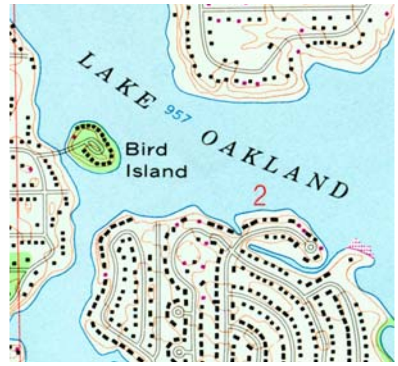

Lake Improvement Plan

Lake Oakland Improvement Plan

Prepared for:

Lake Oakland Lake Improvement Board
c/o Oakland County Drain Commissioner's Office
Building 95 West–One Public Works Drive
Waterford, MI 48328-1907

Prepared by:

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

August 2002

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Executive Summary

Lake Oakland is a 304-acre lake located in Sections 2, 3, and 11 of Waterford Township, and Sections 34 and 35 of Independence Township in Oakland County, approximately 6 miles northwest of the City of Pontiac. The maximum depth in the lake is 64 feet, the average depth is 9.4 feet, and the shoreline is 8.6 miles long. The Lake Oakland watershed is just over 65 square miles, an area well over 100 times the size of the Lake Oakland itself.

Study findings indicate that Lake Oakland is mesotrophic. The lake exhibits some eutrophic characteristics (i.e., moderate to high phosphorus levels, evidence of bottom water oxygen depletion, and substantial rooted aquatic plant growth) as well as some oligotrophic characteristics (i.e., excellent transparency and minimal open-water algae growth).

Lake Oakland has a good diversity of plant species, but is dominated by the exotic species Eurasian milfoil (*Myriophyllum spicatum*). The wide variety of native plants are beneficial to the quality of Lake Oakland, but Eurasian milfoil threatens the stability of the native plant community, and interferes with recreational use of the lake.

Currently, Eurasian milfoil infests approximately 100 acres of the Lake Oakland. This plant should be controlled with systemic herbicides applied early in the growing season (May or early June). If native plants reach nuisance densities, mechanical harvesting can be conducted in select areas to allow full recreational use of the lake. The extent of herbicide treatments or harvesting in any given year would depend on the type and distribution of aquatic plants.

To effectively manage Lake Oakland over the long term, steps must be taken in conjunction with in-lake improvements to reduce pollution inputs from the surrounding watershed. This is especially true in the shoreland areas around the lake that drain directly to the lake. To help curtail watershed pollution inputs, it is recommended that a watershed management publication be mailed to all lake residents that contains information on the physical characteristics of Lake Oakland and its watershed; information on Lake Oakland's water quality; guidelines for property owners including lakefront lawn care; lakeside landscaping; septic system maintenance; and information on wetland locations, functions, regulation, and protection.

The recommended 4-year lake improvement plan includes the control of nuisance aquatic plant growth via the select use of herbicides and mechanical harvesting, and watershed management to reduce pollution inputs to the lake and nuisance plant growth over the long term. The cost of the proposed program is $45,000 per year for nuisance aquatic plant control and $5,000 per year for watershed management.

The improvements to Lake Oakland are proposed to be financed via the establishment of a special assessment district. The special assessment district for Lake Oakland is proposed to include all properties which border the lake and back lots which have deeded or dedicated lake access. Under this plan, lakefront properties are proposed to be assessed one unit of benefit and back lots with deeded or dedicated lake access would be assessed ¼ unit of benefit. Based on these criteria, approximately 550 assessment units exist within the proposed Lake Oakland Special Assessment District. It is proposed that the $50,000 annual cost of the project be assessed for a 4-year period (2002 to 2005). In addition, the cost of the feasibility study ($9,500) and lake board administrative costs ($2,000 for legal notices) would be assessed in 2002. A breakdown of costs based on this approach is presented below:

Parcel Type	Units of Benefit	Assessment (2002)	Annual Assessment (2003-2005)
Lakefront	1	$112	$92
Backlot	¼	$28	$23

Introduction

PROJECT BACKGROUND

Lake Oakland is located in Sections 2, 3, and 11 of Waterford Township, and Sections 34 and 35 of Independence Township in Oakland County (T3-4N, R9E; Figure 1), approximately 6 miles northwest of the City of Pontiac. In May of 2002, Progressive AE was retained by the Lake Oakland Lake Improvement Board to conduct an improvement feasibility study. The objective of the study was to develop and define an improvement plan for Lake Oakland. The purpose of this report is to discuss study findings, conclusions, and recommendations.

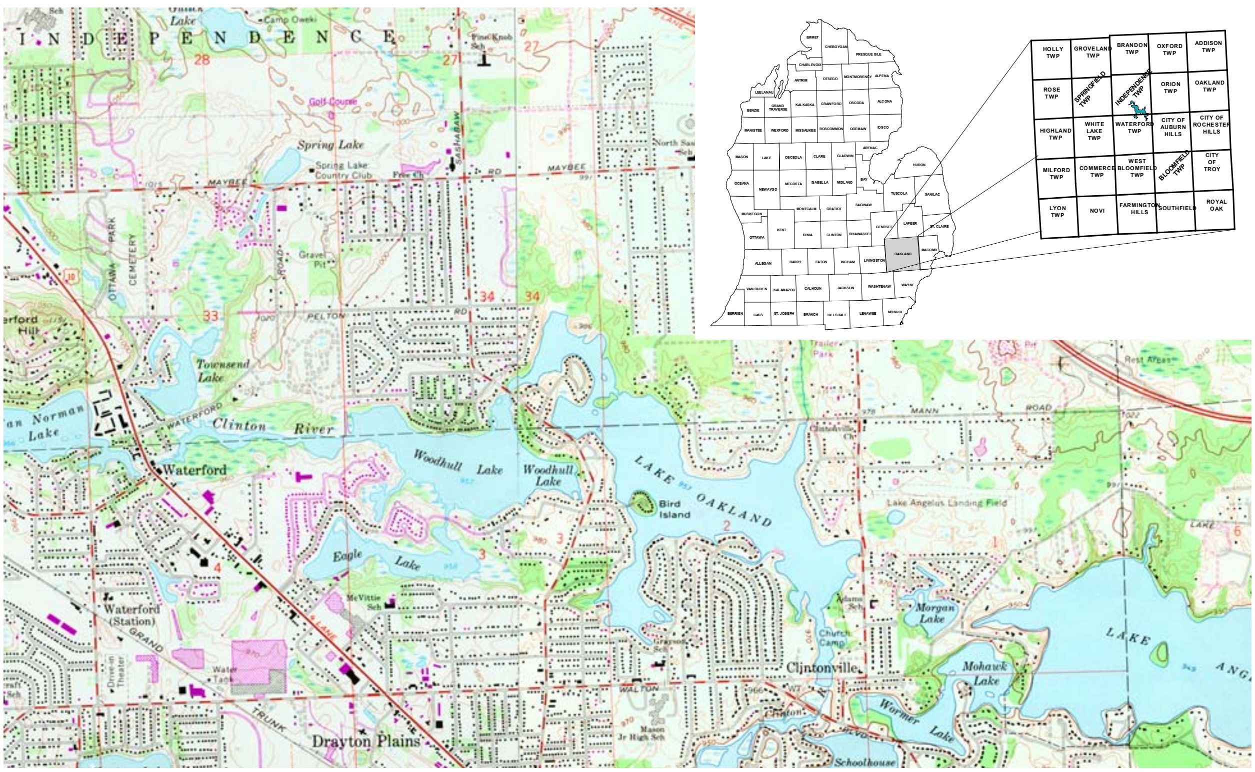

Figure 1. Project location map.

