

2000 SUMMARY REPORT

of

LAKE CHARLES

Lake County, Illinois

Prepared by the

**LAKE COUNTY HEALTH DEPARTMENT
ENVIRONMENTAL HEALTH SERVICES
LAKES MANAGEMENT UNIT**

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LAKE IDENTIFICATION AND LOCATION

Lake Charles (T44N, R10E, Section 28, 29) is located in Libertyville Township, in the Village of Vernon Hills, west of state highway 21 and north of state highway 60.

Lake Charles is a man-made impoundment covering 39.3 acres with a maximum depth of 10.9 feet in April 2000 (see Figure 1), although most of the lake is less than 8 feet. Although no bathymetric (depth contour) map for Lake Charles exists, a mean depth and volume was estimated based on data from lakes with known depths and volumes. The mean depth was obtained by multiplying the maximum depth by 0.5. The volume was obtained by multiplying the mean depth by the lake surface area. Based on these calculations, Lake Charles has an estimated mean depth of 5.45 feet and an estimated volume of 214.2 acre-feet. The elevation of Lake Charles is 692 feet above mean sea level.

The shoreline length is 1.1 miles. The western and southern shores are next to the White Deer Run Golf Course. The eastern shore is currently undeveloped. The sole inlet is at the north end (Hawthorn Drainage Ditch). A concrete spillway at the south end of the lake is the sole outlet. No major streams, rivers, or tributaries drain into Lake Charles. Water leaving Lake Charles flows to Little and Big Bear Lakes, then into Indian Creek and eventually into the Des Plaines River. Lake Charles is in the Indian Creek drainage of the Des Plaines River Watershed. The bottom sediment varies from clay, muck, to sand.

BRIEF HISTORY OF LAKE CHARLES

Damming of the Hawthorn Drainage Ditch (circa 1925) created this lake. Historical records show the maximum depth at 12 feet. The lake was rehabilitated utilizing rotenone (fish poison) to remove carp and all other fish in 1958 and restocked with largemouth bass and bluegill. The lake bottom and surrounding land is owned by the Village of Vernon Hills.

SUMMARY OF CURRENT AND HISTORICAL LAKE USES

Currently, access to Lake Charles is restricted. No designated access points exist. The White Deer Run Golf Course leases the land west of the lake. The golf course is using the lake for aesthetics and irrigation. The volume of water pumped out of Lake Charles for irrigation is difficult to assess. According to estimates from golf course staff, from 1997-2000 approximately 70-80 million gallons have been pumped out of the lake for irrigation. The lake water levels do not appear to be affected by the irrigation. Future development of the western shoreline is possible (personal communication, Ed Teich, Village of Vernon Hills), which will increase the recreational demands on the lake.

Water levels are controlled via the spillway at the south end of the lake.

LIMNOLOGICAL DATA – WATER QUALITY

Water samples were taken monthly from May - September at the deep-hole location near the lake's center (Figure 1). See Appendix A for water sampling methods.

Lake County received a higher than normal amount of precipitation in May, June, and July. June rain amounts were at record levels in some places in Lake County. A rain event occurred within a few days prior to water sampling in each month. In May, 1.53 inches of rain were recorded at the Lake County Stormwater Management Commission's Diamond Lake rain gauge three days prior to water sampling. In June, 1.88 inches were recorded in the four days prior to sampling. In July, 2.75 inches of rain was recorded three days prior to water sampling. It rained 1.0 inch on the day of sampling in August. In the three days prior to September sampling, 2.34 inches were recorded. Since Lake Charles is the recipient of stormwater via the Hawthorn Drainage Ditch, these rain events may have influenced the data collected. This was particularly evident in August when gray silt-laden water was observed at the inlet. Trash was observed floating into Lake Charles on several occasions after a rain event.

A strong carp population still exists in Lake Charles. Due to the shallow nature of the lake, carp activity likely influenced the water quality of the lake by increasing the turbidity and suspending nutrients and sediment into the water column.

Lake Charles' water quality is similar to many lakes in Lake County (Table 1). Most of the water quality parameters measured were near the averages of other lakes in the county that the Health Department has monitored. Several important findings were noted.

In May, high levels of Total Dissolved Solids (TDS) and high conductivity measurements in both the epilimnion (3-foot water sample) and the hypolimnion (deep water sample) were correlated. The TDS were likely dissolved road salts and other minerals that were washed in via the Hawthorn Drainage Ditch. Higher amounts of dissolved particles conduct electricity more effectively, thus the high conductivity readings. Total Suspended Solids (TSS) were also high in May, particularly in the hypolimnion sample. TSS consist of both organic and inorganic particles that are suspended in the water column. High TSS levels in the hypolimnion sample probably resulted in the "settling-out" of sediment particles or the fact that there was a slight density gradient near the 6 foot depth which would suspended some of the finer sediment particles in the water column. In June, TSS was high in both samples, indicating that both coarse and fine particles were present. In addition, the June epilimnion sample was high in Total Volatile Solids (TVS) which are made up of organic materials. Higher TVS may be the result of bacteria or other organic organisms being washed into Lake Charles due to spring rains or stirred up by carp activity. Dredging Lake Charles to increase storage capacity and remove nutrients is an option although it is most likely cost prohibitive. Although accurate cost estimates can only be calculated with a current bathymetric map, to increase the depth of the lake by one foot would cost over \$300,000.

Nitrate nitrogen ($\text{NO}_3\text{-N}$) was high in May, June, and July in both the epilimnion and hypolimnion. Sources of this nitrogen could be numerous, but could have washed in with the high levels of sediment from the Hawthorn Drainage Ditch or from run-off via the golf course. Golf courses use large amounts of nitrogen fertilizer, particularly in the spring, to maintain the course's fairways and greens. Ammonia nitrogen ($\text{NH}_3\text{-N}$) was also present at significant levels in both samples in May and June. High levels of ammonia nitrogen are common in lakes moving towards anoxic conditions (dissolved oxygen levels < 1 mg/L). However, in May and June, the entire water column in Lake Charles was fully oxygenated. High ammonia nitrogen levels are likely the result of run-off via the Hawthorn Drainage Ditch or the golf course. In addition, carp disturbance of the bottom may contribute to these values by resuspending nutrients in the water column.

Lake Charles had high levels of total phosphorus in most samples. Man-made lakes in Lake County are normally high in phosphorus, primarily the result of land management activities (i.e., construction, lawn fertilizing, stormwater run-off, and agriculture). The total nitrogen to total phosphorus ratio was 23:1, indicating a phosphorus-limiting system. Nitrogen, as well as carbon, naturally occur in high concentrations and come from a variety of sources (soil, air, etc.) which are more difficult to control than sources of phosphorus. Lakes that are phosphorus-limited may be easier to manage, since controlling phosphorus is more feasible than controlling nitrogen or carbon.

Secchi disk readings averaged 2.1 feet which is below the county average of 5.0 feet (based on 338 samples, 1995-2000). Low Secchi disk readings likely resulted from high levels of sediment washing in from the Hawthorn Drainage Ditch throughout the season and from carp activity.

Water levels on Lake Charles fluctuated by one foot over the course of the season. Water levels were highest on the water sampling date in June and lowest in August.

Lake Charles stratified only in July. The thermocline was located at the 5-foot depth. The entire water column remained fully oxygenated throughout the season with the exception of July, when anoxic conditions existed only at the 9-foot depth. Based on this data, Lake Charles does not have the dissolved oxygen problem that many man-made lakes have. An aeration system is not needed on Lake Charles. Since the lake is shallow and only weakly stratified in 2000, aeration will likely not significantly improve dissolved oxygen levels or improve water clarity.

