Improvement Plan

Gilbert Lake Improvement Plan

Prepared for:
Gilbert Lake – Lake Board
4200 Telegraph Road
Bloomfield Hills, MI 48302

Prepared by:
Progressive AE
1811 4 Mile Road, NE
Grand Rapids, MI 49525-2442
616/361-2664

September 2008

Project No: 60660101

ProgressiveAE

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Introduction

Gilbert Lake is located in Sections 21 and 28 of Bloomfield Township in Oakland County (T2N, R10E; Figure 1). In October of 2007, Progressive AE was retained by the Gilbert Lake - Lake Board to conduct a lake improvement feasibility study. The objective of the study was to develop and define an improvement plan for Gilbert Lake. The purpose of this report is to discuss study findings, conclusions, and recommendations.

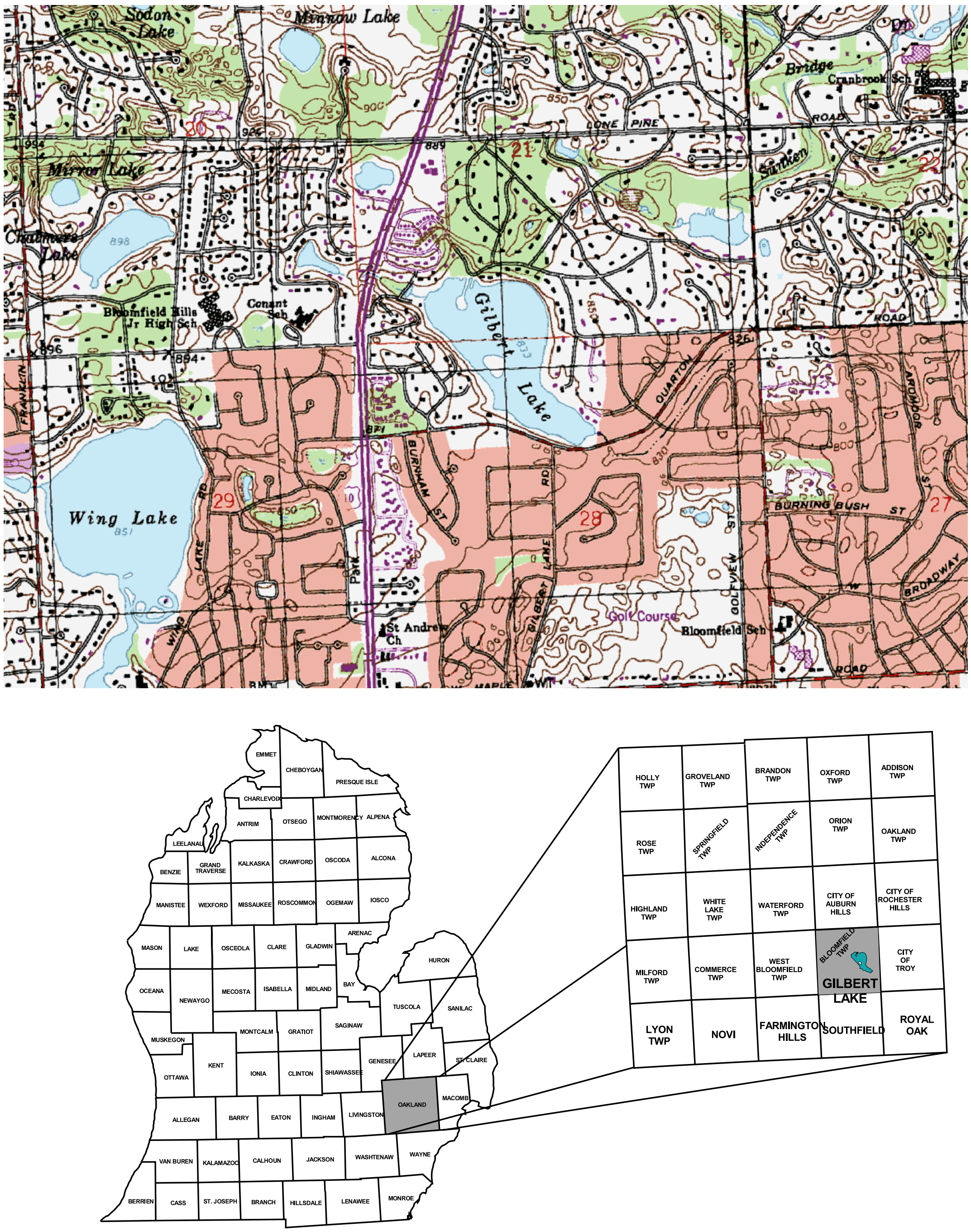


Figure 1. Project location map.

Physical, Chemical, and Biological Characteristics

Lake water quality is determined by a unique combination of processes that occur both within and outside of the lake. In order to make sound management decisions, it is necessary to have an understanding of the current physical, chemical, and biological condition of the lake, and the potential impact of drainage from the surrounding watershed.

Lakes are commonly classified as **oligotrophic, mesotrophic, or eutrophic**. Oligotrophic lakes are generally deep and clear with little aquatic plant growth. These lakes maintain sufficient dissolved oxygen in the cool, deep bottom waters during late summer to support cold water fish such as trout and whitefish. By contrast, eutrophic lakes are generally shallow, turbid, and support abundant aquatic plant growth. In deep eutrophic lakes, the cool bottom waters usually contain little or no dissolved oxygen. Therefore, these lakes can only support warm water fish such as bass and pike. Lakes that fall between these two extremes are called mesotrophic lakes.

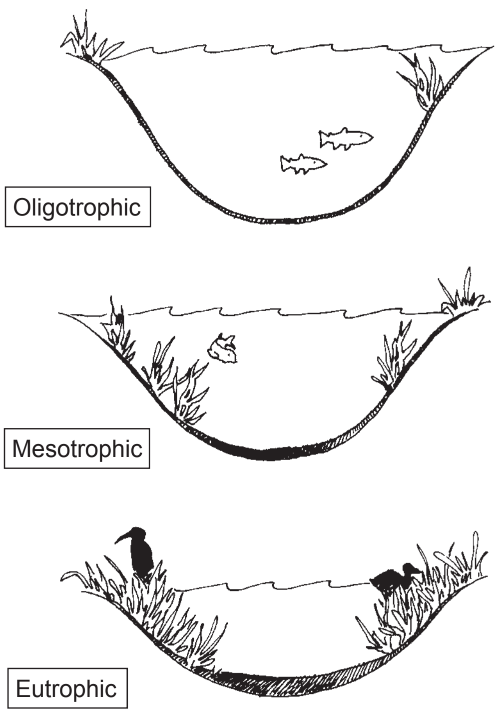


Figure 2. Lake classification.

Under natural conditions, most lakes will ultimately evolve to a eutrophic state as they gradually fill with sediment and organic matter transported to the lake from the surrounding watershed. As the lake becomes shallower, the process accelerates. When aquatic plants become abundant, the lake slowly begins to fill in as sediment and decaying plant matter accumulate on the lake bottom. Eventually, terrestrial plants become established and the lake is transformed to a marshland. The aging process in lakes is called "**eutrophication**" and may take anywhere from a few hundred to several thousand years, generally depending on the size of the lake and its watershed. The natural lake aging process can be greatly accelerated if excessive amounts of sediment and nutrients (which stimulate aquatic plant growth) enter the lake from the surrounding watershed. Because these added inputs are usually associated with human activity, this accelerated lake aging process is often referred to as "**cultural eutrophication**." The problem of cultural eutrophication can be managed by identifying sources of sediment and nutrient loading (i.e., inputs) to the lake and developing strategies to halt or slow the inputs. Thus, in developing a improvement plan, it is necessary to determine the limnological (i.e., the physical, chemical, and biological) condition of the lake and the physical characteristics of the watershed as well. Methods used to study Gilbert Lake are included in Appendix A.

GILBERT LAKE AND ITS WATERSHED

A summary of the physical characteristics of Gilbert Lake and its watershed is provided in Table 1. Gilbert Lake has a surface area of 59 acres, a maximum depth of 18 feet, and a mean or average depth of 5.7 feet. A map depicting approximate depth contours in Gilbert Lake is shown in Figure 3. Gilbert Lake contains about 338 acre-feet of water, which equates to 110 million gallons. The lake has a shoreline 1.8 miles long and a shoreline development factor of 1.6. The shoreline development factor indicates the degree of irregularity in the shape of the shoreline. That is, compared to a perfectly round lake with the same surface area as Gilbert Lake (i.e., 59 acres), the shoreline of Gilbert Lake is 1.6 times longer because of its irregular shape. Currently, approximately 40 homes directly border the lake.

TABLE 1
GILBERT LAKE
PHYSICAL CHARACTERISTICS

Lake Surface Area	59	Acres
Maximum Depth	18	Feet
Mean Depth	5.7	Feet
Lake Volume	338	Acre-Feet
Shoreline Length	1.8	Miles
Shoreline Development Factor	1.6	
Lake Elevation	833	Feet Above Sea Level
Watershed Area	390	Acres
Ratio of Lake Area to Watershed Area	1 :	6.6

The land area surrounding a lake that drains to the lake is called its watershed or drainage basin. The Gilbert Lake watershed encompasses 390 acres, a land area over six times larger than the lake itself (Figure 4). The majority of the watershed is urbanized (Figure 5). Water drains to Gilbert Lake via one intermittent tributary at the northwest end of the lake. Gilbert Lake's outlet flows to the Rouge River which, in turn, flows into the Detroit River.

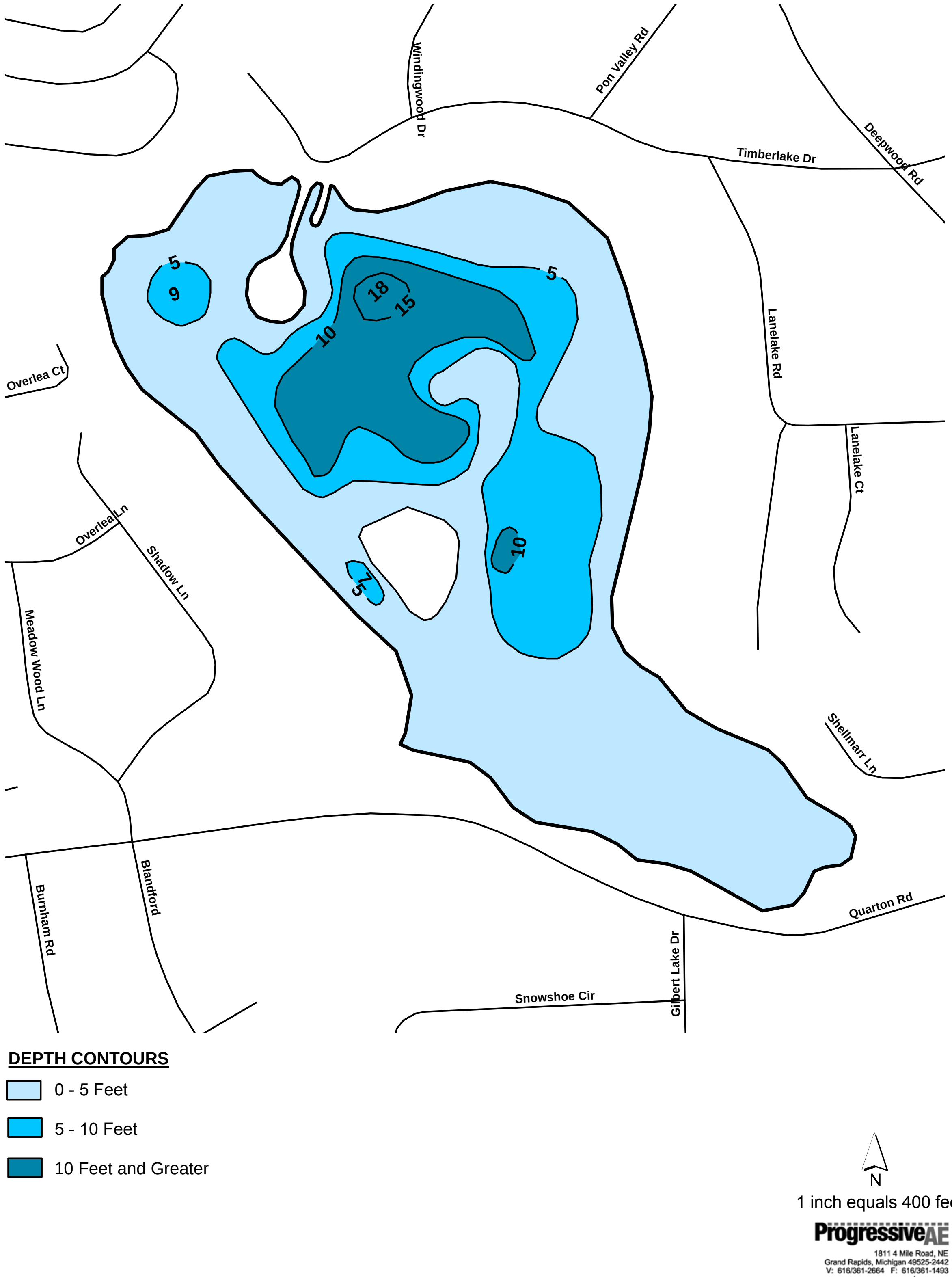


Figure 3. Gilbert Lake depth contour map.