LAKE AND WATERSHED CHARACTERISTICS

A summary of the physical characteristics of Lake Oakland and its watershed is provided in Table 1. Lake Oakland is an impoundment of the Clinton River and Sashabaw Creek, although three smaller lakes pre-existed the impoundment which now form the three deep basins within Lake Oakland (Figure 2). Lake Oakland has a maximum depth of 64 feet and a mean or average depth of only 9.4 feet. Approximately 75% of the lake is less than 10 feet deep. Thus, much of the lake is shallow enough to support aquatic plant growth.

The Lake Oakland shoreline is 8.6 miles long and the lake has a shoreline development factor of 3.5. 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 Lake Oakland (i.e., 304 acres), the shoreline of Lake Oakland is 3½ times longer because of its irregular shape. Currently, approximately 400 homes border the lake.

Lake Oakland has a legal level of 957.5 feet above sea level established by circuit court order. The lake level is maintained by dam structures at the southeast end of the lake.

TABLE 1

LAKE OAKLAND PHYSICAL CHARACTERISTICS

Lake Surface Area	304	Acres
Maximum Depth	64	Feet
Mean Depth	9.4	Feet
Lake Volume	2,848	Acre-Feet
Shoreline Length	8.6	Miles
Shoreline Development Factor	3.5	
Lake Elevation	957.5	Feet
Watershed Area	41,833	Acres
Ratio of Lake Area to Watershed Area	1 :	138

The land area surrounding a lake that drains to the lake is called its watershed or drainage basin. The Lake Oakland watershed is just over 65 square miles (Figure 3), an area well over 100 times the size of Lake Oakland itself. The watershed includes the headwaters of the Clinton River and drainage from Sashabaw Creek. The upper reaches of the Clinton River pass through several lakes before draining to Lake Oakland. Much of the corridor of land adjacent to Sashabaw Creek is composed of wetland or forest land. Most of the shoreland areas bordering Lake Oakland have been urbanized. Water flows from Lake Oakland to the Clinton River which, in turn, flows into Lake St. Clair.

[1]Shoreline length, lake elevation, watershed and lake areas were determined by examining a United States Geological Survey topographic map of the Lake Oakland area (scale: 1" = 2,000'). Lake volume, maximum and mean depths were derived from a depth contour map of Lake Oakland (Bright Spot Map Publishers, 1987).

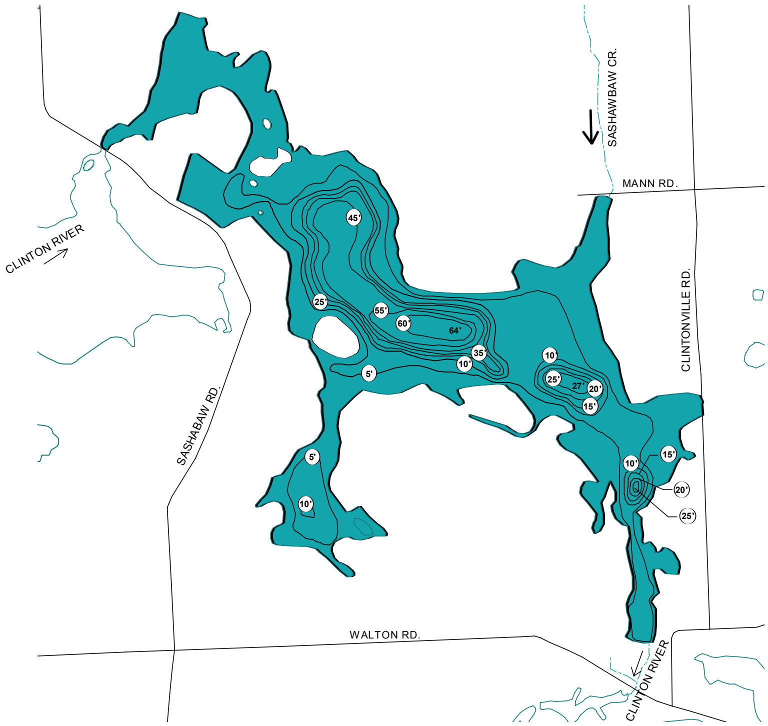

Figure 2. Lake Oakland depth contour map.

