2004 SUMMARY REPORT
of
STOCKHOLM AND MARY LEE LAKES

Lake County, Illinois

Prepared by the

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EXECUTIVE SUMMARY

Stockholm & Mary Lee Lakes, located in the Village of Mundelein, Freemont Township, are two manmade basins. The lakes lie within in the Steeple Chase Golf Club and are owned and operated by the Club. Stockholm Lake has a surface area of 13.7 acres with estimated mean and maximum depths of 4.5 and 9.0 feet, respectively. Mary Lee Lake has a surface area of 15.3 acres with estimated mean and maximum depths of 3.1 and 6.1 feet, respectively. The watersheds of Stockholm and Mary Lee Lakes are approximately 130 acres and 208 acres, respectively. The lakes are connected via a spillway and creek from Stockholm Lake to Mary Lee Lake. They receive water primarily from runoff from the golf course surrounding them.

Water quality parameters, such as nutrients, suspended solids, oxygen, temperature and water clarity were measured and the plant community was assessed each month from May-September 2004. The average total phosphorus (TP) concentration in Stockholm Lake (0.208 mg/L) was over three times higher than the county median (0.063 mg/L) and it appears that the TP concentrations are related to internal processes and groundwater input. Total suspended solids (TSS) levels decreased from May to June and then increased ten fold in July before decreasing again in August and September. The increase in July appeared to be related to a dense planktonic algae bloom. Secchi depths (water clarity) followed TSS concentrations during the summer, decreasing when TSS increased and visa versa. The average TP concentration in Mary Lee Lake (0.068 mg/L) was much lower than Stockholm Lake and nearly equal to the county median (0.063 mg/L). TSS levels were also much lower than Stockholm Lake and Secchi depth reached to bottom three of the five sampling months.

Aquatic plants were present in both lakes, but were much denser in Mary Lee Lake, where no herbicides are used. Reward® is used to treat curlyleaf pondweed in Stockholm Lake early in the summer. Mary Lee Lake has plants growing to the surface across nearly its entire surface area and has a large amount of floating plants as well. Both lakes are surrounded entirely by the Steeple Chase Golf Club, with a small amount of residential and agricultural land also in their watersheds. Stockholm Lake was eroding along 10% of its shoreline, while Mary Lee Lake exhibited no erosion. Both lakes have a large problem with exotic upland plant and tree species, including common buckthorn, purple loosestrife, honeysuckle, reed canary grass and Queen Anne's lace which were present along the majority of Stockholm and Mary Lee's shorelines. Steps should be taken to rid the lakes of these plant species, as they do not provide quality wildlife habitat or erosion control. Despite the presence of the golf course, a large number of wildlife species were observed around the lakes. It is, therefore, very important that the shoreline areas around Mary Lee be kept naturalized and buffer and natural shoreline around Stockholm Lake be improved where possible to provide appropriate habitat for birds and other animals into the future.

LAKE IDENTIFICATION AND LOCATION

Stockholm & Mary Lee Lakes are located in the Village of Mundelein, Freemont Township (T 43N, R 11E, S 26). The lakes lie within in the Steeple Chase Golf Club and are owned and operated by the Club. Stockholm Lake has a surface area of 13.7 acres with an estimated mean and maximum depths of 4.5 and 9.0 feet, respectively, and a volume of 62 acre-feet. Mary Lee Lake has a surface area of 15.3 acres with mean and maximum depths of 3.1 and 6.1 feet, respectively, and an estimated lake volume of 46.9 acre-feet. The watershed of Mary Lee Lake encompasses approximately 208 acres, draining Stockholm Lake and its watershed (130 acres), and the area immediately surrounding it (Figure 1). The watershed to lake surface area ratios of Stockholm and Mary Lee Lakes are approximately 9:1 and 14:1, respectively. These are considered relatively small and are positive in that this may help prevent serious water quality problems that often accompany a larger watershed to lake ratios. However, lakes with small ratios often experience more severe water level fluctuations throughout the summer as well as the accumulation of solids and nutrients because lake retention time (the time it takes all the water in the lake to be replaced) is high. This is true of the two lakes, as it takes approximately 551 and 259 days, respectively for all of the water volume of Stockholm and Mary Lee Lakes to flush out of the lakes and be replenished by new water. This means that according to runoff data, the lakes flush only once or twice per year and that solids and nutrients are likely building up in the systems. Water level fluctuations during the summer 2004 were very stable in Stockholm Lake, and only fluctuated during the first part of the summer in Mary Lee Lake. However, Stockholm Lake is regulated by inputs from a deep well and withdrawals for irrigation, which may affect the flushing rate of the two lakes.

