2001 SUMMARY REPORT
of
TOWER LAKE

Lake County, Illinois

Prepared by the

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EXECUTIVE SUMMARY

Tower Lake is a private 68.8 acre manmade lake located in the Village of Tower Lakes in Cuba Township. Tower Lake was created in 1923 by damming a small tributary of the Fox River and was enlarged in 1927 and again in the 1940s to bring the lake to its current size. Shortly after the lakes construction, the Tower Lake Improvement Association was formed (1931), which oversees the management of the lake. Over the past 70 years, Tower Lake has experienced many lake quality problems including excessive aquatic vegetation, fish kills, and nuisance algae blooms, which have all been addressed with various management techniques. All of these problems are mainly the result of Tower Lake's shallow depth (7.5 feet maximum depth).

Overall, Tower Lake has *poor* water quality as compared to other County lakes. In 2001, average total phosphorus concentrations in Tower Lake was 0.100 mg/L, which is more than double the Lake County median value of 0.047 mg/L. These high concentrations are partially due to internal phosphorus loading from loss of thermal stratification (polymixis) during the summer. The average total phosphorus concentration in Tower Lake has not appreciably changed since the 1988 Lakes Management Unit study. These high phosphorus concentrations, are causing summer long algae blooms. The average total suspended solids concentration in 2001 was 15.0 mg/L and was as high as 26.0 mg/L in August, which is over five times the Lake County median concentration of 5.0 mg/L. These high concentrations of suspended sediment are significantly reducing clarity, and contributing to the internal loading of nutrients in Tower Lake.

In the past, Tower Lake has used several plant management techniques to control excessive aquatic vegetation including herbicides and grass carp. As a result of over-management, Tower Lake is almost devoid of aquatic plants. Surveys in 2001 found aquatic vegetation at only 28 out of 134 sites, despite the fact that there was enough light for plants to support growth in about 60-100% of the lake. The LMU estimates that there is <1% coverage by aquatic plants (30-40% is considered healthy). Tower Lake also has an excessive number of common carp. Due to their disruptive feeding and spawning habits, carp uproot aquatic vegetation and resuspend sediment/nutrients, which negatively impacts water quality/clarity. As a result, the quality of Tower Lake can not be expected to substantially improve until the common carp are eliminated from the lake and a healthy aquatic plant community is reestablished.

A large majority of the shoreline of Tower Lake is developed (87%). Most of the developed shoreline is made up of rip rap (44%) and manicured lawn (20%). The 2001 study found that 23% of Tower Lake's shoreline is experiencing some form of erosion. This is largely due to failing rock rip rap. LMU staff also noted three invasive species (purple loosestrife, buckthorn, and reed canary grass.), that offer little/poor quality habitat. Every effort should made to eliminate these invasive plants from the shores of Tower Lake. The Association, as well as individual property owners, should promote and implement the use of naturalized shoreline types, such as buffer strips of deep rooted native vegetation, when replacing existing structures.

LAKE IDENTIFICATION AND LOCATION

Tower Lake is near the intersection of Route 59 and Roberts Roads in Cuba Township in the Village of Tower Lakes (T43N, R9E, Section 2). Tower Lake is a dumbbell shaped 68.8 acre manmade lake with a current maximum depth of 7.5 feet with an average depth of 4.5 feet [1] (Lake County Health Department – Lakes Management Unit [LMU] data) (Figure 1). Lake volume is approximately 233.51 acre-feet[2] (LMU data). Tower Lake is at the bottom of the Tower Lake drainage basin, which is part of the Fox River watershed. Tower Lake's watershed is relatively small and is approximately 412 acres (LMU data). The Tower Lake drain enters the lake in the far northern bay and is the main inflow to the lake. Secondary inlets are from a few small creeks and storm water inflow. Watershed usage is mainly residential. However, the main inflow (Timber Lake drain) does flow through agricultural land and wetlands before entering the lake. There is a spillway on the west side of the southern half of the lake, which controls the flow out of the lake (Figure 1). This drainage eventually flows into the Fox River.

BRIEF HISTORY OF TOWER LAKE

Tower Lake was constructed in 1923. Initially, Tower Lake was dammed where the suspension bridge is now and the lake only consisted of the northern half of the lake. The dam at its current position was constructed in 1927, which subsequently enlarged the lake. The lake was enlarged even further in the 1940s when the southeastern bay was dredged, bringing the lake to its current size. Since its creation, Tower Lake has always had some kind of development on its shores. Since 1931, the Tower Lakes Improvement Association (TLIA) has overseen the management of Tower Lake. Over this 70 plus year time span, TLIA has faced many management challenges. These have included fish kills, excessive aquatic vegetation, carp infestations and excessive turbidity. All of these problems can be linked to Tower Lake's biggest problem: shallowness. On several occasions governmental agencies such as the Illinois Department of Natural Resources (IDNR) have cited lack of depth as the cause of many lake quality problems. Additionally, it has been recommended in several reports that the lake level be raised or that the lake be dredged. During the past 70 years the lake has been dredged only once (late 1960s) but not on a large scale. Rotenone treatments to manage excessive carp populations were carried out in 1962 and 1968 but were unsuccessful due to reinfestation from upstream sources and low rotenone rate. As a result, a earthen dam was constructed between Tower Lake and Davlin's pond (just north of Roberts Road) in 1968 to prevent reinfestation. However, this dam broke sometime in 1969 and probably washed into Tower Lake. Shortly after this (early 1970s), Tower Lake's quality started to drastically decline. IDNR fishery surveys indicate that suspended sediment loads increased, algal blooms increased, plant densities decreased, and carp populations expanded. The last study of

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[1] This is a corrected maximum /average depth based on the lake level at the spillway.
[2] The lake volume was calculated at a time when the lake level was 18 inches below the spillway. Lake volume with the water at spillway level would be approximately 333.71 acre-feet.

Tower Lake by the LMU in 1988 found that Tower Lake was in a very turbid, nutrient rich state, and experienced summer long algae blooms and had little aquatic plant growth

SUMMARY OF CURRENT AND HISTROICAL LAKE USES

Access to Tower Lake is entirely private and TLIA owns 100% of the lake bottom. There are seven TLIA owned access points on the lake that are open year round to members of the TLIA (Figure 2). Launching of watercraft by non-association and non-approved personnel is prohibited. Recreational opportunities on Tower Lake have gone unchanged since its creation over 70 years ago and largely consist of boating (no motors of any kind allowed), swimming, and fishing. The main park is located just off of East Lake Shore Drive and has a Illinois Department of Public Health (IDPH) licensed swimming beach, which is monitored for fecal coliform bacteria levels. This beach is tested on a bimonthly basis by the LMU from May through September. Additionally, there are several swimming platforms located just offshore of this park. During the 2001 sampling season, the beach was closed only once due to high bacterial counts, which may be due to excessive amounts of goose feces. Visual observations by LMU staff confirm that there were excessive amounts of goose feces at the beach area including the swimming platforms. These dropping should be cleaned up on a daily basis in order to avoid future closures. In addition to the licensed beach, several residents on Tower Lake have private beaches on their property. The other access points on the lake are in differing stages of use and development. They provide access to residents without direct lake access (frontage).

LIMNOLOGICAL DATA - WATER QUALITY

Water samples collected from Tower Lake were analyzed for a variety of water quality parameters. Samples were collected at three feet below the surface and three feet off the bottom (5-6 foot deep) from the deep hole location in the lake (Figure 2). During certain periods of the summer Tower Lake is thermally stratified. This means the lake divides into a warm upper water layer (epilimnion) and cool lower water layer (hypolimnion) (see *Interpreting Your Lake's Water Quality* for further explanation). However, during June, July, and August, Tower Lake went through a period of mixing, then weakly stratifying, and mixing again. This lapse in stratification (termed polymictic) could be due to a change in weather, wind, and precipitation. The separation of the lake into layers and mixing events are reflected in the water quality data. Below is a discussion of the highlights from the complete data set for Tower Lake (*Table 1, Appendix A*).

