# Spring Lake Improvement Plan

**Prepared for:**

Spring Lake - Lake Board
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# Introduction

## PROJECT BACKGROUND

Spring Lake is a drowned river mouth that empties into the Grand River, approximately 2 miles east of the Lake Michigan shoreline. A small portion of the lake is contained within Muskegon County and the remainder lies within Ottawa County. Spring Lake abuts five municipalities: Fruitport Township and the Village of Fruitport in Muskegon County; and Spring Lake Township, the Village of Spring Lake, and the City of Ferrysburg in Ottawa County (T8-9N, R16W; Figure 1).

Spring Lake is heavily used. Currently, approximately 900 homes and businesses border the lake, and approximately 350,000 people reside within about 20 miles of Spring Lake (Table 1). There are 2 state-owned public access sites on the lake. In addition, it is possible to navigate from Spring Lake to Lake Michigan via the Grand River. As such, Spring Lake harbors many large motorboats and sailboats for use on Lake Michigan, and the lake itself sustains heavy traffic for boating, fishing, water skiing and jet skiing.

**TABLE 1**
**POPULATION IN THE VICINITY OF SPRING LAKE[1]**

| | |
|---|---:|
| Fruitport Township | 11,485 |
| Village of Fruitport | 1,090 |
| Muskegon County | 158,983 |
| Spring Lake Township | 10,751 |
| Village of Spring Lake | 2,537 |
| City of Ferrysburg | 2,919 |
| Ottawa County | 187,768 |

In recent years, lake residents expressed a desire to control nuisance aquatic plant growth and improve the water quality of Spring Lake. To address these issues, the Spring Lake Lake Board was formed in 1997 under the provisions of Part 309 of the Natural Resources and Environmental Protection Act, Act 451 of 1994. In April of 1999, Progressive AE was retained by the lake board to develop and define an improvement plan for Spring Lake. The purpose of this report is to discuss study findings and recommendations.

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[1] U.S. Department of Commerce. 1990. Bureau of Census Data.

**Figure 1**. Project location map.

## LAKE AND WATERSHED CHARACTERISTICS

A summary of the physical characteristics of Spring Lake and its watershed is provided in Table 2. A map depicting approximate depth contours in Spring Lake is shown in Figure 2. Spring Lake has a surface area of 1,298 acres and a maximum depth of 42 feet. At 19.7 feet, the mean or average depth of Spring Lake is greater than the maximum depth at which most plants can grow (15 feet).

The lake shoreline is 23 miles in length and the shoreline development factor is 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 Spring Lake (i.e., 1,298 acres), the shoreline of Spring Lake is 5 times longer because of its irregular shape. Spring Lake's shoreline is highly irregular in shape because the lake is actually a drowned river mouth, much like an impoundment, although there is no artificial dam retaining water in Spring Lake. As such, Spring Lake has a long, narrow, convoluted configuration with several large bayous at the mouths of its tributaries. Despite the fact that Spring Lake is relatively deep, its long shoreline provides extensive area for rooted plant growth as well as residential development on shore.

**TABLE 2**
**SPRING LAKE PHYSICAL CHARACTERISTICS**[1]

| | | |
|---|---|---|
| Lake Surface Area | 1,298 | Acres |
| Maximum Depth | 42 | Feet |
| Mean Depth | 19.7 | Feet |
| Lake Volume | 25,253 | Acre-Feet |
| Shoreline Length | 23 | Miles |
| Shoreline Development Factor | 5 | |
| Lake Elevation | 580 | Feet |
| Watershed Area | 31,986 | Acres |
| Ratio of Lake Area to Watershed Area | 1:24.6 | |

| Watershed Land Uses | Acres | Percent of Total |
|---|---|---|
| Agriculture | 4,718 | 15 |
| Orchards | 819 | 3 |
| Residential Development | 4,917 | 15 |
| Commercial, Industrial | 1,408 | 4 |
| Forested | 14,114 | 44 |
| Open Field | 4,029 | 13 |
| Barren (sand dunes) | 133 | >1 |
| Wetlands | 1,848 | 6 |
| Total | 31,986 | 100 |

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[1] From Lauber (1999) updated from 1978 Michigan Department of Natural Resources' Michigan Resource Information System to 1992 and 1997 aerial photography (for various areas within the watershed). Lauber reported a watershed area that included the area of Spring Lake itself which is excluded from the watershed area listed above. Additionally, Lauber categorized approximately 1,588 acres of lowland hardwoods and lowland conifers as forest land; in this report, these areas are classified as wetland.

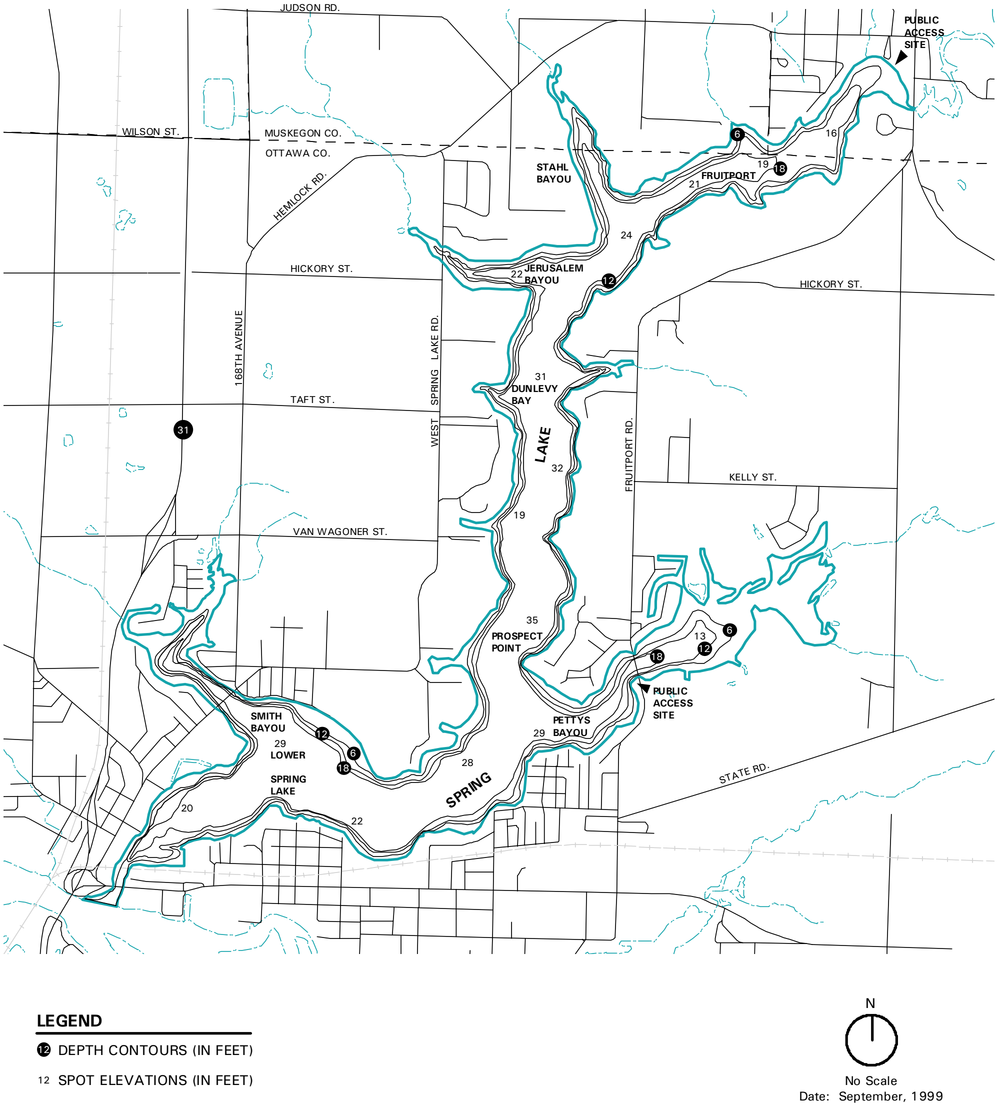

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**Figure 2.** Spring Lake depth contour map.