Based on the most recent land use survey of the Stockholm and Mary Lee Lakes' watershed, conducted in 2000, Public Open Space (Steeple Chase Golf Club) dominates the watershed, making up approximately 48% of Stockholm's and 49% of Mary Lee's watersheds (Figure 2). The lakes and agricultural areas to the north make up 37-41% of each watershed (Table 1, Appendix A). The large amount of golf course area that makes up the watersheds can be good or bad, depending on the activities of golf course managers that maintain the course. If educated about how their daily activities affect the lake, they can take steps to prevent additional sediment and nutrients from entering the water and there could be some improvement in water quality over time. However, if managers go about their daily activities with no regard as to how it may affect the lake, water quality could be degraded over time. Stockholm outlets through a spillway and creek to Mary Lee Lake, which outlets over a spillway to Indian Creek. The lakes are located in the Indian Creek sub basin, within the Des Plaines River watershed.

BRIEF HISTORY OF STOCKHOLM AND MARY LEE LAKES

It is unknown exactly how these two lakes were constructed, but an aerial photograph from 1939 shows that Mary Lee Lake existed as the lake it is today, while Stockholm Lake was a low, wetland in a farm field. Mary Lee Lake is surrounded by farmland, so the origin of the lake may have been as a farm pond. In 1960, Stockholm Lake was constructed and both lakes were still mostly surrounded by agricultural land. Development of the golf club around the lakes began in 1990. Two other ponds exist as part of the golf club. Pond #9 is 0.27 acres in size and Pond #13 is 0.38 acres in size. Management activities began in 1991. Use of the lakes by the general public is totally restricted and their main use is aesthetics.

SUMMARY OF CURRENT AND HISTORICAL LAKE USES

Although Mary Lee Lake has never been treated with herbicides and/or algaecides, Stockholm Lake has been treated for many years (first by Scientific Aquatic Weed Control and now by a licensed applicator on staff with the golf club). A Sonar™ treatment was conducted in 2002, but this was not deemed a viable herbicide option because irrigation was prohibited for six weeks after treatment. Currently, Stockholm Lake is treated with Reward® to target curlyleaf pondweed and with a chelated copper product, Captain®, to target filamentous and planktonic algae. Both chemicals are sprayed from shore. Pond #13 is also treated with Reward® and Captain® throughout the summer.

LIMNOLOGICAL DATA – WATER QUALITY: STOCKHOLM LAKE

Water samples collected from Stockholm were analyzed for a variety of water quality parameters (See Appendix B for methodology). Samples were collected three feet from the surface and three feet off of the lake bottom from the deepest area of the lake (Figure 3). Stockholm remained mixed throughout the summer and the surface waters were well oxygenated except in August. As a result, only the near surface water data will be discussed. Dissolved oxygen (DO) concentrations fell to nearly 5.0 mg/l (a level below which many aquatic organisms become stressed) in August, probably as a result of the decomposition of planktonic algae that had bloomed in July. When a high density of organic material is present, the biological oxygen demand (BOD) in a water body can be very high. A high BOD means that, regardless of the amount of oxygen present, the demand for that oxygen by living organisms (especially bacteria that decompose organic matter such as algae) is very high, and a decrease in DO may occur for a period of time. Photosynthesis does not occur during the night to replace oxygen being taken up by respiration, and oxygen levels often decline overnight and into the early morning before rebounding by mid-morning with the sun. This is especially true in nutrient enriched lakes, such as Stockholm Lake.