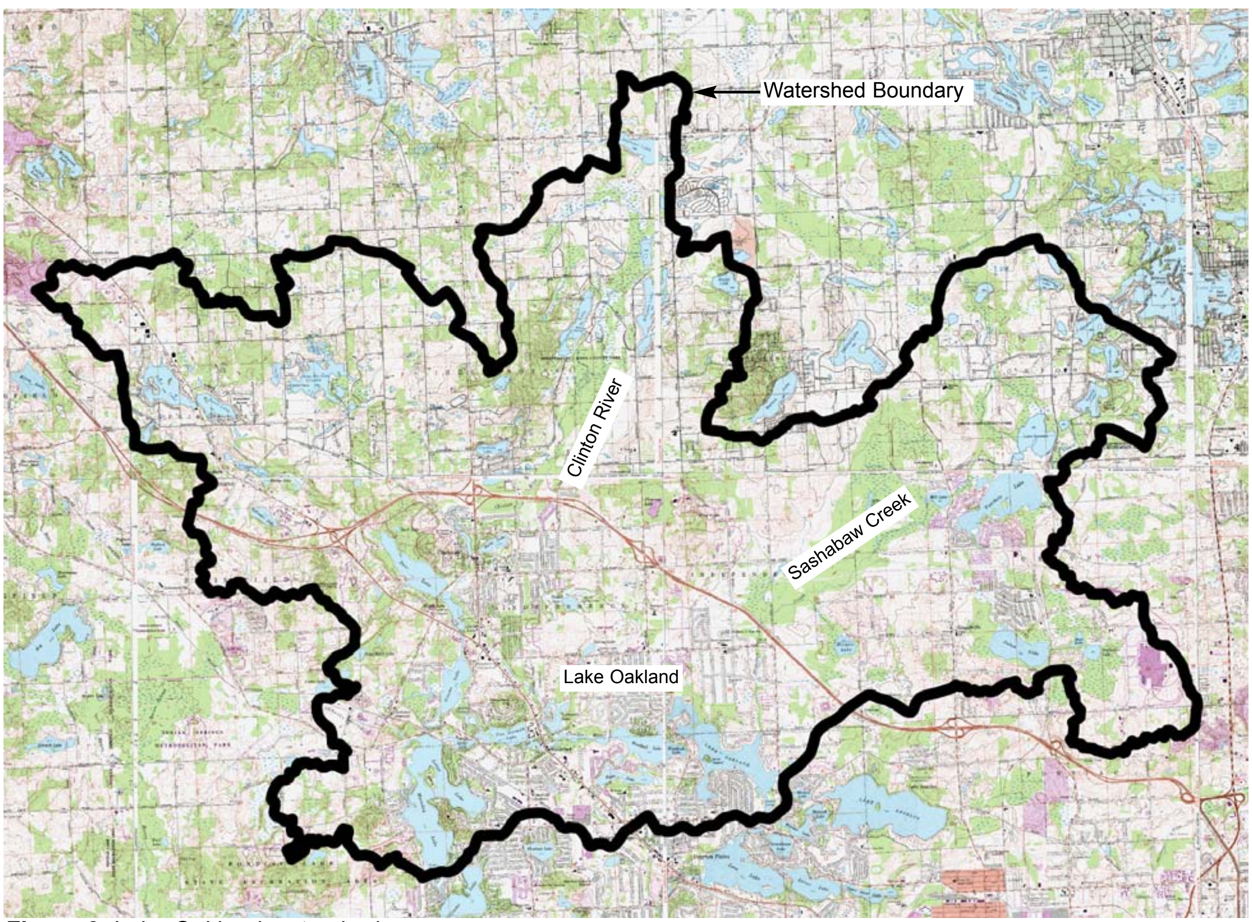

Figure 3. Lake Oakland watershed map.

Lake Water Quality

INTRODUCTION

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 (Figure 4). 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.

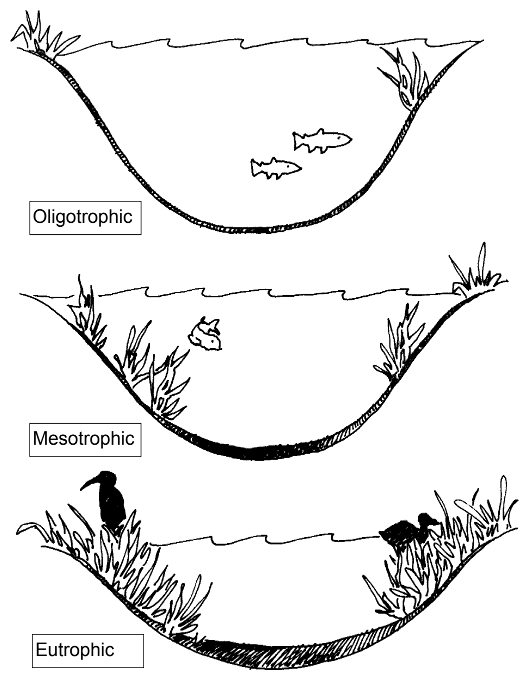

Figure 4. Lake classification.

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 management 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.

Key parameters used to evaluate the limnological condition of a lake include temperature, dissolved oxygen, total phosphorus, chlorophyll-*a*, and Secchi transparency. A brief description of these water quality measurements is provided as an introduction for the reader. Particular attention should be given to the interrelationship of these water quality measurements.

TEMPERATURE

Temperature is important in determining the type of organisms that may live in a lake. For example, trout prefer temperatures below 68NF. 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 32NF) are underlain by slightly warmer water (about 39NF). This is sometimes referred to as "inverse stratification" and occurs because water is most dense at a temperature of about 39NF. As the lake ice melts in the spring, these stratification cycles are repeated (Figure 5). Shallow lakes do not stratify.

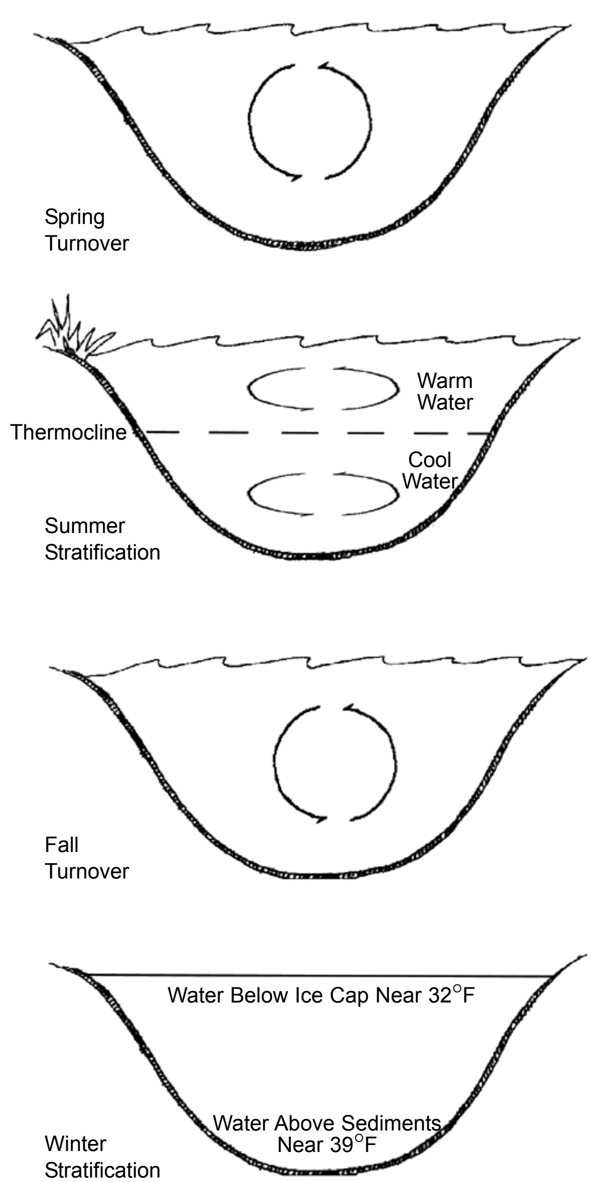

Figure 5. Seasonal thermal stratification cycles.

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 internal 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 6). 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.

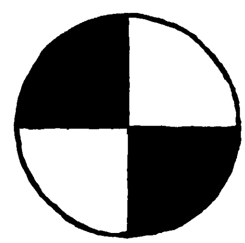

Figure 6. Secchi disk.

LAKE CLASSIFICATION CRITERIA

Ordinarily, as phosphorus inputs (both internal and external) 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)	Chlorophyll-*a* (µg/L)	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

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. In developing an effective aquatic plant control program, the type and distribution of nuisance plant growth must be evaluated so that a balanced, environmentally sound control strategy can be determined.

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 METHODS

Water quality sampling was conducted in spring and late summer at the deepest basin within Lake Oakland (Figure 7). Temperature and dissolved oxygen content were measured at 10-foot intervals in each of the deep basins using a YSI Model 95 probe. Approximately five percent of the total number of measurements were verified with the modified Winkler method (Standard Methods procedure 4500-O C). Samples were collected at 10-foot depth intervals with a Kemmerer bottle to be analyzed for pH, total alkalinity, and total phosphorus. pH was measured in the field using a Hach pH Pal. 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 using U.S. EPA procedure 365.3.