Stratification (and periodic mixing) of the lake is reflected in the temperature and dissolved oxygen (D.O.) concentrations as well as other water quality data. The epilimnetic D.O. concentrations were not problematic in Tower Lake during the 2001 study (see *Appendix C: Multiparameter Data for Tower Lake*). However, the epilimnetic D.O. concentrations fluctuated during the 2001 study. D.O. concentrations in the surface waters were highest in August (9.5 mg/L), which was due to an increase in algae blooms

that month. During biological processes (photosynthesis) these algae blooms produce oxygen, which is released into the surrounding environment (lake water). May had the lowest surface D.O. concentration (5.52 mg/L), which is just above the minimum amount needed to support aquatic life (5.0 mg/L).   Additionally, the depth at which the lake had enough D.O. to support aquatic life varied on a monthly basis from as shallow as 4.5 feet in July (4.7% of lake volume) to as deep as 7+ feet (the lake bottom) in May and September (100% of lake volume).   The amount of the lake that becomes hypoxic (<1.0 mg/l) also varied on a monthly basis due to the mixing events during the summer. As a lake becomes more strongly stratified, oxygen is depleted from the hypolimnion and anoxic conditions form (0 mg/L), biological and chemical processes release nutrients (phosphorus) into the hypolimnion, where they are sequestered until fall turnover. However, since Tower Lake is polymictic, these nutrients are mixed into the surface waters. While the volume of the Tower Lake that becomes anoxic is very low (approximately 4.5%) the area that this water is spread over is about 25% of the surface area of the lake. This is problematic and is part of the reason Tower Lake has such high nutrient concentrations and resulting algae blooms.

Secchi disk depth is a direct indicator of water clarity as well as overall water quality. In general, the greater the Secchi disk depth, the clearer the water and better the water quality. Based on water clarity, Tower Lake has very poor water quality compared to many other lakes in the County. The average Secchi depth on Tower Lake in 2001 was 2.3 feet, which is 45% lower than the median County Secchi depth (4.2 feet). During 2001, the Secchi disk readings in Tower Lake fluctuated over the five-month study. In June, the Secchi disk depth was at its deepest (4.5 feet) but by August, the Secchi depth had decreased to its lowest depth of 1.05 feet. Additionally, all the Secchi disk readings on Tower Lake during the study, except for June, were well below the Lake County median Secchi depth.   Historically, Tower Lake has been turbid due to algae blooms and suspended sediment and as a result has had poor Secchi disk readings for the past three decades. IDNR reports state that Secchi depth during some of their surveys was as shallow as 9 inches (1971). However, limited data previous to the 1970s indicates that the Secchi depth has been as deep as 8 feet (lake bottom) at which time Tower Lake was dominated by aquatic plant growth. These surveys also indicate an increase in turbidity and the frequency/intensity of algae blooms, both of which can be attributed to excessive numbers of carp and a lack of an aquatic plant community. Due to their feeding and spawning habits, carp disrupt sediment and aquatic plant growth, which stabilize sediment and compete with algae for available resources thus improving water clarity/quality (*See Limnological Data – Wildlife Assessment*).

The high concentrations of suspended organic and inorganic particles are the reasons Tower Lake has such poor water clarity. Total suspended solids (TSS) are a measurement of suspended solids such as algae and other organic matter as well inorganic matter such as silt and clay particles. In 2001, the average TSS in Tower Lake was 15.0 mg/L, which is three times the County median value of 5.0 mg/L. The TSS increased from 5.6 mg/L in May to as high as 26.2 mg/L in August, which is over 5 times the County median value. These high concentrations of TSS directly impacted Secchi depth (clarity) (Figure 3). The calculated nonvolatile suspended solids (NVSS), which is the portion of the TSS that can be attributed to inorganic (soil particles) was 10.6 mg/L. This means that 69% of TSS (turbidity) was caused by suspended inorganic particles such as silts and clays. The other 33% can be attributed to organic particles such as algae. Total volatile solids (TVS), which are a measurement of suspended organic matter (such as algae), increased from 176 mg/L in 1988 to 200 mg/L in 2001. Furthermore, TVS and TSS followed very similar trends in 2001, which further reinforces that the turbidity on Tower Lake is being impacted by algae blooms (Figure 4). Interestingly, the average TSS in 2001 was 66% lower than the average TSS during the 1988 LMU study. This decrease may be due to the fact that 1988 was a drought year and the lake level was 18 inches lower, thus resuspension of sediment may have been higher because the lake was shallower. Additionally, the 1988 report noted large sediment inflow into the southeastern portion of the lake from a nearby development. The decrease in TSS from 1988 to 2001 is seen in average Secchi depth, which has increased in the past 13 years (1.8 feet vs. 2.3 feet respectively).

The total dissolved solids (TDS) concentrations in 2001 were also high. TDS is a measurement of the concentration of dissolved minerals such as salts. The average TDS in 2001was 623 mg/L, which is well below the Lake County median value of 452 mg/L. Additionally, conductivity in 2001 was 1.054 milliSiemens/cm, which is 41% higher than the County median value of 0.7473 milliSiemens/cm. The elevated TDS and conductivity are not surprising considering the turbid nature of Tower Lake since both of these parameters can be linked to high concentrations of dissolved ions in the water column.

The other major contributor to poor water clarity on Tower Lake in 2001 was nuisance algae blooms. 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. 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. Most lakes in the County are phosphorus limited. In these phosphorus-limited lakes even a small addition of P can trigger algae blooms. In 2001, Tower Lake had an average TN: TP ratio of 14:1, which means that there are sufficient amounts of both nutrients to support algae growth. This is evident in the season long algae blooms observed on Tower Lake during the 2001 study. These algae blooms are the result of high nutrient concentrations and a lack of a healthy aquatic plant population, which compete with algae for available resources.

The phosphorus concentrations in Tower Lake are *high*. Average TP was 0.10 mg/L in 2001. This is over double the median TP concentration for Lake County lakes (0.047 mg/L). The high TP concentrations cause nuisance algae blooms, which are reducing the water clarity (high TSS) (Figure 5). Due to the polymictic nature of Tower Lake phosphorus concentrations in July, August, and September were at least double the

phosphorus concentrations in May and June. The TP concentrations in August were four times higher than the County median. Furthermore, the TP concentration in Tower Lake has not appreciably changed since the 1988 LMU study. Additionally, there were also above average concentrations of soluble reactive phosphorus (SRP) in the epilimnion during the 2001 study. SRP is a readily available form of phosphorus and is easily utilized by algae and is normally not present in the surface waters of a lake. However, since Tower Lake is polymictic, the SRP that is normally sequestered in the hypolimnion is released into the surface waters (epilimnion) all summer long.

Overall, the average concentration of nitrate nitrogen (NO_3-N) decreased as compared to the LMU study in 1988. In 1988, average NO_3-N concentration was 0.20 mg/L and in 2001 was undetectable (< 0.05 mg/L) the entire study. One possible explanation for the decrease could be lower concentrations in the runoff entering the lake from the surrounding watershed. However, this may not entirely explain the decrease. Another, and more plausible explanation is that the nitrogen is being taken up by the algae blooms. The average total Kjeldahl nitrogen (TKN) concentration, which is a measurement of organic forms of nitrogen (such as algae bound nitrogen), in 2001 was 1.6 mg/L. This is slightly higher than the County median value of 1.120 mg/L. However, the elevated TKN concentration is not surprising considering that Tower Lake is in an algae dominated state, which is supported by the correlation between TKN and TVS (organic solids) (Figure 6).

Another way to look at nutrient concentrations and how they affect the productivity of a lake is the use of a Trophic State Index (TSI) based on average phosphorus concentrations. The TSI can be based on phosphorus concentration, chlorophyll *a*, and Secchi depth to classify and compare lake productivity levels (trophic state). The phosphorus TSI is setup so the higher the phosphorus concentration, the greater amount of algal biomass and as a result, a higher trophic state. Based on a TSI phosphorus value of 70.6, Tower Lake is classified as hypereutropic ($\geq$70 TSI). This means that the lake is a highly productive system that has excessive nutrient levels and high algal biomass (growth). Field observations reinforce that Tower Lake is *hypereutrophic*. For comparison, most lakes in the County are *eutrophic* (TSI values $\geq$50 <70). In 1988, the TSI was 63.3, which is *eutrophic*. However, this TSI calculation includes an April TP sample and without this value (May, June, July, and August data) the TSI in 1988 would have been 74.4 (hypereutrophic). Additionally, the Secchi TSI in 1988 was 70.1 (*hypereutrophic)*, which includes the April data. Out of all of the lakes in Lake Country studied by the LMU since 1988, Tower Lake ranks 68 out of 102 lakes based on an *average* TSI (Table 2, Appendix A) and this ranking includes the lower 1988 TSI. If the 1988 TSI without the April data (74.4) is used, average TSI would be 72.5 and Tower Lake would rank 87 out of 102.

TSI values along with other water quality parameters can be used to compare water quality standards as well as use impairment indexes established by the Illinois Environmental Protection Agency (IEPA). These standards rate a given lake based on several water quality parameters. Based on above average phosphorus concentrations, Tower Lake was listed as having a *Slight* violation of Illinois water quality standards.