Phosphorus is a nutrient that can enter lakes through runoff or be released from or attached to suspended lake sediment, and high levels of phosphorus typically trigger algal blooms or produce high plant density. The average phosphorus concentration in Stockholm Lake was 0.208 mg/l, over three times higher than the Lake County median of 0.063 mg/l (Table 2, Appendix A). The average May total phosphorus (TP) concentration was exactly the same as the county median. However, the TP concentration tripled from May to June and remained extremely high the rest of the summer. Soluble reactive phosphorus (SRP), a dissolved form of phosphorus that is readily available for uptake by algae, was also very high in Stockholm Lake (0.081 mg/l). It appears that fluctuations in the TP and SRP concentrations are related the amount of available nitrogen in the water column, the input of groundwater and removal of lake water for irrigation. During the summer of 2004, Stockholm was nitrogen limited from June-September. Typically, lakes are either phosphorus (P) or nitrogen (N) limited. This means that one of these nutrients is in short supply relative to the other and that any addition of phosphorus or nitrogen to the lake might result in an increase of plant or algal growth. Other resources necessary for plant and algae growth include light or carbon, but these are typically not limiting. Most lakes in Lake County are phosphorus limited, but to compare the availability of nitrogen and phosphorus, a ratio of total nitrogen to total phosphorus (TN:TP) is used. Ratios less than or equal to 10:1 indicate nitrogen is limiting. Ratios greater than or equal to 15:1 indicate that phosphorus is limiting. Ratios greater than 10:1, but less than 15:1 indicate that there are enough of both nutrients to facilitate excess algal or plant growth. Stockholm had an average TN:TP ratio of 7:1. This indicates that the lake, overall, is nitrogen limited, which means that, at times, there was not enough N in the water column to sustain algae growth. If algae is not growing, it will utilize neither N nor P from the water, resulting in a build-up of unused phosphorus. These conditions actually favor the growth of blue-green algae. This type of algae is able to remove nitrogen from the atmosphere and convert it into a usable form. As a result of the nitrogen limitation in Stockholm Lake, a dense blue-green algae bloom of the species *Lyngbia* appeared in July and remained at a relatively high density through September. Phosphorus levels began to drop in August after the bloom appeared because the algae was utilizing the phosphorus for its growth (Table 2, Appendix A).

Additionally, a groundwater well located along the shoreline of Stockholm Lake was run in August and September. This well pumps 185 gallons per minute of water into Stockholm Lake. A sample of the well water was collected on October 27, 2004 and sampled for TP concentration, which was 0.013 mg/L. This is very low relative to the TP concentration in Stockholm Lake. It appears that the addition of this low-TP water may have also contributed to the decrease in TP from July to September.

In October 2003, a soil test conducted on the golf course showed the soil was poor in phosphorus. Since then, phosphorus fertilization has been carried out on all 26 fairways with caution. The greens are fertilized the most consistently, while the rough is fertilized very four years. Fertilizer was applied to the fairways at a rate of 100 pounds per acre in April, May, August and October 2004.

Total suspended solids (TSS) is a measure of the amount of suspended material, such as algae or sediment, in the water column. High TSS values are typically correlated with poor water clarity and can be detrimental to many aspects of the lake ecosystem, including the plant and fish communities. A large amount of material in the water column can inhibit successful predation by sight-feeding fish, such as bass and pike, or settle out and smother fish eggs. High turbidity caused by sediment or algae can shade out native aquatic plants, resulting in their reduction or disappearance from the littoral zone. This eliminates the benefits provided by plants, such as habitat for many fish species and stabilization of the lake bottom. The average TSS concentration in Stockholm Lake (10.6 mg/l) was higher than the median value for Lake County lakes (7.9 mg/l). TSS increased dramatically (tenfold) from 2.2 mg/l in June to 29.2 mg/l in July with the appearance of the blue-green algae bloom. Because TP was not the controlling factor in the growth of the algae, TSS and TP were only slightly correlated during the summer (Figure 4).

Secchi depth (water clarity) in Stockholm Lake was closely related to TSS throughout the summer, reaching the bottom in May and June before dropping to 1.5 feet in July as a result of the algae bloom and increased TSS concentration (Figure 5). Water clarity rebounded somewhat in August before decreasing again in September.

Conductivity is the measure of different chemical ions in solution. As the concentration of these ions increases, conductivity increases. The conductivity of a lake is dependent on the lake and watershed geology, the size of the watershed flowing into the lake, the land uses within that watershed, and evaporation and bacterial activity. Conductivity has been shown to be highly correlated (in urban areas) with chloride ions found in road salt mixtures. Water bodies most subject to the impacts of road salts are streams, wetlands or lakes draining major roadways. Average 2004 conductivity in Stockholm Lake (0.7023 mS/cm) was near the county median of 0.7652 mS/cm). Conductivity was highest in May and decreased throughout the summer until it increased again slightly in September. Typically, when road salt is the primary cause of an increase in conductivity, levels will be very high in May and June, when spring runoff brings a large amount of salt-laden water into the lake and then decreases throughout the summer. However, less than 5% of the watershed of Stockholm Lake is made up of roads. It is likely that the fertilizer and lawn chemicals used on the golf course are contributing to the higher concentration in May as compared to other months. At this time, however, there does not seem to be a problem with conductivity levels in Stockholm Lake.