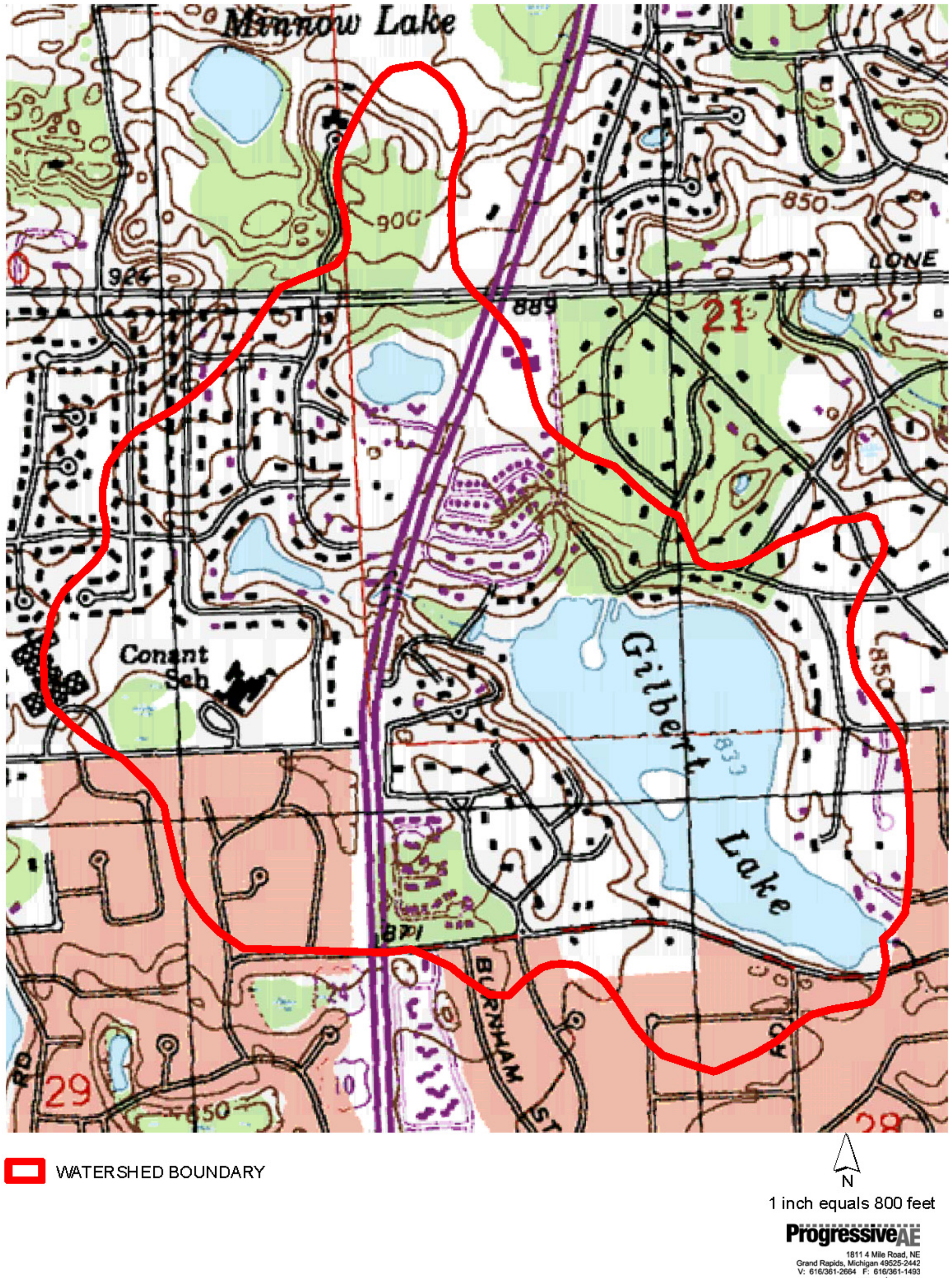


Figure 4. Gilbert Lake watershed on topographic map.

Figure 5. Gilbert Lake watershed on aerial photograph (Photograph Date: Summer 2005).

LAKE WATER QUALITY

There are many ways to measure lake water quality, but there are a few important physical, chemical, and biological parameters that indicate the overall condition of a lake. These measurements include temperature, dissolved oxygen, total phosphorus, chlorophyll-*a*, and Secchi transparency. The latter three measures are used in classifying a lake. Other important parameters include pH, total alkalinity, and fecal coliform bacteria levels.

Temperature

Temperature is important in determining the type of organisms that may live in a lake. For example, trout prefer temperatures below 68°F. Temperature also determines how water mixes in a lake. As the ice cover breaks up on a lake in the spring, the water temperature becomes uniform from the surface to the bottom. This period is referred to as "spring turnover" because water mixes throughout the entire water column. As the surface waters warm, they are underlain by a colder, more dense strata of water. This process is called thermal stratification. Once thermal stratification occurs, there is little mixing of the warm surface waters with the cooler bottom waters. The transition layer that separates these layers is referred to as the "thermocline." The thermocline is characterized as the zone where temperature drops rapidly with depth. As fall approaches, the warm surface waters begin to cool and become more dense. Eventually, the surface temperature drops to a point that allows the lake to undergo complete mixing. This period is referred to as "fall turnover." As the season progresses and ice begins to form on the lake, the lake may stratify again. However, during winter stratification, the surface waters (at or near 32°F) are underlain by slightly warmer water (about 39°F). This is sometimes referred to as "inverse stratification" and occurs because water is most dense at a temperature of about 39°F. As the lake ice melts in the spring, these stratification cycles are repeated. Shallow lakes do not stratify. Lakes that are 15 to 30 feet deep may stratify and destratify with storm events several times during the year.

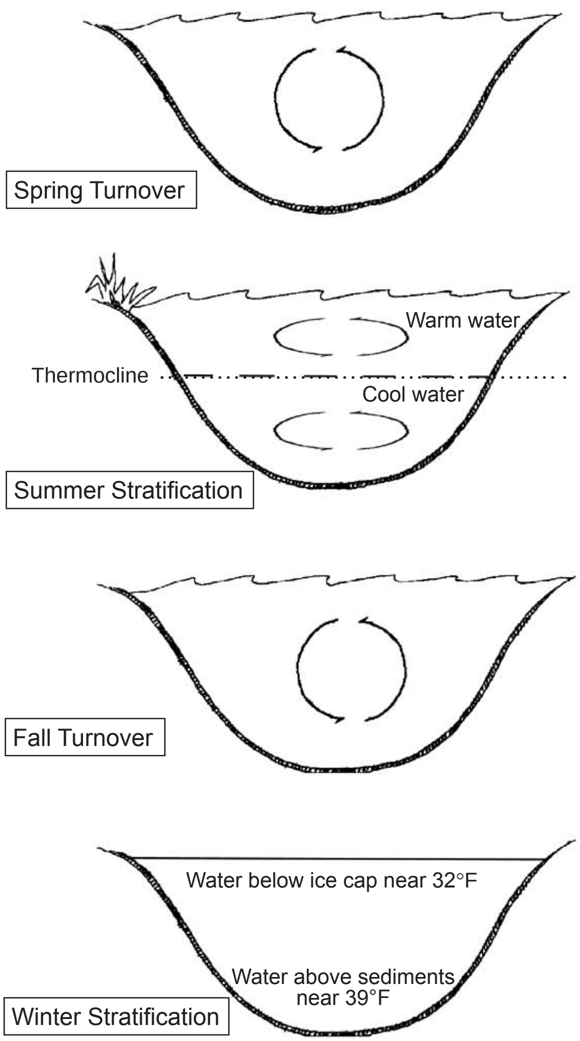


Figure 6. Lake stratification and turnover.

Dissolved Oxygen

An important factor influencing lake water quality is the quantity of **dissolved oxygen** in the water column. The major inputs of dissolved oxygen to lakes are the atmosphere and photosynthetic activity by aquatic plants. An oxygen level of about 5 mg/L (milligrams per liter, or parts per million) is required to support warm water fish. In lakes deep enough to exhibit thermal stratification, oxygen levels are often reduced or depleted below the thermocline once the lake has stratified. This is because deep water is cut off from plant photosynthesis and the atmosphere, and oxygen is consumed by bacteria that use oxygen as they decompose organic matter (plant and animal remains) at the bottom of the lake. Bottom-water oxygen depletion is a common occurrence in eutrophic and some mesotrophic lakes. Thus, eutrophic and most mesotrophic lakes cannot support cold water fish because the cool, deep water (that the fish require to live) does not contain sufficient oxygen.

Phosphorus

The quantity of **phosphorus** present in the water column is especially important since phosphorus is the nutrient that most often controls aquatic plant growth and the rate at which a lake ages and becomes more eutrophic. In the presence of oxygen, lake sediments act as a phosphorus trap, retaining phosphorus and, thus, making it unavailable for aquatic plant growth. However, if bottom-water oxygen is depleted, phosphorus will be released from the sediments and may be available to promote aquatic plant growth. In some lakes, the release of phosphorus from the bottom sediments is the primary source of phosphorus loading (or input). By reducing the amount of phosphorus in a lake, it may be possible to control the amount of aquatic plant growth. In general, lakes with a phosphorus concentration greater than 20 µg/L (micrograms per liter, or parts per billion) are able to support abundant plant growth and are classified as nutrient-enriched or eutrophic.

Chlorophyll-*a*

Chlorophyll-*a* is a pigment that imparts the green color to plants and algae. A rough estimate of the quantity of algae present in lake water can be made by measuring the amount of chlorophyll-*a* in the water column. A chlorophyll-*a* concentration greater than 6 µg/L is considered characteristic of a eutrophic condition.

Secchi Transparency

A **Secchi disk** is often used to estimate water clarity. The measurement is made by fastening a round, black and white, 8-inch disk to a calibrated line (Figure 7). The disk is lowered over the deepest point of the lake until it is no longer visible, and the depth is noted. The disk is then raised until it reappears. The average between these two depths is the Secchi transparency. Generally, it has been found that aquatic plants can grow at a depth of approximately twice the Secchi transparency measurement. In eutrophic lakes, water clarity is often reduced by algae growth in the water column, and Secchi disk readings of 7.5 feet or less are common.

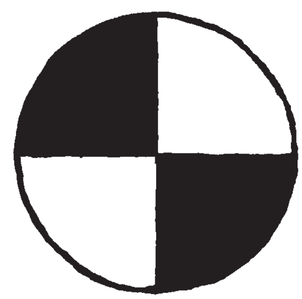


Figure 7. Secchi disk.