Other water quality standards (pH, low D.O., TDS, noxious plants, etc.) were listed as none. Based on IEPA Swimming Use Index, Tower Lake is categorized as providing only *Partial* support. This is due to poor Secchi disk readings and high phosphorus levels, which lead to high algal biomass (increased turbidity) and decreased visibility. Tower Lake's average Secchi disk was only 27.6 inches, which is below the IDPH's recommendation of 48 inches. Based on the Recreational Use Index, Tower Lake was also categorized as providing only *Partial* support. This is due to a high TSI value and high levels of suspended solids, which result in poor visibility and contribute to an overall reduction in use of the lake. Tower Lake provides *Full* support based on the Aquatic Life Use index despite the fact that Tower lake has no aquatic plant community. Based on the average of all of the use impairment indices, Tower Lake is listed as providing *Partial* support for Overall Use.

LIMNOLOGICAL DATA - AQUATIC PLANT ASSESSMENT

Aquatic plant surveys were conducted every month for the duration of the study (*Appendix A* for methodology). Shoreline plants of interest were also observed (Table 3). However, no surveys were made of these shoreline species and all data is purely observational. The extent to which aquatic plants grow is largely dictated by light availability. Aquatic plants need at least 1% of surface light levels in order to survive. Based on light penetration measurements, aquatic plant coverage of Tower Lake could have ranged from 60-100% of the surface area (bottom coverage) and grown to a depth of 7+ feet. However, surveys indicate that plants did not grow anywhere in Tower Lake except for a few sporadic occurrences in the very shallow parts around the islands and various shallow locations throughout the lake. This was despite the fact that there was adequate light penetration throughout most of the lake. Poor substrate type may be a possible explanation for the lack of aquatic plant growth. Visual observations confirm that the substrate in the *shallower* depths of the main body of Tower Lake may be too rocky to support aquatic plant growth. Along much of the lake's shoreline the rock rip rap was poorly installed and has fallen into the lake. In contrast, the sediment in the middle of the main body may be too loose to support plant growth. The areas that did have plant growth, the area between the islands and a few other areas of the lake, have an organic substrate suitable for plant growth.

Many years ago, Tower Lake had problems with excessive aquatic vegetation, which at the time covered a reported 70-80% of the lake, and was treated with various aquatic herbicides. As a result of the nearly 50 years of herbicide treatments, and combined with the disruptive nature of the carp, Tower Lake now has no appreciable aquatic plant community. Additionally, Tower Lake stocked grass carp approximately 10 years ago. These herbivorous fish can cause a variety of water quality problems resulting from the over-removal of aquatic vegetation. **Under no circumstances should Tower Lake stock grass carp again.** This lack of a healthy aquatic plant community has significantly contributed to the poor water quality of Tower Lake.

A healthy aquatic plant population is critical to good lake health. Aquatic vegetation provides important wildlife habitat and food sources. Additionally, aquatic plants provided many water quality benefits such as sediment stabilization and competition with algae for available resources. Aquatic plant ***diversity*** on Tower Lake is *average* and consisted of nine species (Table 3). However, plant ***densities*** were *nonexistent*. During the course of the study, Tower Lake had only 28 sites out of 134 that had any vegetation (*Table 4, Appendix A*). These 28 sites were at the nearly the same locations, the shallow areas between the islands and other various shallow locations throughout the lake, just in different months. However, even these sites had very little vegetation, consisting of only a plant or two at each site. The LMU staff has estimated that aquatic vegetation covers <1% of the surface area (bottom coverage) of the lake. As a result, Tower Lake is experiencing a variety of water quality problems including increased nutrient concentrations, increased turbidity, nuisance algae blooms, and poor fishery health. Optimally, a lake should have between 30-40% coverage. Not only does this help reduce resuspension of bottom sediment but also provides quality habitat for fish and other wildlife.

Floristic quality index (FQI) (Swink and Wilhelm 1994) is a rapid assessment metric 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 submersed and floating aquatic plant species (emergent shoreline species were not counted) in the lake is assigned a number between 1 and 10 (10 indicating the plant species most sensitive to disturbance). Nonnative species were also counted in the FQI calculations for Lake County lakes. These numbers are then 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. A low FQI indicates that there are a low number of species and that possibly these species are of lower quality. In 2001, Tower Lake has a FQI of 15.2. The average FQI of lakes studied by the LMU in 2000-2001 was 14.0. This FQI supports that Tower Lake has *average* aquatic plant **diversity** compared to other lakes in Lake County.

Table 3. Aquatic and shoreline plants on Tower Lake, May-September 2001.

Aquatic Plants	
Chara	*Chara sp.*
Coontail	*Ceratophyllum demersum*
Eurasian Water Milfoil	*Myriophyllum spicatum*
White Water Lily	*Nymphaea tuberosa*
Small Pondweed	*Potamogeton pusillus*
Sago Pondweed	*Potamogeton pectinatus*
Flatstem Pondweed	*Potamogeton zosterifomis*
Horned Pondweed	*Zannichellia palustris*
Common Bladderwort	*Utricularia vulgaris*
Shoreline Plants	
Purple Loosestrife	*Lythrum salicaria*
Swamp Smartweed	*Polygonum coccineum*
Common Buckthorn	*Rhamnus cathartica*
Reed Canary Grass	*Phalaris arundinacea*

LIMNOLOGICAL DATA – SHORELINE ASSESSMENT

A shoreline assessment was conducted at Tower Lake on August 2, 2001. The shoreline was assessed for a variety of criteria (*Appendix B* for methodology). Based on this assessment, several important findings were made. A majority of Tower Lake's shoreline is developed (87%). The portion of the shoreline that was undeveloped was made up of shrub, wetlands, and woodlands. The two main types of *developed* shoreline are rock rip rap (44%) and manicured lawn (20%) (Figure 7). Both of these shoreline types are considered *undesirable*. Rip rap offers little habitat and can be prone to erosion and wave reflection if not installed properly. Several rock rip rapped areas on the lake were in disrepair and were either eroding or are at risk. Manicured lawn is a poor shoreline water interface. This is due to the shallow root structure of turf grasses, which are unable to stabilize soils and may lead to erosion. Other types of developed shoreline included buffer strips (19%), seawall (9%), woodland (6%) and beach (3%). The moderate occurrence of buffered shoreline is encouraging on a residential lake such as Tower Lake. Shorelines that have established, *well-maintained* buffer strips are less likely to experience erosion and also provide improved habitat for wildlife. Beach can make a poor shoreline type due to the tendency of sand to be easily eroded and continually washed into the lake. However, due to the recreational uses of the lake it is near impossible not to have some beach frontage. Seawalls are undesirable because of their tendency to reflect waves back into the lake. This can cause resuspension of near shore sediment, which can lead to a variety of water quality problems. Additionally, all four of these shoreline types; lawn, beach, rip rap and seawall, provide poor wildlife habitat. It is the recommendation of the LMU that the TLIA should promote the use of well-maintained, naturalized shoreline and to minimize the use of rip rap, seawalls, and manicured lawns to the waters edge. Additionally, TLIA should promote the use of buffer strips of deep rooted native vegetation around the entire lake regardless of shoreline type. This includes establishing buffer strips behind existing seawalls and rip rap and using buffer strips when replacing any failing erosion control structures. Additionally, it would be beneficial to extend these buffers into the lake by planting emergent vegetation (cattails, arrowhead, pickeral weed, etc), which will help to dissipate wave action.

Shorelines were also assessed for the presence of erosion. The overall occurrence of erosion on Tower Lake is *moderate* (Figure 8). Based on the LMU assessment, 77% (13,322 feet) of the shoreline on Tower Lake was listed as having no form of erosion. This is largely due to the overwhelming dominance of rock rip rapped shorelines. Of the total shoreline, only 5.0 % was assessed as having *Slight* erosion. However, 18% of the shoreline was assessed as having *Moderate* erosion. There were no shorelines assessed as having severe erosion. The eroded shorelines (slight and moderate) mainly consisted of rip rap areas that were poorly maintained/installed and woodland areas that were overgrown with the invasive tree species, common buckthorn, which provides little sediment stabilization. Individual homeowners and TLIA could easily address these *slightly* eroded areas by establishing *well-maintained* buffer strips consisting of prairie grasses and wildflowers with the use of biologs or coconut rolls to aid in stabilization

of steeper areas. The moderately eroded shorelines will require a more involved effort (removal of old structures, grading, etc.).

Extreme water level fluctuations can have a negative impact on shoreline by causing erosion. Overall, the lake level dropped from May through September. In the spring/early summer, lake levels increased 6.3 inches from May to June. However, after spring rains, the lake fell 3.9 inches from June to July, decreased further (2.3 inches) from July to August and then increased only slightly (1.7 inches) in September. Since Tower Lake is near the end of a drainage basin it experiences these fluctuations in water level year round. This might be one possible explanation for the shoreline erosion, particularly the deterioration of the rip rapped shoreline. Since the rip rap size on Tower Lake is relatively small, the water fluctuations could easily carry the smaller sized cobble into the lake over time.