Phosphorus levels can also be used to indicate the trophic state (productivity level) of a lake. The Trophic State Index (TSI) uses phosphorus, chlorophyll *a* (algae biomass) and Secchi depth to classify and compare lake trophic states using just one value. The TSI is set up so that an increase in phosphorus concentration is related to an increase in algal biomass and a corresponding decrease in Secchi depth. A moderate TSI value (TSI=40-49) indicates mesotrophic conditions, typically characterized by relatively low nutrient concentrations, low algae biomass, adequate DO concentrations and relatively good water clarity. High TSI values indicate eutrophic (TSI=50-69) to hypereutrophic (TSI ≥70) lake conditions, typically characterized by high nutrient concentrations, high algal

biomass, low DO levels, a rough fish population, and low water clarity. Stockholm Lake had an average phosphorus TSI (TSIp) value of 81.1, indicating hypereutrophic conditions. This means that the lake is a highly enriched system with relatively poor quality. The lake ranked 148th out of 161 lakes studied in Lake County since 2000 (Table 4, Appendix A).

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

LIMNOLOGICAL DATA – WATER QUALITY: MARY LEE LAKE

Water samples collected from Mary Lee Lake were analyzed for a variety of water quality parameters (See Appendix B for methodology). Samples were collected three feet below the water surface, from the deepest area of the lake (Figure 3). Mary Lee Lake remained mixed as a result of its shallow morphometry and the effects of wind and wave action across the lake. The surface waters of Mary Lee Lake were well oxygenated in May and June but dissolved oxygen (DO) concentrations fell below 5.0 mg/l (a level below which many aquatic organisms become stressed) in August and September. The primary reason for the low DO concentrations appears to be the decomposition of curlyleaf pondweed, filamentous algae and duckweed (see BOD discussion above).

Phosphorus is a nutrient that can enter lakes through runoff or be released or attached to suspended lake sediment, and high levels of phosphorus typically trigger algal blooms or produce high plant density. The average phosphorus concentration in Mary Lee Lake (0.068 mg/l) was much lower than in Stockholm and was equal to the county median (Table 3, Appendix A). Total phosphorus (TP) concentrations increased dramatically from May to June as a result of a switch from phosphorus limitation in May to nitrogen limitation in June. When the algae and floating plants in the lake were unable to utilize the available phosphorus for growth (see discussion above), TP built up in the water column. The lake switched back to phosphorus limitation in July and TP concentrations then decreased for the remainder of the summer as the algae and duckweed were able to use the phosphorus in the water column again. The difference in TP between the two lakes is primarily related to the difference in the plant communities in the lakes. Mary Lee Lake is not treated with herbicides and, therefore, has a much higher density of submersed and floating plants than Stockholm Lake. These plants provide many benefits to water quality by reducing sediment resuspension and competing with planktonic algae for various resources, including nutrients.

The average TSS concentration in Mary Lee Lake (3.5 mg/l) was half the median value for Lake County lakes (7.5 mg/l). TSS and TP were correlated during the summer, and TSS doubled from May to June with the increase in TP (Figure 6). This was likely the result of decomposing curlyleaf pondweed in June that was releasing phosphorus into the water column and contributing to TSS through organic debris. The average TSS concentration in Mary Lee Lake was one-third the concentration in Stockholm Lake, also as a result of the higher density of aquatic plants.

As a result of relatively low TP and TSS concentrations throughout the summer, Secchi depth (water clarity) on Mary Lee Lake reached the lake bottom in May, August and September and was relatively high in June and July (Table 3, Appendix A). The abundance of plants in the lake contributed to low overall TSS and high Secchi depth by reducing sediment resuspension and competing with planktonic algae for resources (Figure 7).