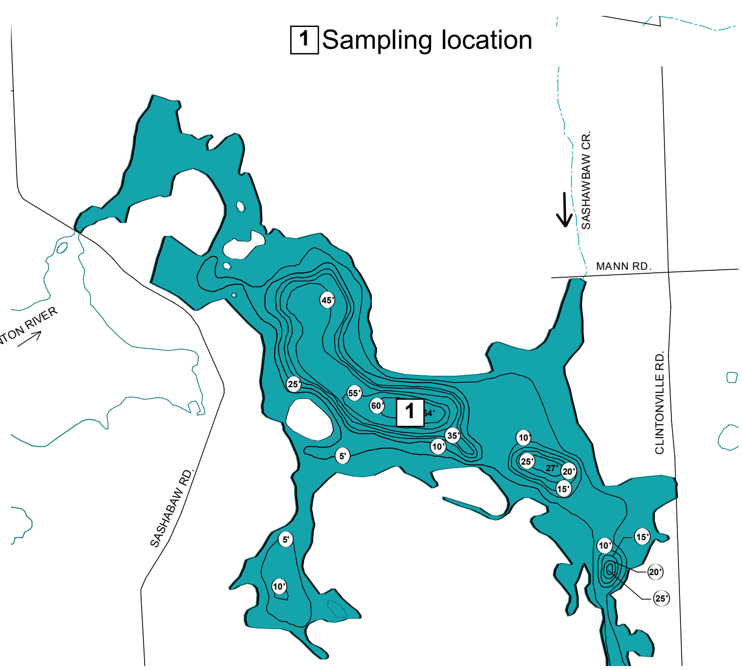

Figure 7. Lake Oakland sampling location map.

[1]Prein and Newhof Environmental and Soils Laboratory, 3260 Evergreen, NE, Grand Rapids, MI.

In addition to the depth-interval samples at the 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. Fecal coliform bacteria samples were collected at 10 locations around the shoreline (Figure 8) and were analyzed at the Michigan Department of Community Health Laboratory in Grand Rapids.

Aquatic plant surveys of Lake Oakland were also conducted in spring and late summer in accordance with Michigan Department of Environmental Quality (MDEQ) procedures (Appendix A).

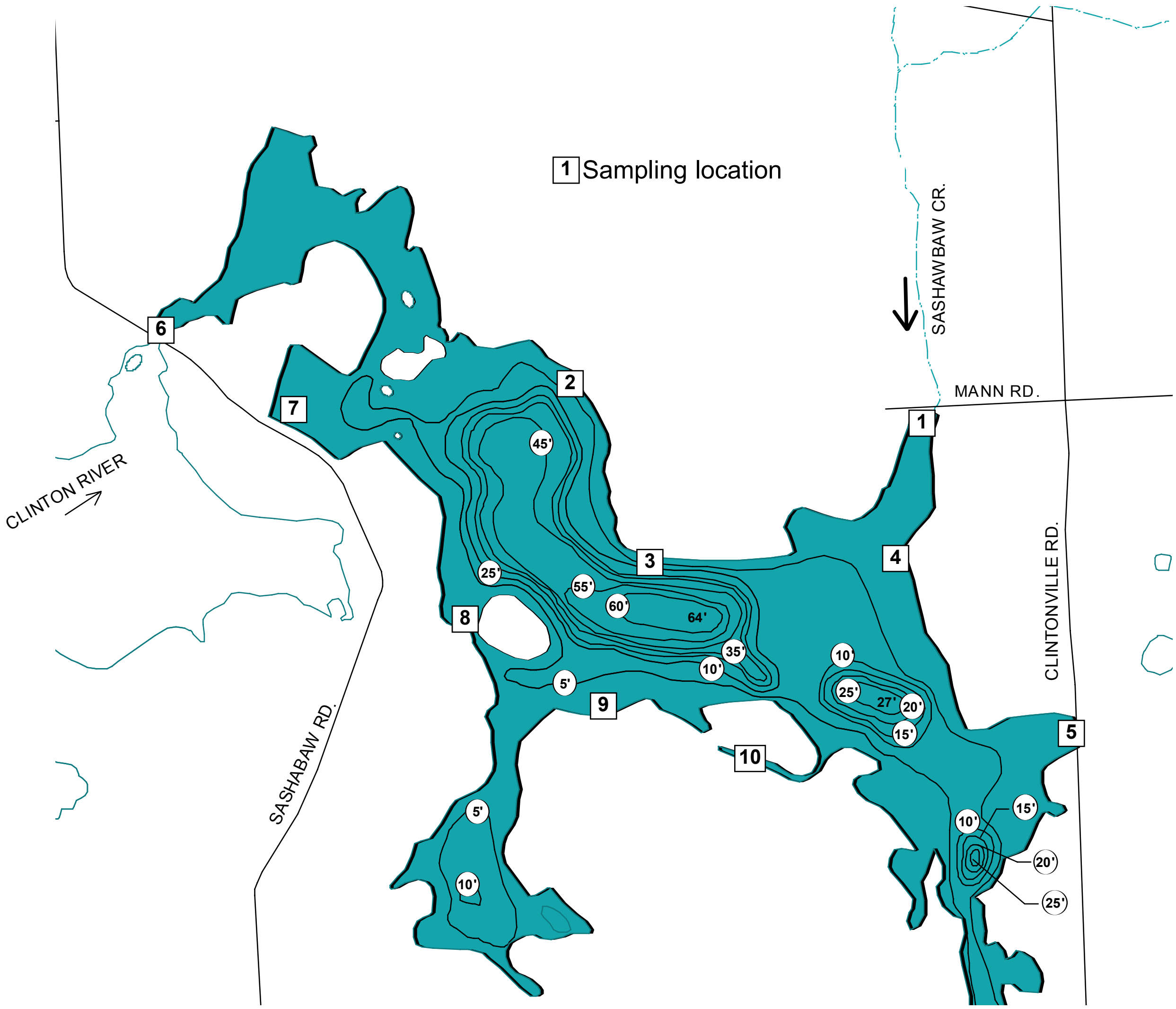

Figure 8. Lake Oakland fecal coliform bacteria sampling location map.

RESULTS AND DISCUSSION

Deep basin water quality data is provided in Table 3. Surface water quality data is provided in Table 4. Fecal coliform bacteria results are shown in Table 5. Aquatic plant survey data is included in Table 6 and Figures 9 and 10.

TABLE 3
LAKE OAKLAND DEEP BASIN WATER QUALITY DATA

Date	Sampling Location	Sample Depth (feet)	Temperature (°F)	Dissolved Oxygen (mg/L)[1]	Total Phosphorus (μg/L)[2]	pH (S.U.)	Total Alkalinity (mg/L as $CaCO_3$)[3]
1-May-02	1	1	51	11	24		199
1-May-02	1	10	51	11	16	8.7	198
1-May-02	1	20	50	11	28	8.7	196
1-May-02	1	30	48	11	19	8.7	197
1-May-02	1	40	43	12	12	8.6	198
1-May-02	1	50	42	11	53	8.6	202
1-May-02	1	60	42	10	19	8.6	200
16-Jul-02	1	1	81	8	6	8.8	166
16-Jul-02	1	10	80	7	11		
16-Jul-02	1	20	63	6	12		
16-Jul-02	1	30	54	5	5	8.2	197
16-Jul-02	1	40	47	4	10		
16-Jul-02	1	50	44	3	16		
16-Jul-02	1	60	43	1	25	8.0	199