Lake Classification Criteria

Ordinarily, as phosphorus inputs to a lake increase, the amount of algae will also increase. Thus, the lake will exhibit increased chlorophyll-*a* levels and decreased transparency. A summary of lake classification criteria developed by the Michigan Department of Natural Resources is shown in Table 2.

TABLE 2
LAKE CLASSIFICATION CRITERIA

Lake Classification	Total Phosphorus (µg/L)[1]	Chlorophyll-a (µg/L)[1]	Secchi Transparency (feet)
Oligotrophic	Less than 10	Less than 2.2	Greater than 15.0
Mesotrophic	10 to 20	2.2 to 6.0	7.5 to 15.0
Eutrophic	Greater than 20	Greater than 6.0	Less than 7.5

[1] µg/L = micrograms per liter = parts per billion.

pH and Alkalinity

pH is a measure of the amount of acid or base in water. The pH scale ranges from 0 (acidic) to 14 (alkaline or basic) with neutrality at 7. The pH of lakes generally ranges between 6 and 9 (Wetzel 1983). The concentration of gases, such as oxygen and carbon dioxide, directly influence pH. Most organisms tolerate only very narrow ranges in pH; therefore, large amounts of alkalinity are needed as natural buffers to changes in pH.

Alkalinity is the measure of the pH-buffering capacity of water. Lakes that have high alkalinity (over 100 mg/L as calcium carbonate) are able to sustain large inputs of acid with little change in pH. Addition of acid can occur naturally (e.g., during bacterial decomposition of organic material in the sediments; during natural diffusion of carbon dioxide into the surface waters), or because of pollution (acid deposition, both wet and dry fall). The ability of the lake to maintain a stable pH is crucial to the survival of its aquatic inhabitants.

Fecal Coliform Bacteria

A primary consideration in evaluating the suitability of a lake to support swimming and other water-based recreational activities is the level of bacteria in the water. ***Escherichia coli*** **(*E. coli*)** is a bacteria commonly associated with fecal contamination. The current State of Michigan public health standard for total body contact recreation (e.g., swimming) for a single sampling event requires that the number of E. coli bacteria not exceed 300 per 100 milliliters of water.

SAMPLING RESULTS AND DISCUSSION

Samples were collected at the surface, mid-depth, and bottom over the deep basin in Gilbert Lake on August 29, 2007, and on April 7, 2008. These sampling dates corresponded to the periods of summer thermal stratification and spring turnover, respectively. Data collected from Gilbert Lake are presented in Tables 3 through 5.

Summer sampling data indicates Gilbert Lake was thermally stratified; there was a 12-degree difference in water temperature top to bottom, with the warm surface waters in the lake underlain by cooler bottom waters (Table 3). During the summer sampling period, bottom-water dissolved oxygen was nearly depleted as a result of bacterial decomposition at the lake bottom. Gilbert Lake does not sustain sufficient dissolved oxygen in the cool bottom-water during the summer months to support cold-water fish species such as trout. However, dissolved oxygen levels are adequate throughout most of the lake to sustain a warm-water fishery.

Total phosphorus levels in Gilbert Lake ranged from a low of 5 parts per billion to a high of 47 parts per billion (Table 3). Phosphorus levels in Gilbert Lake generally exceed the eutrophic threshold concentration of 20 parts per billion, indicating sufficient phosphorus is available in the lake to support abundant aquatic plant growth.

Secchi transparency in Gilbert Lake measured 8.0 feet during the summer sampling period and 4.5 feet during the spring sampling. No chlorophyll-*a* was detected in the water column during the summer sampling period, indicating there was very little algae growth in the water column at that time. However, during the spring sampling period, moderate chlorophyll-*a* levels were measured and transparency was somewhat decreased, indicating significant algae growth in the water column was occurring at that time.

pH measured in Gilbert Lake ranged from a low of 7.9 to a high of 9.0 (Table 4). These readings are normal for Michigan inland lakes. Gilbert Lake contains high alkalinity, indicating the lake is well-buffered and naturally resistant to the effects of acid rain. The high alkalinity measured in Gilbert Lake suggests that groundwater springs (rich in calcium carbonate) may be a significant source of water to Gilbert Lake.

Bacteria levels measured in Gilbert Lake in August were well below the state health standard (Table 5). These data indicate that, at the time of sampling, Gilbert Lake was safe for swimming and other total body contact recreational activities.

Based on the data collected, Gilbert Lake is eutrophic in that phosphorus levels are elevated, bottom-water oxygen is depleted, and transparency is reduced on occasion. However, algae growth in the lake was minimal during the period of sampling. The overall water quality of Gilbert Lake is reasonably good. Data collected during the course of this study are generally consistent with historical data collected from Gilbert Lake (Crowe 1959). A complete copy of the historical water quality report is included in Appendix B.

TABLE 3
GILBERT LAKE
DEEP BASIN WATER QUALITY DATA

Sample Location	Sample Depth (feet)	Temp. (°F)	Dissolved Oxygen (mg/L)[1]	Total Phosphorus (µg/L)[2]	pH (S.U.)[3]	Total Alkalinity (mg/L as $CaCO_3$)[4]
August 29, 2007						
1	1	78	8.6	5	9.0	127
1	8	74	6.5	29	8.6	138
1	17	66	0.2	16	7.9	154
April 7, 2008						
1	1	47	12.5	32	8.5	146
1	10	47	13.5	26	8.4	148
1	20	41	1.4	47	8.1	202

TABLE 4
GILBERT LAKE
SURFACE WATER QUALITY DATA

Date	Sample Location	Secchi Transparency (feet)	Chlorophyll-*a* (µg/L)[2]
August 29, 2007	1	8.0	0.0
April 7, 2008	1	4.5	3.4

[1] mg/L = milligrams per liter = parts per million.
[2] µg/L = micrograms per liter = parts per billion.
[3] S.U. = standard units.
[4] mg/L as $CaCO_3$ = milligrams per liter as calcium carbonate.

TABLE 5
GILBERT LAKE BACTERIOLOGICAL DATA
AUGUST 29, 2007

Site No.	*E. Coli* Bacteria/100 mL[1]
1	56
2	19
3	28
4	43
5	50
6	69
7	44
8	4
9	12
10	16

AQUATIC PLANTS

The distribution and abundance of aquatic plants are dependent on several variables, including light penetration, bottom type, temperature, water levels, and the availability of plant nutrients. The term “aquatic plants” includes both the algae and the larger aquatic plants or macrophytes. The macrophytes can be categorized into four groups: the emergent, the floating-leaved, the submersed, and the free-floating.

Aquatic plant surveys of Gilbert Lake were conducted on August 29, 2007, and May 19, 2008 (Table 6). The vegetation surveys were conducted in accordance with a procedure developed by the Department of Environmental Quality (DEQ). This procedure involved dividing the lake into individual assessment sites and determining the type and relative abundance of all plants within each assessment area. Information regarding the DEQ’s vegetation mapping procedure is included in Appendix C.

Due to its shallow depth, aquatic plants can colonize much of the bottomlands in Gilbert Lake and the lake contains an abundant and diverse plant community. In total, 18 species of plants were observed in the lake. A listing of plants observed beginning with the most abundant to the least abundant is provided in Table 6. Diagrams of many of the plants listed are included in Figure 8.

The most abundant emergent species were cattails and bulrush, and the most abundant submersed species were large-leaf pondweed, thin-leaf pondweed, and naiad. Although control efforts in recent years have helped reduce nuisance plant growth, growth patterns observed during the period of study are similar to historical accounts of plant growth in the lake (Crowe 1959). Crowe (1959) noted:

> The most outstanding biological characteristic of the lake is the lush growth of aquatic vegetation which fills most of the basin to depths of five or six feet. Vegetation is everywhere, even in the vicinity of docks and bathing beaches where there is a good deal of activity. Abundant vegetation is indicative of a fairly productive lake, and one in which the enrichment process is far advanced. Original conditions at the lake were conducive to the growth of aquatic plants, and the addition of nutrients from surface run-off (lawn

[1] mL = milliliters.

fertilizers for example) has accelerated the process. The fairly steep slope around much of the basin facilitates the entry of nutrients into the lake basin. In some lakes, the addition of nutrients might stimulate algal blooms and increase plankton production but at Gilbert Lake the nutrients have accelerated the growth of rooted aquatics.

TABLE 6
GILBERT LAKE AQUATIC PLANTS

Common Name	Scientific Name	Group	No. of Assessment Sites Where Plant Was Observed
Cattail	*Typha* sp.	Emergent	46
White waterlily	*Nymphaea odorata*	Floating-leaved	43
Large-leaf pondweed	*Potamogeton amplifolius*	Submersed	39
Thin-leaf pondweed	*Potamogeton* sp.	Submersed	27
Bulrush	*Scirpus* sp.	Emergent	22
Naiad	*Najas flexilis*	Submersed	17
Eurasian milfoil	*Myriophyllum spicatum*	Submersed	9
Curly-leaf pondweed	*Potamogeton crispus*	Submersed	8
Purple loosestrife	*Lythrum salicaria*	Emergent	8
Illinois pondweed	*Potamogeton illinoensis*	Submersed	8
Yellow waterlily	*Nuphar* sp.	Floating-leaved	6
Arrowhead	*Sagittaria latifolia*	Emergent	5
Sago pondweed	*Potamogeton pectinatus*	Submersed	4
Pickerelweed	*Pontederia cordata*	Emergent	2
Coontail	*Ceratophyllum demersum*	Submersed	2
Wild celery	*Vallisneria americana*	Submersed	1
Water shield	*Brasenia schreberi*	Floating-leaved	1
Chara	*Chara* sp.	Submersed	1

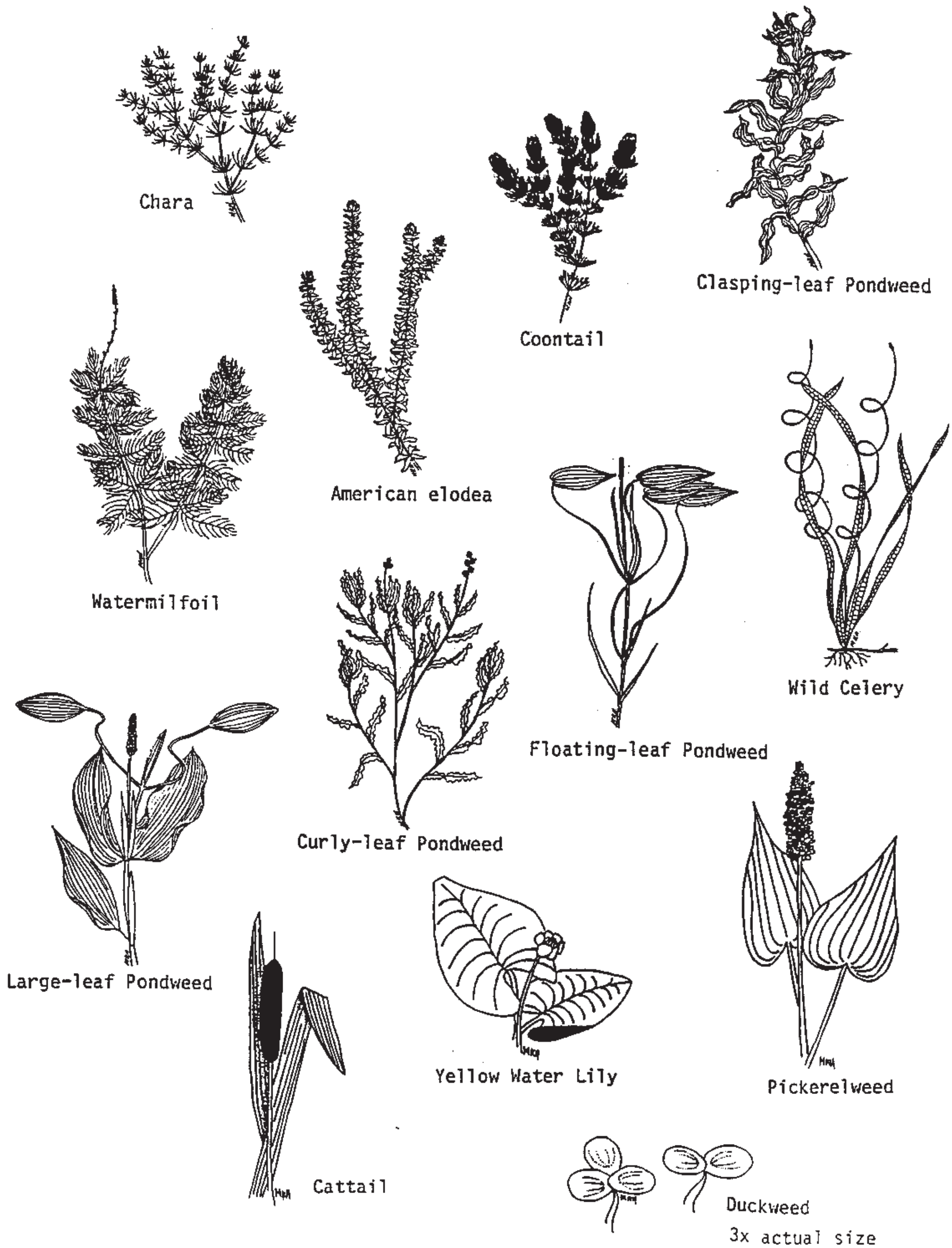


Figure 8. Common aquatic plants.