The land area surrounding a lake that drains to the lake is called its watershed or drainage basin. The Spring Lake watershed comprises 31,986 acres (Figure 3), which is nearly 25 times larger than the lake itself, and includes 11 municipalities. Municipalities abutting the lake are shown in Figure 4. Water drains to Spring Lake via approximately 11 tributaries and 81 storm drains (Lauber 1999).

It is interesting to note that the predominant land use in the Spring Lake watershed is not agriculture but rather forested land (Figure 5). Intensive agriculture is precluded from much of the watershed because of poor soils. Most of the soils in the vicinity of the Norris Creek drainage area comprise the Rubicon-Au Gres-Roscommon soil association, which is referred to as “association 2" by the U.S. Department of Agriculture Soil Conservation Service (SCS) in its Soil Survey of Muskegon County (1968). According to SCS (1968), “the soils are poor for farming.” SCS notes further:

> The soils in this association, like those in association 1, were cleared of trees and farmed, were severely damaged by soil blowing, and were abandoned. . . After the logging period, nearly all farms in association 2 consisted of a combination of Rubicon, Au Gres and Roscommon soils. The dry, sloping Rubicon soils were planted largely to grape vineyards and orchards, and the wetter Au Gres and Roscommon soils were used for general crops. The vineyards and orchards did not last long, because they could not withstand the frost, drought, erosion, and low fertility. Some of the worst wind-eroded areas in the county were those old vineyards and orchards and tracts of Rubicon soils. Blowouts, 5 to 10 feet deep, appeared on many of the dry sandy ridges. In Sullivan Township, a blowout area of 2,000 acres was widely known as Sullivan Sahara.
>
> The soils in this association are suited as woodland and for community developments, limited farming, and recreation.

Lauber (1999) recorded land use changes in the watershed since 1978. Residential lands have replaced agriculture as the second largest land use (after forest land). In fact, agriculture was the only land use to decrease between 1978 and the mid 1990's. While approximately 4,700 acres of agriculture remain, nearly 2,500 acres were converted to other land uses, including forest land (949 acres), residential land (773 acres), orchards (330 acres), commercial land (215 acres), and open field (180 acres).

In general, agricultural and residential lands tend to contain large quantities of nutrients and sediments in runoff, while forest land and wetland are considered beneficial land uses for protecting water quality. Urban land in the Spring Lake watershed is most problematic because of its proximity to the lake and the lack of detention or filtration of runoff prior to entering the lake. Indeed, some 81 stormwater outfalls discharge directly to the lake. Conversely, agricultural land in the watershed is situated far from the lake, and agricultural runoff tends to be filtered by watershed wetlands and forests. Although agricultural runoff in the Spring Lake watershed should be controlled to the extent possible, management of urban runoff should be a higher priority.

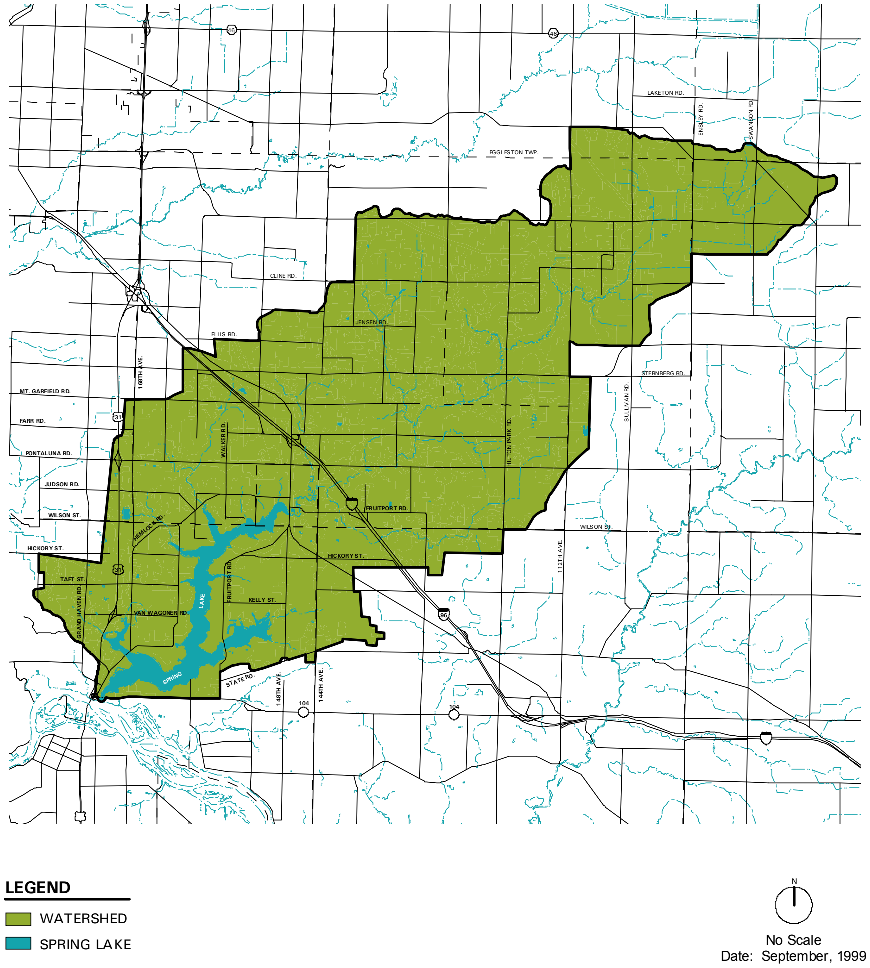

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**Figure 3.** Spring Lake watershed map. Source: Lauber (1999).