TABLE 4
LAKE OAKLAND SURFACE WATER QUALITY DATA

Date	Sample Location	Secchi Transparency (feet)	Chlorophyll-*a* (μg/L)[2]
1-May-02	1	16.0	0
16-Jul-02	1	15.0	2

TABLE 5
LAKE OAKLAND FECAL COLIFORM BACTERIA SAMPLING DATA

Date	Site Number	*E. coli* Bacteria/100 milliliters
4-Sep-02	1	687
4-Sep-02	2	33
4-Sep-02	3	10
4-Sep-02	4	6
4-Sep-02	5	3
4-Sep-02	6	13
4-Sep-02	7	5
4-Sep-02	8	3
4-Sep-02	9	28
4-Sep-02	10	11

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

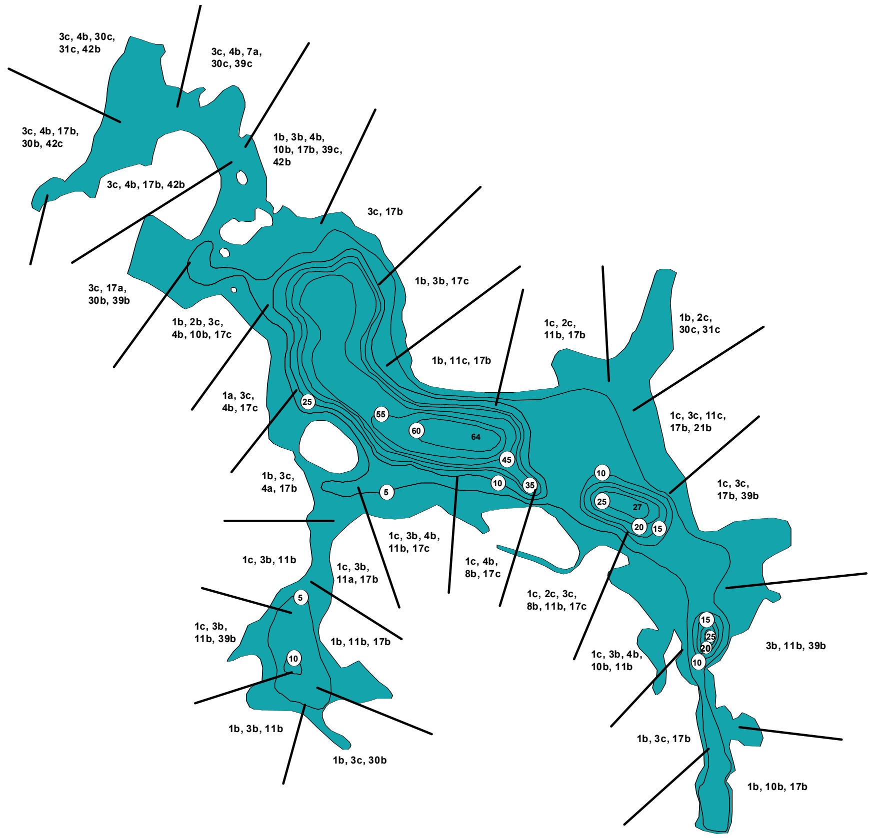

Figure 9. Lake Oakland aquatic plant distribution map, May 1, 2002.

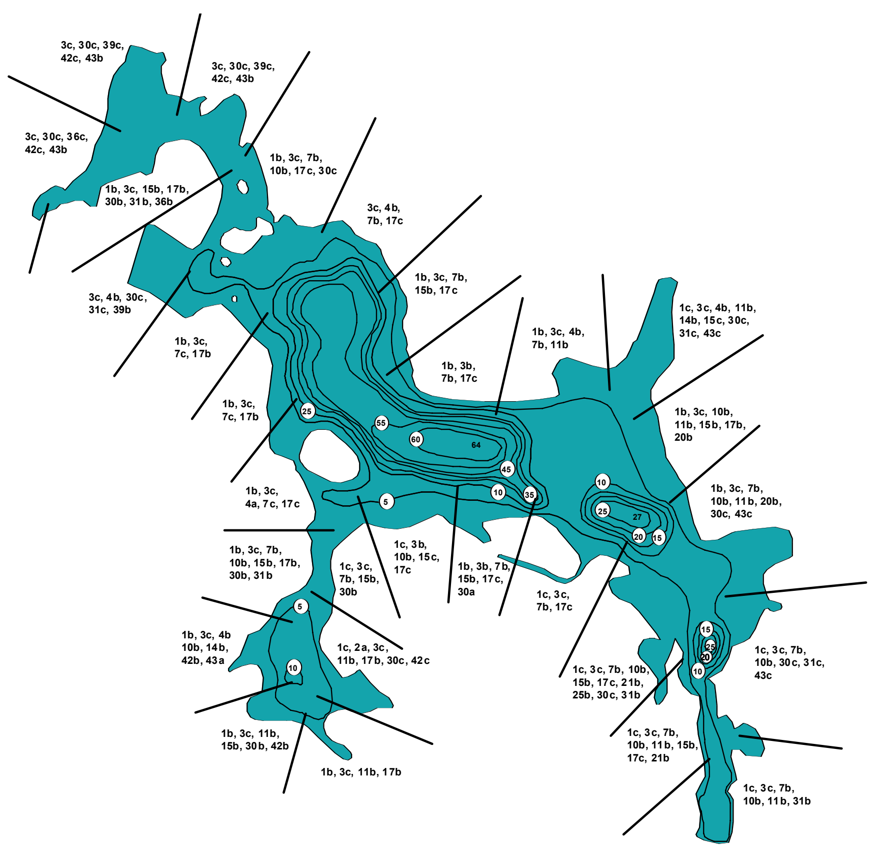

Figure 10. Lake Oakland aquatic plant distribution map, July 16, 2002.

1 Eurasian milfoil
2 Curly-leaf pondweed
3 Chara
4 Thin-leaf pondweed
5 Flat-stem pondweed
6 Robbins pondweed
7 Variable pondweed
8 Whitestem pondweed
9 Richardson's pondweed
10 Illinois pondweed
11 Large-leaf pondweed
12 American pondweed
13 Floating-leaf pondweed
14 Water stargrass
15 Wild celery
16 Sagittaria
17 Northern milfoil
18 Green milfoil
19 Milfoil
20 Coontail
21 Elodea
22 Bladderwort
23 Mini bladderwort
24 Buttercup
25 Southern naiad
26 Brittle-leaf naiad
30 White waterlily
31 Yellow waterlily
32 Water shield
33 Duckweed
34 Big duckweed
35 Watermeal
36 Arrowhead
37 Pickerelweed
38 Arrow arum
39 Cattail
40 Bulrush
41 Iris
42 Swamp loosestrife
43 Purple loosestrife