Based on data collected in 2000, standard classification indices compiled by the Illinois Environmental Protection Agency were used to determine the current condition of Lake Charles. A general overall index that is commonly used is called a trophic state index or TSI. The TSI index classifies the lake into one of four categories: oligotrophic (nutrient-poor, biologically unproductive), mesotrophic (intermediate nutrient availability and biological productivity), eutrophic (nutrient-rich, highly productive), or hypereutrophic (extremely nutrient-rich productive). This index is calculated using total phosphorus values obtained at or near the surface, what is known as the epilimnion. The TSI for Lake Charles classified it as a eutrophic lake. Eutrophic lakes are the most common

types of lakes throughout the Midwest, and they are particularly common among man-made lakes. In Lake Charles, both phosphorus and suspended solids are considered high and contributing to the total impairment of the lake. Despite the high levels of phosphorus and suspended solids, aquatic life impairment index was low, indicating a full degree of support in the lake. However, due to the nutrient and sediment levels and the amount of plants in the lake, the swimming and recreation use indices showed a partial impairment of these activities. This classification is based primarily on water clarity issues. No tests were made on bacteria or other pathogens on Lake Charles in 2000.

LIMNOLOGICAL DATA – AQUATIC PLANT ASSESSMENT

Aquatic vegetation was sampled on Lake Charles monthly from May - September (see Appendix A). Seven aquatic plant species and several emergent shoreline plants were found (see Table 2). The average plant sample depth was 5.3 feet. The maximum depth at which plants were noted was 5.8 feet (May).

Most aquatic vegetation did not reach the water surface, with the exception of American pondweed and some of the curlyleaf pondweed.

Curlyleaf pondweed and Eurasian water milfoil, comprised most of the biomass observed (Table 3). Additional submerged species were recorded, but were found in smaller numbers. During the course of the sampling season, curlyleaf pondweed peaked in June-July and died back substantially by August. Presence of Eurasian water milfoil increased after May and persisted through September.

The 1% light level (the point where plants cannot photosynthesize) averaged 3.5 feet with a maximum depth of 5.3 feet in July and a minimum depth of 2.3 feet in May and September. Light levels were poor in May, gradually increasing in July, then decreasing in August and September. Plant growth is limited to this area of light penetration (known as the photic zone). Based on data collected in 2000, a significant portion of the bottom of Lake Charles does not receive sufficient light to support plant growth. As mentioned previously, this poor water clarity likely resulted from stormwater run-off and carp activity.

Two exotic aquatic plant species were found in the lake: curlyleaf pondweed and Eurasian water milfoil. Both plants can cause significant problems if the right conditions exist. Currently, they do not pose a problem, but careful monitoring of the lake's vegetation should be conducted to prevent their spread.

Lake Charles did not have a significant noxious aquatic weed or algae problem in 2000. Minimal amounts of algae were seen during the sampling season. However, given the biology of the aquatic plants present (particularly Eurasian water milfoil and curlyleaf pondweed), potential problems may arise in the future (see **Objective II: Aquatic Vegetation Management**). The lake was last chemically treated in April, 1997 with Sonar™ to control aquatic vegetation. If future chemical treatments are needed, a systemic herbicide like fluridone (includes Sonar™) may not be the best option. Fluridone is not recommended for lakes that flush rapidly (like Lake Charles) since the

chemical needs 30 days or more to be most effective. Water in systems like Lake Charles probably moves through in less than 30 days. Fluridone is also used for whole-lake treatments and is non-selective at high concentrations (> 8 ppb). If chemical treatments on Lake Charles are necessary, spot treatments with a contact herbicide like diquat or endothall is recommended since they are most effective on curlyleaf pondweed, the most common aquatic plant in the lake.

Due to the shallow nature of Lake Charles, if the water clarity improved, plant coverage in the lake could theoretically be 100%. Aquatic vegetation is important for a healthy lake. Plants compete with algae for nutrients and stabilize the bottom sediment. It is recommended that aquatic vegetation cover 25 – 40% of the lake's bottom.

Table 2. Obligate hydrophitic plants found in Lake Charles, May - September 2000.

Aquatic Plants

Coontail	<i>Ceratophyllum demersum</i>
Eurasian Water Milfoil	<i>Myriophyllum spicatum</i>
Slender Naiad	<i>Najas flexilis</i>
American Pondweed	<i>Potamogeton nodosus</i>
Curlyleaf Pondweed	<i>Potamogeton crispus</i>
Small Pondweed	<i>Potamogeton pusillus</i>
Sago Pondweed	<i>Stuckenia pectinatus</i>

Shoreline Plants

Water Plantain	<i>Alisma plantago-aquatica</i>
Honey Locust	<i>Gelditsia triacanthos</i>
Purple Loosestrife	<i>Lythrum salicaria</i>
Common Reed	<i>Phragmites australis</i>
Reed Canary Grass	<i>Phalaris arundinacea</i>
Water Smartweed	<i>Polygonum amphibium</i>
Cottonwood	<i>Populus deltoides</i>
Buckthorn	<i>Rhamnus cathartica</i>
Common Arrowhead	<i>Sagittaria latifolia</i>
Willow	<i>Salix</i> sp.
Hardstem Bulrush	<i>Scirpus acutus</i>
River Bulrush	<i>Scirpus fluviatilis</i>
Softstem Bulrush	<i>Scirpus validus</i>
Common Cattail	<i>Typha latifolia</i>

LIMNOLOGICAL DATA – SHORELINE ASSESSMENT

A shoreline assessment was conducted in May 2000 to determine the condition of the lake shoreline (see Appendix A). Of particular interest was the condition of the shoreline at the water/land interface. The Lake Charles shoreline is nearly 100% vegetation, with the only non-vegetative area being the spillway on the south end. No piers or any other structures extend into the lake.

Terrestrial plants, primarily reed canary grass dominated shoreline vegetation, but significant stands of emergent vegetation such as hardstem and softstem bulrush exist. In addition, common reed, river bulrush, and water plantain were also recorded (Table 3). Several purple loosestrife and buckthorn plants were located on the eastern shore. Purple loosestrife and buckthorn as well as reed canary grass are exotics that spread quickly and out-compete native vegetation. Buckthorn should be removed. The spread of loosestrife and reed canary grass should be monitored and if necessary, controlled (see **Objective IV: Exotic Species**).

On the western and southern shores, manicured turfgrass is maintained by the golf course. Along these shores a 2-foot buffer strip consisting of a mix of turfgrass and reed canary grass exists. As mentioned previously, the eastern shore is undeveloped and is wooded or nearly so. Slopes along the shoreline range from flat to moderate on the east shore to flat on the west shore.

During the shoreline assessment, several problem areas were identified. Moderate or severe erosion was observed on 50.3% of the shoreline (see Figure 1). Evidence of moderate bank undercutting was seen along most of the western shoreline. An area of approximately 300 feet along the northwest shoreline was the most severe and due to the steep slope of this area requires immediate attention. A smaller section (approximately 150 feet) of the southeastern shoreline near the spillway also has moderate erosion (see **Objective VI: Shoreline Erosion Control**).

LIMNOLOGICAL DATA – WILDLIFE ASSESSMENT

In 1958, the Illinois Department of Natural Resources stocked largemouth bass and bluegill into Lake Charles. No fish surveys were conducted during 2000. However, large numbers of carp were seen in shallow water throughout the summer, which probably contributed to the poor water clarity.

Overall, moderate wildlife habitat occurs along the shores of Lake Charles. Numerous wildlife species were observed using the lake (Table 4, below). See Appendix A for methods. Good terrestrial habitat exists in the wooded area along the eastern shore. Most of the terrestrial bird species observed were recorded along this shore which

consists of mature willow, honey locust, and various shrub and herbaceous species, and scattered emergent aquatic vegetation (i.e., cattails and bulrushes). Scattered large cottonwood trees along the western and northern shores also harbored good numbers of bird life.

Notable absences from Lake Charles were mammals, amphibians and reptiles. While these animals likely occur around Lake Charles, poor habitat may limit their numbers.

One bird species observed on Lake Charles, the black-crowned night heron, is listed as an endangered species in Illinois. While no nest was located, two adult birds and a young-of-the-year bird were observed, indicating that a nest was nearby, although not necessarily at Lake Charles. Black-crowned night herons can nest solitarily or in colonies, often with other herons such as great blue herons. This is noteworthy due to the potential planned development of the eastern shore.

Table 4. Wildlife species observed on Lake Charles, May – September 2000.