Conductivity is the measure of different chemical ions in solution. As the concentration of these ions increases, conductivity increases. The conductivity of a lake is dependent on the lake and watershed geology, the size of the watershed flowing into the lake, the land uses within that watershed, and evaporation and bacterial activity. Conductivity has been shown to be highly correlated (in urban areas) with chloride ions found in road salt mixtures. Water bodies most subject to the impacts of road salts are streams, wetlands or lakes draining major roadways. Average 2004 conductivity in Mary Lee Lake (0.6324 mS/cm) was lower than the county median of 0.7503 mS/cm. Conductivity was highest in May and decreased throughout the summer (Table 3, Appendix A). This is typical when the source of conductivity is external and spring runoff causes an increase in conductivity levels. This low level is a good indication that the buffer around Mary Lee Lake is protecting it from golf course runoff, which can cause very high conductivity levels. Stockholm Lake, which does not have a high density of buffer around it has a higher average conductivity level than Mary Lee Lake.

Conductivity changes can occur seasonally and even with depth, but over the long term, increased conductivity can be a good indicator of potential watershed or lake problems or an increase in pollutants entering the lake if the trend is noted over a period of years. High conductivity levels (which often indicate an increase in sodium or potassium chloride) can eventually change the plant community, as more salt tolerant plants take over. Sodium, potassium and chloride ions can bind substances in the sediment, preventing their uptake by plants and reducing native plant densities. Additionally, juvenile aquatic organisms may be more susceptible to high chloride concentrations. It is very important that the buffer around Mary Lee Lake remain intact in order to maintain the protection currently being offered.

Mary Lee Lake had an average phosphorus TSI (TSIp) value of 65.0, indicating eutrophic conditions. This means that the lake is a highly enriched system. Some of the conditions typical to eutrophic lakes were not observed in Mary Lee Lake because the abundance of submersed aquatic plants provided higher water quality relative to other lakes in this category. The lake ranked 76th out of 161 lakes studied in Lake County since 2000 (Table 4, Appendix A).

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

LIMNOLOGICAL DATA – AQUATIC PLANT ASSESSMENT

Aquatic plant surveys were conducted every month for the duration of the study (See Appendix B for methodology). Shoreline plants of interest were also recorded. However, no quantitative surveys were made of these shoreline plant species and these data are purely observational. Light level was measured at one-foot intervals from the water surface to the lake bottom. When light intensity falls below 1% of the level at the water surface, plants are no longer able to grow. Based on 1% light level, Stockholm could have and did support plants across the entire bottom of the lake throughout most of the summer (Appendix C). The only exotic species present was curly leaf pondweed, which dominated the plant community in May and June, before naturally dying back in late July and August. Sago pondweed and *Chara* were also found throughout the summer. The lake was treated with Reward® and Captain® (chelated copper sulfate) on May 27, 2004, targeting curlyleaf pondweed and native pondweed species. The treatment did achieve good control of the plants and the density of plants found in Stockholm Lake was minimal later in the summer (Tables 5 & 6). We recommend that this one-time treatment, mainly to target curlyleaf pondweed, to continue. Curlyleaf pondweed is typically the first plant to appear in the spring because its growth is dependent on cold water temperatures. When the water begins to warm up in late June, curlyleaf pondweed naturally dies back. If this plant can be targeted with a single, early herbicide treatment (possibly early May), it may allow other native pondweeds to flourish during the remainder of the summer. These other pondweeds do not typically reach nuisance levels and an increase in plant density may improve water clarity later in the summer.

Table 5. Aquatic and shoreline plants on Stockholm Lake, May-September 2004.

Aquatic Plants	
Chara	*Chara* sp.
Duckweed	*Lemna minor*
Curlyleaf Pondweed^	*Potamogeton crispus*
Small Pondweed	*Potamogeton pusillus*
Sago Pondweed	*Potamogeton pectinatus*
Horned Pondweed	*Zannichellia palustris*
Shoreline Plants	
Common Milkweed	*Asclepias syriaca*
Sedges	*Carex* sp.
Lamb's Quarters^	*Chenopodium album*
Bull Thistle^	*Cirsium vulgare*
Jewelweed	*Impatiens pallida*
Purple Loosestrife^	*Lythrum salicaria*
Reed Canary Grass^	*Phalaris arundinacea*
Kentucky Blue Grass^	*Poa pratensis*
Softstem Bulrush	*Scirpus validus*
Dandelion^	*Taraxacum officinale*
Common Cattail	*Typha latifolia*
Blue Vervain	*Verbena hastate*
Wild Grape	*Vitis* sp.
Trees/shrubs	
Box Elder	*Acer negundo*
Honeysuckle^	*Lonicera* sp.
Common Buckthorn^	*Rhamnus cathartica*
Weeping Willow	*Salix alba tristis*
Willow	*Salix* sp.