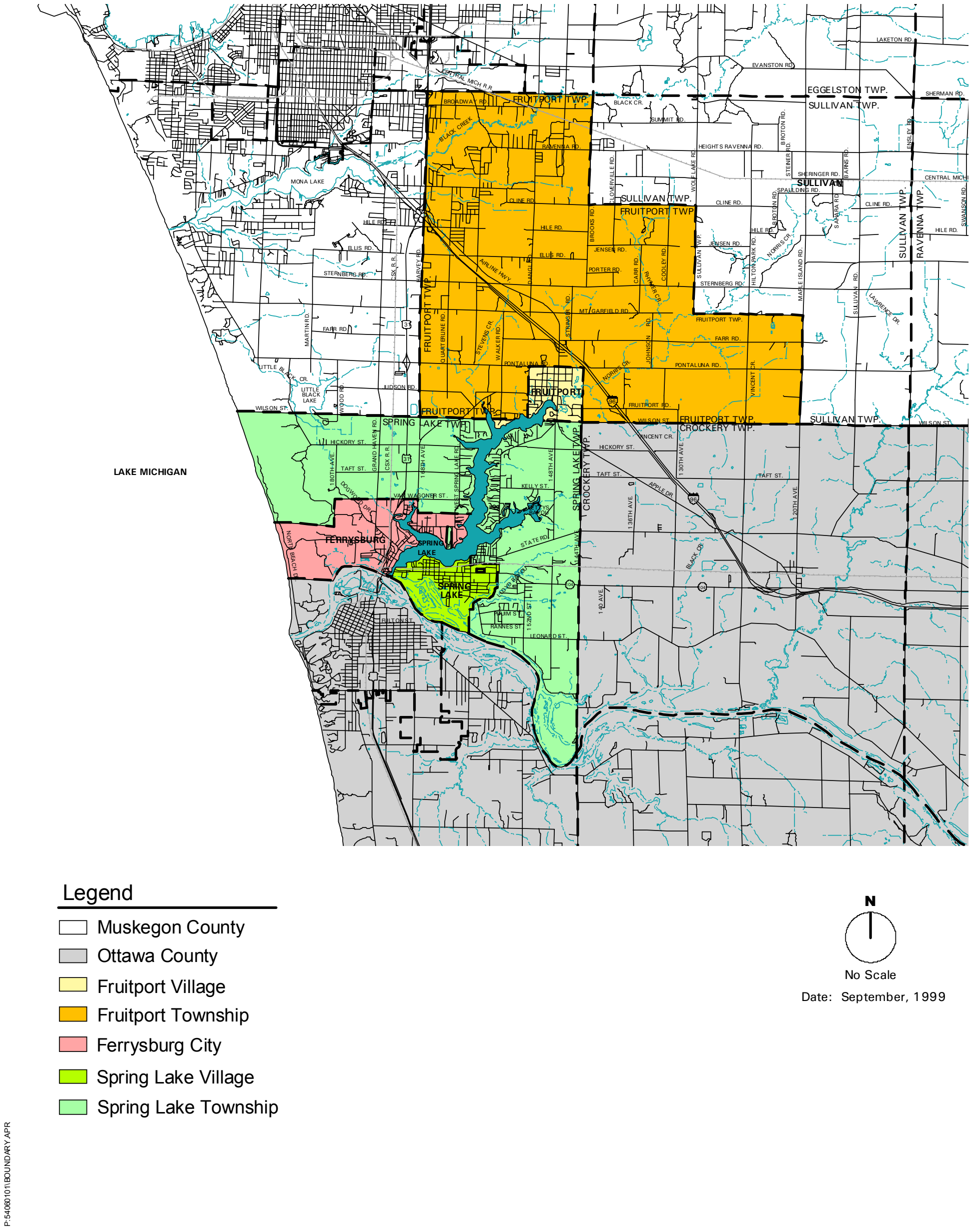

**Figure 4.** Spring Lake political jurisdiction map.

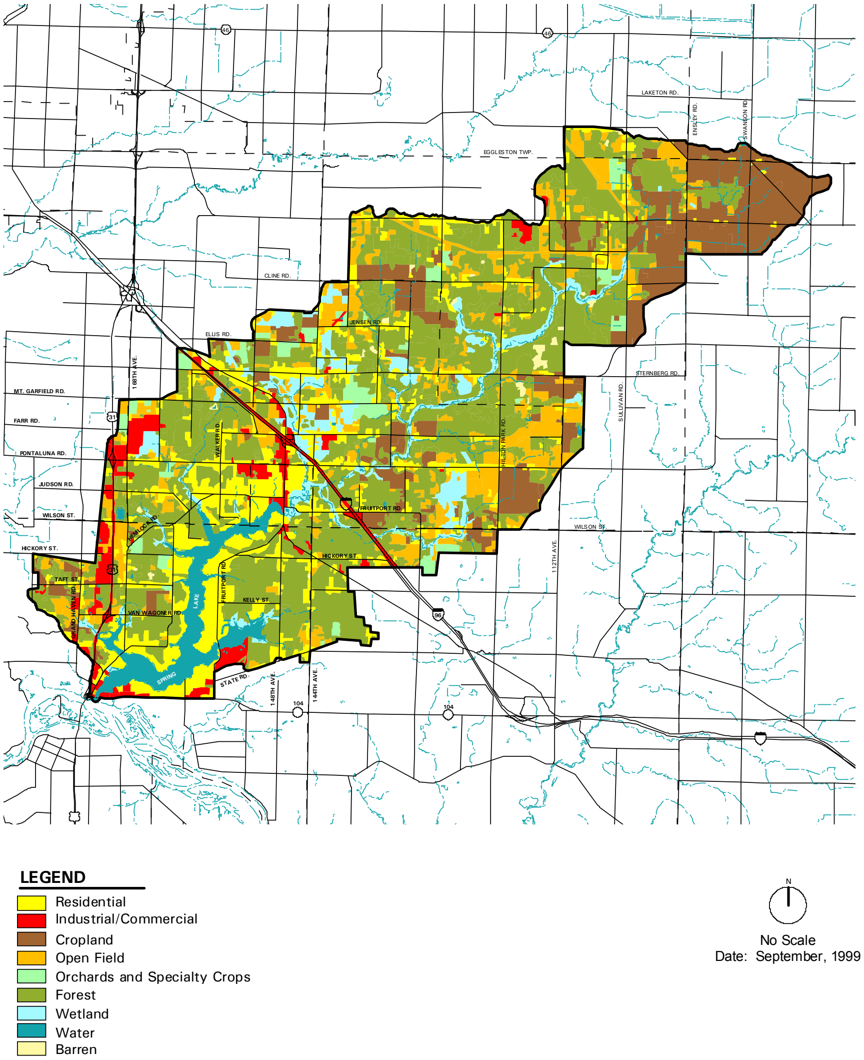

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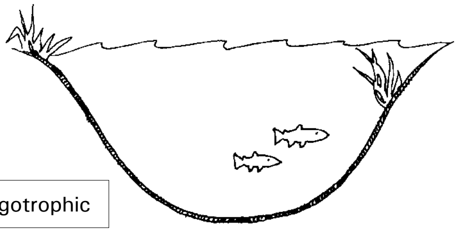
**Figure 5.** Spring Lake watershed land use map. Source: Lauber (1999).

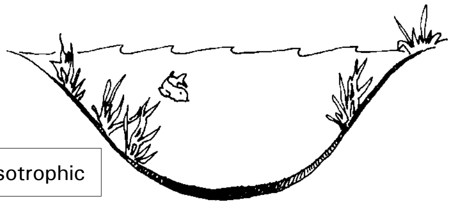
# Lake Water Quality

## INTRODUCTION

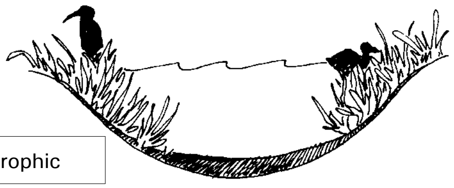
Lake water quality is determined by a unique combination of processes that occur both within and outside of the lake. In order to make sound management decisions, it is necessary to have an understanding of the current physical, chemical, and biological condition of the lake, and the potential impact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



Oligotrophic



Mesotrophic



Eutrophic

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.

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 an 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.

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 68EF. 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 32EF) are underlain by slightly warmer water (about 39EF). This is sometimes referred to as "inverse stratification" and occurs because water is most dense at a temperature of about 39EF. As the lake ice melts in the spring, these stratification cycles are repeated. Shallow lakes do not stratify. Lakes that are 15 - 30 feet deep may stratify and destratify with storm events several times during the year.