<u>Birds</u>	
Common Loon	<i>Gavia immer</i>
Double Crested Cormorant	<i>Phalacrocorax auritus</i>
Mallard	<i>Anas platyrhynchos</i>
Canada Goose	<i>Branta canadensis</i>
Ring-billed Gull	<i>Larus delawarensis</i>
Great Egret	<i>Casmerodius albus</i>
Great Blue Heron	<i>Ardea herodias</i>
Green Heron	<i>Butorides striatus</i>
Black-crowned Night Heron*+	<i>Nycticorax nycticorax</i>
Killdeer	<i>Charadrius vociferus</i>
Spotted Sandpiper	<i>Actitis macularia</i>
Red-tailed Hawk	<i>Buteo jamaicensis</i>
Belted Kingfisher	<i>Megaceryle alcyon</i>
Downy Woodpecker	<i>Picoides pubescens</i>
Common Flicker	<i>Colaptes auratus</i>
Least Flycatcher	<i>Empidonax minimus</i>
Barn Swallow	<i>Hirundo rustica</i>
Rough-wing Swallow	<i>Stelgidopteryx ruficollis</i>
American Crow	<i>Corvus brachyrhynchos</i>
Blue Jay	<i>Cyanocitta cristata</i>
Black-capped Chickadee	<i>Poecile atricapillus</i>
House Wren	<i>Troglodytes aedon</i>
American Robin	<i>Turdus migratorius</i>
Catbird	<i>Dumetella carolinensis</i>
Cedar Waxwing	<i>Bombycilla cedrorum</i>
Red-eyed Vireo	<i>Vireo olivaceus</i>
Warbling Vireo	<i>Vireo gilvus</i>
Red-winged Blackbird	<i>Agelaius phoeniceus</i>

Brown-headed Cowbird	<i>Molothrus ater</i>
Common Grackle	<i>Quiscalus quiscula</i>
Starling	<i>Sturnus vulgaris</i>
Baltimore Oriole	<i>Icterus galbula</i>
Northern Cardinal	<i>Cardinalis cardinalis</i>
American Goldfinch	<i>Carduelis tristis</i>
Indigo Bunting	<i>Passerina cyanea</i>
Song Sparrow	<i>Melospiza melodia</i>
Savannah Sparrow	<i>Passerculus sandwichensis</i>
 <u><i>Mammals, Amphibians and Reptiles</i></u>	
None noted	
 <u><i>Insects</i></u>	
Cicada	
Dragonfly species	
Damselfly species	
Sulphur Butterfly species	
* Endangered species in Illinois	
+ Young observed	

EXISTING LAKE QUALITY PROBLEMS

- *Lack of a bathymetric map*

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

- *Sediment, nutrients, and trash flowing into the lake*

Run-off from the Hawthorn Drainage Ditch probably contributes considerable amounts of sediment, nutrients, and trash. Poor water clarity and high levels of certain nutrients (i.e., ammonia, nitrate, and phosphorus) significantly diminish the water quality of Lake Charles. Watershed control options (i.e., buffer strips, no or low phosphorus lawn fertilizer, proper construction and agriculture practices, etc.) are needed to control excessive flow of these materials into the lake, particularly from the Hawthorn Drainage Ditch. Additional contributions of these nutrients are likely

coming via run-off from the golf course. Establishment of a wider buffer strip (> 20 feet) along the shoreline adjacent to the golf course would help filter some of the nutrients coming in from runoff. Dredging to increase the water storage capacity of the lake is expensive and may not be a viable option for Lake Charles.

- *Lack of an aquatic plant management plan*

While Lake Charles did not have an aquatic plant problem in 2000, the lake has been treated with herbicides in the past. A healthy lake will have between 25 – 40% plant coverage. If the water clarity in Lake Charles was improved plant coverage could be 100%. Thus, a good aquatic plant management plan is important. Herbicide treatments, if needed, should be limited to isolated problem areas. Since curlyleaf pondweed will likely be the problem plant growing in the lake, using a contact herbicide like diquat or endothall in spot treatments early in the season may be necessary.

- *Excessive numbers of carp*

Carp were seen throughout the season in Lake Charles. Their activity likely contributed to the poor water quality conditions measured. Elimination of the carp may help in improving water clarity. However, because Lake Charles is part of the Hawthorn Drainage Ditch it receives water from other sources, the total elimination of carp from the lake may not be possible.

- *Presence of exotic plant species*

Several exotic plant species (i.e., purple loosestrife, common buckthorn, reed canary grass, and common reed) were noted growing along the shoreline. Exotic species, if left unchecked, often dominate an area quickly and severely limit use of the shoreline by fish, wildlife, and people. Buckthorn should be controlled immediately. At this time, none of the other species are a problem, but monitoring and, if needed, control of these species is recommended.

- *Enhance wildlife habitat*

Improvement of wildlife habitat should be addressed. Both natural (i.e., dead and fallen trees) and artificial (nest boxes) structures could be incorporated into the overall management plan. Increased buffer widths on the shoreline adjacent to the golf course would improve habitat. Also, pending development of the eastern shore should incorporate wildlife and other natural habitats.

- *Shoreline erosion control*

Over half (50.3%) of the shoreline of Lake Charles showed signs of moderate or severe erosion. Evidence of moderate bank undercutting was seen along most of the western shoreline. An area of approximately 300 feet along the northwest shoreline

was the most severe and due to the steep slope of this area requires immediate attention. A smaller section (approximately 150 feet) of the southeastern shoreline near the spillway also has moderate erosion. This section along with most of the western shoreline could be improved by installing vegetated buffer strips. Due to the steeper slope of the northwest section, more extensive rehabilitation (e.g., grading and/or placement of rock rip-rap or steel seawall) would be needed.

- *Minimal vegetation on the southern and western shores*

The 2-foot wide buffer strip along the southern and western shorelines should be increased. This will aid in the reduction of nutrient-laden run-off from the golf course. It will also improve habitat for wildlife.

POTENTIAL OBJECTIVES FOR THE LAKE CHARLES MANAGEMENT PLAN

- I. Bathymetric Map
- II. Aquatic Plant Management
- III. Eradication of Carp
- IV. Control of Exotic Species
- V. Enhance Wildlife Habitat
- VI. Erosion Control and Improvement of Buffer Strip Along Shorelines

ALTERNATIVES FOR ACHIEVING THE LAKE MANAGEMENT PLAN OBJECTIVES

Objective I: Bathymetric Map

A bathymetric (depth contour) map is an essential tool for effective lake management since it provides critical information on the morphometric features of the lake (i.e., acreage, depth, volume, etc.). This information is particularly important when intensive management techniques (i.e., chemical treatments for plant or algae control, dredging, fish stocking, etc.) are part of the lake's overall management plan. Some bathymetric maps for lakes in Lake County do exist, but they are frequently old, outdated and do not accurately represent the current features of the lake.

Maps can be created by agencies like the Lake County Health Department - Lakes Management Unit or other companies. Costs vary, but can range from \$3,000-10,000 depending on lake size.

Objective II: Aquatic Plant Management

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

Lake Charles did not have a plant problem in 2000. However, if sedimentation and nutrient input are controlled plant beds may expand, causing problems later. Control of excess plant growth with herbicides should be carefully coordinated with the lake's overall management plan.

Option 1: No Action

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

Pros

There are positive aspects associated with the no action option for plant management. The first, and most obvious, is that there is no cost. However, if an

active management plan for vegetation control were eventually needed, the cost would be substantially higher than if the no action was taken in the first place. Another benefit of this option would be the lack of environmental manipulation. Under this option, no chemicals, mechanical alteration, or introduction of any organisms would take place. This is important since studies have shown that nuisance plants are more likely to invade disrupted areas. Expansion of the native plant population would increase the overall biodiversity and health of the lake. Habitat, breeding areas, and food source availability would greatly improve. Use of the lake would continue as normal and in some cases might improve (fishing) if native plants kept “weedy” plants under control.

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

Cons

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

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

severe enough, fish kills. All of the impacts above could in turn have negative impacts on numerous aspects of the lake's ecosystem.