LIMNOLOGICAL DATA – WILDLIFE ASSESSMENT

Common carp started to appear in IDNR fishery surveys in 1962. Two partial rotenone treatments have been conducted on Tower Lake in the past in an effort to try to control the carp. However, both were unsuccessful and the carp became problematic again within a few years after the treatments. The cause of the short duration of these treatments was low rotenone application rates and reinfestation from upstream sources. Rotenone is typically applied to the whole lake at a rate of 6 parts per million (ppm). In 1962, rotenone was applied at a rate of 1 ppm to only half of the lake (0.5 ppm to the whole lake). In 1968, rotenone was applied to the whole lake but at a rate of 2.2 ppm. Additionally, several winter fish kills have also exacerbated the carp problem. Winter fish kills occur because of low D.O. conditions, of which carp are tolerant. As a result, almost all other fish are eliminated from the system and the carp are allowed to flourish. Due to their disruptive feeding and spawning habits, carp disturb the lake bottom sediment and resuspend sediment. This activity is especially damaging because Tower Lake is so shallow. Carp activity has also eliminated most aquatic plant growth in the lake, which has contributed to a variety of lake quality problems.

Wildlife observations were made on a monthly basis during water quality and plant sampling actives. All observations were visual. Wildlife habitat on Tower Lake is above average for a manmade, residential lake. Several types of waterfowl were observed during the course of the study including the American bittern, which is a State of Illinois endangered species (Table 5). There are healthy populations of mature trees that provide good habitat for a variety of bird species. There are also a few large dead trees that provide excellent habitat for Double Breasted Cormorants. Additionally, there are several shrub and wetland areas that provide habitat for smaller bird and mammal species.

There are three invasive plant species (purple loosestrife, buckthorn, and reed canary grass) that were observed along the shores of Tower Lake and should be controlled/eliminated. Thirty-one and half percent of the shoreline parcels had some

invasive species growth. This means that some portion of roughly 5,379 lineal feet (31%) of Tower Lake's shoreline is infested with one of these three species (Figure 9). Some shoreline areas, such as the woodlands on the south shore, have heavy infestations of buckthorn and purple loosestrife. Other areas, such as Devil's and Snake Islands, are almost a complete monoculture of buckthorn. These plants are seldom used by wildlife for food or shelter. They should be controlled/eliminated before they spread and displace other native and more desirable plant species.

Table 5. Wildlife species observed on Tower Lake, May-September 2001.

Birds	
Double Breasted Cormorant	*Phalacrocorax auritus*
Mute swans	*Cygnus olor*
Canada Goose	*Branta canadensis*
Mallard	*Anas platyrhnchos*
Ring-billed Gull	*Larus delawarensis*
Great Blue Heron	*Ardea herodias*
Green Heron	*Butorides striatus*
American Bittern*	*Botaurus lentiginosus*
Red-tailed Hawk	*Buteo jamaicensis*
Purple Martin	*Progne subis*
Barn Swallow	*Hirundo rustica*
American Crow	*Corvus brachyrhynchos*
Mammals	
White-tail Deer	*Odocoileus virginianus*

*****Endangered in Illinois

EXISTING LAKE QUALITY PROBLEMS

- *Polymixis Leading to Internal Phosphorus Loading*

  As lakes thermally stratify, the hypolimnion becomes devoid of oxygen. Under these low D.O conditions, nutrients, most importantly phosphorus, are released into the hypolimnion, which remains in a stratified state for the summer. Due to stratification these nutrients remain in the hypolimnion until fall turnover. However, Tower Lake experiences polymixis (periodic mixing events) during the summer. As a result, the hypolimnetic phosphorus is mixed into the rest of the lake where it is then available for algal growth. This phenomenon is causing an increase in algae blooms and a reduction in clarity, which was evident in water quality data from July through September of the 2001 study. The TP concentrations during these months was double the concentrations in May and June and were over double the County median TP concentration. Even without these mixing events Tower Lake has high TP concentrations. This is a common problem in many of the County's lakes. A possible solution to this situation would be the installation of an aeration system. This system would prevent stratification from occurring, thus eliminating the build up of phosphorus and the release upon mixing. Additionally, high internal phosphorus concentrations could be reduced using aluminum sulfate (alum). However, alum treatments are often very expensive and longevity may be short term in Tower Lake due to an excessive number of carp and the overall shallow depth of the lake.

- *Poor Plant Diversity/Densities*

  One key to a healthy lake is a healthy aquatic plant population. Tower Lake has average plant diversity but **extremely poor** plant *densities*. The negative impacts associated with the absence of a quality aquatic plant community are wide spread and include those on water quality and fishery health. The lack of quality aquatic plants, and subsequent loss of water quality, is more than likely the result of poor substrate and carp activity since there is adequate light available throughout the lake. Establishment of a healthy aquatic plant community is essential in improving the quality of Tower Lake. Establishing aquatic vegetation will stabilize sediment and help to reduce algae blooms thus improving clarity. Additionally, these vegetated areas will provide valuable fish and wildlife habitat. This is a long-term process and involves other management practices as well. The first step is the elimination of carp, which are possibly the biggest limiting factor in plant growth for Tower Lake.

- *Excessive Number of Carp*

  IDNR surveys have found on several occasions since the early 1970s that the fishery of Tower Lake is in poor health due to the lack of habitat, low D.O. problems (winter kills), and overabundance of carp. Therefore, carp should be major management concern for Tower Lake. Tower Lake's problems with carp are not a new one and have existed for over 40 years. Whole lake rotenone treatments have been unsuccessful in the past. This is probably due to low rates and reinfestation from surviving carp and upstream sources. Due to their disruptive nature, carp bring about many negative impacts to a lake ecosystem such as increased turbidity. The water quality of Tower Lake may not substantially improve until this carp problem is brought under control.

- *Invasive Species*

  There are many invasive species that have become established in Lake County and Tower Lake is no exception. Three exotic invasive species that were commonly found along Tower Lake's shoreline are buckthorn, reed canary grass, and purple loosestrife. These three plants were found along 31% of the shoreline. None of these species provide quality food or habitat to wildlife. Furthermore, they are extremely aggressive and will displace desirable, native vegetation, which will lead to further loss of food and habitat. The spread of these three aggressive species must be stopped before they become further established on Tower Lake. In areas that are already infested they should be removed as soon as possible. If any new growth is observed around the lake, these plants should be removed before they become established. All of these noxious weeds can easily be controlled using several different management techniques. The TLIA should educate residents about these unwanted shoreline plants and promote their immediate removal.

- *Shoreline Erosion*

  The overall occurrence of erosion on Tower Lake was moderate. As stated previously, Tower Lake has some form of erosion on 23% of its shoreline. This erosion is occurring for several reasons. These include lack of suitable shoreline vegetation, failing structures (rip rap), ice damage, and water fluctuations. Erosion is contributing to other water quality problems such as sedimentation, nutrient enrichment and resulting nuisance algae blooms. If left unattended the problem will continue to worsen, further aggravating related water quality issues. Shoreline erosion on Tower Lake should be addressed immediately. Depending on the severity of erosion these techniques on Tower Lake include the use of rip-rap, biologs, and buffer strips. The TLIA, as well as individual property owners should promote and implement the use of more naturalized shoreline types (buffer strips) when replacing existing structures and to extend these buffers into the lake by planting emergent vegetation, which will help to dissipate wave action. This will benefit not only the water quality of Tower Lake, but may also improve the wildlife habitat surrounding the lake.

- *Shallow Depth*

  Sedimentation can bring about negative impacts on the lake's fishery and aquatic plant community. Sedimentation can also bring about an increase in algae blooms and turbidity and an overall decrease in lake health. Dredging may reduce impacts from this ongoing problem. For overall lake health it is advisable to increase the depth so that 25% of the lake is greater than 10 feet deep (17 acres). In order to accomplish this goal an estimated 105,000 cubic yards would have to be removed. This would be extremely expensive. Typically, dredging costs \$3-10/yd^3 and this 105,000 yd^3 would cost \$315,000 – \$1,049,000. These costs include plan design and execution. Additionally, a bathimetry study, sediment thickness survey and dewatering site construction and leasing would inflate costs further (possibly double). The main question the TLIA must ask themselves is *what do they want to achieve with dredging*? If it is fishery health, then increasing the lake depth so that 25% is deeper than 10 feet is an appropriate plan. On the other hand, if the goal of the association is to deepen the lake for navigational purposes, then dredging specific locations would be more appropriate and possibly reduce costs.