## 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 $\mu$g/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 $\mu$g/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. 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.

## 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 (DNR) is shown in Table 3.

**TABLE 3**
**LAKE CLASSIFICATION CRITERIA**

| Lake Classification | Total Phosphorus ($\mu$g/L)[1] | Chlorophyll-*a* ($\mu$g/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

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 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.

## SAMPLING REGIME

For this report, water quality samples were collected on April 19, May 21, and July 7, 1999. On April 19, samples were collected from the surface, mid-depth, and bottom of three sites within the main body of Spring Lake (designated as Lower Spring Lake, Prospect Point, and Fruitport) and from four bayous (designated as Smith, Petty's, Jerusalem, and Stahl), shown in Figure 6. On May 21 and July 7, samples were collected only from the three sites within the main body of Spring Lake. To better discern stratification, temperature was measured at 5-foot intervals; dissolved oxygen, pH, and total alkalinity were measured at 10-foot intervals; and total phosphorus was measured at the surface, mid-depth, and bottom. For each sampling date and site, chlorophyll-*a* samples were collected as a composite throughout a depth equivalent to twice the Secchi transparency measurement. Aquatic plant surveys of Spring Lake were conducted on May 21 and July 7, 1999.

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[1] $\mu$g/L = micrograms per liter = parts per billion.

Samples were collected by Lauber (1999) at the same seven in-lake sites periodically from May of 1997 until October of 1998. The DNR collected samples from a location between the lower Spring Lake and Prospect Point sites on April 4, 1967 and September 2, 1981.

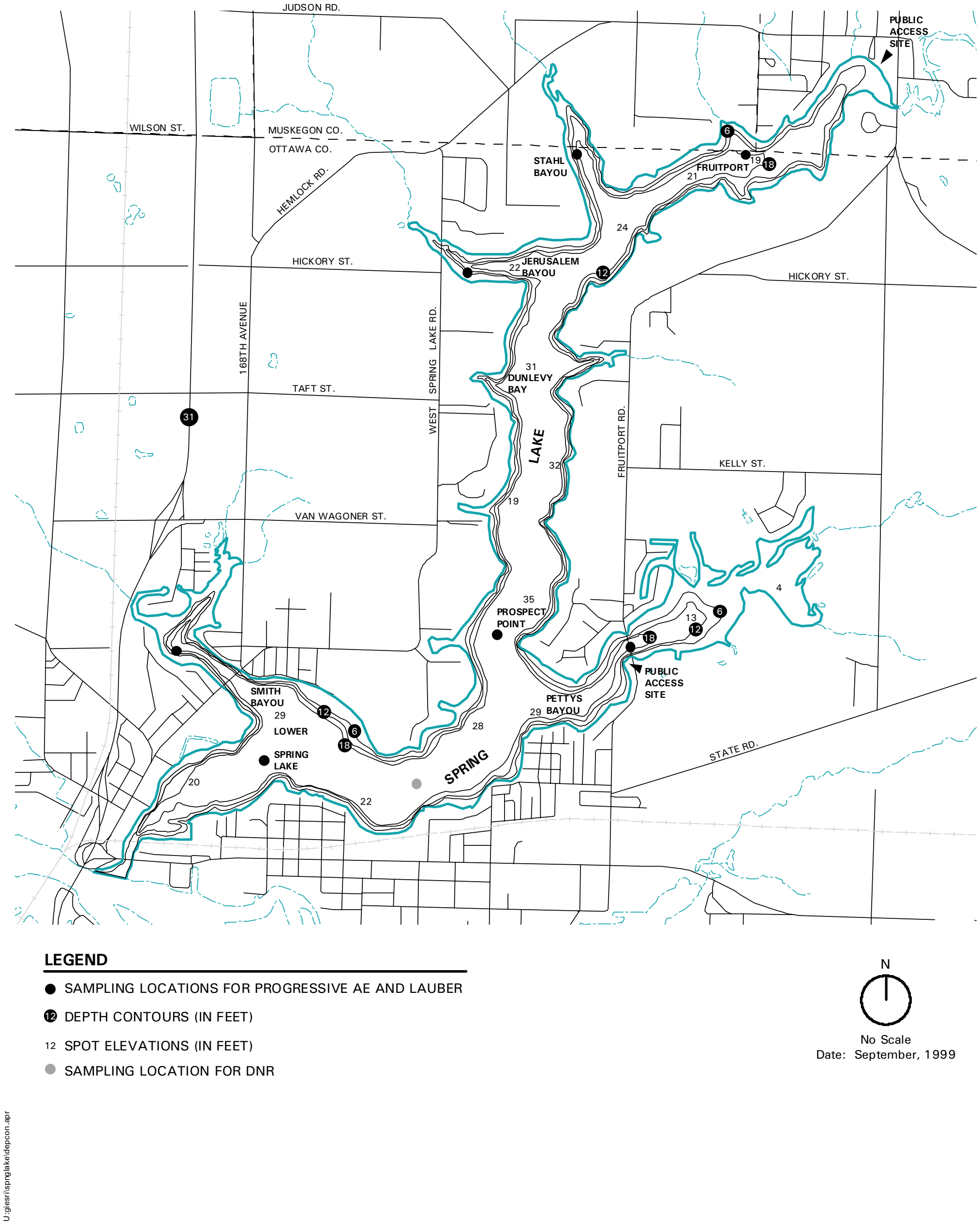

**Figure 6.** Sampling location map.

## SAMPLING RESULTS

Deep basin water quality data is provided in Tables 4, 5, 6, and 7 for Lower Spring Lake, Prospect Point, Fruitport, and the bayous, respectively. Surface water quality data for all sites is shown in Table 8. Aquatic plant survey data is included in Table 9.

### TABLE 4
### SPRING LAKE DEEP BASIN WATER QUALITY DATA
### LOWER SPRING LAKE

| Date | Sample Depth (feet) | Temp. (EF) | Dissolv. Oxygen (mg/L)[1] | Total Phosph. (µg/L)[2] | pH (S.U.)[3] | Total Alkalin. (mg/L as $CaCO_3$)[4] |
|---|---|---|---|---|---|---|
| 19-Apr-99 | 1 | 51.0 | 11.4 | 43 | 8.3 | 153 |
| 19-Apr-99 | 15 | 50.0 | 10.8 | 34 | 8.3 | 158 |
| 19-Apr-99 | 30 | 49.0 | 9.3 | 68 | 8.2 | 162 |
| 21-May-99 | 1 | 65.0 | 8.7 | 50 | 7.9 | 161 |
| 21-May-99 | 5 | 64.5 | | | | |
| 21-May-99 | 10 | 63.0 | 7.5 | | 7.8 | 144 |
| 21-May-99 | 15 | 62.0 | | 35 | | |
| 21-May-99 | 20 | 60.5 | 5.5 | | 7.6 | 147 |
| 21-May-99 | 25 | 59.0 | | | | |
| 21-May-99 | 30 | 58.0 | 4.1 | 73 | 7.6 | 147 |
| 7-Jul-99 | 1 | 79.0 | 12.6 | 35 | | 156 |
| 7-Jul-99 | 5 | 78.0 | 12.3 | | | 159 |
| 7-Jul-99 | 10 | 77.0 | 8.4 | | | 151 |
| 7-Jul-99 | 15 | 74.0 | 8.2 | 39 | | 152 |
| 7-Jul-99 | 20 | 63.0 | 6.9 | | | 153 |
| 7-Jul-99 | 25 | 63.0 | 1.4 | | | 152 |
| 7-Jul-99 | 30 | 63.0 | 0.5 | 631 | | 169 |