In addition to the ecological impacts, many physical uses of the lake will be negatively impacted. Boating could be nearly impossible without becoming entangled in thick mats of plants. Swimming could also become increasingly difficult due to thick vegetation that would develop at beaches. Fishing could become more and more exasperating due in part to the thick vegetation and also because of stunted fish population. In addition, the aesthetics of the lake will also decline due to large areas of the lake covered by tangled mats of vegetation and the odors that will develop when they decay. The combination of the above events could cause property values on the lake to suffer. Property values on lakes with weedy plant/algae problems have been shown to decrease by as much as 15-20%.

Costs

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

Option 2: Aquatic Herbicides

Aquatic herbicides are the most common method to control nuisance vegetation/algae. When used properly, they can provide selective and reliable control. Products can not be licensed for use in aquatic situations unless there is less than a 1 in 1,000,000 chance of any negative effects on human health, wildlife, and the environment. Aquatic herbicides are not allowed to be environmentally persistent, bioaccumulate, or have any bioavailability. Prior to herbicide application, licensed applicators should evaluate the lake's vegetation and, along with the lake's management plan, choose the appropriate herbicide and treatment areas, and apply the herbicides during appropriate conditions (i.e. low wind speed). It is also important to know the morphology of the lake, particularly when applying chemicals to the lake. At the present time, no bathymetric map of Lake Charles exists.

There are two groups of herbicides: contact and systemic. Contact herbicides, like their name indicates, kill on contact. These herbicides affect only the above ground portion of the plant that they come into contact with and therefore do not kill the root system. An example of a contact herbicide is diquat. Systemic herbicides are taken up by the plant and disrupt cellular processes, which in turn cause plant death. These herbicides kill both the upper portions of the plant as well as the root system. An example of a systemic herbicide is fluridone. Both types of herbicides are available in liquid or granular forms. Liquid forms are concentrated and need to be mixed into water to obtain the desired concentration. The solution is then sprayed on the water's surface or injected into the water in the treatment areas. Granular herbicides are broadcast in a known rate over the treatment area where they sink to the bottom and slowly release the herbicide which is then taken up by the plant. These are referred to as SRP formulations (Slow Release Pellet). Other granular herbicides come in crystal form and dissolve as they come in

contact with water. This is typical of herbicides such as copper sulfate. Many herbicides come in both liquid and granular forms to fit the management needs of the lake. Herbicide applications can either be done as whole lake treatments or as more selective spot treatments. Multiple herbicides are often mixed and applied together. This is called a tank mix. This is done to save time, energy, and cost.

Aquatic herbicides are best used on actively growing plants to ensure optimal herbicide uptake. For this reason, herbicides are normally applied mid to late spring when water temperatures are above 60⁰F. This is the time of year when the plants are most actively growing and before seed/vegetative propagule formation. Follow up applications should be done as needed. When choosing an aquatic herbicide it is important to know what plants are present, which ones are problematic, which plants are beneficial, and how a particular herbicide will act upon these plants. The herbicide label is very important and should always be read before use. As with other management options, proper usage is the key to their effectiveness, benefits, and disadvantages.

Golf course staff indicated that Lake Charles was last treated with herbicides in 1997 with Sonar™. While the lake did not have an aquatic plant problem in 2000, future potential exists. However, instead of a whole-lake treatment, it is recommended that only specific portions of the lake be treated, with diquat (i.e., Reward®) or endotholl (i.e., Aquathol®). If curlyleaf pondweed is the target, endotholl would be the best option. If a more broad control of all aquatic plants is desired, diquat should be used. Treatment for curlyleaf pondweed should be done early in the season. Plant presence in Lake Charles is important particularly due to the high rate of sediment and nutrients entering the lake. Total elimination of plants will likely increase nutrient loads and potentially cause nuisance algal blooms. In addition, fluridone is most effective if retained in the lake for 30 days or longer. While the holding time of Lake Charles is unknown, it may be short due to its impoundment nature. The Sonar™ treatment in 1997 may have been aided by the fact that rainfall amounts in 1997 were below normal.

Pros

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

The fisheries and waterfowl populations of the lake would greatly benefit due to an increase in quality habitat and food supply. Dense stands of plants would be thinned out and improve spawning habitat and food source availability for fish.

Waterfowl population would greatly benefit from increases in quality food sources, such as large-leaf pondweed (*Potamogeton amplifolius*). Another environmental benefit of using aquatic herbicides over other management options is that they are organism specific. The metabolic pathways by which herbicides kill plants are plant specific which humans and other organisms do not carry out. Organisms such as fish, birds, mussels, and zooplankton are generally unaffected.

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

Cons

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

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

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

Overremoval, and possible regrowth of nuisance vegetation that may follow will drastically impair recreational use of the lake. Swimming could be adversely affected due to the likelihood of increased algal blooms. Swimmers may become entangled in large mats of filamentous algae. Blooms of planktonic species, such as blue-green algae, can produce harmful toxins as well produce noxious odors. If regrowth of nuisance vegetation were to occur, motors could become entangled making boating difficult. Fishing would also be negatively impacted due to the decreased health of the lake's fishery. The overall appearance of the lake would also suffer due to an increase in unsightly algal blooms and massive stands of vegetation. This in turn could have an unwanted effect on property values. Studies have shown that problematic algal blooms can decrease property values by 15-20%.

Costs

To calculate total cost it will be necessary to calculate surface acreage (SA) or acre-feet (AF) of the area(s) to be treated according to each lake's aquatic plant management plan. For example, to treat 10 acres of curlyleaf pondweed with Reward® would cost approximately \$4,250.

Option 3: Reestablishing Native Aquatic Vegetation

Revegetation should only be done when existing nuisance vegetation, such as Eurasian water milfoil, are under control using one of the above management options. If the lake has poor clarity due to excessive algal growth or turbidity, these problems must be addressed before a revegetation plan is undertaken. Without adequate light penetration, revegetation will not work. At minimum, planting depth light levels must be greater than 1-5% of the surface light levels for plant growth and photosynthesis.

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 5 lists common, native plants that should be considered when developing a revegetation plan. Included in this list are aquatic shoreline vegetation (rushes, cattails, etc) and deeper water 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 is less expensive than other options. Expanded native plant populations will also help with sediment stabilization. This in turn will have a positive effect on water clarity by reducing suspended solids and nutrients that decrease clarity and cause excessive algal growth. Properly revegetating shallow water areas with plants such as cattails, bulrushes, and water lilies can help reduce wave action that can lead to shoreline erosion. Increases in desirable vegetation will increase the plant biodiversity and also provide better quality habitat and food sources for fish and other wildlife. Recreational uses of the lake such as fishing and boating will also 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 5 for list of plants, seeding and planting rates and pricing.

Objective III: Eradication of Carp

A frequent problem that plagues many of the lakes in the County is the presence of common carp (*Cyprinus carpio*). Common carp were first introduced into the United States from Europe in the early 1870's, and were first introduced into Illinois river systems in 1885 to improve commercial fishing. The carp eventually made their way into many inland lakes and are now so 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 sediments. 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 sediments 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, and 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. However, rarely does any technique 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 recommended.

Option 1: No Action

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

Pros

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

Cons

There are many negative aspects to a no action management plan for carp management. The feeding habits of carp cause most of the associated problems. As carp feed they root around in the lake sediment. This causes resuspension of sediment and nutrients. Increased nutrient levels can lead to increased algal blooms, which, combined with resuspended sediments, lead to increased turbidity. As a result there is a decrease in light penetration, negatively impacting aquatic plants. Additionally, the rooting action of the carp causes the direct disruption of aquatic plants. Loss of aquatic plants can further aggravate sediment and nutrient loads in the water column due to loss of sediment stabilization provided by the plants. Additionally, the fishery of the lake may decline and/or become stunted due to predation issues related to decreased water clarity and loss of habitat. Other wildlife, such as waterfowl, which commonly forage on aquatic plants and fish, would also be negatively impacted by the decrease in vegetation.

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

Costs

There is no cost associated with the no action option.