Lake Improvement Alternatives

INTRODUCTION

Gilbert Lake is a highly productive lake that is naturally able to support abundant rooted plant growth. In order to effectively manage the lake over the long-term, steps will need to be taken in conjunction with in-lake improvements to reduce watershed pollution inputs.

AQUATIC PLANT CONTROL

Although an overabundance of undesirable plants can limit recreational use and enjoyment of a lake, it is important to realize that aquatic plants are a vital component of aquatic ecosystems. They produce oxygen during photosynthesis, provide food and habitat for fish and other organisms, and help stabilize shoreline and bottom sediments.

The objective of a sound aquatic plant control program is to remove plants only from problem areas where nuisance growth is occurring. Under no circumstance should an attempt be made to remove all plants from the lake.

Mechanical harvesting (i.e., plant cutting and removal) and chemical herbicide treatments are methods commonly employed to control aquatic plant growth (Figures 9 and 10). For large-scale aquatic plant control, harvesting may be advantageous over herbicide treatments since plants removed from the lake will not sink to the lake bottom and add to the buildup of organic sediments. In addition, some nutrients contained within the plant tissues are removed with the harvested plants. With the use of herbicides, treated plants die back and decompose on the lake bottom while bacteria consume dissolved oxygen reserves in the decomposition process. Since the plants are not removed from the lake, sediment buildup on the lake bottom continues, often creating a bottom substrate ideal for future aquatic plant growth.

Figure 9. Mechanical harvesting.

Figure 10. Aquatic herbicide treatments.

It should be noted, however, that attempts to control certain plant types by harvesting alone may not prove entirely effective. This is especially true with Eurasian milfoil (*Myriophyllum spicatum*) due to the fact that this plant may proliferate and spread via vegetative propagation (small pieces break off, take root, and grow) if the plant is cut (Figure 11). Eurasian milfoil is especially problematic in that it often becomes established early in the growing season and can grow at greater depths than most plants. Eurasian milfoil often forms a thick canopy at the lake surface that can degrade fish habitat and seriously hinder recreational activity (Figure 12). Once introduced into a lake system, Eurasian milfoil often out-competes and displaces more desirable plants and becomes the dominant species. When Eurasian milfoil is present, it may be possible to control the growth and spread of the plant by treating the lake with a species-selective systemic herbicide.

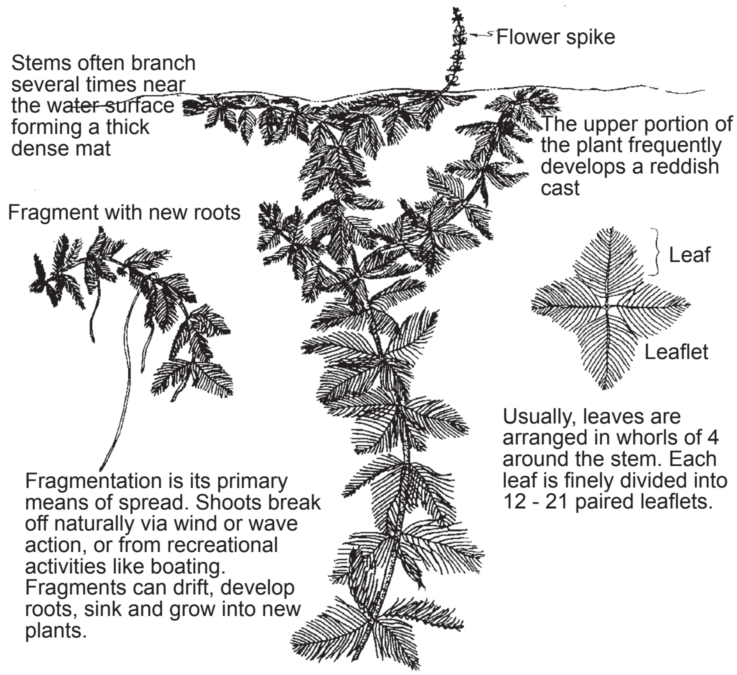


Figure 11. Eurasian milfoil.

In Michigan, Part 33, Aquatic Nuisance Control, of the Natural Resources and Environmental Protection Act, PA 451 of 1994, requires that a permit be acquired from the Department of Environmental Quality before any herbicides are applied to inland lakes. The permit will include a list herbicides that are approved for use in the lake, respective dose rates, use restrictions, and will show specific areas in the lake where treatments are allowed.

Eurasian milfoil is present in Gilbert Lake; therefore, it is recommended that consideration be given to spot-treating Eurasian milfoil beds with systemic herbicides, where permitted. Herbicide treatments for Eurasian milfoil control generally work best when conducted early in the growing season (i.e., May or early June) when the plants are actively growing.

Figure 12. Eurasian milfoil canopy.

If Eurasian milfoil were to gain dominance in Gilbert Lake, another alternative to control the infestation would be a whole-lake treatment with a herbicide called fluridone (trade names Sonar or Avast). Fluridone is a systemic herbicide that, at low doses, selectively controls Eurasian milfoil while not significantly impacting desirable native plant species. In accordance with Department of Environmental Quality permit requirements, fluridone is applied in what is called a “6-bump-6” treatment. With this approach, fluridone is applied at an initial concentration of 6 parts per billion. About two weeks after the initial treatment, the concentration of fluridone in the lake is measured and the lake is treated again to bring the concentration back up to 6 parts per billion. The initial fluridone application is generally scheduled for late April or early May. At the low dose rates permitted, fluridone is slow acting. It takes several weeks for the Eurasian milfoil to be noticeably impacted. Although the response to fluridone is initially slow, Eurasian milfoil is generally controlled the entire year of treatment and is greatly reduced the following year as well. As part of the approval process for the use of fluridone, the Department of Environmental Quality (DEQ) requires that a three-year lake management plan be prepared and submitted along with the standard herbicide treatment permit application. The lake management plan must include:

- A detailed description of the physical characteristics of the lake.
- Water quality information including pre-treatment data.
- Information on the lake’s plant community, fishery, and endangered and threatened species.
- A history of management on the lake.
- A discussion of control options and reasons for using or not using different options.
- A detailed three-year vegetation management plan for the lake.
- Documentation of stakeholder involvement in the development of the plan.
- Calculations for applying the correct dosage of fluridone to the lake.
- A series of maps including a depth contour map, a wetland inventory map, a shoreline land use map, a water quality sampling location map, a fluridone residue sampling location map, fluridone distribution application map, a targeted nuisance species map, a vegetation goal map, and the proposed vegetation management maps for each year of the plan.

In addition to the information required for the management plan, the DEQ requires a detailed aquatic plant survey of the lake in the year before the treatment, monitoring of treatment dose and aquatic plants during the year of treatment, and follow-up plant surveys in the second and third year after the treatment. With each plant survey, the type and relative abundance of each species throughout the lake are mapped using a protocol developed by the DEQ (Appendix C). This data is used to document the need for a fluridone treatment and to assess treatment impacts.

In addition to herbicide treatments for Eurasian milfoil, herbicides can also be used to control other plants that may be growing at nuisance levels. Generally, treatments for native plant species are conducted later in the growing season to correspond with the growth characteristics of the target plant species.

In conjunction with herbicide applications, consideration should also be given to the harvesting of vegetation where plants (other than Eurasian milfoil) are growing at nuisance densities. Harvesting equipment is generally operated parallel to shore in about three feet of water or greater. To avoid the potential for damage to moored boats and docks, mechanical harvesters are generally not operated between docks. In order to maximize removal of plant material, plant harvesting is often conducted during the peak of the growing season in July or early August.

With lake board projects, plant control activities are generally coordinated under the direction of the project consultant. The consultant would be responsible for preparing bid documents and/or contract extensions for the plant control program, conducting surveys of the lake to determine the scope of work to be performed by the plant control contractor, and performing follow-up inspections to ensure work is performed in a satisfactory manner. The consultant would evaluate contractor performance and would make recommendations regarding payments to the contractor.

LAKE DREDGING

Currently, shallow water conditions in Gilbert Lake create ideal conditions for abundant rooted plant growth. Dredging the lake could help to reduce the abundance of plants in the lake. There are two major dredging methods: Drag-line and hydraulic (Figures 13 and 14). Drag-line dredging involves excavation using a crane, backhoe, or similar equipment. The crane is placed on shore or on a floating barge and excavates material with its "clamshell" or bucket. Excavated material is placed in an interim location to drain or "dewater" the dredged material. If a location is available nearby, dredge spoils can be placed directly in the final disposal location. Drag-line dredging is limited to areas that are within reach of the crane arm. With hydraulic dredging, excavated material is pumped in a slurry through a floating pipeline to the point of disposal. Most large-scale lake dredging projects are conducted with a hydraulic dredge. Hydraulic dredging can be limited by underwater obstructions such as stumps, logs, rocks, etc.

Figure 13. Drag-line (backhoe) dredging.

Figure 14. Hydraulic dredging.

A primary consideration in a lake dredging project is identifying a suitable location (or locations) for the placement of dredged material. When a hydraulic dredge is used, disposal sites are usually constructed by excavating an area and creating an earthen dike to contain the dredged slurry (Figure 15). Given the flocculent nature of the organic sediments found in most lakes and the extended time frame for dredged material to dewater and consolidate, the disposal cell must be adequately sized to accommodate the amount of dredged material produced. The disposal cell should be designed to maximize the settling of solids while allowing excess water to drain. After dredged materials have been deposited and sufficiently drained and dried, the disposal area may be graded and seeded. Another disposal alternative for hydraulic dredging is pumping to sealed, permeable, geotextile tubes which are filled with dredged materials and allowed to dewater by percolation through the geotextile fabric walls (Figure 16). The drier sediments are retained inside the tube.

Pursuant to provisions of Part 301, Inland Lakes and Streams, of the Natural Resource and Environmental Protection Act, PA 451 of 1994, a permit must be acquired from the Michigan Department of Environmental Quality (MDEQ) before a dredging project can be initiated. Permit conditions will generally require that the dredge disposal site be located in an upland location and that steps be taken during the dredging operation to prevent excessive sediment transport to adjacent areas. Dredge spoils are not typically allowed to be placed in wetland areas. MDEQ has recently developed testing procedures for sediments proposed for dredging that require non-sandy sediments to be tested for certain heavy metals, polychlorinated biphenyls (PCBs),

Figure 15. Dredged sediment disposal cell.

and polynuclear aromatic hydrocarbons (PNAs). If sediment proposed for dredging is found to be contaminated, the MDEQ may require special disposal requirements or, in extreme cases, that sediments be placed in a licensed landfill. These requirements can substantially increase the cost of a dredging project.