^Exotic plant or tree species

Based on 1% light level, Mary Lee Lake also could have and did support plants across the entire bottom of the lake (Appendix C). Coontail dominated the plant community, which also included a large amount of sago pondweed, giant duckweed, common duckweed and watermeal (Tables 7 & 8). Curlyleaf pondweed was also present at the beginning of the summer. Because no herbicide treatment occurs on Mary Lee Lake, the density of plants is much greater than on Stockholm Lake. As mentioned above, this is one reason that the water quality of this lake is better than that of Stockholm Lake. Aquatic plants typically provide for higher water clarity and lower TSS concentrations by reducing sediment resuspension. They also provide high quality fish habitat and can compete with algae for resources.

FQI (Floristic Quality Index) is a rapid assessment tool designed to evaluate the closeness of the flora of an area to that of undisturbed conditions. It can be used to: 1) identify natural areas, 2) compare the quality of different sites or different locations within a single site, 3) monitor long-term floristic trends, and 4) monitor habitat restoration efforts (Nichols, 1999). Each floating or submersed aquatic plant is assigned a number between 1 and 10 (10 indicating the plant species most sensitive to disturbance). An FQI is calculated by multiplying the average of these numbers by the square root of the number of these plant species found in the lake. A high FQI number indicates that there are a large number of sensitive, high quality plant species present in the lake. Non-native species were also included in the FQI calculations for Lake County lakes. The average FQI for 2000-2004 Lake County lakes is 14.5. Stockholm Lake has an FQI of 12.1, while Mary Lee Lake has an FQI of 13.1.

Table 7. Aquatic and shoreline plants on Mary Lee Lake, May-September 2004.

Aquatic Plants	
Chara	*Chara* sp.
Coontail	*Ceratophyllum demersum*
Small Duckweed	*Lemna minor*
Northern Watermilfoil	*Myriophyllum sibiricum*
Curlyleaf Pondweed	*Potamogeton crispis*
Sago Pondweed	*Potamogeton pectinatus*
White Water Crowsfoot	*Ranunculus longirostris*
Giant Duckweed	*Spirodella polyrhiza*
Watermeal	*Wollfia columbiana*
Shoreline Plants	
Deadly Nightshade	*Atropa belladonna*
Queen Anne's Lace^	*Daucus carota*
Ivyleaf Morning Glory^	*Ipomoea hederacea*
Purple Loosestrife^	*Lythrum salicaria*
Virginia Creeper	*Parthenocissus quinquefolia*
Common Arrowhead	*Sagittaria latifolia*
Common Cattail	*Typha latifolia*
Wild Grape	*Vitis* sp.
Trees/Shrubs	
Box Elder	*Acer negundo*
Honeysuckle^	*Lonicera* sp.
Cottonwood	*Populus deltoides*
Common Buckthorn^	*Rhamnus cathartica*
Willow	*Salix* sp.

^Exotic plant or tree species

LIMNOLOGICAL DATA – SHORELINE ASSESSMENT

A shoreline assessment was conducted at Stockholm and Mary Lee Lakes on July 22, 2004 and August 3, 2004, respectively. The shorelines were assessed for a variety of criteria (See Appendix B for methods), and based on these assessments, several important generalizations could be made. Nearly all of Stockholm's shoreline is developed and comprised of seawall (24%), lawn (15%), buffer (10%), shrub (11%) and wetland (5%). The undeveloped shoreline is comprised entirely of shrub. Only 29% of Mary Lee Lake's shoreline is developed and comprised of buffer and seawall. The undeveloped shoreline is comprised of wetland (39%), woodland (27%) and shrub (6%) (Figure 8). No erosion is occurring on Mary Lee Lake and slight erosion is occurring on only 10% of Stockholm Lake. The large amount of undeveloped shoreline on Mary Lee Lake is ideal for preventing erosion, filtering runoff and providing quality wildlife habitat. It should be maintained as much as possible and this type of buffered shoreline should be added to as much of Stockholm Lake's shoreline as possible.