Option 2: Rotenone

Rotenone is a piscicide that is naturally derived from the stems and roots of several tropical plants. Rotenone is approved for use as a piscicide by the USEPA and has been used in the U.S. since the 1930's. It is biodegradable (breaks down into CO₂ and H₂O) 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 in humans. Furthermore, due to its unstable nature, it is unlikely that the rotenone would still be active at the time of consumption, and 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 concentration will need to be increased based on high alkalinity and/or high turbidity. Rotenone is most effectively used when waters are cooling down (fall) not warming up (spring) and is most effective when water temperatures are <50°F. Under these conditions, rotenone is not as toxic as in warmer waters but it breaks down slower and provides a longer exposure time. If treatments are done in warmer weather they should be done before spawn or after hatch as fish eggs are highly tolerant to rotenone.

Rotenone rarely kills every fish (normally 99-100% effective). Some fish can escape removal and 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 minnows) 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. 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. The approximate cost to treat Lake Charles with rotenone would range from \$21,600-32,000. This does not include application, removal of dead fish, and fish restocking.

Objective IV: Control of Exotic Species

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

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 (*Alliaria officinalis*) 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 5 lists several native plants that can be planted along shorelines.

Cons

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

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

Costs

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

Option 3: Control by Hand

Controlling exotic plants by hand removal is most effective on small areas (< 1 acre) and if done prior to heavy infestation. Some exotics, such as purple loosestrife and reed canary grass, can be controlled to some degree by digging, cutting, or mowing if done early and often during the year. Digging may be required to ensure the entire root mass is excavated. 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 4: Herbicide Treatment

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

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

Pros

Herbicides provide a fast and effective way to control or eliminate nuisance vegetation. Unlike other control methods, herbicides kill the root of the plant,

which prevents regrowth. If applied properly, herbicides can be selective. This allows for removal of selected plants within a mix of desirable and undesirable plants.

Cons

Since most herbicides are non-selective, they are not suitable for broadcast application. Thus, chemical treatment of large stands of exotic species may not be practical. Native species are likely to be killed inadvertently and replaced by other non-native species. Off target injury/death may result from the improper use of herbicides. If herbicides are applied in windy conditions, chemicals may drift onto desirable vegetation. Care must also be taken when wicking herbicides as not to drip on to non-targeted vegetation such as native grasses and wildflowers. Another drawback to herbicide use relates to their ecological soundness and the public perception of them. Costs may also be prohibitive if plant stands are large. Depending on the device, cost of the application equipment can be high.

Costs

Glyphosate (sold as Rodeo®), that is used to control plants like reed canary grass, purple loosestrife, and common reed, should be applied at a rate of one gallon per acre at a cost of \$200-220 per gallon. Buckthorn should be controlled by cutting and stump treatment (wicking) with glyphosate or triclopyr (sold as Garlon© at \$100/gallon). Triclopyr should not be used near water. A Hydrohatchet®, a hatchet that injects herbicide through the bark, is about \$300.00. Another injecting device, E-Z Ject® is \$450.00. Hand-held and backpack sprayers costs from \$25-\$45 and \$80-150, respectively. Wicking devices are \$30-40.

Objective V: Enhance Wildlife Habitat

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

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

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

Option 1: No Action

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

Pros

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

Cons

If environmental conditions change or substantial land use actions occur (i.e., development) wildlife use of the area may change. For example, if a new housing development with manicured lawns and roads is built next to an undeveloped property, there will probably be a change in wildlife present.

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

Costs

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

Option 2: Increase Habitat Cover

This option can be incorporated with Option 3 (see below). One of the best ways to increase habitat cover is to leave a minimum 25-foot buffer between the edge of the water and any mowed grass. Allow native plants to grow or plant native vegetation along shorelines, including emergent vegetation such as cattails, rushes, and bulrushes (see Table 5 for costs and seeding rates). This will provide cover from predators and provide nesting structure for many wildlife species and their prey. It is important to control or eliminate non-native plants such as buckthorn, purple loosestrife, garlic mustard, and reed canary grass, since these species out-compete native plants and provide little value for wildlife.

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

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

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

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

Pros

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

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

Cons

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

Costs

The cost of this option would be minimal. The purchase of native plants can vary depending upon species and quantity. Based upon 100 feet of shoreline, a 25-foot buffer planted with a native forb and grass seed mix would cost between \$165-270 (2500 sq. feet would require 2.5, 1000 sq. feet seed mix packages at \$66-108

per package). This does not include labor that would be needed to prepare the site for planting and follow-up maintenance. This cost can be reduced or minimized if native plants are allowed to grow. However, additional time and labor may be needed to insure other exotic species, such as buckthorn, reed canary grass, and purple loosestrife, do not become established.

Option 3: Increase Natural Food Supply

This can be accomplished in conjunction with Option 2. Habitats with a diversity of native plants will provide an ample food supply for wildlife. Food comes in a variety of forms, from seeds to leaves or roots to invertebrates that live on or are attracted to the plants. Plants found in Table 5 should be planted or allowed to grow. In addition, encourage native aquatic vegetation, such as water lily, sago pondweed, largeleaf pondweed, and wild celery to grow. Aquatic plants such as these are particularly important to waterfowl in the spring and fall, as they replenish energy reserves lost during migration.

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

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

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

Pros

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

Migrating wildlife can be attracted with a natural food supply, primarily from seeds, but also from insects, aquatic plants or small fish. In fact, most migrating

birds are dependent on food sources along their migration routes to replenish lost energy reserves. This may present an opportunity to view various species that would otherwise not be seen during the summer or winter.

Cons

Feeding wildlife can have adverse consequences if populations become dependent on hand-outs or populations of wildlife exceed healthy numbers. This frequently happens when people feed waterfowl like Canada geese or mallard ducks. Feeding these waterfowl can lead to a domestication of these animals. As a result, these birds do not migrate and can contribute to numerous problems, such as excess feces, which is both a nuisance to property owners and a significant contribution to the lake's nutrient load. Waterfowl feces are particularly high in phosphorus. Since phosphorus is generally the limiting factor for nuisance algae growth in many lakes in the Midwest, the addition of large amounts of this nutrient from waterfowl may exacerbate a lake's excessive algae problem. In addition, high populations of birds in an area can increase the risk of disease for not only the resident birds, but also wild bird populations that visit the area.

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

Costs

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

Option 4: Increase Nest Availability

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

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

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

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

Pros

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

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

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

Cons

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

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

Costs

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

Option 5: Limit Disturbance

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

Pros

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

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

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

Cons

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

Costs

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

Objective VI: Erosion Control and Improvement of Buffer Strip Along Shorelines

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

Option 1: No Action

Pros

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

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

Cons

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

Costs

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

Option 2: Install a Steel or Vinyl Seawall

Seawalls are designed to prevent shoreline erosion on lakes in a similar manner they are used along coastlines to prevent beach erosion or harbor siltation. Today, seawalls are generally constructed of steel, although in the past seawalls were made of concrete or wood (frequently old railroad ties). Concrete seawalls cracked or were undercut by wave action requiring routine maintenance. Wooden seawalls made of old railroad ties are not used anymore since the chemicals that made the ties rot-resistant could be harmful to aquatic organisms. A new type of construction material being used is vinyl or PVC. Vinyl seawalls are constructed of a lighter, more flexible material as compared to steel. Also, vinyl seawalls will not rust over time as steel will.

Pros

If installed properly and in the appropriate areas (i.e. shorelines with severe erosion) seawalls provide effective erosion control. Seawalls are made to last numerous years and have relatively low maintenance.

Cons

Seawalls are disadvantageous for several reasons. One of the main disadvantages is that they are expensive, since a professional contractor and heavy equipment are needed for installation. Any repair costs tend to be expensive as well. 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. Permits and surveys are needed whether replacing and old seawall or installing a new one (see costs below).

Wave deflection is another disadvantage to seawalls. Wave energy not absorbed by the shoreline is deflected back into the lake, potentially causing sediment disturbance and resuspension, which in turn may cause poor water clarity and problems with nuisance algae, which use the resuspended nutrients for growth. If seawalls are installed in areas near channels, velocity of run-off water or channel flow may be accelerated. This may lead to flooding during times of high rainfall and run-off, shoreline erosion in other areas of the lake, or a resuspension of sediment due to the agitation of the increased wave action or channel flow, all of which may contribute to poor water quality conditions throughout the lake. Plant growth may be limited due to poor water clarity, since the photosynthetic zone where light can penetrate, and thus utilized by plants, is reduced. Healthy plants are important to the lake's overall water clarity since they can help filter some of the incoming sediment, prevent resuspension of bottom sediment, and compete with algae for nutrients. However, excessive sediment in the water and high turbidity may overwhelm these benefits.