A previous study of Gilbert Lake found that dredging should not adversely impact the hydrology of the lake (CTI and Associates, Inc. 1985, Appendix B). However, the cost of dredging would likely be prohibitive. In order to deepen Gilbert Lake to a sufficient depth to reduce plant growth, at least 5 feet of sediment would need to be removed from the lake. Dredging to deepen about 25 acres of the lake by 5 feet would require removal of over 200,000 cubic yards of sediment. Assuming a cost of $15 dollars per cubic yard for dredging and disposal of sediment, a preliminary estimate of project cost is $3,000,000. Dredging of Gilbert Lake is not being recommended.

Figure 16. Geotextile tubes.

WATERSHED MANAGEMENT

Much of the Gilbert Lake watershed is urbanized. As such, watershed drainage is likely high in phosphorus residue from lawn fertilizers. In fact, fertilizer runoff is probably the single greatest controllable source of phosphorus loading to Gilbert Lake. Phosphorus is the nutrient that most often stimulates excessive growth of aquatic plants and algae, leading to a number of problems collectively known as *eutrophication*. Once in a lake, a pound of phosphorus can generate hundreds of pounds of aquatic plants.

To address the problem of fertilizer runoff, many communities across Michigan have adopted ordinances to regulate the application of phosphorus lawn fertilizers. Communities that have adopted regulations include the cities of Ann Arbor, Battle Creek, and East Grand Rapids; the townships of Cannon (Kent County), Commerce (Oakland County), Grattan (Kent County), Spring Lake (Ottawa County), and West Bloomfield (Oakland County), and the counties of Bay, Muskegon, and Ottawa. Many other communities are considering ordinances. Minnesota and Florida have state-wide phosphorus fertilizer regulations, and Michigan is considering legislation to limit phosphorus lawn fertilizer use.

Often, properties directly bordering the lake have the greatest potential to have fertilizer runoff directly to the lake. Until such time as state-wide or local phosphorus fertilizer regulations are in place, property owners bordering Gilbert Lake should be provided information on an annual basis on lake-safe landscaping practices. Information that can be downloaded for public distribution can be found at www.michiganlakeinfo.com.

Recommended Improvement Plan

Study findings indicate that Gilbert Lake is eutrophic in that phosphorus levels are elevated and aquatic plant growth is abundant. The shallow depth of the lake inhibits recreational utilization and creates conditions ideal for plant growth. In order to improve conditions in the lake over the long term, it is recommended that the management plan for Gilbert Lake include the following elements:

1. A nuisance aquatic plant control program that focuses on the control of exotic species such as Eurasian milfoil and native plant species growing at nuisance densities. Eurasian milfoil should be controlled with systemic herbicides. Native plants growing at nuisance densities should be controlled through a combination of herbicide treatments and/or mechanical harvesting, in which plants are cut and removed from the lake. The scope of the program in any given year would depend on the type and location of aquatic plants.
2. A watershed management program which focuses on the annual dissemination of lake-safe landscaping techniques to all property owners bordering the lake.

Project Implementation and Financing

Improvements for Gilbert Lake are proposed to be implemented in accordance with Part 309, Inland Lake Improvements, of the Natural Resources and Environmental Protection Act, PA 451 of 1994. Under this act, a lake board has been established to oversee the project. The Gilbert Lake Improvement Board includes the following members:

- A Gilbert Lake property owner.
- Two representatives of Bloomfield Township.
- An Oakland County Commissioner.
- The Oakland County Drain Commissioner (or his or her designee).

A proposed budget for the Gilbert Lake Improvement Plan is presented in Table 7.

TABLE 7
GILBERT LAKE IMPROVEMENT PLAN
PROPOSED BUDGET (2009 THROUGH 2013)

Improvement	Annual Cost
Aquatic Plant Control[1] (50 acres at $350 per acre)	$17,500
Administration & Contingency	$ 2,500
TOTAL	**$20,000**

[1] The scope of plant control in any given year will depend upon the type and location of aquatic plants.

Pursuant to provisions of Part 309, a public hearing must be held to determine if lake residents support the proposed improvements to Gilbert Lake. If public support is demonstrated, a special assessment district would be established from which revenue would be generated to finance the improvements.

The Special Assessment District for Gilbert Lake is proposed to include all properties which border the lake and back lots which have dedicated lake access. Under this plan, waterfront properties are proposed to be assessed one unit of benefit and back lots with deeded or dedicated lake access would be assessed one-tenth unit of benefit. In addition, contiguous lots in common ownership are proposed to be assessed as one parcel provided only one house exists on the parcel.

Based on these criteria, approximately 62 assessment units exist within the proposed Gilbert Lake Assessment District. It is proposed that the $20,000 annual cost of the project be assessed for a 5-year period (2009 to 2013). In addition, the cost of the feasibility study would be assessed in 2009. A breakdown of costs based on this approach is presented in Table 8 below:

TABLE 8
GILBERT LAKE IMPROVEMENT PLAN
APPROXIMATE ASSESSMENTS

Parcel Type	Units of Benefit	2009 Assessment[1]	2010 - 2013 Assessment
Waterfront	1.0	$565	$322
Backlot	.10	$ 56	$ 32

[1] Includes the cost of the feasibility study.

Appendix A
Study Methods

Study Methods

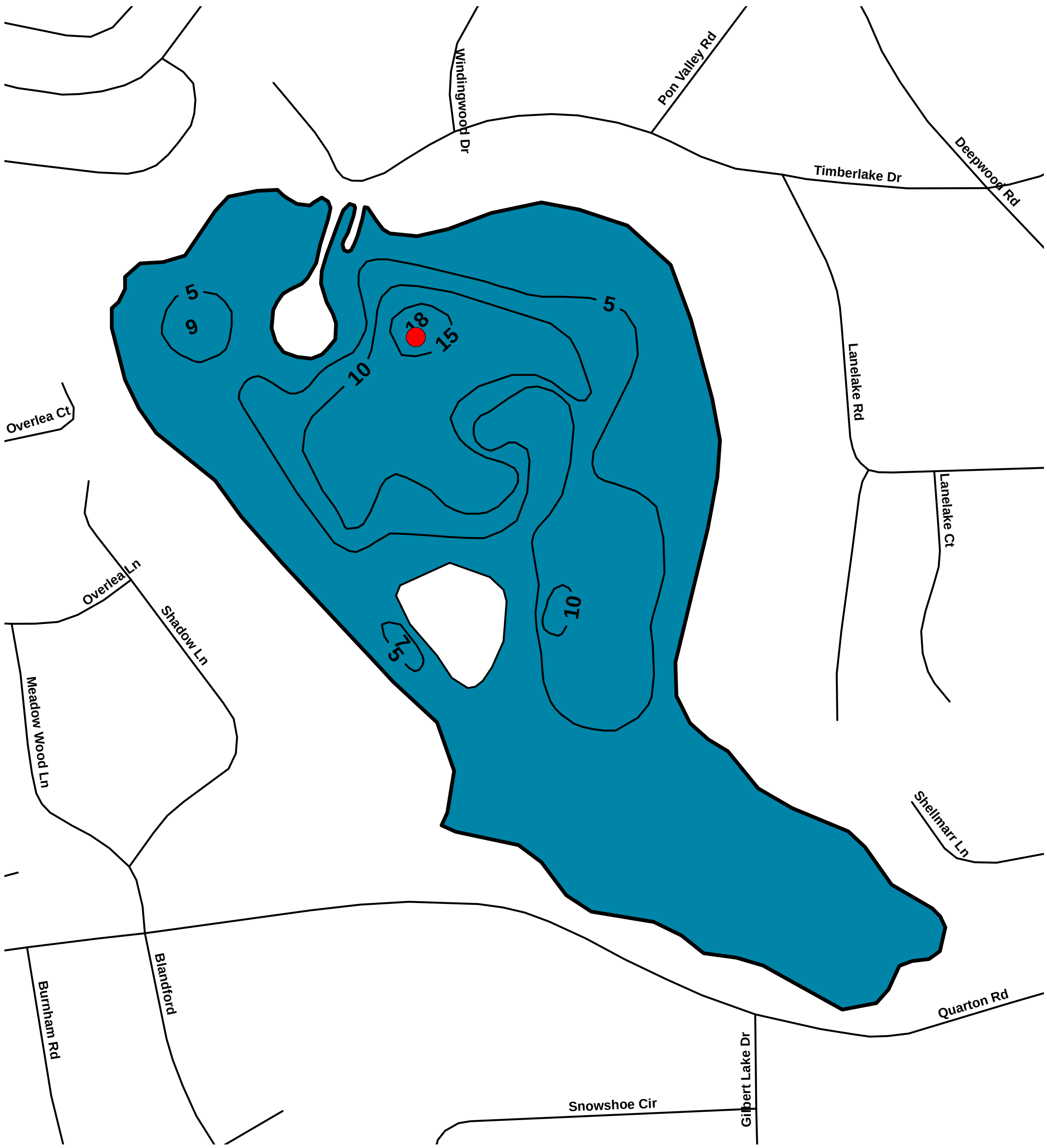
Lake and Watershed Physical Characteristics

Depth contours were digitized from a bathymetric map from Bright Spot Map Publishers, which was redrawn from the map prepared by the Michigan Department of Conservation (currently, the Michigan Department of Natural Resources). Watershed area was delineated using a U.S. Geological Survey topographic map (Pontiac South, Michigan, 1983), then digitized for analysis. Lake area, shoreline length, watershed area, and land use were computed from Michigan Department of Natural Resources (MDNR) Michigan Resource Information System (MIRIS 1978) updated with aerial photography. Lake volume was estimated using the conical-segment method. Mean depth was calculated from lake volume and surface area.

Lake Water Quality

Temperature was measured using a YSI Model 550A probe. Samples were collected at the surface, mid-depth, and just above the lake bottom with a Kemmerer bottle to be analyzed for dissolved oxygen, pH, total alkalinity, and total phosphorus. Dissolved oxygen samples were fixed in the field and then transported to Progressive AE for analysis using the modified Winkler method (Standard Methods Procedure 4500-O C). pH was measured in the field using a YSI EcoSense pH meter. Total alkalinity and total phosphorus samples were placed on ice and transported to Progressive AE and to Prein and Newhof[1], respectively, for analysis. Total alkalinity was titrated at Progressive AE using Standard Methods Procedure 2320.B, and total phosphorus was analyzed at Prein and Newhof using Standard Methods Procedure 4500-P E. In addition to the depth-interval samples at each deep basin, Secchi transparency was measured and composite chlorophyll-*a* samples were collected from the surface to a depth equal to twice the Secchi transparency. Chlorophyll-*a* samples were analyzed by Prein and Newhof using Standard Methods Procedure 10200H. Water samples from near-shore areas were collected in sterilized bottles and analyzed by the Kent County Health Department to determine *E. coli* bacteria levels.

[1] Prein and Newhof, 3260 Evergreen Drive, NE, Grand Rapids, MI 49525.



SAMPLING LOCATION

N

1 inch equals 400 feet

ProgressiveAE
1811 4 Mile Road, NE
Grand Rapids, Michigan 49525-2442
V: 616/361-2664 F: 616/361-1493
www.progressiveae.com

Figure A1. Gilbert Lake sampling location map.

Appendix B
Historical Studies

REPORT ON GILBERT LAKE, OAKLAND COUNTY

INTRODUCTION

At the request of the Gilbert Lake Protective Association a biological inventory of Gilbert Lake was made in July and August of 1959. The purpose of the investigation was to assess problems at the lake and, if possible, offer remedies and provide the owners with a management program for the lake. The investigation included (1) preparation of a map of the lake showing depth contours, bottom soils, and distribution of aquatic vegetation, (2) collection of fish to determine kinds, abundance, and growth rates, (3) chemical tests of the water to determine hardness and dissolved oxygen content, (4) water temperatures at different depths, (5) observations on water clarity, and (6) general observations including examination of fish for disease and parasites, amount of fish food, availability of spawning areas and cover, and prevalence of fish predators.