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[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
## SPRING LAKE DEEP BASIN WATER QUALITY DATA
## PROSPECT POINT

| Date | Sample Depth (feet) | Temp. (EF) | Dissolv. Oxygen (mg/L)[1] | Total Phosph. ($\mu$g/L)[2] | pH (S.U.)[3] | Total Alkalin. (mg/L as $CaCO_3$)[4] |
|---|---|---|---|---|---|---|
| 19-Apr-99 | 1 | 51.5 | 12.7 | 30 | 8.6 | 149 |
| 19-Apr-99 | 18 | 50.5 | 11.6 | 46 | 8.4 | 153 |
| 19-Apr-99 | 35 | 49.5 | 10.8 | 30 | 8.3 | 141 |
| 21-May-99 | 1 | 65.5 | 10.4 | 30 | | 140 |
| 21-May-99 | 5 | 65.5 | | | | |
| 21-May-99 | 10 | 65.0 | 10.6 | | 8.3 | 132 |
| 21-May-99 | 15 | 63.5 | | 28 | | |
| 21-May-99 | 20 | 61.0 | 6.1 | | 7.8 | 140 |
| 21-May-99 | 25 | 60.0 | | | | |
| 21-May-99 | 30 | 59.0 | 3.9 | | 8.0 | |
| 21-May-99 | 35 | 57.0 | 3.8 | 46 | 7.8 | 142 |
| 07-Jul-99 | 1 | 79.5 | 9.1 | 35 | | 101 |
| 07-Jul-99 | 5 | 79.0 | 7.8 | | | 131 |
| 07-Jul-99 | 10 | 79.0 | 6.8 | | | 134 |
| 07-Jul-99 | 15 | 78.0 | 6.5 | | | 143 |
| 07-Jul-99 | 20 | 76.5 | 5.0 | 52 | | 143 |
| 07-Jul-99 | 25 | 72.0 | 3.0 | | | 146 |
| 07-Jul-99 | 30 | 64.0 | 0.7 | | | 161 |
| 07-Jul-99 | 37 | 64.0 | 0.4 | 465 | | 159 |

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[1] mg/L = milligrams per liter = parts per million.

[2] $\mu$g/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 6
## SPRING LAKE DEEP BASIN WATER QUALITY DATA
## FRUITPORT

| Date | Sample Depth (feet) | Temp. (EF) | Dissolv. Oxygen (mg/L)[1] | Total Phosph. ($\mu$g/L)[2] | pH (S.U.)[3] | Total Alkalin. (mg/L as $CaCO_3$)[4] |
|---|---|---|---|---|---|---|
| 19-Apr-99 | 1 | 51.5 | 12.6 | 19 | 8.2 | 130 |
| 19-Apr-99 | 9 | 50.0 | 10.9 | 41 | 8.2 | 138 |
| 19-Apr-99 | 17 | 49.5 | 10.9 | 32 | 8.1 | 131 |
| 21-May-99 | 1 | 68.0 | 10.4 | 35 | 8.1 | 123 |
| 21-May-99 | 5 | 67.0 |  | 28 |  |  |
| 21-May-99 | 10 | 66.0 | 7.4 |  | 8.0 | 125 |
| 21-May-99 | 15 | 62.5 | 7.8 | 25 | 7.8 | 123 |
| 7-Jul-99 | 1 | 80.5 | 6.1 | 59 |  | 125 |
| 7-Jul-99 | 9 | 79.0 | 4.0 | 64 |  | 130 |
| 7-Jul-99 | 17 | 77.5 | 3.1 | 84 |  | 135 |

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[1] mg/L = milligrams per liter = parts per million.

[2] $\mu$g/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 7
## SPRING LAKE DEEP BASIN WATER QUALITY DATA
## BAYOUS

| Date | Bayou | Sample Depth (feet) | Temp. (EF) | Dissolv. Oxygen (mg/L)[1] | Total Phosph. (μg/L)[2] | pH (S.U.)[3] | Total Alkalin. (mg/L as $CaCO_3$)[4] |
|---|---|---|---|---|---|---|---|
| 19-Apr-99 | Smith | 1 | 51.0 | 11.6 | 24 | 8.3 | 152 |
| 19-Apr-99 | Smith | 9 | 49.5 | 11.7 | 34 | 8.2 | 150 |
| 19-Apr-99 | Smith | 18 | 48.0 | 10.8 | 27 | 8.2 | 158 |
| 19-Apr-99 | Petty's | 1 | 51.5 | 12.2 | 35 | 8.5 | 146 |
| 19-Apr-99 | Petty's | 9 | 51.0 | 11.6 | 78 | 8.4 | 147 |
| 19-Apr-99 | Petty's | 18 | 50.5 | 11.3 | 32 | 8.3 | 153 |
| 19-Apr-99 | Jerusalem | 1 | 52.0 | 11.1 | 22 | 8.2 | 142 |
| 19-Apr-99 | Jerusalem | 9 | 50.0 | 11.5 |  | 8.2 | 149 |
| 19-Apr-99 | Jerusalem | 17 | 49.0 | 10.3 | 34 | 8.1 | 152 |
| 19-Apr-99 | Stahl | 1 | 52.0 | 11.7 | 39 | 8.2 | 147 |
| 19-Apr-99 | Stahl | 8 | 50.0 | 11.4 | 44 | 8.2 | 151 |
| 19-Apr-99 | Stahl | 15 | 49.0 | 11.1 | 32 | 8.1 | 149 |

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[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 8
## SPRING LAKE SURFACE WATER QUALITY DATA

| Date | Sample Location | Secchi Transparency (feet) | Chlorophyll-*a* (µg/L)[1] |
|---|---|---|---|
| 19-Apr-99 | Spring Lake | 4.5 | 2 |
| 19-Apr-99 | Prospect Point | 5.0 | 7 |
| 19-Apr-99 | Fruitport | 4.5 | 10 |
| 19-Apr-99 | Smith Bayou | 6.5 | 5 |
| 19-Apr-99 | Petty's Bayou | 5.0 | 12 |
| 19-Apr-99 | Jerusalem Bayou | 6.0 | 7 |
| 19-Apr-99 | Stahl Bayou | 5.5 | 10 |
| 21-May-99 | Spring Lake | 4.0 | 2 |
| 21-May-99 | Prospect Point | 4.5 | 1 |
| 21-May-99 | Fruitport | 3.5 | 5 |
| 07-Jul-99 | Spring Lake | 3.0 | 46 |
| 07-Jul-99 | Prospect Point | 3.5 | 13 |
| 07-Jul-99 | Fruitport | 3.5 | 12 |