Finally, seawalls provide no habitat for fish or wildlife. Because there is no structure for fish, wildlife, or their prey, few animals use shorelines with seawalls. In addition, poor water clarity that may be caused by resuspension of sediment from deflected wave action contributes to poor fish and wildlife habitat, since sight feeding fish and birds (i.e. bass, herons, and kingfishers) are less successful at catching prey. This may contribute to a lake's poor fishery (i.e. stunted fish populations).

Costs

Depending on factors such as slope and shoreline access, cost of seawall installation ranges from \$65-80 per linear foot for steel and \$70-100 per linear foot for vinyl. A licensed contractor installs both types of seawall. Additional costs may occur if the shoreline needs to be graded and backfilled, has a steep slope, or poor accessibility. Price does not include the necessary permits required. Additional costs will be incurred if compensatory storage is needed. Prior to the initiation of work, permits and/or surveys from the appropriate government agencies need to be obtained. For seawalls, a site development permit and a building permit are needed. Costs for permits and surveys can be \$1,000-2,000 for installation of a seawall. Contact the Army Corps of Engineers, local municipality, or the Lake County Planning and Development Department.

Based on these calculations, installing a steel seawall on the areas on Lake Charles identified in the Shoreline Assessment section would cost approximately \$19,500-24,000 for the northwest shoreline (300 feet). The other erosion problems around the lake can be addressed using other erosion control techniques such as buffer strips. This does not include costs of any necessary grading or backfilling or the required permits and surveys.

Option 3: Install Rock Rip-Rap or Gabions

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. Gabions are wire cages or baskets filled with rock. They provide similar protection as rip-rap, but are less prone to displacement. They can be stacked, like blocks, to provide erosion control for extremely steep slopes. Both rip-rap and gabions 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 or gabions, fill will probably be needed to cover the rocks and provide an acceptable medium for plants to grow on. Prior to the initiation of work, permits and/or surveys from the appropriate government agencies need to be obtained (see costs below).

Pros

Rip-rap and gabions 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 and gabions 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 severe erosion problems may benefit from using rip-rap or gabions. 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 or gabions 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 and gabions 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. Costs for gabions are approximately \$20-30 per linear foot, and approximately \$60-100 per linear foot when filled with rocks. 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 or gabions, 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.

Based on these calculations, installing rock rip-rap on the areas on Lake Charles identified in the Shoreline Assessment section would cost approximately \$9,000-13,500 for the northwest shoreline (300 feet), and \$4,500-6,750 for the southeastern shoreline (150 feet). To rip-rap the entire western shore (2,400 feet) would cost at least \$75,000. This does not include costs of any necessary grading or backfilling or the required permits and surveys.

Rock-filled gabion baskets would cost approximately \$18,000-30,000 for the northwest shoreline (300 feet) and \$9,000-15,000 for the southeastern shoreline (150 feet). This does not include costs of any necessary grading or backfilling or the required permits and surveys.

Option 4: Create a Buffer Strip

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

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

Buffer strips can be constructed in a variety of ways with various plant species. Generally, buffer strip vegetation consists of native terrestrial (land) species and emergent (at the land and water interface) species. Terrestrial vegetation such as native grasses and wildflowers can be used to create a buffer strip along lake shorelines. This is the recommended option for the western shoreline of Lake Charles. Table 5 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 highly erodible, willow posts may have to be used in conjunction with another erosion control technique such as biologs, A-Jacks ®, or rip-rap.

Emergent vegetation, or those plants that grow in shallow water and wet areas, can be used to control erosion more naturally than seawalls or rip-rap. Native emergent vegetation can be either hand planted or allowed to become established on its own over time. Some plants, such as native cattails (*Typha* sp.), quickly spread and help stabilize shorelines, however they can be aggressive and may pose a problem later. Other species, such as those listed in Table 5 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 are the water-milfoil weevils (*Euhrychiopsis lecontei* and *Phytobius leucogaster*), which have been shown to naturally reduce stands of exotic Eurasian water-milfoil (*Myriophyllum spicatum*). 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. 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.

Based on these calculations, installing a buffer strip on the problem areas identified in the Shoreline Assessment section would cost approximately \$3,000 for the northwest shoreline (300 feet) and \$1,500 for the southeastern shoreline. The cost to intensively modify the buffer strip along the entire shoreline adjacent to the golf course would be approximately \$25,000. This does not include costs of any necessary grading or backfilling or the required permits and surveys. Due to the severe nature of the erosion on the northwest shoreline, buffer strips are not recommended until there is a substantial reduction of the slope.

Option 5: Install A-Jacks®

A-Jacks® are made of two pieces of pre-cast concrete when fitted together resemble a child's playing jacks. These structures are installed along the shoreline and covered with soil and/or an erosion control product. Native vegetation is then planted on the backfilled area. They can be used in areas where severe erosion does not justify a buffer strip alone.

Pros

The advantage to A-Jacks® is that they are quite strong and require low maintenance once installed. In addition, once native vegetation becomes established the A-Jacks® can not be seen. They provide many of the advantages that both rip-rap and buffer strips have. Specifically, they absorb some of the wave energy and protect the existing shoreline from additional erosion. The added benefit of a buffer strip gives the A-Jacks® a more natural appearance, which may provide wildlife habitat and help filter run-off nutrients, sediment, and pollutants. Less run-off entering a lake may have a positive effect on water quality.

Cons

The disadvantage is that installation cost can be high since labor is intensive and requires some heavy equipment. A-Jacks® need to be pre-made and hauled in from the manufacturing site. These assemblies are not as common as rip-rap, thus only a limited number of contractors may be willing to do the installation.

Costs

The cost of installation is approximately \$40-75 per linear foot, but does not include permits and surveys, which can cost \$1,000-2,000 and must be obtained prior to any work implementation. Additional costs will be incurred if compensatory storage is needed.

Based on these calculations, installing a steel seawall on the areas on Lake Charles identified in the Shoreline Assessment section would cost approximately \$12,000-22,500 for the northwest shoreline (300 feet). This does not include costs of any necessary grading or backfilling or the required permits and surveys.

Option 6: Install Biolog, Fiber Roll, or Straw Blanket with Plantings

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

Pros

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

Cons

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

Costs

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

Based on these calculations, installing a biologs, fiber rolls, and/or straw blankets on the areas identified in the Shoreline Assessment section would cost approximately \$7,500-10,500 for the northwest shoreline (300 feet) and \$3,750-5,250 for the southeastern shoreline (150 feet). The entire western shore (2,400

feet) would cost approximately \$60,000. This does not include costs of any necessary grading or backfilling or the required permits and surveys.

Water quality data.