PHYSICAL-CHEMICAL CHARACTERISTICS

The characteristics of a lake are determined by the complex interaction of many factors, geographical, physical, chemical, and biological. A lake is the product of its environment as influenced by human activities. A lake can be modified only within certain limits imposed by its physical, chemical, and biological characteristics. Human activities can sometimes accelerate or retard the aging process in a lake but they cannot halt or reverse it. Generally speaking, man's activities on lakes in urban areas have tended to accelerate the enrichment process.

Gilbert Lake is located in Oakland County, Town 2 North, Range 10 East, Sections 21 and 28. It has a surface area of 50 acres, and a maximum depth of 18 feet. Much of the basin is shallower than five feet. Bottom soils are marl mixed with a good deal of organic material, organic soil in the deeper water and a few other areas, and a small amount of sand (brought in from outside?). The deeper sediments of the basin are fairly firm and several feet (8 to 10?) deep. Bottom soils have an important effect on plant growth and fish food supplies as well as the recreational use of the lake. Clean sand beaches provide nice swimming areas but they produce little fish food. Chemical and thermal tests of the water were made on July 26, 1959. The water in Gilbert Lake is fairly clear (Secchi Disc, a standard for measuring clarity was visible at 12 feet) and moderately hard, with 60 to 80 parts per million of dissolved salts, mostly lime. The water in the lake was thermally and chemically stratified. In many lakes in mid-summer the water, because of temperature differences, becomes divided into distinct layers which do not mix with each other except to a very limited degree. In the typical stratified lake there is a layer of warm water on top, a middle layer of water in which temperatures decrease rapidly with increasing depth, and a bottom layer of uniformly cool water. Technically, these layers are known as epilimnion (top layer), thermocline (middle layer), and hypolimnion (bottom layer). In many lakes only the epilimnion is well supplied with oxygen throughout the summer, and the deeper layers become devoid of dissolved oxygen as the summer progresses. In other lakes, usually deep and rather barren ones, the cooler, deeper waters carry enough dissolved oxygen to support fish and fish food organisms throughout the year. Such lakes will support cold-water fish such as trout. Thermal stratification is accompanied by chemical stratification. At Gilbert Lake water termperatures ranged from 77.8°F. at the surface to 74.0°F. at 12 feet, then dropped rapidly from 69.0°F. at 14 feet to 59.8°F. at 17 feet. Dissolved oxygen, in parts per million, was 6.2 at the surface, 5.4 at 12 feet, 2.8 at 15 feet. At Gilbert Lake in midsummer there is insufficient dissolved oxygen to support fish below a depth of 12 - 14 feet but since a very small part of the basin is as deep as 12 to 14 feet virtually the entire basin is habitable throughout the year.

BIOLOGICAL CHARACTERISTICS

The fish population of Gilbert Lake is typical of small lakes in southern Michigan. Fish were collected with trap nets, gill nets, and by angling. The species collected were: bluegills, pumpkinseeds, bluegill x pumpkinseed hybrids, yellow perch, yellow bullhead, brown bullhead, largemouth bass and northern pike. Other species, carp, bowfin, gar, rock bass, may be present but they are not numerous enough to form an important segment of the fish population. Minnows were noticeably absent. The growth rate of the different species in a lake provides an excellent index to living conditions for that species. If growth is rapid, and if fish of different ages are represented in the collections, conditions are good. Slow growth is an indication of too little food, excessive competition, or some lack in the environment. Growth rates of important species, as determined from examination of scales in the laboratory, are shown in the table.

Growth of fish in Gilbert Lake, Oakland County, Michigan. Figures denote average total length in inches for each age-group. State-wide averages are shown in parentheses.

Species	Age Group II	III	IV	V	VI	VII
Bluegill	4.1 (4.3)	4.9 (5.5)	5.7 (6.5)	6.1 (7.3)		
Pumpkinseed	4.3 (4.1)	5.0 (4.9)	5.8 (5.7)	6.3 (6.2)		
Largemouth	8.4 (8.7)	10.7 (10.0)	12.2 (12.1)	15.0 (13.7)	17.4 (15.1)	18.0 (16.1)
Perch		6.5 (6.8)	7.0 (7.9)			
Pike			24.6 (23.9)	21.1 (25.4)		

The bluegill and the largemouth bass are the most important species. Growth of the bluegill is less than average, that of the largemouth somewhat better. Growth rate of the yellow perch is retarded. The northern pike probably makes about average growth. Only two specimens were secured so the sample does not mean too much. Bullhead ages were not determined. Bullheads of several sizes were represented in the collection and they probably make at least fair growth at Gilbert Lake. Few parasites were found and most of the fish were quite "clean". Suitable spawning areas are available for the species present, except possibly for the northern pike. Young-of-the-year sunfishes (bluegills and pumpkinseeds) were very numerous all around the lake, and a few young-of-the-year largemouth bass were also observed.

The most outstanding biological characteristic of the lake is the lush growth of aquatic vegetation which fills most the the basin to depths of five or six feet. Vegetation is everywhere, even in the vicinity of docks and bathing beaches where there is a good deal of activity. Abundant vegetation is indicative of a fairly productive lake, and one in which the enrichment process is far advanced. Original conditions at the lake were conducive to the growth of aquatic plants, and the addition of nutrients from surface run-off (lawn fertilizers for example) has accelerated the process. The fairly steep slope around most of the basin facilitates the entry of nutrients into the lake basin. In some lakes the addition of nutrients might stimulate algal blooms and increase plankton production but at Gilbert Lake the nutrients have accelerated growth of rooted aquatics.

PROBLEMS

Three problems, all interdependent, exist at Gilbert Lake. They are not separate problems, and in a general way, anything that will help to alleviate one problem will help with the others also. These problems are:

1. The aging process is far advanced in this small, shallow, rather productive lake. Fish habitat does not vary greatly from one place in the lake to another. Human activity has contributed to the enrichment of the lake, and thereby accelerated senescence.

2. The lush growth of aquatic plants interferes (mechanically) with the use of the lake for swimming, boating, and fishing. The vegetation also contributes to the imbalance of the fish population by affording too much protection to small fish. Nutrients entering the lake, which might go into the production of plankton are absorbed by the rooted aquatics.

3. The lake contains an over abundance of small fish, especially bluegills. The bluegills (and perch) are not growing as fast as they should and consequently are not very highly prized by anglers. These small bluegills, perch, and pumpkinseeds dominate the economy of the lake and they exert a tremendous pressure on the other fish, and on the supplies of fish food.

There are no simple solutions to these problems. It is improbable that any one of them can be permanently eliminated, but they can be alleviated, and the owners could get more enjoyment from the lake. Relief can be brought about only by some rather drastic procedures. These procedures are likely to produce some nuisance of themselves. The owners will have to decide if the possible benefits are commensurate with costs. No one can promise that fishing can be made very good, that all weeds can be eliminated, and that a lake whose basin is filling rather rapidly can be changed to one with clean, bold shores. Elimination of weeds from a mucky bottom will not change the mucky bottom. A mass of dead and dying weeds will create a nuisance. Weed control, especially in a lake so well suited to plant growth will not be permanent. Treatments will probably have to be made annually. An over abundance of small fish is a problem common to many lakes in Michigan. Once the pan fish (bluegill or perch) assume a dominant position the problem becomes chronic and half-measures will accomplish little. Stocking and/or angling will have little effect. Because of the pressure exerted by the numerous small, slow-growing, pan fish reproduction by the larger predators, bass and pike, is curtailed through predation of eggs and fry by the ever-hungry pan fish. Growth of the predators, bass and pike, is likely to be fairly good, but because their reproductive rate is depressed by the pan fish, they barely hold their own in the lake. Anglers remove an appreciable percentage of the diminishing annual crop. Bass and pike will persist in the lake, but eventually they become so scarce that they provide very little sport. In such lakes vegetation is often abundant, affording still more protection to the small fish. The situation can be corrected, or alleviated but rather intensive management measures are required.

MANAGEMENT PROGRAM

If the lake basin could be deepened and reduced in area the aging process would be retarded. For dredging to provide lasting benefit, the shallow areas would have to be dredged to a depth of at least 8 to 10 feet. Several possible benefits could result -- nutrients which have been absorbed in bottom muds would be recirculated and might produce algal blooms which might help in the production of more plankton. Algal blooms and more plankton would increase the turbidity of the water and thereby help to shade out aquatic plants. If dredging were attempted, a part of the very shallow southeast bay could be deepened. The spoil could be used to fill the remainder of the bay to the east in the vicinity of the intermittent outlet. Spoil from other shallow areas could be used as fill and the present shore of the lake could be extended out into lake. The final result would be a smaller, deeper, lake which would not be weed-filled. Conditions for boating, swimming, and fishing would be improved. I suppose filled areas could be used for additional home sites. A small amount of dredging in a few limited areas would provide only very temporary benefits. Dredged areas, unless they were fairly extensive and reasonably deep would fill very quickly. The deeper sediments of the Gilbert Lake basin are fairly firm and dredging would probably be physically possible. No calculations as to cubic yards which should be removed have been made but the lake map would provide a basis for such calculations. Cost of such an operation might well be prohibitive but the "construction" of additional home sites might make the venture feasible.

There is another means whereby the filling of the lake basin could be retarded and growth of plants inhibited. If the lake level were lowered and the very shallow areas permitted to dry out, plant growth very close to shore would be slowed. Present docks would have to be extended farther into the lake. At Gilbert Lake an annual fluctuation in water level would be desirable and the more extreme the fluctuation, the better the chance that growth of vegetation would be retarded. Such fluctuation would be inconvenient for property owners but it would benefit the lake.

Aquatic vegetation can be controlled with chemicals. As yet no single chemical which will control pond-weeds, algae, and emergent plants such as water lilies and cattails has been developed. Neither has any chemical which will give permanent relief been found. Chemical control of aquatic plants gives best results in small bodies of water, such as farm ponds, or in lakes where the nuisance occurs in local areas only. Effective vegetation control at Gilbert Lake would require treatment of shore areas to a depth of about five feet. The operator would have to treat for algae (musk grass) with copper sulphate, for submerged aquatics with sodium arsenite, and for coarse emergent plants (cattails, water lilies) with 2-4-D. I want to emphasize that control by means of chemicals is practical, but it would probably have to be done each year, and it is probably impossible and unwise to attempt to eliminate the aquatic vegetation in Gilbert Lake except in specific areas. Probably even with a control program aquatic vegetation will remain something of a nuisance in the lake. If it is not controlled its abundance will gradually increase. If it is controlled the dead and dying vegetation itself will be unsightly and cause some inconvenience.

It would help fishing and benefit the fish population of the lake if an appreciable number of the pan fish, especially bluegills were removed. Recently, techniques have been developed which permit the use of a toxicant to eliminate a part of the fish population, i.e., destruction of small fish without destroying the larger ones. The technique has not been perfected and when one is dealing with natural populations absolute control is very difficult. Still, the partial destruction of the fish population at Gilbert Lake offers much promise. The objective is to change the structure of the fish population for the benefit of anglers and predatory fish (bass and pike) and to the disadvantage of the very prolific and abundant pan fishes.

If a considerable number of the pan fish were eradicated, the survivors would make better growth. Reproduction by bass and pike might improve, unless the void were filled immediately by pan fish. At present no one knows what portion of a pan fish population must be removed to change the structure of a fish population. However, the effects of even a very heavy removal are temporary, and recruitment quickly replaces fish which are lost. Ideally, pan fish numbers should be kept in check until their dominant position is upset -- either by heavy stocking with predatory fish, or until the predators already in the lake can build up their own numbers. Gilbert Lake should be treated with toxaphene to reduce numbers of pan fish. The treatment should be made in late summer after spawning has been completed. Dead and dying fish will create a nuisance but they can be buried or they will gradually disappear. Toxaphene has a long contact time and distribution in the water is brought about by wind and currents. This simplifies application. Since very dilute concentrations are effective cost is low. Gilbert Lake should be treated at a concentration of about four parts per billion (this concentration for a preparation containing six pounds per gallon of active ingredient). Benefits would not be apparent immediately but should be noticeable in a season or two. If too few fish (small ones, that is) were removed by the initial treatment, it could be repeated. Effectiveness of the treatment can be measured in terms of bigger pan fish being caught by anglers. When the number of pan fish is reduced, anglers will not catch more fish, but those they do catch will be of better size.