## TABLE 9
## SPRING LAKE AQUATIC PLANTS

| Common Name | Scientific Name | Type | Density |
|---|---|---|---|
| Watershield | *Brasenia schreberi* | Floating-leaved | Common |
| Coontail | *Ceratophyllum demersum* | Submerged | Abundant |
| Water stargrass | *Heteranthera dubia* | Submerged | Common |
| Purple loosestrife | *Lythrum salicaria* | Emergent | Common |
| Eurasian milfoil | *Myriophyllum spicatum* | Submerged | Abundant |
| Naiad | *Najas flexilis* | Submerged | Common |
| Yellow waterlily | *Nuphar advena* | Floating-leaved | Common |
| Smartweed | *Polygonum sp.* | Emergent | Sparse |
| Curly-leaf pondweed | *Potamogeton crispus* | Submerged | Common |
| Sago pondweed | *Potamogeton pectinatus* | Submerged | Common |
| Richardson's pondweed | *Potamogeton richardsonii* | Submerged | Sparse |
| Thin-leaf pondweed | *Potamogeton sp.* | Submerged | Sparse |
| Arrowhead | *Sagittaria latifolia* | Emergent | Common |
| Bulrush | *Scirpus sp.* | Emergent | Sparse |
| Cattail | *Typha sp.* | Emergent | Common |
| Wild celery | *Vallisneria americana* | Submerged | Sparse |

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

## DISCUSSION

Current and historical water quality data indicate Spring Lake is eutrophic (Table 10). Deep-water dissolved oxygen becomes depleted in late summer; levels of the plant nutrient phosphorus are very high; algae growth is excessive as reported by lake residents and as indicated by periodic high concentrations of chlorophyll-*a*; rooted plant growth is abundant; and water clarity is low. Spring Lake is nutrient-enriched and highly productive. Spring Lake contains excess levels of plant nutrients that support abundant rooted plants and algae, which form the base of a very productive food chain. Because the lake is so biologically active, plant and animal matter rapidly accumulates on the lake bottom, causing oxygen to be depleted relatively early in the summer in the course of decomposition. Water clarity is reduced by excessive algae growth, but may also be caused by sediments that are resuspended from the lake bottom or that wash into the lake from the shoreline, tributaries, and storm drains.

**TABLE 10**
**SPRING LAKE 1999 WATER QUALITY DATA SUMMARY**

| | Total Phosphorus (Fg/L) | Chlorophyll-*a* (Fg/L) | Secchi Transparency (feet) |
|---|---|---|---|
| Median | 35 | 7 | 5 |
| Minimum | 19 | 1 | 3 |
| Maximum | 631 | 46 | 7 |

Spring Lake stratified thermally and chemically at all sampling sites, although stratification occurred earlier and was sustained for longer periods at Lower Spring Lake and Prospect Point. Deep-water dissolved oxygen began to decrease as early as mid to late May, and was essentially depleted at the lake bottom by mid June at some sites. Oxygen depletions have been occurring since at least 1981 when the DNR measured levels as low as 0.1 parts per million at depths of 30 feet to the bottom.

Spring Lake contains high levels of the plant nutrient phosphorus. The lowest phosphorus concentration measured in 1999 was 19 parts per billion, which is only slightly below the eutrophic threshold concentration of 20 parts per billion. The median concentration was 35 and the highest was 631 parts per billion, measured at the bottom of the lower Spring Lake sampling site on July 7. Thus, phosphorus is released from the sediments when dissolved oxygen becomes depleted from the bottom waters through the process called internal loading. Phosphorus also enters Spring Lake from sources outside of the lake including the tributaries, stormwater outfalls, septic systems, lawn fertilizer, waterfowl droppings, and the atmosphere (Lauber 1999).

High phosphorus concentrations in Spring Lake have caused nuisance growth of both attached and free-floating algae. Lauber (1999) described the periphytic, or attached, algae that occurs in Spring Lake:

> *Vaucheria*, a blue-green felt-like algae occurs in most transects because it grows on shoreline rocks, whereas *Rhizoclonium* formed huge dense beds of horsehair-like algae weighing down other aquatic plants.

Dense growth of planktonic, or free-floating, algae is known as an algae “bloom.” Depending on the type of algae in the bloom, a lake may become brown, bright green, or dark green in color, and tiny clumps of algae may even be visible to the naked eye. Algae blooms occur sporadically on Spring Lake as evidenced by the periodic high chlorophyll-*a* measurements (Table 8) which are consistent with measurements reported by Lauber (1999) and Michigan Sea Grant[1]. Lauber (1999) states “the algae that has caused the green cast on the lake during the summer for the past few years is due most likely to *Microcystis*.” *Microcystis* blooms are very unsightly and are especially problematic because the algae is not a preferred food item for most organisms higher on the food chain, including zebra mussels.

Zebra mussels (*Dreissena polymorpha*) invaded Spring Lake in the mid 1990's (Lauber 1999) and were attached to aquatic plants in 90% of Lauber’s (1999) aquatic plant transects. Zebra mussels filter lake water and ingest some types of algae while rejecting others. For example, research has shown that zebra mussels in Saginaw Bay reject *Microcystis*:

> These experiments have shown that the colonial *Microcystis* which dominates Saginaw Bay is not ingested or assimilated. Experiments with laboratory cultures of small algae showed that *Dreissena* can selectively remove small algae while leaving the *Microcystis* behind. This is strong evidence that *Dreissena* can, through its selective grazing, promote *Microcystis* blooms. [Vanderploeg et al. 1997]

Thus, zebra mussels often improve water clarity by actively filtering the water column. Conversely, water clarity may decrease if zebra mussels promote *Microcystis* blooms, which appears to be the case in Spring Lake. Water clarity, as measured by Secchi transparency, is consistently low in Spring Lake. (Table 8). All measurements were below the eutrophic threshold level of 7-1/2 feet.

Spring Lake also contains larger aquatic plants, known as macrophytes (Table 9). While most of the plants in Spring Lake are beneficial, Eurasian milfoil and coontail are nuisance plants. 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 7). Eurasian milfoil spreads by a process known as vegetative propagation or fragmentation. Small pieces of the plant break off, float to new areas of the lake, sink to the bottom, take root, and grow. As such, Eurasian milfoil can quickly spread throughout a lake. Once introduced into a lake,

**Figure 7**. Eurasian milfoil canopy.

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[1] Frank Drexler, Michigan Sea Grant College Program, 333 Clinton Street, Grand Haven, Michigan 49417-1492.

Eurasian milfoil may out-compete and displace more desirable plants and become the dominant species. Thus, Eurasian milfoil is considered a nuisance whenever it is present, whether sparse or abundant.

Although coontail is generally considered a beneficial plant, it has reached nuisance densities in Spring Lake and is interfering with recreational use of the lake. Nuisance growth of macrophytes is limited to a great extent, however, by the low water clarity; if clarity were to increase in Spring Lake, macrophyte growth may increase because of the abundance of nutrients to stimulate plant growth.

Overall, Spring Lake is a highly enriched, eutrophic lake. Spring Lake is impacted by both internal and external inputs of phosphorus, and perhaps sediment as well. Excessive nutrient levels are promoting nuisance growth of macrophytes and algae. In order to control plant growth over the long term, runoff from the watershed and nutrient recycling from the lake sediments must be reduced.

# Lake Improvement Alternatives

## INTRODUCTION

The primary objectives of the lake improvement plan for Spring Lake include reducing nuisance plant growth, increasing water clarity, and reducing pollution inputs to Spring Lake. Alternatives to accomplish these objectives are both short- and long-term, and involve implementation of measures in the lake itself and in the watershed.

## AQUATIC PLANT CONTROL

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. 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. 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. 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. Also, since it is not economically feasible to mechanically harvest planktonic (i.e., free-floating) algae in a lake, herbicides, such as copper sulfate and chelated copper products, are often utilized to control nuisance algae growth. In Michigan, state law requires that a permit be acquired from the Department of Environmental Quality before any herbicides are applied to inland lakes.

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.