Epilimnion															
DATE	DEPTH	ALK	TKN	NH ₃ -N	NO ₃ -N	TP	SRP	TDS	TSS	TS	TVS	SECCHI	COND	pH	DO
5/11/00	3	162	0.98	0.259	0.553	0.065	0.013	558	14.3	579	107	2.13	0.9684	7.84	5.3
6/15/00	3	161	0.89	0.146	0.761	0.068	<0.005	429	27.2	487	160	1.38	0.6774	7.89	6.9
7/13/00	3	123	0.98	<0.1	0.479	0.02	0.007	290	9	302	87	2.43	0.4372	8.32	9.3
8/17/00	3	145	0.65	<0.1	0.058	0.077	<0.005	366	16	414	101	2.63	0.5883	8.34	6.6
9/14/00	3	116	1.26	<0.1	0.198	0.06	0.013	No Data	15	337	91	1.97	0.5156	8.07	6.7

Average 141 0.95 0.203^k 0.45 0.058 0.011^k 411 16.3 424 109 2.11 0.6374 8.09 7

Hypolimnion															
DATE	DEPTH	ALK	TKN	NH ₃ -N	NO ₃ -N	TP	SRP	TDS	TSS	TS	TVS	SECCHI	COND	pH	DO
5/11/00	6.5	163	1.2	0.291	0.563	0.106	0.021	560	34.8	561	80	NA	0.9751	7.7	3.7
6/15/00	7	161	0.93	0.147	0.773	0.063	<0.005	436	27.4	465	112	NA	0.6762	7.89	6.8
7/13/00	7	147	0.91	0.177	0.77	0.073	0.023	342	9.8	358	103	NA	0.5296	7.32	3.4
8/17/00	6	143	0.94	<0.1	0.078	0.07	<0.005	358	17	415	121	NA	0.5881	8.32	6.5
9/14/00	6	119	1.35	<0.1	0.196	0.079	<0.005	No Data	15	340	91	NA	0.5179	8.05	6.6

Average 147 1.07 0.205^k 0.48 0.078 0.022^k 424 20.8 428 101 NA 0.6574 7.86 5.4

Glossary

ALK = Alkalinity, mg/L CaCO₃
 TKN = Total Kjeldahl nitrogen, mg/L
 NH₃-N = Ammonia nitrogen, mg/L
 NO₃-N = Nitrate nitrogen, mg/L
 TP = Total phosphorus, mg/L
 SRP = Soluble reactive phosphorus, mg/L
 TDS = Total dissolved solids, mg/L
 TSS = Total suspended solids, mg/L
 TS = Total solids, mg/L

TVS = Total volatile solids, mg/L
SECCHI = Secchi Disk Depth, Ft.
COND = Conductivity, milliSiemens/cm
DO = Dissolved oxygen, mg/L

Note: "k" denotes that the actual value is known to be less than the value presented.

NA = Not Applicable

Table 3. Seasonal and monthly occurrence of aquatic plants in Lake Charles, May – September 2000.

Seasonal Summary 5/12/00-9/14/00	American Pondweed	Coontail	Curlyleaf Pondweed	Eurasian Water Milfoil	Sago Pondweed	Small Pondweed	Unknown
Num. of Sites	2	10	49	34	14	1	2
% Occurrence	1%	6%	32%	22%	9%	1%	1%

Monthly Summary 5/12/00	American Pondweed	Coontail	Curlyleaf Pondweed	Eurasian Water Milfoil	Sago Pondweed	Small Pondweed	Unknown
Num. of Sites	0	0	8	1	0	0	2
% Occurrence	0%	0%	20%	2%	0%	0%	5%

6/13/00	American Pondweed	Coontail	Curlyleaf Pondweed	Eurasian Water Milfoil	Sago Pondweed	Small Pondweed	Unknown
Num. of Sites	0	2	12	6	1	1	0
% Occurrence	0%	5%	30%	15%	3%	3%	0%

7/6/00	American Pondweed	Coontail	Curlyleaf Pondweed	Eurasian Water Milfoil	Sago Pondweed	Small Pondweed	Unknown
Num. of Sites	1	5	21	14	11	0	0
% Occurrence	3%	13%	53%	35%	28%	0%	0%

8/17/00	American Pondweed	Coontail	Curlyleaf Pondweed	Eurasian Water Milfoil	Sago Pondweed	Small Pondweed	Unknown
Num. of Sites	1	0	6	7	1	0	0
% Occurrence	5%	0%	30%	35%	5%	0%	0%

9/14/00	American Pondweed	Coontail	Curlyleaf Pondweed	Eurasian Water Milfoil	Sago Pondweed	Small Pondweed	Unknown
Num. of Sites	0	3	2	6	1	0	0
% Occurrence	0%	15%	10%	30%	5%	0%	0%

Plant Sampling Point Statistics

Average Sample Depth 5.31 feet
 Min. Sample Depth 0.75 feet
 Max Sample Depth 10.9 feet
 Max Plant Depth 5.8 feet
 Total # of Samples 155

Table 5. Native plants for revegetation of shorelines.

Terrestrial-Dry soil	Seeding Rate	Seed Price	Planting Rate	Price/Plant
Big Bluestem Grass (<i>Andropogon gerardii</i>)	10-25b lbs/acre	\$20/lb	NA	\$4-5
Bluejoint Grass (<i>Calamagrostis canadensis</i>)	2 lbs/acre	\$2-4/oz	NA	\$4-5
Little Bluestem Grass (<i>Andropogon scoparius</i>)	10-25 lbs/acre	\$20/lb	NA	\$4-5
Prairie Cord Grass (<i>Spartina pectinata</i>)	0.25-1.0 lbs/acre	\$2-3/oz	250-500/acre	\$2-4
Switch Grass (<i>Panicum virgatum</i>)	0.5-2.0 lbs./acre	\$6-7/oz	NA	\$1-5
Terrestrial-Wet Soil	Seeding Rate	Seed Price	Planting Rate	Price/Plant
Blue Flag (<i>Iris versicolor</i>)	NA	\$10/oz	1000/acre	\$0.60-1.50
Blue Vervain (<i>Verbena hastata</i>)	NA	\$6/oz	500-1000/acre	\$0.80-1.00
Blunt Spike Rush (<i>Eleocharis obtusa</i>)	NA	\$30/oz	500-1000/acre	\$0.50-1.00
Boneset (<i>Eupatorium perfoliatum</i>)	0.006-0.25 lbs./acre	\$6-7/oz	500-700/acre	\$1.00
Water Horsetail (<i>Equisetum fluviatile</i>)	NA	NA	1000/acre	\$0.50
Joe-Pye-Weed (<i>Eupatorium maculatum</i>)	NA	\$8/oz	500-700/acre	\$0.50-1.00
Sweet Flag (<i>Acorus calamus</i>)	NA	\$10/oz	250/acre	\$0.50-1.00
Wild Rice (<i>Zizania aquatica</i>)	NA	\$5.00/lb	1000/acre	\$0.50-0.20
1'-1.5' Deep	Seeding Rate	Seed Price	Planting Rate	Price/Plant
Arrow Arum (<i>Peltandra virginica</i>)	NA	\$4-5/oz	1000/acre	\$0.40-1.00
Bottle Brush Sedge (<i>Carex comosa</i>)	0.12-0.19 lbs./acre	\$6-8/oz	NA	NA
Chairmakers Rush (<i>Scirpus americanus</i>)	0.06-0.25 lbs/acre	\$8-15/oz	1000/acre	\$0.25-0.85
Common Arrowhead (<i>Sagittaria latifolia</i>)	0.06-0.125 lbs/acre	\$15-16/oz	1000/acre	\$0.60-1.25
Common Burreed (<i>Sparganium euycapum</i>)	0.06-0.25 lbs/acre	\$10-15/oz	1000/acre	\$0.22-0.50
Common Cattail (<i>Typha latifolia</i>)	0.06-0.5 lbs/acre	\$3-15/oz	1000/acre	\$0.40-1.00
Hardstem Bulrush (<i>Scirpus acutus</i>)	0.06-0.25 lbs/acre	\$8-15/oz	1000/acre	\$0.25-0.50
Pennsylvania Smartweed (<i>Polygonum pensylvanicum</i>)	0.06-0.25 lbs/acre	\$5/oz	NA	NA
River Bulrush (<i>Scirpus fluviatilis</i>)	0.06-0.25 lbs/acre	\$5/oz	NA	NA
Soft Rush (<i>Juncus effusus</i>)	0.06-0.125 lbs/acre	\$15-16/oz	\$4-5	\$0.25-0.90
Softstem Bulrush (<i>Scirpus validus</i>)	NA	\$20/oz	1000/acre	\$0.25-0.90
Water Plantain (<i>Alisma subcordatum</i>)	0.06-0.25 lbs/acre	\$10-15/oz	1000/acre	\$0.25-0.85
Water Smartweed (<i>Polygonum fluitans</i>)	0.06-0.5 lbs/acre	\$3-25/oz	1000/acre	\$0.35-0.50
White Water Buttercup (<i>Ranunculus longirostris</i>)	NA	NA	500/acre	\$0.40-0.50
Yellow Water Buttercup (<i>Ranunculus flabellaris</i>)	NA	NA	500/acre	\$0.70-1.51
1.5'-3' Deep	Seeding Rate	Seed Price	Planting Rate	Price/Plant
Watersheid (<i>Brasenia schreberi</i>)	NA	NA	1000/acre	\$0.65-1.49
White Water Lily (<i>Nymphaea tuberosa</i>)	NA	NA	200/acre	\$0.30-0.40
Yellow Water Lily (<i>Nuphar advena</i>)	NA	NA	200/acre	\$3.75
3'-8' Deep	Seeding Rate	Seed Price	Planting Rate	Price/Plant
Elodea (<i>Elodea canadensis</i>)	NA	NA	1000/acre	\$0.25-0.51
Large-leaved Pondweed (<i>Potamogeton amplifolius</i>)	NA	NA	1000/acre	\$0.25-0.51
Richardson's Pondweed (<i>Potamogeton richardsonii</i>)	NA	NA	250lbs/acre	\$2/lb
Sago Pondweed (<i>Potamogeton pectinatus</i>)	NA	NA	1000/acre	\$0.35-0.50
Vallisneria, Eel Grass (<i>Vallisneria americana</i>)	NA	NA	1000/acre	\$0.40-0.75
Water Stargrass (<i>Zosterella dubia</i>)	NA	\$4.00/lb	1000/acre	\$0.25-0.50
Trees and Shrubs	Seeding Rate	Seed Price	Planting Rate	Price/Plant
Bur Oak (<i>Quercus macrocarpa</i>)	NA	NA	NA	\$5-6
Buttonbush (<i>Cephalanthus occidentalis</i>)	NA	NA	NA	\$6-7
Red Osier Dogwood (<i>Cornus stolonifera</i>)	NA	\$9/oz	NA	\$2-5
White Oak (<i>Quercus alba</i>)	NA	\$5-8/oz	NA	\$6-7
Seed Mixes	Seeding Rate	Seed Price	Planting Rate	Price/Plant
Forb and Grass Seed Mix	500 square ft	\$20-60	NA	NA
Forb and Grass Seed Mix	1000 square ft	\$66-108	NA	NA

