In addition to a traditional wood or wire fence, an effective exclusion control is to suspend netting over the area where geese are unwanted. Geese are reluctant to fly or walk into the area. A similar deterrent that is often used is a single string or wire suspended a foot or so above the ground along the length of the shoreline.

### ***Pros***

Depending on the type of barrier used, areas of exclusion will have less fecal mess and may have higher recreational uses. Vegetation that was overgrazed by geese may also be able to recover.

### ***Cons***

This technique will not be effective if the geese are using a large area. Also, use of the area by people is severely limited if netting is installed. Fences can also limit recreational uses. The single string or wire method may be effective at first, but geese often learn to go around, over, or under the string after a short period of time. Finally, excluding geese from one area will force them to another area on a different part of the same lake or another nearby lake. While this solves one property owners problem, it creates one (or makes one worse) for another. Also, problems associated with excess feces entering the lake (i.e., increased phosphorus levels) will continue.

### ***Costs***

The costs of these techniques are minimal, unless a wood or wire fence is constructed. String, wire, or netting can be purchased or made from materials at local stores.

## **Option 5: Habitat Alteration**

One of the best methods to deter geese from using an area is through habitat alteration. Habitats that consist of mowed turfgrass to the edge of the shoreline are ideal for geese. Low vegetation near the water allows geese to feed and provides a wide view with which to see potential predators. In general, geese do not favor habitats with tall vegetation. To achieve this, create a buffer strip (approximately 10-20 feet wide) between the shoreline and any mowed lawn. Planting natural shoreline vegetation (i.e., bulrushes, cattails, rushes, grasses, shrubs, and trees, etc.) or allowing the vegetation to establish naturally can create buffer strips. A table in Appendix A has a list of native plants, seeding rates, and approximate costs that can be used when creating buffer strips.

Geese prefer ponds and lakes that have shorelines with gentle slopes to ones with steep slopes. While this alone will not prevent geese from using an area, steeper slopes used along with other techniques will be more effective. This option may not be practical for existing lake shorelines since any grading and/or filling would require permits and surveys, which would drive up the costs of redoing the shoreline considerably.

Aeration systems that run into the fall and winter prevent the lake from freezing, thus not forcing geese to migrate elsewhere. To alleviate this problem, turn aerators off during fall and early winter. Once the lake freezes over and the geese have left, wait a few weeks before turning the aerators on again if needed.

### ***Pros***

Altering the habitat in an area can not only make the habitat less desirable for geese, but may be more desirable for many other species of wildlife. A buffer strip has additional benefits by filtering run-off of nutrients, sediments, and pollutants and protecting the shoreline from erosion from wind, wave, or ice action. Finally, the more of the area that is in natural vegetation, the less turfgrass that needs to be constantly manicured and maintained.

### ***Cons***

Converting a portion or all of an area to tall grass or shrub habitat may reduce the lake access or visibility. However, if this occurs, a small path can be made to the lake or shorter plants may be used at the access location in the buffer strip.

### ***Costs***

If minimal amount of site preparation is needed to create a buffer strip, costs can be approximately \$10 per linear foot, plus labor. 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. Compensatory storage is the process of excavating in a portion of a property or floodplain to compensate for the filling in of another portion of the floodplain. The permitting process is costly, running as high as \$1,000-2,000 depending on the types of permits needed.

Once established, a buffer strip of native plants needs little maintenance. If aerators are not run for several months, there will be a reduction in electrical costs.

### **Option 6: Do Not Feed Waterfowl!**

There are few “good things”, if any, that come from feeding waterfowl. Birds become dependent on handouts, become semi-domesticated, and do not migrate. This causes populations to increase and concentrate, which may create additional problems such as diseases within waterfowl populations. The nutritional value in many of the “foods” (i.e., white bread) given to geese and other waterfowl are quite low. Since geese are physiologically adapted to eat a variety of foods, they can actually be harmed by filling-up on human food. Geese that are accustomed to hand feeding may become aggressive toward other geese or even the people feeding the geese.

### ***Costs***

There are no costs to this option, except the public education that is needed to encourage people not to feed waterfowl. In some cases, signs could be posted to discourage waterfowl feeding.

**Reference:**

Manny, B. A., R. G. Wetzel, and W. C. Johnson. 1975. Annual contribution of carbon, nitrogen, and phosphorus by migrant Canada geese to a hardwater lake. *Verh. Internat. Verein. Limnol.* 19:949-951.