- *Historical Lake Data*

  The lack of quality lake data is a common problem for many of the lakes in Lake County. This is either due to poor record keeping or lack of involvement on the part of the management entity/residents. The TLIA has been actively managing the lake for over 70 years, but accurate records may not have always been kept. Additionally, data such as Secchi depth, water fluctuations, and D.O. profiles, and nutrient concentrations are not collected/monitored on a regular basis. Collection of this type of lake data can be very important in making decisions on the management of the lake. This data can be used to track changes (or lack of) in lake quality over many years. Additionally, this data is very important to agencies, such as the LMU, when conducting studies of the lake and allows for a more complete analysis. It is the recommendation of the LMU that Tower Lake becomes involved in the IEPA's Volunteer Lake Monitoring Program (VLMP). This program uses volunteer lake residents to collect bimonthly lake data for the IEPA. This program is worth the time and effort and provides valuable information about the lake.

POTENTIAL OBJECTIVES FOR TOWER LAKE MANAGEMENT PLAN

I. Destratification Using Artificial Aeration
II. Aquatic Revegetation
III. Fishery Rehabilitation
IV. Eradicate/Control Invasive Species
V. Shoreline Erosion Control
VI. Volunteer Lake Monitoring Program

OPTIONS FOR ACHIEVING THE LAKE MANAGEMENT PLAN OBJECTIVES

Objective I: Destratification Using Artificial Aeration

Fish and other aquatic organisms need oxygen to live. As water moves past their gills (or other breathing apparatus), microscopic bubbles of oxygen gas in the water, called dissolved oxygen (D.O.), are transferred from the water to their blood. Like any other gas diffusion process, the transfer of D.O. to aquatic organisms can only occur above certain concentrations. In other words, oxygen can be present in the water, but at too low a concentration to sustain aquatic life. Oxygen also is needed by virtually all algae and all aquatic plants, and for many chemical reactions that are important to lake functioning. Lake D.O. concentrations naturally vary and are controlled by several biological, chemical and physical processes.

Dissolved oxygen concentrations in a lake can vary greatly depending on the time of day. This is mainly due to oxygen being produced during photosynthesis and consumed during respiration and decomposition. Because it requires light, photosynthesis occurs only during the daylight hours. Respiration and decomposition, on the other hand, occurs 24 hours a day. This difference alone can account for large daily variations in D.O. concentrations. During the night, when photosynthesis cannot counter balance the loss of oxygen through respiration and decomposition, D.O. concentration may steadily decline. D.O. concentrations are generally lowest just before dawn, when photosynthesis resumes.

Ice-covered (nutrient-enriched) lakes may also develop variations of D.O. dependent on depth. If there is little or no snow cover to block sunlight, algae and some plants may continue to photosynthesize, resulting in a small increase in D.O. just below the ice. But as microorganisms continue to decompose material in the lower water column and in the sediments, they consume oxygen, and the D.O. is depleted. No oxygen input from the air occurs because of the ice cover, and, if snow covers the ice, it becomes too dark for photosynthesis. This condition can cause high fish mortality during the winter, known as "winter kill." Lakes in this area that do not have at least 25% of their surface area with a depth of at least 10 feet are prone to winter kill. Tower Lake does not have a maximum depth of 10 feet and as a result has experienced winter kills in the past.

Temperature effects can also cause reduced D.O. in deeper lakes (usually greater than 10 feet deep) as thermal stratification may cut-off all oxygen sources from reaching the lower depths. D.O. concentrations drop as organisms continue to respire and consume oxygen. The bottom layer of the lake may eventually become anoxic, that is, totally devoid of oxygen. Oxygen losses can also occur in summer if large amounts of plants or algae quickly die naturally, or as a result of an application of fast acting aquatic herbicides or algicides. Decomposition is more rapid in the summer due to warmer water temperature, which uses a large amount of D.O. very quickly, causing a D.O. crash. The anoxia causes chemical reactions, which result in the release of phosphorus in this bottom layer. If the phosphorus is then distributed to the surface layer through frequent mixing of the water column, algae blooms could result. This appears to be occurring in Tower

Lake each summer. If the entire water column remained oxygenated throughout the summer, internal phosphorus release should decrease or be eliminated and should result in a decrease of planktonic (and possibly filamentous) algae.

Option 1. No Action

Lakes that experience low D.O. concentrations either during the summer or winter are almost always nutrient-enriched or eutrophic lakes that are very productive biologically. Lakes such as Lake Michigan that are deep, but nutrient-poor rarely have problems with low D.O.. Therefore, D.O. measurements should be collected at least monthly in summer and winter to determine if low D.O. is a problem for the specific lake. If low D.O. is a problem, then the underlying cause should be investigated and additional tests conducted prior to taking management actions. As stated previously, lakes have natural variations of D.O. dependent on physical processes and the amount of biological and chemical activity. With a no action management plan for lakes with low D.O., nothing would be done to improve the D.O. concentrations. The D.O. concentrations would continue to vary and fluctuate dependent on time and lake condition.

Pros

If no efforts are made to increase D.O. concentrations, there are no D.O. management expenses. Although, equipment costs and other management options may increase in price over time. In most cases, low D.O. in the lower water layer of a thermally stratified, productive lake is a natural, physical and chemical phenomenon and is not necessarily bad. In many cases, the amount of total volume that has low D.O. is relatively small (sometimes less than 30% in Lake County). Thus, ample volume can exist with sufficient D.O. for aquatic organisms to survive. Generally, nutrients released from sediment, due to low D.O. in a thermally stratified lake, are contained in the lower water and are not available for additional growth of plants and algae until fall turnover. As stated above, this is not the case in Tower Lake. The phosphorus released from bottom sediment appears to be making its way into the epilimnion many times during the summer. No action may also be warranted in cases of productive, shallow lakes that regularly experience fish kills as it may not be cost effective to maintain suitable conditions (year-round) for gamefish populations. In some cases, D.O. management options such as aeration (artificial circulation) have increased phosphorus concentrations and/or exacerbated algae blooms.

Cons

If no action is taken, fish in lakes that experience D.O. concentrations of less than 3.0 mg/l (bass/bluegill/pike) or 5.0 mg/l (trout) throughout the water column can suffer severe oxygen stress. Under severe D.O. depletion in summer or winter, fish kills can occur. Lakes that frequently experience low D.O. concentrations throughout the water column usually can only support tolerant fish species such as carp and green sunfish. Also, some lakes have a small amount of the lake volume that has sufficient oxygen (<30%) which is entirely in the sunlit zone. Fish are squeezed into a smaller volume and can be easily seen, which may cause increased predation leading to an unbalanced fish population. A high quality fishery will be difficult to sustain or achieve under these circumstances. Other aquatic organisms such as invertebrates require 4.0 mg/l to avoid severe oxygen stress. Besides the direct effects to aquatic organisms, low D.O. levels (<1 mg/l) can lead to increased release of phosphorus from the sediment that can fuel algal blooms when mixed into the sunlit zone. It also leads to the buildup of chemically reduced compounds such as ammonium and hydrogen sulfide (H_2S, rotten egg gas) which can be toxic to bottom dwelling organisms. In extreme cases, sudden mixing of H_2S into the upper water column can cause fish kills. These gases are released causing potential odor problems and reduced enjoyment for lakeside residents. Since aerobic (with oxygen) decomposition breaks down organic matter faster than anaerobic (without oxygen), organic matter may buildup faster in the sediment due to low D.O. concentrations.

Cost:
There is no cost associated with the no action option.

Option 2: Aeration via Artificial Circulation

Artificial circulation of lakes has been employed as a management technique since at least the early 1950s. Initially it was used to prevent fish kills during winter in shallow, ice-covered lakes. Since the 1960s it has also been used as a technique to obtain additional water quality improvements and control nutrient enrichment. Artificial circulation is probably the most widely used lake management technique for lake rehabilitation. The installation of an artificial circulation system could possibly inhibit thermal stratification from occurring in Tower Lake. However, this may not reduce the internal loading of TP. In fact artificial circulation may increase internal TP loading in Tower Lake due to resuspension of sediment bound nutrients since the lake is so shallow.