Currently, Spring Lake contains approximately 100 acres of Eurasian milfoil and 100 acres of other nuisance plants, primarily coontail (Figure 8). If Eurasian milfoil can be treated early in the growing season with a herbicide, then other nuisance plants can be harvested later in the season. In addition, nuisance algae blooms occur throughout Spring Lake. Copper-based products are effective in controlling algae, but only for a short time period. Because the copper in algacides accumulates in the sediments, only minimal use of copper-based algacides is recommended.

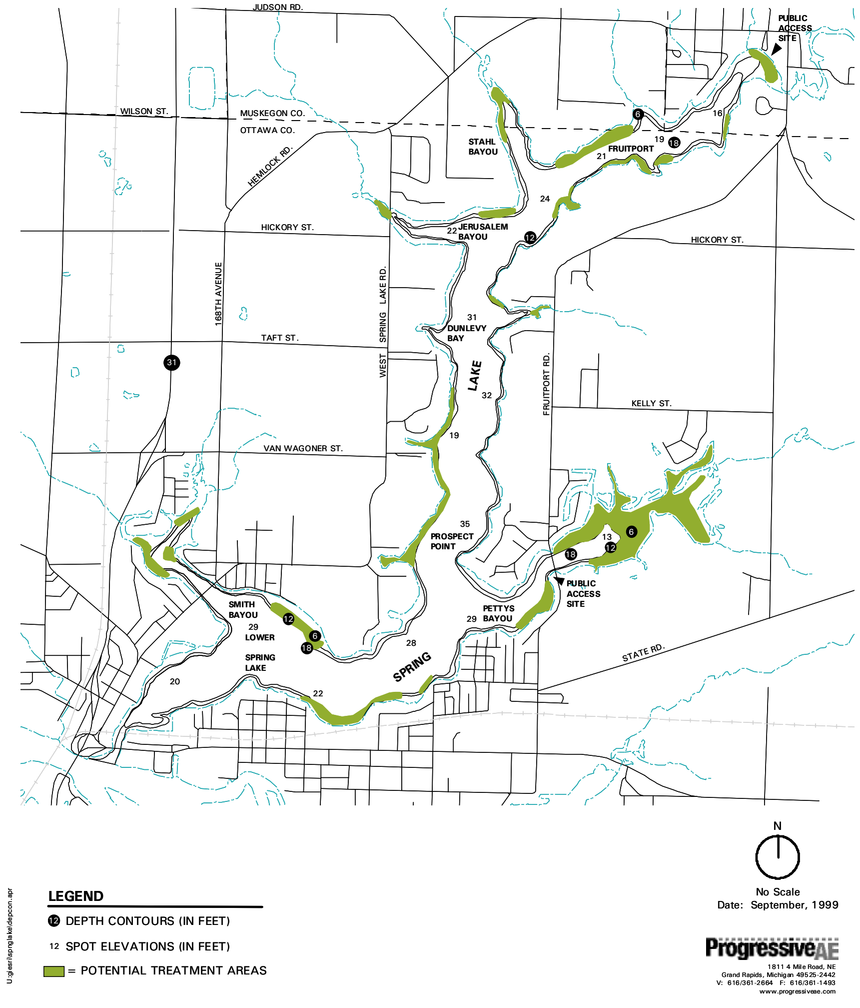

**Figure 8.** Milfoil distribution map.

## LAKE ALUM TREATMENT

Phosphorus loading can be categorized into two sources: internal and external. Using the lake itself to delineate these two sources, phosphorus that enters the lake from beyond the shoreline or above the surface is considered external, and phosphorus recycled within the lake is considered internal. There are many external loading sources: surface runoff from agricultural, residential, and other land use types; groundwater seepage; rainfall and dry fall; and wastewater effluent are some examples. Some sources may be controlled (e.g., wastewater effluent), while others remain largely uncontrollable (e.g., rainfall). Internal loading sources are more difficult to see and define, and involve complex physical, chemical, and biological interactions within the lake. Also, it is not necessary for phosphorus to enter the lake via land runoff or other external sources in order for internal loading to occur. Therefore, if internal recycling of phosphorus is of major significance in a lake, removal of external loadings such as septic seepage or surface runoff may have very little effect on the eutrophic or fertilized, condition of the lake.

There are many pathways of phosphorus recycling within a lake. Algae withdraw phosphorus from the water into their cells during growth and release it when they die. Fish take up phosphorus during feeding as well and release it by excretion. Rooted aquatic plants are able to extract phosphorus from the bottom sediments and pump it to the leaves and other parts of the plant. Rooted plants often leak phosphorus through their leaves where it is then available for uptake by algae. Thus, one particle of phosphorus may be used over and over again within the aquatic system as it is released by one organism and taken up by another.

Phosphorus may also be transported internally through physical and chemical means. If the water lying just above the rich sediments is devoid of oxygen, phosphorus will be released (from the sediments) into the water column. From there, phosphorus can be taken up by aquatic organisms as discussed above, or it can be moved upward through a process called vertical entrainment. When a strong unidirectional wind blows across the lake for several days, water actually begins to pile up on the lee end of the lake. The accumulated water sinks to the stratified thermocline layer and slides back toward the opposite end of the lake. If the prevailing wind stops, the surface continues to rock back and forth for several days. This "see-saw" type of movement occurs not only on the surface but to an even greater extent in the thermally stratified waters beneath. Material from the bottom will be picked up on the down side of the see-saw, then is moved upward as the cool, dense bottom waters rock upward again. Phosphorus can be redistributed in this manner to the upper regions of the lake where it will be available for uptake by plants (Wetzel 1983).

There are many compounds that can bind with phosphorus and remove it from the water column. Alum, an aluminum sulfate and/or sodium aluminate compound, is optimal for use in lake treatments in that it continues to bind phosphorus under anaerobic conditions and under most pH ranges encountered in natural waters. Two methods may be used to reduce phosphorus availability with alum. One is to add it to the lake surface in a concentration that is only slightly higher than the ambient phosphorus concentration. The alum-phosphorus compound forms a heavy floc, which sinks to the bottom; thus, the nutrient is no longer available for algal growth. The other technique involves adding alum just above the anaerobic sediments in very high concentrations to restrict phosphorus release from the sediments and, thus, reducing internal loading. Both techniques have been employed in many lakes across the country with good to excellent results (Cooke et al. 1986). However, it should be noted that, for long-term control of internal phosphorus recycling, the higher dose rate is required. It has been demonstrated that, at higher dose levels, up to 90 percent removal of phosphorus can be expected with continued low nutrient levels for up to 15 years after treatment (Cooke et al. 1986).

Not all lakes are good candidates for alum treatments, and individual lakes considered for treatment must be tested to ascertain correct dosage levels. While alum is stable in the pH range of most lakes, it may convert to the toxic dissolved aluminum form at pHs below 6.0 (Cooke et al. 1986; Cooke et al. 1978), which can be harmful to fish and other aquatic organisms. During the addition of alum to lake water and/or sediments, the pH will decrease as the water's buffering capacity (alkalinity) is used up. Water quality monitoring must be conducted during treatment to ensure the pH does not drop below 6.0. In addition, there may be an inherent trade-off in water quality with the use of alum. Because water clarity will improve, often dramatically, when phosphorus is removed, the increased light penetration can be a stimulus for increased macrophyte (large aquatic plant) growth. In other words, it may be possible to trade an algae problem for a macrophyte problem since rooted plants may still extract phosphorus from the sediments. Also, lakes receiving excessive phosphorus loadings from external (i.e., watershed) sources may not be good candidates for an alum treatment in that the longevity of the alum treatment may be greatly reduced.