a = found
b = sparse
c = common
d = dense

TABLE 6
LAKE OAKLAND AQUATIC PLANTS

Common Name	Scientific Name	Group	Occurrence
Eurasian milfoil	*Myriophyllum spicatum*	Common	Submersed
Northern milfoil	*Myriophyllum sibiricum*	Common	Submersed
Chara	*Chara* sp.	Common	Submersed
White waterlily	*Nymphea odorata*	Common	Floating-leaved
Coontail	*Ceratophyllum demersum*	Sparse	Submersed
Swamp loosestrife	*Decodon verticillatus*	Sparse	Emergent
Elodea	*Elodea canadensis*	Sparse	Submersed
Water stargrass	*Heteranthera dubia*	Sparse	Submersed
Purple loosestrife	*Lythrum salicaria*	Sparse	Emergent
Naiad	*Najas flexilis*	Sparse	Submersed
Yellow waterlily	*Nuphar* sp.	Sparse	Floating-leaved
Large-leaf pondweed	*Potamogeton amplifolius*	Sparse	Submersed
Curly-leaf pondweed	*Potamogeton crispus*	Sparse	Submersed
Variable pondweed	*Potamogeton gramineus*	Sparse	Submersed
Illinois pondweed	*Potamogeton illinoensis*	Sparse	Submersed
Whitestem pondweed	*Potamogeton praelongus*	Sparse	Submersed
Thin-leaf pondweed	*Potamogeton* sp.	Sparse	Submersed
Arrowhead	*Sagittaria latifolia*	Sparse	Emergent
Cattail	*Typha* sp.	Sparse	Emergent
Wild celery	*Vallisneria americana*	Sparse	Submersed

Lake Oakland was well oxygenated in spring with moderate to high phosphorus concentrations, excellent water clarity, and sparse algae growth. By summer, bottom-water oxygen levels were nearly depleted, although phosphorus concentrations were moderate, algae growth was low (as indicated by the low chlorophyll-*a* concentration), and water clarity remained excellent. During both sampling periods, pH and total alkalinity were within the range expected for southern Michigan lakes.

The excellent water clarity in Lake Oakland may be influenced, in part, by the presence of zebra mussels (*Dreissena polymorpha*) in the lake. Zebra mussels feed by filtering planktonic algae from the water column. This filtering action by the zebra mussels can result in increased water clarity and greater penetration of sunlight to the lake bottom. The shallow depth in Lake Oakland, coupled with the excellent water clarity and ample phosphorus supply, creates conditions that favor rooted aquatic plant growth.

Currently, Lake Oakland has a good diversity of rooted plant species, but is dominated by the exotic species Eurasian milfoil (*Myriophyllum spicatum*). Illustrations of several of the plant varieties in Lake Oakland are provided in Figure 11. The wide variety of native plants (i.e., those plants other than Eurasian milfoil and curlyleaf pondweed) are beneficial to the quality of Lake Oakland, but Eurasian milfoil threatens the stability of the native plant community, and interferes with recreational use of the lake.

In general, fecal coliform bacteria levels were low in Lake Oakland at the time of sampling, with the exception of the Sashabaw Creek inlet area. Thus, at the time of sampling, the lake was safe for swimming and other total body contact recreational activities. The high bacteria level in the Sashabaw Creek area may have been caused by the presence of wildlife fecal matter, in particular, waterfowl droppings. Additional sampling would be necessary to determine more precisely the source and extent of the high count.

Study findings indicate that Lake Oakland is mesotrophic. The lake exhibits some eutrophic characteristics (i.e., moderate to high phosphorus levels, evidence of bottom water oxygen depletion, and substantial rooted aquatic plant growth) as well as some oligotrophic characteristics (i.e., excellent transparency and minimal open-water algae growth).

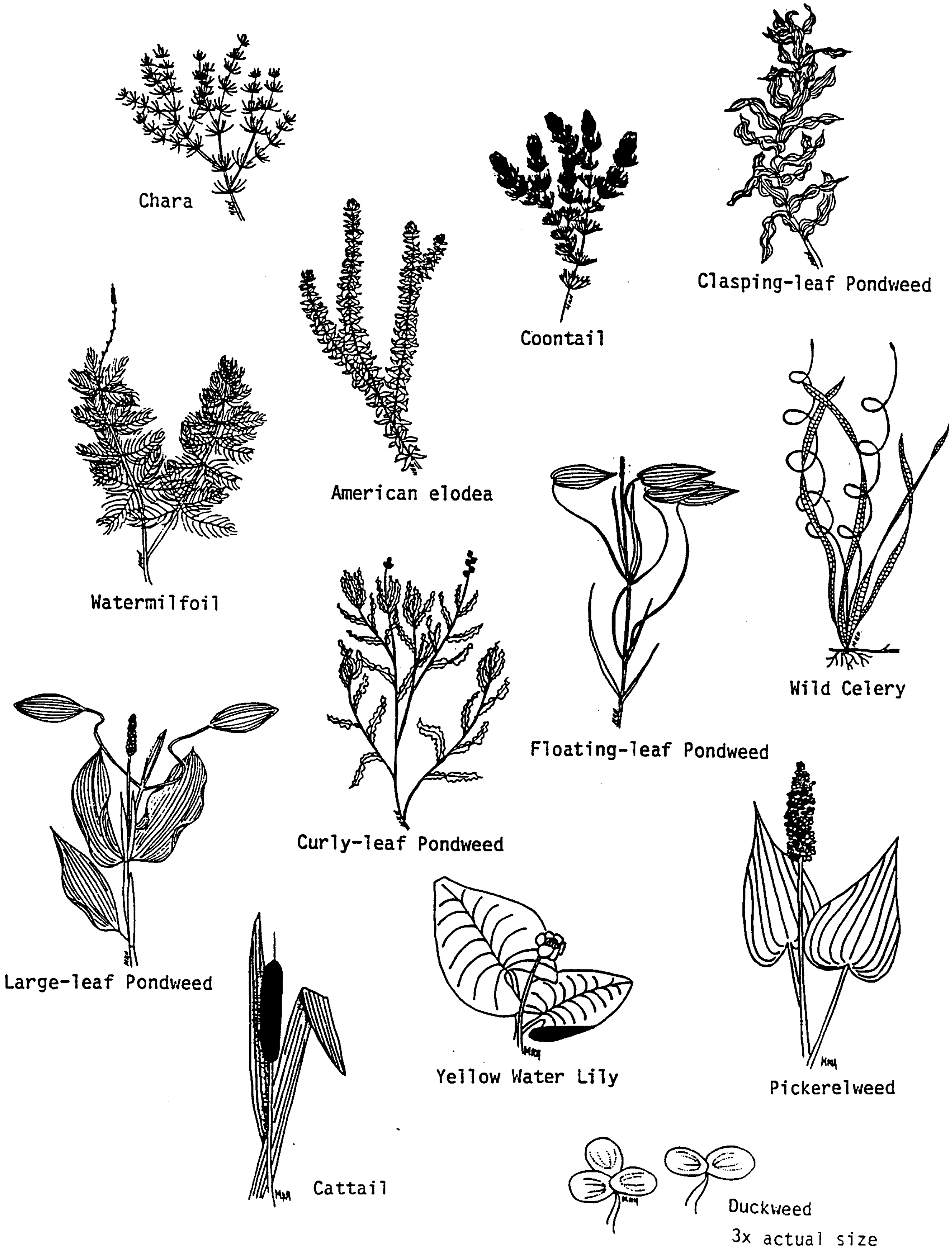

Figure 11. Common aquatic plants.