As a part of the fish population control program owners might consider releasing all bass and pike captured, except for those deeply hooked. At the same time they should catch as many pan fish as possible. All efforts directed towards changing the ratio between pan fish and bass are proper.

If the Association has some interest in put-and-take fishing my recommendation would be for rainbow trout. The lake is not a trout lake, but it will probably support trout for about 10 months a year. If trout were considered a trial planting of about 1,000 7-to-9 inch trout should be made in early fall after the water has cooled. Owners should fish hard for the planted trout, fall, winter, spring and early summer. A return of 20 to 40 percent could be expected. If trout were not planted, northern pike might be considered. They would survive and reproduce in the lake. If reproduction was good, they might help to control pan fish numbers. I do not know of a source for northern pike.

SUMMARY

Three related problems exist at Gilbert Lake. They are:

1. The lake is well along the road towards extinction. The shallow basin is filling rapidly, and human activities have probably accelerated the process.

2. The lush growth of aquatic plants interferes with swimming, boating, and fishing.

3. There is an over-abundant population of slow-growing pan fish (especially bluegills) in the lake. These fish exert a tremendous pressure on the whole economy of the lake.

The following management procedures should be considered by the owners. They are designed to alleviate the problems mentioned above.

1. Dredging to deepen and confine the lake basin. If the lake were deepened, and the spoil used to fill shallow areas, the aging process would be slowed, and plant growth retarded.

2. Natural fluctuation in water levels at Gilbert Lake should be permitted. The drying out of shore areas might help to inhibit plant growth, and would at least retard it.

3. Chemical control of aquatic vegetation. Initially control should be confined to certain areas. If results appear commensurate with costs, control could then be extended to additional areas. It is unlikely that too much vegetation would be eliminated. However, control should probably be confined to shore areas where the plants are an actual nuisance. Two pamphlets describing chemical control of plants are included with this report.

4. Treat the lake with toxaphene to eliminate small fish. The toxicant should be applied in late summer at a rate of 4 to 5 parts per billion.

5. As an adjunct to the removal of pan fish, anglers should release all bass and pike captured, except those deeply hooked.

6. Put-and-take stocking can be considered. Costs for benefits derived are considerable.

Walter R. Crowe

October 6, 1959

COPY

HYDROGEOLOGIC STUDY

RESTORATION OF GILBERT LAKE
BLOOMFIELD HILLS, MICHIGAN
(PROJECT NO. D-10537)

NOVEMBER 6, 1985

CTI and Associates, Incorporated
Novi Office—46408 Grand River Ave., Novi, Michigan 48050 (313) 349-3744
Ann Arbor Office—607 South Maple, Ann Arbor, Michigan 48103 (313) 995-3777

November 6, 1985

Mr. Nathan Feldman
1001 Timber Lake Drive
Bloomfield, Michigan 48013

Re: Hydrogeologic Study for
Restoration of Gilbert Lake
Bloomfield Hills, Michigan
(Project No. D-10537)

Dear Mr. Feldman:

Submitted herewith is the report of the Hydrogeologic investigation conducted for the subject project. The report has been prepared on the basis of available geologic (subsoil and groundwater) data for the site and the general region, together with several test borings made and monitor wells installed at the site. The investigation was conducted under the direction of the writer, who was assisted by other engineers and geologists of the firm.

We appreciate the opportunity to be of service to you on this project. If there are any questions regarding this report, please feel free to contact us.

Very truly yours,

CTI & ASSOCIATES, INC.

P. D. Deo

P.D. Deo, Ph.D., P.E.
Director of Engineering

PD/jt

TABLE OF CONTENTS

HYDROGEOLOGIC STUDY

RESTORATION OF GILBERT LAKE
BLOOMFIELD HILLS, MICHIGAN
(PROJECT NO. D-10537)

1.0 INTRODUCTION

1.1 General

This report presents the results of a hydrogeologic study performed for Gilbert Lake in Bloomfield Hills, Michigan. It is understood that the present plans call for the restoration of the lake, which is reported to be heavily silted and contains considerable amounts of undesirable vegetation. It is desired to clean the lake in a cost efficient manner.

1.2 Purpose and Scope

A permit from the Michigan Department of Natural Resources (MDNR) is necessary before any excavation, backfilling or lowering of water level in the lake is permitted. The requirements of the MDNR include a hydrogeologic study to determine the effect of these operations on the surface and groundwaters of the area. The present study is being performed to satisfy the requirements of a hydrogeologic study for the lake.

The points of concern include:

a) How soon the lake will fill with water to its original level after lowering the lake level or removal of silt from the bottom?

b) Is there a clay seal at the base of the lake?

c) Can the clay seal be damaged by excavation or dredging operations?

d) If the clay seal is broken, will there be upward or downward flow of water resulting in drying of the lake or flooding of the area?

Specifically, the purpose of this study was to:

i) Obtain and review any available geologic and hydrogeologic information of the general lake area.

ii) Perform test borings and install monitor wells to determine the subsoil and groundwater conditions including the determination of the direction of groundwater flow.

iii) Determine the depth of the lake bottom below the water surface.

iv) Determine the general nature of the sediments at the base of the lake.

The report presents an evaluation of the geologic and hydrogeologic conditions with respect to the effect of the lake restoration on surface and groundwaters of the area.

2.0 GENERAL SITE CONDITIONS

Gilbert Lake is a private lake and is located within the northeast quadrant of the intersection of Quarton and Telegraph Roads in Bloomfield Hills, Michigan. A map prepared by the Michigan Conservation Department during 1959 was available to us. The map shows the lake outline, general topographic and vegetation features, as well as the depth of the lake. During the site visit, several discrepencies were noted from the 1959 map. The 1959 map shows that over 50 percent of the shoreline is wooded and the remainder is partially wooded. At the present time, very few wooded areas remain. Scattered trees predominate the shoreline. Essentially, the entire lake shore has either existing, or under construction houses. Lake vegetation shown in the 1959 map is essentially the same, as at this time. An exception was noted along the east shore directly across from the island where the emeregent vegetation has been removed in front of the residences.

3.0 STUDY PROCEDURES

The study procedures for the investigation included a review of available geologic and hydrogeologic data, drilling of test borings and installation of monitor wells, probing the lake bottom for its depth and sediment types and chemical testing of the sediments obtained from the lake bottom. The various phases of the investigation are described in the following sections.

3.1 Review of Available Data

The known available data that was obtained for this study included the following:

i) Geologic publications describing the geology of Michigan and Oakland County. Section 4.0, which describes the hydrogeologic conditions of the site area, was prepared on the basis of these reports.

ii) U.S.G.S. topographic survey map of the region. This map showed topographic features, surface water bodies, such as lakes, streams, etc. The map had a contour interval of 10.0 feet.

iii) Logs of domestic water wells of the general area of the project. Logs of these wells are included in the appendix of the report. The locations of the wells are also shown on General Location Map, Plate 1.

3.2 Test Borings and Monitor Wells

Following the review of theoretical data, three (3) test borings designated as TB-1, TB-2 and TB-3 were made at the locations shown on Test Boring Location Plan, Plate 2. The borings extended to depths ranging from 25.5 feet to 50.5 feet below the ground surface. In the three borings, groundwater monitor wells were installed at depths of 20.0 feet to 27.0 feet below the surface.

The test borings were advanced with 6.0 inch Outside diameter hollow stem auger. Within the test borings, soil samples were obtained at intervals of 5.0 feet. The soil samples were obtained by the Standard Penetration Test Method, (ASTM D-1586), whereby a 2.0 inch outside diameter split-barrel sampler is driven into the soil with a 140 pound weight falling freely through a distance of 30.0 inches.

The sampler is generally driven three successive 6.0 inch increments, with the number of blows for each increment being recorded. The number of blows required to advance the sampler the last 12.0 inches is termed the Standard Penetration Resistance, (N).

The soil samples obtained with the split-barrel sampler were sealed in jar containers and transported to the CTI laboratory for further classification.

Soil conditions observed in the borings have been evaluated and are presented on the Logs of Borings included in the appendix.

Groundwater monitor wells were installed in all three borings. The wells were constructed of 2.0 inch diameter galvanized steel with stainless steel screens.

3.3 Investigation of Lake Bottom

Depth of the lake and the nature of the sediments at the base were determined by making probes at several locations in the lake. A boat was utilized for this part of the study. The locations of the probes and the depth of the water at the probed locations are presented on Plate 2, Test Boring Location Plan. At 10 locations, samples of sediments were also obtained. The sample locations are also shown on Plate 2. The nature of the sediments encountered at the sample locations are presented on Table 1.

3.4 Chemical Testing of the Lake Bottom Sediments

Two samples of the sediments from the lake bottom were tested by Canton Analytical Laboratory for drinking water herbicides, PCB's and pesticides. The results of these analyses as reported by Canton Analytical Laboratory are included in the appendix.

4.0 REGIONAL GEOLOGIC and HYDROGEOLOGIC CONDITIONS

The regional land surface which encompasses the Gilbert Lake area slopes basically from the northwest to the southeast and has a total relief of approximately 360 feet. Pitted outwash plains and morainal hills that are more than 1,000 feet above the sea level traverse this region of Michigan from the northwest of Gilbert Lake to its southeast in a sequence of terminal moraines and intervening till plains.

The Gilbert Lake area lies on the southeast edge of the Michigan Basin and the bedrock is composed of northwest dipping strata of the Devonian and Mississippian systems. The Antrim shale, of late Devonian and early Mississippian age, is the oldest formation cropping out beneath the mantle of glacial drift in this area. The Bedford shale, Bera sandstone, and Sunbury shale overlie the Antrim and are overlain by the Coldwater shale, their areas of outcrop beneath the drift lying successively further to the northwest. These formations are of the early Mississippian age (Dorr, John A., and Eschman, Donald, Geology of Michigan, U. of Michigan Press, Ann Arbor, 1971).

Throughout this area the bedrock is covered by glacial drift which ranges in thickness from at least 100 feet to more than 350 feet. The drift increases in thickness from southeast to northwest, but considerable relief on the underlying bedrock surface greatly modifies this trend. Extensive moraines, tillplains and gravel outwash plains cover this area. In the immediate area and to the northwest is an area of upland gravel plains in which many of the Kettle lakes have formed and ranging in depth from a few feet to more than 100 feet.

Most of the surface water drainage of this area is to the south, and eventually into the Rouge River. Percipitation is the perennial source of all water in this region whether on the surface or underground. Less than one-third of the annual percipitation reappears as surface discharge from the watersheds of this area. (Ferris, J.G. Burt, E.M., Stramel G.J. and Crosthwaite E.G., Ground Water Resources of Southeastern Oakland County Michigan U.S. Geological Survey, State of Michigan, Dept. of Conservation Geological Survey Division, Nov. 16, 1954).

About two-thirds of the annual percipitation in the area is lost by evaporation from water and land surfaces and by transpiration from vegetative cover. A large part of this large annual loss is from the many lakes and other exposed water surfaces and from the contiguous lands where the depth of the water table is slight.

The principal aquifers are the alluvial deposits bordering the nearby streams, and the buried outwash deposits represent alluvial fills in preglacial or interglacial stream channels. Problems arise however, when intensive well developments in the surrounding urban area greatly lower groundwater levels in the buried outwash deposits, and bring localized problems of declining well yield.

A review of the water well logs of the area indicates the presence of extensive sand deposits in the general area. The available information indicates that the lakes of this region are generally hydraulically connected with each other having moderate to steep hydraulic gradients.

5.0 GENERAL SUBSOIL and GROUNDWATER CONDITIONS AT SITE

The three test borings made along the shore lines of the lake indicate extensive deposits of sand materials. At the location of Test Boring No. 1, the upper soils consisted of fill and organic soils which extended to a depth of 14.0 feet below the surface. Below 14.0 feet, the subsoils consisted of medium compact to compact sands which extended to the termination depth of the boring (50.5'). At the location of Test Boring No. 2, sand materials were encountered throughout the full depth of the boring. At the location of Test Boring No. 3, the subsoils were sand materials with some layers and seams of clay.