The principal, and probably most reliable if properly sized, effect of artificial circulation is to raise the D.O. content throughout the lake. In fact, artificial circulation should be called stratification prevention, as the mixing process prevents thermal stratification. This lack of stratification allows water undersaturated with oxygen to come in contact with the air at the surface permitting oxygen diffusion to occur. While the vertical movement of water is usually achieved by entraining water through releasing compressed air at some depth, little oxygen increase is achieved through direct diffusion from bubbles (King, 1970; Smith et al. 1975). In order to vertically move the entire water volume, the system must be sized properly. A recommended air flow rate for a typical disk diffuser aeration system is equivalent to 1.33 standard cubic feet per minute (scfm) per lake surface acre (Lorenzen and Fast, 1977). Case studies have shown that artificial circulation can be achieved at a flow rate as low as 0.7 scfm/acre (Kortmann, personal communication 2001). Our Unit recommends that the minimum sizing flow rate should be 0.9 scfm/acre, but to ensure success to use 1.33 scfm/acre as finances allow. The higher flow rate per acre should be chosen for lakes that strongly stratify thermally and that have very high relative thermal resistance to mixing. The physical shape of the lake should also be considered. Mixing a lake that is shaped like a “martini glass” is a lot easier than mixing a big “spaghetti” bowl. Lakes shaped like a martini glass that have a single deep hole may only require one diffuser that can handle the required flow rate. Whereas, a lake with multiple holes and bays may require several diffusers and a flow manifold to properly distribute the required airflow. Lakes that are less than 6 feet deep rarely stratify in the summer and usually do not benefit from this option as they are already circulated. These shallow lakes may benefit from this option in the winter months.

There are several types and manufacturers of electrical compressors and blowers on the market and even windpowered systems that force the required airflow through submersed tubing to a diffuser or air stone that releases the air and circulates the water column. The most commonly used electrical compressor is a carbon vane compressor. This compressor operates at low pressure (usually below 10 pounds per square inch or PSI) and produces a large volume of airflow. This type of compressor is designed for continual operation, low maintenance and has the average lifespan of 15-25 years. This type of compressor works well in lakes that are less than 25 feet deep as water pressure effects performance. These compressors do not require oil for lubrication and thus, no oil will move into the lake with the compressed air. Some rotary vane compressors only operate at 5 PSI and thus would not work well in lakes deeper than 11 feet. For these deeper lakes, or for large airflow requirements, electrical high-pressure units such as piston or rotary screw compressors are utilized. These compressors can operate at or higher than 100 PSI, which can easily overcome lake water pressure effects for all lakes in Lake County. Some of the piston compressors, like the rotary vanes are oil-free, whereas the rotary screw compressors all require oil for lubrication. Special biodegradable oils are a must as miniscule quantities of oil are carried in the air to the lake. Both compressors are also for continuous operation, although the rotary screws do require more maintenance than the oil-free piston and rotary vane compressor. Additionally, the higher operating pressure does reduce the amount of airflow generated by the compressor and more horsepower may be required than a low-pressure system.

There are several types and manufacturers of diffusers. They are generally subdivided into fine and coarse bubble units. All diffusers are rated for a specific minimum and maximum flow rate. It is very important to properly size the diffusers with the amount of compressed airflow to ensure performance. Most fine bubble units are either a membrane air diffuser or an air stone. The major advantages of the membrane air diffuser are low maintenance, ease of installation and higher oxygen transfer efficiency. Air stones tend to produce a medium bubble and may need to be removed and cleaned with acid if clogging occurred. Coarse bubble diffusers are also low maintenance, easy to install, but may provide less oxygen transfer efficiency. However, they are able to transfer more oxygen to the water since they can operate at much higher gas flow rates with less required pressure than the fine bubble units. Line diffusers (soaker hoses) consist of porous hose lines that distribute small bubbles over a large area near the water bottom. They, like fine bubble units, produce high oxygen transfer efficiencies. However, if high gas flow rates are required, the length of hose must be extended. Simple slits in the air tubing can also cause mixing to occur. This is usually used in winter aeration strategies to open specific areas of lake ice.

Pros

When properly sized for the lake, these systems can improve D.O. concentrations in the water column to help prevent fish kills and increase habitat for aquatic life. Zooplankton and warmwater fish such as bass and bluegill can inhabit a larger volume of the lake, due to higher D.O. concentrations throughout the lake.

Algal blooms may be controlled, possibly through one or more of these processes: 1) mixing to the lake's bottom will increase an algae cell's time in darkness, leading to reduced net photosynthesis due to light limitation; 2) introduction of dissolved oxygen to the lake's bottom may inhibit phosphorus release from sediment; 3) rapid contact of water with the atmosphere, as well as the introduction of carbon dioxide-rich water during the initial period of mixing, can lower pH, leading to a shift from blue-greens to less noxious green algae; and 4) when zooplankton are mixed to the lake's bottom, they are less vulnerable to sight-feeding fish, resulting in the increase of consumption of algal cells by the zooplankton (Olem & Flock, 1990; Lorenzen and Fast, 1977; Vandermeulen, 1992).

Internal loading of phosphorus can theoretically be decreased through increased circulation. By aerating the sediment-water interface of lakes where iron is controlling phosphorus solubility, phosphorus would be prevented from migrating into the water column.

Artificial circulation in winter can help alleviate low oxygen conditions when the systems are able to keep about 2.3% of the lake's surface free from snow and ice cover (Wirth, 1988). Usually, critically low D.O. concentrations do not appear until late in winter. Weekly D.O. measurements may be necessary to determine the need for operating an aeration system. If the lake's D.O. was found to be 4.0 mg/L less than 2 to 3 feet below the ice, operation of the aeration system should begin.

Cons

Mixing anoxic water from the hypolimnion (deep water) with oxygen poor surface waters can cause D.O. concentrations in the entire water column to fall below the amount needed for fish survival. Aeration systems should be started just after spring/fall turnover to avoid this situation. Also if artificial circulation is only used during the winter and the D.O. concentration is well below 4.0 mg/l near the surface, it may be too late to activate the aeration system. Mixing the anoxic water near the bottom with marginally oxygenated water near the surface can cause the entire water column to have D.O. concentrations below what is needed for fish survival.

Calcium may control phosphorus solubility in most of the hardwater Lake County lakes or the iron/phosphorus ratio may be too low, in which case the phosphorus release rate could be largely a function of aerobic decomposition of organic matter (Kamp-Nielsen, 1975). In that event, internal phosphorus loading may actually increase as temperature at the sediment-water interface is raised in the circulation process. Also, some sediments have a high organic and water content and are very flocculent, and may have a high loosely bound phosphorus fraction (Bostrom, 1984) which may be disturbed causing increased loading. If nutrient-rich waters are brought to the surface by the circulating water, algae and plant growth can become a greater nuisance. For shallow lakes where light is not a limiting factor, algae populations may not decrease. In some lakes, they may actually increase, as explained above.

Depending on the size and type of the compressor(s), seasonal or annual electrical costs may run in the hundreds or thousands of dollars. Some Lake Associations utilize the entire annual budget on electrical costs and maintenance of the aeration system. Therefore, proper sizing and monitoring of the aeration system's performance is requisite.

Costs

An aerator for Tower Lake should be located near the deep hole location. Additionally, diffusers should be placed in several locations in both the north and south portions of the lake. The recommended compressor for the main lake is a rotary screw unit, requiring 14.5-20.0 HP at a cost of $5,900-$7,000. If a 20 HP unit is used, electricity usage is approximately 14.9 kw/hr. If the system is run from mid-May (before stratification begins) through the end of August, electricity costs will be approximately $3,500-4,900 per summer (if the residential electricity rate of $.08/kwh applies). Additional costs will be incurred for diffuser heads and hoses, housing the compressor and miscellaneous installation costs. The total cost for the installation of an adequate aeration unit for Tower Lake could be as high as $20,000. As mentioned above, yearly electricity and maintenance costs of approximately $3,500 will be incurred after the unit has been installed. However, if aeration of the lake reduces or eliminates algae blooms it may lead to an increase in native aquatic plants and an overall increase in the quality of Tower Lake

Option 3. Reduce Lake Phosphorus Concentrations

If a lake has an overabundance of plants and algae, severe oxygen losses can occur if they rapidly die and decompose. Reducing phosphorus can decrease algal populations and (possibly) plant populations. In-lake phosphorus can be reduced by using alum (aluminum sulfate). 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 through internal loading. 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 treatments typically last 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 ratio (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. One of the most serious side effects has to do with pH. The application of alum can dramatically reduce the pH of a lake, resulting in the formation of toxic, soluble forms of aluminum and the death of many aquatic organisms.

An alum application would probably dramatically reduce the amount of phosphorus in Lake Tower and prevent internal phosphorus loading for several years. However, due to the shallow, polymictic nature of Tower Lake, the longevity of an alum application may not be more than 3-5 years. Based on a lake volume of 334 acre feet, Tower Lake would need to apply approximately 27 tons of alum at a cost of $18,900 - $32,000 ($0.35-$0.60/pound). This price is just for the alum and does not include transportation or application fees.

Objective II: Reestablishing Native Aquatic Vegetation

Revegetation should only be done when 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. Additionally, the overabundance of carp must also be addressed as carp may significantly hamper revegetation efforts.