Lake Improvement Alternatives

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. 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 (Figure 12). 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 12. Mechanical harvesting.

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 (Figures 13 and 14). 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 15).

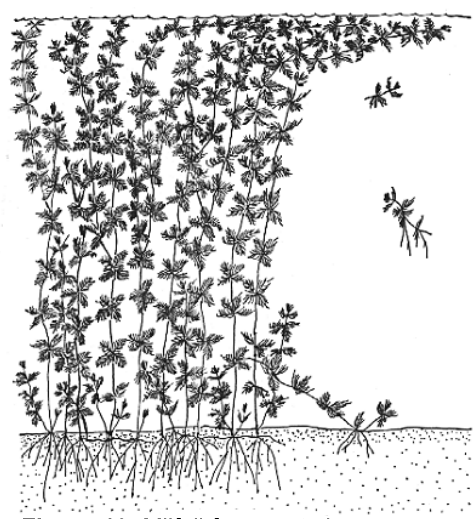

Figure 13. Milfoil fragmentation.
Source: Vermont Agency of Natural Resources

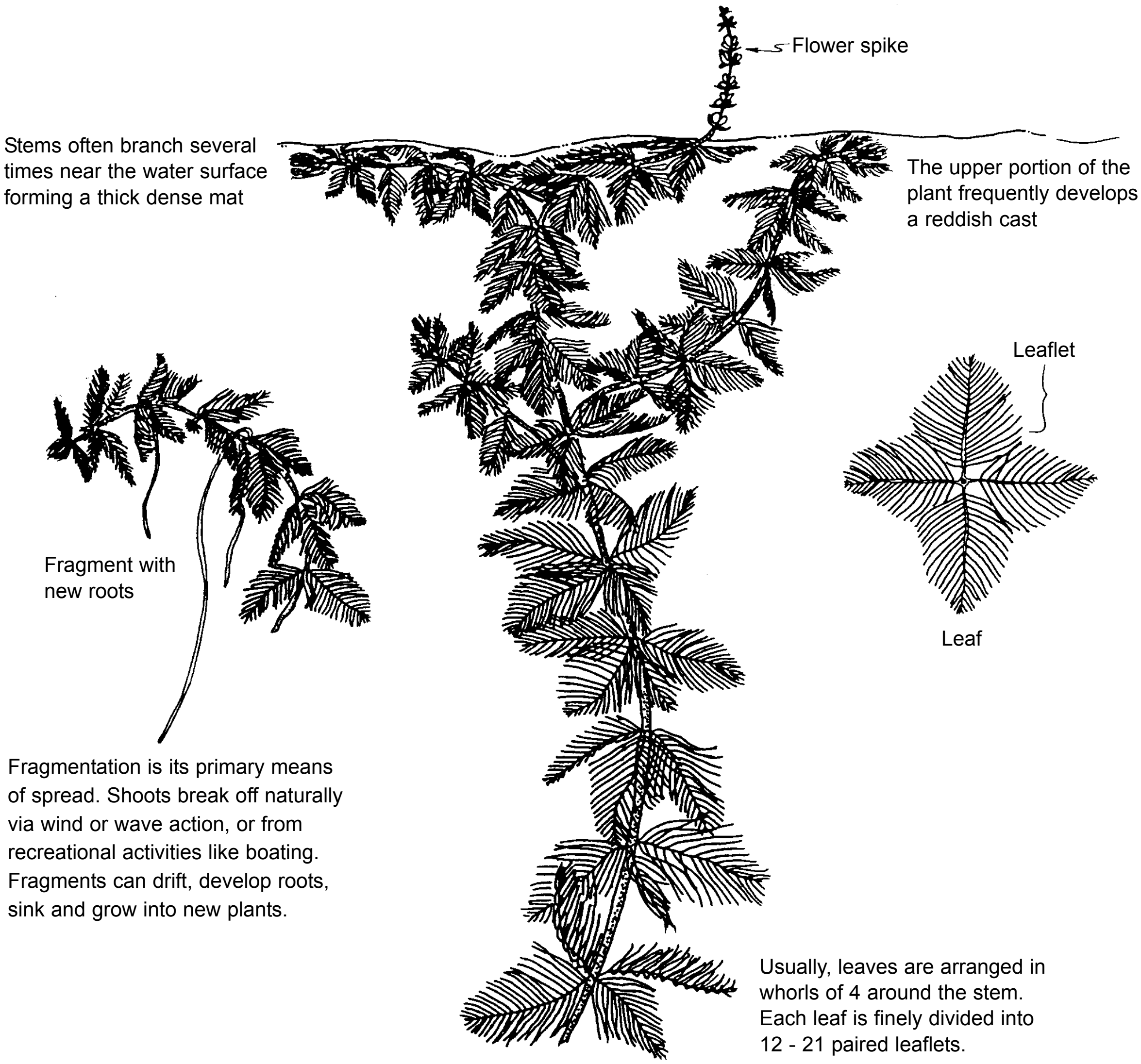

Figure 14. Eurasian milfoil.

Figure 15. Eurasian milfoil canopy.

Once introduced into a lake system, Eurasian milfoil may out-compete and displace more desirable plants and become the dominant species. When Eurasian milfoil is present, it may be possible to control the growth and spread of the plant by spot-treating the lake with a species-selective systemic herbicide. Another approach that may prove effective in Lake Oakland is a lake-wide treatment with a systemic herbicide called fluridone. At low doses, fluridone has proven to be extremely effective in controlling Eurasian milfoil while not significantly impacting non-target, beneficial plant species. In Michigan, Act 368 of 1978 (the Public Health Code) 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.

In recent years, considerable research has been conducted on the biological control of Eurasian milfoil. This approach currently focuses on the introduction of a small weevil (*Euhrychiopsis lecontei*), commonly referred to as the milfoil weevil. This weevil has been found to selectively feed on Eurasian milfoil while ignoring other plants. In some cases, substantial reductions in Eurasian milfoil growth in lakes have been observed as a result of consumption by the milfoil weevil. The milfoil weevil is native to the northeastern United States but apparently is not abundant in Michigan lakes. Research is currently underway in Michigan to evaluate the effectiveness of introducing the weevil for milfoil control. The introduction of the milfoil weevil is not being recommended at this time but may provide a viable control method for Eurasian milfoil control in the future.

The primary nuisance plant in Lake Oakland is Eurasian milfoil and occurs in approximately 100 acres of the lake. Systemic herbicides should be used to control the Eurasian milfoil, to the extent possible, early in the growing season (May or early June). Once milfoil has been controlled, more beneficial native plants may begin to inhabit areas of the lake that once contained milfoil. If native plants reach nuisance densities, mechanical harvesting can be conducted in select areas to allow full recreational use of Lake Oakland. The extent of herbicide treatments or harvesting in any given year would depend on the type and distribution of aquatic plants.

Another plant commonly found in Lake Oakland is Chara which looks like a rooted plant, but it is actually an algae. Chara is considered a beneficial plant in that it is low-growing (therefore generally does not interfere with recreational activities); it forms a net-like mat at the bottom which helps to hold sediments in place; it absorbs phosphorus and helps improve water clarity; it is an important food source for waterfowl; and it provides habitat benefits for fish and wildlife. If Chara is removed from the lake, it will likely be replaced with milfoil which is a greater nuisance and provides far fewer water quality benefits. In general, it is highly recommended that Chara be left in place.