Overall review of the test borings and water well logs indicate that the subsoils in the vicinity of the lake are basically sand materials.

The probes made at the bottom of the lake indicate that the materials at the bottom of the lake consist of relatively thick organic soils consisting of marl with small amounts of silt. At the probed locations, the thickness of the soft organic soils was noted to range from approximately 5.0 feet to 25.0 feet.(Top of this layer was 3 to 19 feet below water)

Presented on Table II are the piezometric surface levels observed in the monitor wells. The data indicates that the general direction of the groundwater flow is to the south and southeast. This is in conformity to the evaluations presented in Section 4.0 of this report.

6.0 EVALUATIONS and ANALYSES

6.1 Subsoil Conditions

Based upon an evaluation of the subsoil conditions encountered in the three test borings and the subsoil conditions reported on the logs of the water wells, it appears that the subsoils along the perimeter of the lake are basically sand materials. These soils have relatively high coefficient of permeability. The subsoil data does not indicate the presence of a continuous impervious layer of clayey soils below the lake or along the lake perimeter.

One of the test borings drilled for this study indicates that the sand materials are present to a depth of at least 50.0 feet below the surface. On this basis, it is expected that hydrostatic head within approximately 50.0 feet of the upper materials is the same with no vertical gradients.

The lake bed is blanketed with a layer of organic soils consisting of basically marl and silt. At the probed locations, the depth to the top of this layer ranged from approximately 3.0 feet to 19.0 feet. The chemical analyses of the lake bottom sediments indicate that the level of herbicides, pesticides and PCB's was below the detection limits.

Probes to determine the depths to the lake bottom indicate that in several areas the depth of the lake was greater than that reported on the 1959 map. The depth of the lake bed are presented on Plate 2, Test Boring and Monitor Well Location Plan. The bay north of the peninsula (at the northwest portion of the lake) has areas up to 6.0 feet deeper than that shown on the 1959 map. Along the north shore, east of the peninsula, depths were greater than those shown on the 1959 map.

6.2 <u>Groundwater</u>

Due to the granular nature of the soils and the presence of numerous lakes in the area, it is anticipated that the recharge rate of the lake will be very fast, had the lake level lowered. Actually, the subsoil and groundwater conditions of the area indicate that it will be extremely difficult to lower the lake levels, even for a short period of time.

6.3 Effect of Lake cleaning on the area Groundwater and surface water

The cleaning of the lake bottom is not likely to affect the groundwater or surface water systems of the area. Due to the removal of the sediments from the lake bottom, there is no possibility of any upward or downward flow of groundwater.

7.0 CONCLUSIONS

Based upon the preceding discussions the following conclusions are made for the project.

1. It does not appear to be likely that this lake can be cleaned by lowering the water level in the lake or portions of the lake, and then by excavating the bottoms in shallow areas with a backhoe.
2. The lake is likely to have a fast rate of recharge. On this basis, the removal of the sediments from the bottom will not change the lake level.
3. The excavations from the bottom of the lake will not cause any upward or downward flow of the water.
4. The cleaning of the lake will not affect the groundwater and surface water systems of the area.
5. The sediments at the bottom of the lake consist of organic soils (marl and organic silt). These sediments appear to be free of any chemicals. It appears that these sediments will have to be disposed off at a solid waste disposal facility. The available data indicates that these sediments can be disposed off at a Type III landfill.
6. The lake bottom can be cleaned by dredging operations conducted from a barge.

TABLE I RESULTS of PROBES BELOW LAKE BED

GILBERT LAKE, BLOOMFIELD HILLS, MICHIGAN

Probe No.	Depth of Lake Bed below water surface	Depth of Probe below Lake Bed	Material Encountered
S-1	6.3'	9.5'	silt and marl
S-2	11.3'	11.3'	thick marl
S-3	6.0'	11.0'	marl-sand bottom
S-4	13.8'	17.0'	marl
S-5	4.5'	25.5'	soft marl
S-6	8.5'	9.0'	soft marl-sand bottom
S-7	8.5'	14.6'	soft material-marl
S-8	7.0'	12.5'	soft material-marl
S-9	4.3'	5.5'	soft material-marl
S-10	2.8'	7.0'	soft material

TABLE II PIEZOMETRIC SURFACE LEVELS IN MONITOR WELLS

Well	Elevation		
	Top of Casing	Ground Surface	Water Surface on 11-4-85
MW-1	91.54	89.31	85.59
MW-2	91.49	89.48	78.69
MW-3	90.99	89.0	84.69

Elevation of Lake Surface = 86.2±

Arrow on Fire hydrant #3941 Quarton

Road assumed at Elevation 100

Appendix C
Michigan Department of Environmental Quality Procedures for Aquatic Vegetation Surveys

DEQ

DEPARTMENT OF ENVIRONMENTAL QUALITY
PROCEDURES FOR AQUATIC VEGETATION SURVEYS

These aquatic vegetation survey procedures have been designed to ensure easily replicable surveys of aquatic plant communities. The methods are easy to use, and they are flexible enough to be used on many different types of lakes, regardless of the extent of littoral zone and shoreline sinuosity. The individual(s) using these methods should be proficient in the identification of aquatic plants. For a listing of recommended aquatic plant identification reference materials, contact the Aquatic Nuisance Control and Remedial Action Unit.

A survey is carried out by sampling individual Aquatic Vegetation Assessment Sites (AVAS's) throughout a lake's littoral zone. The locations of AVAS's are determined by dividing up a lake's shoreline into segments approximately 100 to 300 feet in length. Each AVAS is sampled by using visual observations, dependent upon water clarity, and weighted rake tows. Each separate plant species found in each AVAS is recorded along with an estimate of each species' density. Plant species are identified by numbers designated on the survey map's plant species list, and densities are recorded by using the following code:

- **(a)** = **found**: one or two plants of a species found in an AVAS, equivalent to ***less than 2%*** of the total AVAS surface area.
- **(b)** = **sparse**: scattered distribution of a species in an AVAS, equivalent to ***between 2% and 20%*** of the total AVAS surface area.
- **(c)** = **common**: common distribution of a species where the species is easily found in an AVAS, equivalent to ***between 21% and 60%*** of the total AVAS surface area.
- **(d)** = **dense**: dense distribution of a species where the species is present in considerable quantities throughout an AVAS, equivalent to ***greater than 60%*** of the total AVAS surface area.

AVAS's should not be confined solely to a lake's shoreline. In cases where a lake possesses an extensive littoral zone, additional AVAS's should be drawn out near the extent of submergent vegetation growth. This can be done by drawing transect lines divided in proportion to the shoreline AVAS's or by inserting individually drawn boxes with their dimensions proportional to the shoreline AVAS's (see attached sample map). AVAS's should also be drawn around the shoreline of any islands if present.

PRE-SURVEY PROCEDURES

A. Obtain a map of the lake to be surveyed. Bathymetric maps are preferred; however, if bathymetric maps cannot be located, enlarged copies of United States Geological Survey topographical maps may be used. If a pre-drawn map of the lake does not exist, hand-drawn maps will suffice, as long as they accurately depict the shape of the lake and are drawn to scale. Make a larger format (11" x 17") photocopy of the lake map for ease of editing and survey recording.

B. Designate the location of the separate AVAS's by drawing lines perpendicular to the lake shoreline (see the attached sample map) every 100 to 300 feet. Keep the AVAS lengths consistent throughout the lake, and add any additional AVAS's where necessary, based upon lake bathymetry. If additional AVAS's are not added at this time, they may be added during the actual survey, based upon current lake conditions.

C. Attach a copy of a plant species list identifying common species of aquatic plants directly to the survey map. This list should include either the common or scientific names of common aquatic plants corresponding to a specific number for each separate species. The corresponding numbers will be used to record the presence of a species in an AVAS.

D. Make several copies of the competed lake map for future use, to maintain consistency, and in case multiple maps are necessary during the survey due to inclement weather.

FIELD SURVEY PROCEDURES

A. Initiate the survey by determining your exact location on the lake. It is helpful to take this time to familiarize yourself with the dominant plant species of the lake that you are surveying. Do this by making several rake tows and identify all of the species found. Morphological variations occur in several species of aquatic plants due to differing lake conditions and hybridization; therefore, identification to species can be difficult. If specific identification is unattainable, group similar species, such as thin leaf pondweeds (*Potamogeton spp.*) or native milfoils (*Myriophyllum spp.*).

B. Begin the survey by recording the date, time, weather conditions, your name, names of assistants, and any other pertinent information directly on the survey map.

C. Locate the beginning AVAS, and survey each successive AVAS by documenting the presence and density of both emergent and submergent aquatic plants. Drive the survey boat in a zig-zag pattern through each AVAS so that a majority of each AVAS can be effectively surveyed. It is important to make use of rake tows even in clear water, since many low-growing species of submergent plants are not readily noticeable by visual observation alone.

D. Document each species found utilizing the corresponding plant species list number and the appropriate density code. Repeat this for each separate AVAS until all of the AVAS's have been surveyed. If an AVAS is found to be void of any vegetation, record "none" in the respective location on the survey map. Include these AVAS's in the final AVAS count when summarizing the survey data. If an AVAS is dominated by emergent vegetation to the point that boat access is impossible, document the plant species present and draw the extent of the edge of the emergent vegetation as it extends out into the lake.

SURVEY SUMMARY PROCEDURES

A. Number each AVAS sequentially from beginning to end on the survey map. Record the density codes for each species found on the attached Standard Aquatic Vegetation Assessment Site Species Density Sheets. Each AVAS number corresponds to the column numbers found on the attached Standard Aquatic Vegetation Assessment Site Species Density Sheets.

B. Sum the numbers of each of the separate density codes for each of the plant species found on the Standard Aquatic Vegetation Assessment Site Species Density Sheets and transfer these totals to the appropriate columns 1 through 4 (A, B, C, and D) on the attached Standard Aquatic Vegetation Summary Sheet.

C. Multiply these totals by the appropriate constants (A = 1, B = 10, C = 40, and D = 80) and transfer the calculations to the calculations columns 5 through 8.

D. Add the results of these calculated columns (5, 6, 7, and 8) for each species and transfer the totals to column 9.

E. Divide the values of column 9 by the total number of AVAS's surveyed (column 10), and transfer these values to column 11. These values represent the cumulative cover percentages for each of the plant species found in the survey. Make sure that you use the total number of AVAS's surveyed on the lake for column 10 and not the total number of AVAS's where each individual plant species was found.

F. Write a summary of the notes recorded during the field survey and attach it to the completed species density and summary sheets, along with the survey map and any other survey documentation.

Code #	Plant Name
1	E. Milfoil
2	Curlyleaf pndwd
3	Chara
4	Thinleaf pndwd
5	Flatstem pndwd
6	Robbins pndwd
7	Variable pndwd
8	Whitestem pndwd
9	Richardsons pndwd
10	Illinois pndwd
11	Largeleaf pndwd
12	American pndwd
13	Floating leaf pndwd
14	Water stargrass
15	Wild celery
16	Sagittaria
17	Northern milfoil
18	M. verticillatum
19	M. heterophyllum
20	Coontail
21	Elodea
22	Utricularia vulgaris
23	Bladderwort-mini
24	Buttercup
25	Southern naiad
30	Nymphea
31	Nuphar
32	Brasenia
33	Lemna minor
34	Spirodella
35	Watermeal
36	Arrowhead
37	Pickerelweed
38	Arrow arum
39	Cattail
40	Bulrush
41	Iris
42	Swamp loosestrife
43	Purple loosestrife

Density Codes
a = Rare or found, less than 3 percent cover.
b = Sparse, 3 to 20 percent cover.
c = Common, 20 to 60 percent cover.
d = Dense, over 60 percent cover.

References

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CTI and Associates, Inc. 1985. Restoration of Gilbert Lake Bloomfield Hills, Michigan (Project No. D-10537).

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