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 plants. 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, Appendix A 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 vegetation. This provides a more natural approach as compared to other management options. In addition, using established native plants to control excessive invasive plant growth can be less expensive in the long run 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 increase 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 is used costs would be substantially higher. Additional costs could be associated with constructing proper herbivory protection measures.

Costs

See Table 6, Appendix A for plant pricing. Additional costs will be incurred if a consultant/nursery is contracted for design and labor.

Objective III: Fishery Rehabilitation

Option 1: Conduct a Fisheries Assessment

Many lakes in Lake County have a fish stocking program in which fish are stocked every year or two to supplement fish species already occurring in the lake or to introduce additional fish species into the system. However, very few lakes that participate in stocking check the progress or success of these programs with regular fish surveys. Lake managers should have information about whether or not funds delegated to fish stocking are being well spent, and it is very difficult to determine how well stocked fish species are surviving and reproducing or how they are affecting the rest of the fish community without a comprehensive fish assessment.

A simple, inexpensive way to derive direct information on the status of a fishery is to sample anglers and evaluate the types, numbers and sizes of fish caught by anglers actively involved in recreational fishing on the lake. Such information provides insight on the status of fish populations in the lake, as well as a direct measure of the quality of fishing and the fishing experience. However, the numbers and types of fish sampled by anglers are limited, focusing on game and large, catchable-sized fish. Thus, in order to obtain a comprehensive assessment of the fish community status, including non-game fish species, more quantitative methods must be employed. These include gill netting, trap netting, seining, trawling, angling (hook and line fishing) and electroshocking. Each method has its advantages and limitations, and frequently multiple gear and approaches are employed. The best gear and sampling methods depend on the target fish species and life stage, the types of information desired and the environment to be sampled. The table below lists examples of suitable sampling gear for collecting adults and young of the year (YOY) of selected fish species in lakes.

Typically, fish populations are monitored at least annually. The best time of year depends on the sampling method, the target fish species and the types of data to be collected. In many lakes and regions, the best time to sample fish is during the fall turnover period after thermal stratification breaks down and the lake is completely mixed because (1) YOY and age 1+ (one year or older) fish of most target species should be present and vulnerable to most standard collection gear, including seines, trap nets and electroshockers; (2) species that dwell in the hypolimnion during the summer may be more vulnerable to capture during fall overturn; and (3) lower water temperatures in the fall can help reduce sampling-related mortality. Sampling locations are also species-, life stage-, and gear-dependent. As with sampling methods and time, locations should be selected to maximize capture efficiency for the target species of interest and provide the greatest gain in information for the least amount of sampling effort.

The Illinois Department of Natural Resources (IDNR) will perform a fish survey at no charge on most public and some private water bodies. In order to determine if your lake is eligible for a survey by the IDNR, contact Frank Jakubecik, Fisheries Biologist at (815) 675-2319. If a lake is not eligible for an IDNR fish survey, or if a more comprehensive survey is desired, two known consulting firms have previously conducted fish surveys in Lake County: EA Engineering, Deerfield, IL, (847) 945-8010 and Richmond Fisheries, Richmond, IL, (815) 675-6545.

Option 2: Carp Removal

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 wide spread 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 is 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, it is not being recommended by the LMU at this time.

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_2 and H_2O) 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 $<50^{o}$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 rotenone retreatment needs 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

There are no negative impacts associated with removing excessive numbers of carp from a lake. However, 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 off-set 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), approximately 673 gallons of rotenone would be needed based on the lake volume with water at spillway height (334 acre feet). The rotenone total cost would be between $33,500 – $50,600. In waters with high turbidity and/or planktonic algae blooms, the ppm may have to be higher which will further increase costs. A IDNR fisheries biologist will be able to determine if higher concentrations will be needed. To reduce costs the lake could be drawn down to reduce the volume that is being treated. If the lake was drawn down approximately three feet, the cost of treatment could be cut by as much as two thirds.

Objective IV: Eliminate or Control Invasive Species

Numerous exotic plant species have been introduced into our local ecosystems. Some of these plants are aggressive, quickly out-competing native vegetation and flourishing in an environment where few natural predators exist. Plants such as purple loosestrife (*Lythrum salicaria*), buckthorn (*Rhamnus cathartica*), and reed canary grass (*Phalaris arundinacea*) are three examples. These exotic and invasive plants have made their way onto the shores of Tower Lake. 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 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 and is quick to become established on disturbed soils. Reed canary grass is an aggressive plant that if left unchecked will dominate an area, particularly a wetland or shoreline, in a short period of time. Since it begins growing early in the spring, it quickly out-competes native vegetation that begins growth later in the year. Control of 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. This is particularly important in remote areas of lake shorelines where the spread of exotic species may go unnoticed for some time.

Option 1: No Action

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

Pros

There are few advantages with this option. Some of the reasons exotics were brought into this country are no longer used or have limited use. However, in some cases having an exotic species growing along a shoreline may actually be preferable if the alternative plant is commercial turfgrass. Since turfgrass has shallow roots and is prone to erosion along shorelines, exotics like reed canary grass or common reed (*Phragmites australis*) will control erosion more effectively. Native plants should take precedent over exotics when possible. Table 6 (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 monoculture. Access to lake shorelines may be impaired due to dense stands of non-native plants. Other recreational activities, such as swimming and boating, may not be effected.

Costs

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

Option 2: Hand Removal

Controlling exotic plants by hand removal is most effective on small areas (< 1 acre) and if done prior to heavy infestation. This is probably the best method (combined with herbicides) for removal of some of the invasive species on Tower Lake. 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 excavated. This is probably the most effective method of removal on Tower Lake for purple loosestrife on individual homeowner's lots. Spring or summer is the best time to cut or mow, since late summer and fall is when many of the plant seeds disperse. Proper disposal of excavated plants is important since seeds may persist and germinate even after several years. Once exotic plants are removed, the disturbed ground should be planted with native vegetation and closely monitored. Many exotic species, such as purple loosestrife, buckthorn, and garlic mustard are proficient at colonizing disturbed sites.

Pros

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

Cons

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

Costs

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

Option 3: Herbicide Treatment

Treatment with herbicides is one of the best options for controlling **mature stands** of invasive species, such as buckthorn and purple loosestrife, on Tower Lake. 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. The label is the law. Table 7 (Appendix A) contains herbicides that are approved for use near water for control of nuisance vegetation. Included in this table are rates, costs, and restrictions on use.

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

See Table 7 (Appendix A) for herbicide rates and prices. Total cost to treat the limited amount of purple loosestrife and other invasive species on Tower Lake would be minimal and could be done by individual homeowners or the TLIA. Hand-held and backpack sprayers costs from $25-$45 and $80-150, respectively. Wicking devices are $30-40. For other species, such as buckthorn, a device such as a Hydrohatchet®, a hatchet that injects herbicide through the bark (about $300) may be needed. Another injecting devise, E-Z Ject® is $450. Hand-held and backpack sprayers costs from $25-$45 and $80-150, respectively. Wicking devices are $30-40. A low cost alternative to specialized spray equipment is the use of household spray bottles (commonly used for window and bathroom cleaners). These bottles can be purchased at department stores for minimal costs. However, after there use for herbicide application they should not be used for anything else. Similarly, spray canisters like those used to apply lawn chemicals also provide lower costs alternatives to commercial spray equipment.

Objective V: Shoreline Improvement and Erosion Control

Erosion to shorelines on Tower Lake is a potential problem. Shoreline erosion occurs as a result of wind, wave, or ice action or from overland rainwater runoff. While some erosion to shorelines is natural, human alteration of the environment can accelerate and exacerbate the problem. Erosion not only results in loss of shoreline, but negatively influences the lake's overall water quality by contributing nutrients, sediment, and pollutants into the water. This effect is felt throughout the food chain since poor water quality negatively affects everything from microbial life to sight feeding fish and birds to people who want to use the lake for recreational purposes. The resulting increased amount of sediment will over time begin to fill in the lake, decreasing overall lake depth and volume and potentially impairing various recreational uses. During the 2001 survey of Tower Lake a large majority of shoreline was found to be uneroded. However, approximately 23% (2,528 feet) of Tower Lake's shoreline had some form of erosion. The slightly and moderately eroded areas should be addressed as soon as possible in order to avoid further deterioration.

Option 1: No Action

Pros

There are no short-term costs to this option. However, extended periods of erosion may result in substantially higher costs to repair the shoreline in the future. Eroding banks on steep slopes can provide habitat for wildlife, particularly bird species (e.g. kingfishers and bank swallows) that need to burrow into exposed banks to nest. In addition, certain minerals and salts in the soils are exposed during the erosion process, which are utilized by various wildlife species.