A proposed budget for the recommended plant control program for Lake Oakland is included in Project Implementation and Financing Section of the report.

LAKE DREDGING

Lake dredging is a lake management alternative that is often considered to improve navigation and to control aquatic plant growth. There are two major dredging methods: drag-line and hydraulic (Figures 16 and 17). 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, or, 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 dredging projects are conducted with a hydraulic dredge.

Figure 16. Backhoe dredging.

Figure 17. Hydraulic dredging. The floating pipeline is visible behind the barge at the bottom of the photograph.

Figure 18. Dredged sediment disposal cell (aerial view).

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 18). 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 large amount of dredged material produced. The disposal cell should be designed to maximize the settling of solids while allowing excess water to drain off. After dredged materials have been deposited and sufficiently drained and dried, the disposal area may be graded and seeded. (In general, less water is associated with drag-line dredging, therefore dredge disposal sites need not be so large.) 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 19). The drier sediments are retained inside the tube. The tubes can then be split open and the dried sediments hauled to the final disposal location.

Figure 19. Geotextile tubes can be used to store and dewater hydraulically dredged sediments.

Pursuant to provisions of Part 301 of P.A. 451 of 1994, the Natural Resource and Environmental Protection Act, 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), and polynuclear aromatic hydrocarbons (PNAs). If sediment proposed for dredging is found to be contaminated, the MDEQ may require that sediments be placed in a licensed landfill. This requirement can substantially increase the cost of a dredging project.

The cost to dredge and dispose of lake sediments can range from $15 to $20 per cubic yard. Although Lake Oakland is a relatively deep lake (maximum depth 64 feet), much of the lake is less than 10 feet deep.

However, with the exception of some near-shore areas, most of the lake is easily navigable. Thus, it does not appear that dredging is currently required for navigation in the lake. Given the excellent transparency in Lake Oakland, dredging to a depth of at least 15 feet would be required to inhibit plant growth. Dredging to inhibit plant growth in Lake Oakland would require removal of several hundred thousand yards of lake sediment at a cost of several million dollars. Given its apparent limited benefit that a project of this magnitude would afford, large-scale dredging is not being recommended as a lake improvement alternative for Lake Oakland.

WATERSHED MANAGEMENT

In general, lakes with large watersheds are of poorer quality than those with small watersheds because of the greater quantity of runoff. Thus, it might be assumed Lake Oakland's water quality would be quite poor given the very large size of the watershed. However, watershed size is not the only consideration; the quality of watershed drainage can also greatly impact lake water quality. The type of land use in a watershed directly influences the quantity and quality of runoff. For example, the runoff from residential areas (with roof tops, roads, driveways, and other impermeable surfaces) will generally be of greater quantity and poorer quality in terms of sediment and nutrient content than runoff from a wooded area of equal size. In wooded areas, much of the potential pollution load is retained and assimilated by the vegetative ground cover.

As previously discussed, watershed drainage transported to Lake Oakland via the Clinton River passes through several upstream lakes which act to retain many of the pollutants that would otherwise continue downstream to Lake Oakland. As such, the potential pollutant load from the Clinton River drainage area is largely mitigated. Similarly, much of the land adjacent to Sashabaw Creek is wetland or woodland. Thus, pollution transport to Lake Oakland via Sashabaw Creek would not be expected to be excessive. Currently, runoff from the highly urbanized land immediately surrounding the lake itself has the greatest potential to adversely impact the lake. Lake Oakland's long, convoluted shoreline allows substantial development to occur around the lake and very little undeveloped land remains along the shoreline to buffer pollutant runoff. Instead, impermeable surfaces hasten the delivery of pollutants to the lake. Based on these considerations, it is recommended that a watershed management strategy be implemented for Lake Oakland that focuses on reducing the runoff of nutrients and other pollutants to Lake Oakland from the urbanized shorelands around the lake.

Since no regulations are in place, either locally or state-wide, which specifically address the issue of eutrophication from watershed runoff, a watershed management program for Lake Oakland must rely heavily on the efforts of area residents. In order to achieve the greatest level of effectiveness, a publication which includes information on watershed management practices and concepts should be mailed to all lake residents. The publication should be tailored specifically for Lake Oakland and contain the following:

- Information on the physical characteristics of Lake Oakland and its watershed
- A general discussion of lake water quality and specific information on Lake Oakland's water quality
- Guidelines for property owners including lakefront lawn care; lakeside landscaping; septic system maintenance; and wetland locations, functions, regulation, and protection
- Sources of additional information

Project Implementation and Financing

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

- A Lake Oakland resident.
- A representative of Waterford Township.
- A representative of Independence Township.
- An Oakland County Commissioner.
- The Oakland County Drain Commissioner.
- A representative of the Department of Environmental Quality.

A proposed budget for the Lake Oakland Management Plan is presented in Table 7.

TABLE 7
LAKE OAKLAND IMPROVEMENT PLAN PROPOSED BUDGET (2003 THROUGH 2006)

Improvement	Cost
Nuisance Aquatic Plant Control	
Herbicides, Mechanical Harvesting (100 acres at $325 per acre)	$32,500
Engineering, Administration, and Inspections[1]	$7,500
Contingency	$5,000
Subtotal	$45,000
Lake and Watershed Management Publication	$5,000
Total Annual Project Cost	$50,000 per year

[1]Plant control activities are proposed to be coordinated under the direction of the lake board's consultant. The consultant would be responsible for preparing bid documents for the plant control program, assisting the lake board with the selection of plant control contractors, conducting surveys of the lake to determine the scope of work to be performed by plant control contractors, and performing follow-up inspections to ensure work is performed in a satisfactory manner. The consultant would report to the lake board regarding the performance of the plant control contractors and would make recommendations to the lake board regarding payments to the contractors.

Pursuant to provisions of the Act, a public hearing must be held to determine if lake residents support the proposed improvements to Lake Oakland. 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 Lake Oakland is proposed to include all properties which border the lake and back lots which have dedicated lake access. Under this plan, lakefront properties are proposed to be assessed one unit of benefit and back lots with deeded or dedicated lake access would be assessed ¼ unit of benefit.

Based on these criteria, approximately 550 assessment units exist within the proposed Lake Oakland Special Assessment District. It is proposed that the $50,000 annual cost of the project be assessed for a 4-year period (2002 to 2005). In addition, the cost of the feasibility study ($9,500) and lake board administrative costs ($2,000 for legal notices) would be assessed in 2002. A breakdown of costs based on this approach is presented below:

TABLE 8
LAKE OAKLAND IMPROVEMENT PLAN APPROXIMATE ASSESSMENTS

Parcel Type	Units of Benefit	Assessment (2002)	Annual Assessment (2003-2005)
Lakefront	1	$112	$92
Backlot	¼	$28	$23

Appendix A

Procedures for Aquatic Vegetation Surveys

DEQ
LAND AND WATER MANAGEMENT DIVISION
INLAND LAKES AND WETLANDS UNIT
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 Inland Lakes and Wetlands 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 Services 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. Count up 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.