Invasive plant and tree species, including purple loosestrife, Queen Anne's lace, reed canary grass, lamb's quarters, bull thistle, honeysuckle and buckthorn were present along nearly all of Mary Lee Lake and most of Stockholm Lake. Although the plants and trees were scattered and only at a moderate density, they are extremely invasive and can exclude native plants from the areas they inhabit. Buckthorn and honeysuckle provide poor shoreline stabilization and may lead to increasing erosion problems in the future. Reed canary grass and purple loosestrife inhabit wetland areas and can easily outcompete native plants. Additionally, they do not provide the quality wildlife habitat or shoreline stabilization that native plants provide. Steps to eliminate invasive plant and tree species should be carried out in order to reduce competition with native species and enhance the wildlife habitat already present around the Mary Lee and Stockholm Lakes.

LIMNOLOGICAL DATA – WILDLIFE ASSESSMENT: STOCKHOLM LAKE & MARY LEE LAKE

To our knowledge, a fish survey by the Illinois Department of Natural Resources (IDNR) has never been conducted on the lakes and no fish stocking of any kind has been carried out.

Wildlife observations were made on a monthly basis during water quality and plant sampling activities (See Appendix B for methodology). As a result of the dominance of buffer around Mary Lee Lake, an large number of wildlife species were observed, including the state endangered black-crowned night heron (Table 9). This is unusual for a lake ecosystem that is surrounded by a golf course, but speaks highly of the quality of the buffered areas around the two lakes. It is very important that the shrub and buffered areas around the lakes be maintained to provide the appropriate habitat for birds and other animals now and into the future.

Table 9. Wildlife species observed at Stockholm and Mary Lee Lakes, May-September 2004.

Stockholm Lake

<u>*Birds*</u>	
Double-crested Cormorant	*Phalacrocorax auritus*
Mute Swan	*Cygnus olor*
Canada Goose	*Branta canadensis*
Mallard	*Anas platyrhnchos*
Common Goldeneye	*Bucephala clangula*
Bufflehead	*Bucephala albeola*
Great Egret	*Casmerodius albus*
Green Heron	*Butorides striatus*
Barn Swallow	*Hirundo rustica*
Tree Swallow	*Iridoprocne bicolor*
Rough-wing Swallow	*Stelgidopteryx ruficollis*
American Crow	*Corvus brachyrhynchos*
American Robin	*Turdus migratorius*
Red-winged Blackbird	*Agelaius phoeniceus*
Common Grackle	*Quiscalus quiscula*
Northern Cardinal	*Cardinalis cardinalis*
American Goldfinch	*Carduelis tristis*
<u>*Amphibians*</u>	
Western Chorus Frog	*Pseudacris triseriata triseriata*
<u>*Reptiles*</u>	
Snapping Turtle	*Chelydra serpentina*

Mary Lee Lake

Birds	
Double-crested Cormorant	*Phalacrocorax auritus*
Mute Swan	*Cygnus olor*
Canada Goose	*Branta canadensis*
Mallard	*Anas platyrhnchos*
American Wideon	*Anas americana*
Wood Duck	*Aix sponsa*
Blue-winged Teal	*Anas discors*
Great Egret	*Casmerodius albus*
Great Blue Heron	*Ardea herodias*
Green Heron	*Butorides striatus*
Black-crowned Night Heron*	*Nycticorax nycticorax*
Mourning Dove	*Zenaida macroura*
Belted Kingfisher	*Megaceryle alcyon*
Barn Swallow	*Hirundo rustica*
Tree Swallow	*Iridoprocne bicolor*
American Robin	*Turdus migratorius*
Cedar Waxwing	*Bombycilla cedrorum*
Yellow Warbler	*Dendroica petechia*
Common Yellowthroat	*Geothlypis trichas*
Catbird	*Dumetella carolinensis*
Red-winged Blackbird	*Agelaius phoeniceus*
Common Grackle	*Quiscalus quiscula*
Starling	*Sturnus vulgaris*
Northern Cardinal	*Cardinalis cardinalis*
Mammals	
Muskrat	*Ondatra zibethicu*s
Eastern Cottontail	*Sylvilagus floridanus*
Mink	*Mustela vison*
Amphibians	
American Toad	*Bufo americanus*
Reptiles	
Painted Turtle	*Chrysemys picta*
Snapping Turtle	*Chelydra serpentina*

* Endangered in Illinois

EXISTING LAKE QUALITY PROBLEMS

- *Lack of a Quality Bathymetric Map*

A bathymetric (depth contour) map is an essential tool in effective lake management, especially if the long term lake management plan includes intensive treatments, such as fish stocking, dredging, chemical application or alum application. No bathymetric map currently exists for Stockholm or Mary Lee Lakes. Morphometric data obtained in the creation of a bathymetric map is necessary for calculation of equations for correct application of many types of treatments. It is also necessary to determine the volume of water affected by low DO concentrations.