Cons

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

Costs

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

Option 2: Install Rock Rip Rap

Rip rap is the term for using rocks to stabilize shorelines. Size of the rock depends on the severity of the erosion, distance to rock source, and aesthetic preferences. Generally, four to eight inch diameter rocks are used. *The use of rip rap should be viewed as a last resort* after other alternatives such as biologs have been tried or are inappropriate. Rip rap can be incorporated with other erosion control techniques such as plant buffer strips. If any plants will be growing on top of the rip rap fill will probably be needed to cover the rocks and provide an acceptable medium for plants to grow on. *It is imperative that filter fabric be used under the rip rap to provide quality, long lasting results.* Prior to the initiation of work, permits and/or surveys from the appropriate government agencies need to be obtained (see costs below). Rip rap is best used for areas of **moderate erosion** and gentle to moderately sloped shores (<2:1). If rip rap is to be used on shorelines steeper than 2:1, then grading must be done in order to reduce grade to $\leq$ 2:1, preferably 3:1. *Every effort should be made to use more natural, less intrusive methods of shoreline stabilization (buffer strips and biologs).* However, the site must be prepared (grading, etc.) accordingly.

Pros

Rip rap can provide good shoreline erosion control. Rocks can absorb some of the wave energy while providing a more aesthetically pleasing appearance than seawalls. If installed properly, rip rap will last for many years. Maintenance is relatively low; however, undercutting of the bank can cause sloughing of the rip rap and subsequent shoreline. Areas with slight to moderate erosion problems may benefit from using rip rap. In all cases, a filter fabric should be installed under the rocks to maximize its effectiveness.

Fish and wildlife habitat can be provided if large boulders are used. Crevices and spaces between the rocks can be used by a variety of animals and their prey. Small mammals, like shrews can inhabit these spaces and prey upon many invertebrate species, including many harmful garden and lawn pests. Also, small fish may utilize the structure created by large boulders for foraging and hiding from predators.

Cons

A major disadvantage of rip rap is the initial expense of installation and associated permits. Installation is expensive since a licensed contractor and heavy equipment are generally needed to conduct the work. Permits are required if replacing existing or installing new rip rap and must be acquired prior to work beginning. If any fill material is placed in the floodplain along the shoreline; compensatory storage may also be 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. While rip rap absorb wave energy more effectively than seawalls, there is still some wave deflection that may cause resuspension of sediment and nutrients into the water column.

Small rock rip rap is poor habitat for many fish and wildlife species, since it provides limited structure for fish and cover for wildlife. As noted earlier, some small fish and other animals will inhabit the rocks if boulders are used. Smaller rip rap is more likely to wash way due to rising water levels or wave action. On the other hand, larger boulders are more expensive to haul in and install.

Rip rap may be a concern in areas of high public usage since it is difficult and possibly dangerous to walk on due to the jagged and uneven rock edges. This may be a liability concern to property owners.

Costs

Cost and type of rip rap used depend on several factors, but average cost for installation (rocks and filter fabric) is approximately $30-45 per linear foot. Based on assessed *moderately* eroded shoreline, Tower Lake would need approximately 1663 linear feet of rip rap. This would come to a cost of approximately $49,890 – $74,835. The steeper the slope and severity of erosion, the larger the boulders that will need to be used and thus, higher installation costs. In addition, costs will increase with poor shoreline accessibility and increased distance to rock source. Costs for permits and surveys can be $1,000-2,000 for installation of rip rap, depending on the circumstances. Additional costs will be incurred if compensatory storage is needed. Contact the Army Corps of Engineers, local municipalities, and the Lake County Planning and Development Department.

<u>Option 3: Buffer Strips</u>

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

Stabilizing the shoreline with vegetation is most effective on shorelines with **slight erosion** and slopes no less than 2:1 to 3:1, horizontal to vertical or flatter. Usually a buffer strip of at least 25 feet is recommended, however, wider strips (50 or even 100 feet) are recommended on steeper slopes or areas with more severe erosion problems. Areas where erosion is severe or where slopes are greater than 3:1, additional erosion control techniques may have to be incorporated such as Biologs or rip rap. Furthermore, it is the recommendation of the LMU that buffer strips be established along all applicable shorelines of Tower Lake regardless of shoreline type (including beach and seawalls).

Buffer strips can be constructed in a variety of ways with various plant species. Generally, buffer strip vegetation consists of native terrestrial (land) species and emergent (at the land and water interface) species. Terrestrial vegetation such as native grasses and wildflowers can be used to create a buffer strip along lake shorelines. Table 6 gives some examples, seeding rates and costs of grasses and seed mixes that can be used to create buffer strips. Native plants and seeds can be purchased at regional nurseries or from catalogs. When purchasing seed mixes, care should be taken that native plant seeds are used. Some commercial seed mixes contain non-native or weedy species or may contain annual wildflowers that will have to be reseeded every year. If purchasing plants from a nursery or if a licensed contractor is installing plants, inquire about any guarantees they may have on plant survival. Finally, new plants should be protected from herbivory (e.g., muskrats) by placing a wire cage over the plants for at least one year.

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

Emergent vegetation, or those plants that grow in shallow water and wet areas, can be used to control erosion more naturally than seawalls or rip rap. Native emergent vegetation can be either hand planted or allowed to become established on its own over time. Some plants, such as native cattails (*Typha* sp.), quickly spread and help stabilize shorelines, however they can be aggressive and may pose a problem later. Other species, such as those listed in Table 6 should be considered for native plantings.

Pros

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

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

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

Many fish and wildlife species prefer the native shoreline vegetation habitat. This habitat is an asset to the lake's fishery since the emergent vegetation cover may be used for spawning, foraging, and hiding. Various wildlife species are even dependent upon shoreline vegetation for their existence. Certain birds, such as marsh wrens (*Cistothorus palustris*) and endangered yellow-headed blackbirds (*Xanthocephalus xanthocephalus*) nest exclusively in emergent vegetation like cattails and bulrushes. Hosts of other wildlife like waterfowl, rails, herons, mink, and frogs to mention just a few, benefit from healthy stands of shoreline vegetation. Dragonflies, damselflies, and other beneficial invertebrates can be found thriving in vegetation along the shoreline as well. Two invertebrates of particular importance for lake management, the water-milfoil weevils (*Euhrychiopsis lecontei* and *Phytobius leucogaster*), which have been shown to naturally reduce stands of exotic Eurasian water-milfoil. Weevils need proper over wintering habitat such as leaf litter and mud which are typically found on naturalized shorelines or shores with good buffer strips. Many species of amphibians, birds, fish, mammals, reptiles, and invertebrates have suffered precipitous declines in recent years primarily due to habitat loss. Buffer strips may help many of these species and preserve the important diversity of life in and around lakes.

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

Cons

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

Costs

If minimal amount of site preparation is needed, costs can be approximately $10 per linear foot, plus labor. Cost of installing willow posts is approximately $15-20 per linear foot. Based on assessment *slightly* eroded shoreline, Tower Lake would need approximately 865 linear feet of buffer strip. This would come to a cost of $8,650. It is advisable that buffer strips be planted on all appropriate shoreline areas on Tower Lake including behind beach areas. This could be a cost sharing joint project between the lake front property owners and the TLIA. However, some of this shoreline would be better suited for use of biologs incorporated with buffer vegetation (see *Option 4* below), which includes the use of buffer strips. The labor that is needed can be completed by the property owner in most cases, although consultants can be used to provide technical advice where needed. This cost will be higher if the area needs to be graded. If grading is necessary, appropriate permits and surveys are needed. If filling is required, additional costs will be incurred if compensatory storage is needed. The permitting process is costly, running as high as $1,000-2,000 depending on the types of permits needed.

Option 4: Install Biolog, Fiber Roll, or Straw Blanket with Plantings

These products are long cylinders of compacted synthetic or natural fibers wrapped in mesh. The rolls are staked into shallow water. Once established, a buffer strip of native plants can be planted along side or on top of the roll (depending if rolls are made of synthetic or natural fibers). They are most effective in areas where plantings alone are not effective due to already severe erosion. These products are best used in areas on more **moderately** eroded shorelines or areas with highly erodable soil types. Many times biologs are used in conjunction with vegetated buffer strips as an alternative to rip rap.

Pros

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

Cons

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

Costs

Costs range from $25 to $35 per linear foot of shoreline, including plantings. Based on *moderately* eroded shorelines, Tower Lake would need 1663 linear feet of one of the above products on the moderate eroded areas of shoreline. This would cost approximately $41,575-58,205. This does not include the necessary permits and surveys, which may cost $1,000 – 2,000 depending on the type of earthmoving that is being done. Additional costs may be incurred if compensatory storage is needed.

Objective VI: Volunteer Lake Monitoring Program

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

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

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

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