Appendix A. Methods for Field Data Collection and Laboratory Analyses

Water Sampling and Laboratory Analyses

Two water samples were collected once a month from May through September. Sample locations were generally at the deepest point in the lake (see sample site map), three feet below the surface, and approximately two feet off the bottom. Samples were collected with a horizontal or vertical Van Dorn water sampler. Approximately three liters of water were collected for each sample for all lab analyses. After collection, all samples were placed in a cooler with ice until delivered to the Lake County Health Department lab, where they were refrigerated. TestAmerica Incorporated, an environmental services lab, analyzed samples collected for total Kjeldahl nitrogen (TKN). The Health Department lab analyzed all other samples. Analytical methods for the parameters are listed in Table A1. Except nitrate nitrogen, all methods are from the Eighteenth Edition of Standard Methods, (eds. American Public Health Association, American Water Works Association, and Water Pollution Control Federation, 1992). Methodology for nitrate nitrogen was taken from the 14th edition of Standard Methods. Total Kjeldahl nitrogen was analyzed by method 351.2 from the Methods for Chemical Analyses of Water and Wastes (EPA 600 Series). Dissolved oxygen, temperature, conductivity and pH were measured at the deep hole with a Hydrolab DataSonde® 4a. Photosynthetic Active Radiation (PAR) was recorded using a LI-COR® 192 Spherical Sensor attached to the Hydrolab DataSonde® 4a. Readings were taken at the surface and then every foot until reaching the bottom in lakes ≤ 15 feet deep, and every two feet in lakes >15 feet.

Plant Sampling

Plants were sampled using a garden rake fitted with hardware cloth. The hardware cloth surrounded the rake tines and is tapered two feet up the handle. A rope was tied to the end of the handle for retrieval. At random locations in the littoral zone, the rake was tossed into the water, and using the attached rope, was dragged across the bottom, toward the boat. After pulling the rake into the boat, any plants on the rake were identified and recorded. Plants that were not found on the rake but were ocularly seen in the immediate vicinity of the boat at the time of sampling, were also recorded. Plants difficult to identify in the field were placed in plastic bags and identified with plant keys after returning to the office. The depth of each sampling location was measured either by a hand-held depth meter, or by pushing the rake straight down and measuring the depth along the rope or rake handle. One-foot increments were marked along the rope and rake handle to aid in depth estimation. Approximate locations of each point were drawn on an aerial photo of the lake. Locations of the plant edge were also identified and marked on the aerial photo. The plant edge was defined as the area where aquatic plants presence dissipated, typically toward the deeper portions of the lake. The number of sample locations was contingent upon lake surface area, area of littoral zone, and presence and distribution of plants.

Shoreline Assessment

To assess the current condition of each lake's shoreline, a shoreline assessment was completed in 2000. This survey was conducted with the use of a boat, aerial photos, and county parcel maps. The shoreline along the land/water interface on each parcel was observed from a boat and various parameters were assessed (Table A2). Shorelines were first identified as developed or undeveloped. The type of shoreline was then determined and length of each type was recorded based on the parcel map or was ocularly estimated. In addition, several other parameters were measured including: the extent of shoreline vegetation, the degree of slope and erosion, and the presence of inlets, recreational structures (including boats, canoes, jetskis, boat ramps, piers, boat lifts, swimming platforms, etc.), aerators, irrigation pumps, water control structures, invasive vegetation, beaver activity, and deadfall (trees or shrubs lying in the water).

Frequently a parcel consisted of several shoreline types. For example, a parcel may have a beach, a steel seawall, and rip-rap along the its shore. In this case, the parcel was subdivided into three separate sections.

Data was entered and analyzed in ArcView 3.2[®] Geographic Information System (GIS) software. Total shoreline lengths and percentages for each category were determined using Excel software.

Wildlife Assessment

Species of wildlife were noted during visits to each lake. When possible, wildlife was identified to species by sight or sound. However, due to time constraints, collection of quantitative information was not possible. Thus, all data should be considered anecdotal. Some of the species on the list may have only been seen once, or were spotted during their migration through the area.

Table A1. Analytical Methods Used for Water Quality Parameters.

<i>Parameter</i>	<i>Method</i>
Temperature	Hydrolab DataSonde® 4a
Dissolved oxygen	Hydrolab DataSonde ®4a
Nitrate nitrogen	Brucine method
Ammonia nitrogen	Electrode method, #4500F
Total Kjeldahl nitrogen	EPA 600 Series, Method 351.2
pH	Hydrolab DataSonde® 4a, Electrometric method
Total solids	Method #2540B
Total suspended solids	Method #2540D
Total dissolved solids	Method #2540C
Total volatile solids	Method #2540E, from total solids
Alkalinity	Method #2320B, titration method
Conductivity	Hydrolab DataSonde® 4a
Total phosphorus	Methods #4500-P B 5 and #4500-P E
Soluble reactive phosphorus	Methods #4500- P E and #4500-P B1
Clarity	Secchi disk
Color	Illinois EPA Volunteer Lake Monitoring Color Chart
Photosynthetic Active Radiation (PAR)	Hydrolab DataSonde® 4a, LI-COR® 192 Spherical Sensor

Table A2. Shoreline Type Categories and Assessment.

<i>Category</i>	<i>Assessment</i>
Developed	Yes, No
Inlets	None, Culvert, Creek, Farm Tiles, Storm Water Outlet, Swale, Sump
Shoreline Vegetation	None, Light, Moderate, Heavy
Type	Prairie, Shrub, Wetland, Woodland, Beach, Buffer, Canopy, Lawn, Rip-rap, Seawall, Vacant
Slope	Flat, Gentle, Steep
Erosion	None, Slight, Moderate, Severe
Water Control Structures	None, Culvert, Dam, Spillway
Recreational Structures	Yes, No
Irrigation Present	Yes, No
Aerator Present	Yes, No
Invasive Vegetation	Yes, No
Beaver Activity	Yes, No
Deadfall	Yes, No

Appendix B. Multiparameter Data for Lake Charles