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

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

- *Invasive Shoreline Plant Species*

Numerous exotic plant species have been introduced into our local ecosystems. Some of these plants are aggressive, quickly out-competing native vegetation and flourishing in an environment where few natural predators exist. The outcome is a loss of plant and animal diversity. Reed canary grass and purple loosestrife are exotic plants found in wetland habitat. They spread very quickly and are not well utilized by wildlife. Buckthorn, Canada thistle and honeysuckle are aggressive shrub species that grow along lake shorelines as well as most upland habitats. They shade out other plants and are quick to become established on disturbed soils. Exotic shoreline plants species are present along most of the shoreline of Stockholm Lake and Mary Lee Lake, and attempts should be made to control their spread before they become a larger problem.

POTENTIAL OBJECTIVES FOR THE STOCKHOLM & MARY LEE LAKES MANAGEMENT PLAN

I. Create a Bathymetric Map, Including a Morphometric Table
II. Participate in the Volunteer Lake Monitoring Program
III. Eliminate or Control Invasive Species

OPTIONS FOR ACHIEVING THE LAKE MANAGEMENT PLAN OBJECTIVES

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

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

Objective II: Participate in the Volunteer Lake Monitoring Program

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

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

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

For more information about the VLMP contact:

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Objective III: Eliminate or Control Invasive Species

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

Buckthorn and honeysuckle are aggressive shrub species that grow along lake shorelines as well as most upland habitats. They shade out other plants and are quick to become established on disturbed soils. Reed canary grass is an aggressive plant that if left unchecked will dominate an area, particularly a wetland or shoreline, in a short period of time. Since it begins growing early in the spring, it quickly out-competes native vegetation that begins growth later in the year. Control of 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 (*Allilaria officianalis*) or honeysuckle (*Lonicera* spp.) as well as some aggressive native species, such as box elder (*Acer negundo*).

Presence of exotic species along a lakeshore is by no means a death sentence for the lake or other plant and animal life. If controlled, many exotic species can perform many of the original functions that they were brought here for. For example, reed canary grass was imported for its erosion control properties. It still contributes to this objective (offering better erosion control than commercial turfgrass), but needs to be isolated and kept in control. Many exotics are the result of garden or ornamental plants escaping into the wild. One isolated plant along a shoreline will probably not create a problem by itself. However, problems arise when plants are left to spread, many times to the point where treatment is difficult or cost prohibitive. A monitoring program should be established, problem areas identified, and control measures taken when appropriate. Exotic species were found along most of the shorelines of Stockholm and Mary Lee Lakes, and the density of the plant species in these areas was moderate to high in many places, especially along Mary Lee Lake's shoreline. Therefore, control measures should be carried out as soon as possible to prevent further spread.

Option 1: No Action

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

> ***Pros***
>
> There are few advantages with this option. Some of the reasons exotics were brought into this country are no longer used or have limited use. However, in some cases having an exotic species growing along a shoreline may actually be preferable if the alternative plant is commercial turfgrass. Since turfgrass has shallow roots and is prone to erosion along shorelines, exotics like reed canary

grass or common reed (*Phragmites australis*) will control erosion more effectively. Native plants should take precedent over exotics when possible. Tables 10 &11, 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 zero initially, however, when control is eventually needed, costs will be substantially more than if action was taken immediately. Additionally, the eventual loss of ecological diversity is difficult to calculate financially.

Option 2: 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 before seed heads appear, since late summer and fall is when many of the plant seeds disperse. Proper disposal of excavated plants is important since seeds may persist and germinate even after several years. Once exotic plants are removed, the disturbed ground should be planted with native vegetation and closely monitored. Many exotic species, such as purple loosestrife, buckthorn, and garlic mustard are proficient at colonizing disturbed sites. Due to the low density of exotic plants, this option is probably the most cost effective.

Pros

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

Cons

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

Costs

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

Option 3: Herbicide Treatment

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

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

Pros

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

Cons

Since most herbicides are non-selective, they are not suitable for broadcast application. Thus, chemical treatment of large stands of exotic species may not be practical unless it is a monocrop of a specific plant species. 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.