In evaluating the feasibility and effectiveness of an alum treatment for phosphorus inactivation and aquatic plant control in Spring Lake, the following considerations are of primary importance:

C Water quality sampling conducted during the period of study indicates substantial bottom water phosphorus buildup occurs in Spring Lake during the period of summer stratification. Thus, internal recycling of phosphorus has the potential to contribute significantly to the total amount of phosphorus available to stimulate plant growth in the lake.

C Temperature profile data indicates Spring Lake has sufficient depth to achieve thermal stratification. Because the colder bottom water does not mix with the surface, the phosphorus-alum floc can be expected to remain bound to the deep water sediments for many years.

C Chemical conditions (i.e., alkalinity and pH) that exist are such that an alum dose rate sufficient to inactivate phosphorus on a long-term basis could be applied with due precautions without adversely impacting aquatic life.

C As discussed, alum is effective in controlling algae growth by removing phosphorus from the water column. However, rooted plants generally are not significantly impacted, in that they are able to draw the nutrients required for growth from the lake bottom sediments where phosphorus is still available. If alum were effective in reducing algae growth in Spring Lake, water clarity would be expected to increase, and nuisance macrophyte growth may increase as well.

C Additional water quality monitoring is recommended to better evaluate the feasibility and effectiveness of an alum treatment for Spring Lake.

## WATER QUALITY MONITORING AND TESTING

In order to determine the feasibility of an alum treatment as a means for controlling nuisance algae in Spring Lake, further monitoring is needed to establish the temporal and geographic extent of deep-water dissolved oxygen depletion, the concentration of phosphorus overlying the oxygen-depleted sediments, the rate of vertical transport or diffusion of phosphorus to the surface waters, potential alum dose rates, and a qualitative comparison of external versus internal loading rates. In order to discern temperature-oxygen-phosphorus gradients, more extensive mapping of the lake's bathymetry, or bottom contours, is required. This can be accomplished using a global positioning system (GPS) and a depth-sounder. To accomplish these sampling objectives, samples should be collected from the lake periodically from April to October from the surface to the bottom at the three in-lake sampling stations to measure temperature, dissolved oxygen, total phosphorus, pH, and total alkalinity. Additional temperature and dissolved measurements should be made at numerous points throughout the lake to determine the vertical and horizontal extent of dissolved oxygen consumption. Discharge and total phosphorus measurements should be made at the most downstream location possible for the major tributaries during major storm events and during base-flow conditions to evaluate storm and base-flow loadings. Water quality monitoring can be used to better document baseline water quality conditions and to gauge the effectiveness of ongoing management efforts.

## WATERSHED MANAGEMENT

Nutrients and sediments which stimulate nuisance plant growth and reduce water clarity enter Spring Lake from the surrounding watershed. In order to improve conditions in Spring Lake, it will be necessary to reduce watershed inputs.

Watershed sources of phosphorus to Spring Lake include lawn fertilizers, septic systems, storm sewer outfalls, and agricultural runoff. By contrast, wetlands reduce runoff of nutrients and sediments by trapping and filtering runoff before it reaches the lake. Therefore, managing runoff from the watershed should include reducing phosphorus inputs and protecting wetlands. These watershed management practices are described in more detail as follows:

### Shoreland Management

The portion of the watershed that directly abuts Spring Lake is known as the shoreland area, and is used primarily for residential or commercial purposes. Shoreland pollution inputs are caused by excessive fertilizer use, use of fertilizers that contain phosphorus, improper disposal of yard waste, and other improper lawn care practices. In addition, although most Spring Lake shoreland residences are serviced by a community sewer system, some residences use on-site septic systems which can leach nutrients to the lake. In order to reduce shoreland nutrient and sediment inputs, residents should be informed of proper lawn care and septic system maintenance practices; shoreland soils should be tested for nutrient content prior to application of fertilizers; and, where appropriate, shoreline vegetative filter strips should be installed.

### Stormwater Management

Spring Lake is also impacted by stormwater inputs from at least 81 outfalls that connect to the lake. In addition to sediments and nutrients, urban stormwater systems can contain illicit sanitary or industrial connections which further pollute receiving waters. With recent advancements in the technology for street sweeping–now more accurately described as street vacuuming–sediment and nutrient pollutants can be more effectively removed from stormwater. Illicit connections can only be addressed by painstaking investigation and correction.

### Farmland Management

Although farming in the Spring Lake watershed is not intensive, agricultural runoff in general tends to be high in nutrients and sediments. Thus, reducing the concentration of nutrients and sediments in agricultural runoff to the extent possible will benefit downstream water quality. Agricultural improvements in the Spring Lake watershed will consist primarily of vegetative filter strips, streambank stabilization, and nutrient management (i.e., fertilizer and manure controls).

### Critical Land Management

As discussed previously, wetlands protect water quality as well as reducing the severity of stormwater surges and providing fish and wildlife habitat. As such, lake residents and the lake board should be vigilant in wetland protection efforts. Currently, some wetlands are protected at the state level under the provisions of Part 303 of the Natural Resources and Environmental Protection Act, Act 451 of 1994, as amended. However, local governments can also adopt wetland protection ordinances to emphasize the local commitment to wetland protection. In some areas of the watershed, it may be appropriate to obtain a conservation easement over those lands that are particularly important in protecting the quality of Spring Lake. These critical lands may include wetlands, steeply sloped areas with unstable soils, or lands suitably located for future installation of water quality improvement facilities such as a sedimentation or stormwater detention/retention basins.

### Grant Funding

Fortunately, there is state funding available to support watershed management efforts. In November of 1998, Michigan voters passed the Clean Michigan Initiative (CMI) bond. Of the $675 million in bond monies, $50 million is earmarked for nonpoint source pollution control, and $90 million for the Clean Water Fund. Before any grant funds can be expended, however, the Department of Environmental Quality (DEQ) must promulgate rules that describe how the grant funds may be used. The nonpoint source rules were promulgated in October of 1999, but at the time of this writing, promulgation of the Clean Water Fund rules was not completed. The nonpoint source rules and the draft Clean Water Fund rules state that in order to be eligible for either fund, applicants must have a watershed management plan approved by the DEQ prior to submitting a grant application. At this time, both rules define the contents of an approved watershed management plan similarly. The promulgated nonpoint rules describe watershed management plans as follows:

> R 324.8810 Approvable watershed management plans.
> Rule 10. (1) A local unit of government or a not-for-profit entity may submit a watershed management plan to the department for approval under these rules.
> (2) A watershed management plan submitted to the department for approval under this section shall contain current information, be detailed, and identify all of the following:
>
> (a) The geographic scope of the watershed.
> (b) The designated uses and desired uses of the watershed.
> (c) The water quality threats or impairments in the watershed.
> (d) The causes of the impairments or threats, including pollutants.
> (e) A clear statement of the water quality improvement or protection goals of the watershed management plan.
> (f) The sources of the pollutants causing the impairments or threats and the sources that are critical to control in order to meet water quality standards or other water quality goals.
> (g) The tasks that need to be completed to prevent or control the critical sources of pollution or address causes of impairment, including, as appropriate, all of the following:
>
> (i) The best management practices needed.
> (ii) Revisions needed or proposed to local zoning ordinances and other land use management tools.
> (iii) Informational and educational activities.
> (iv) Activities needed to institutionalize watershed protection.
>
> (h) The estimated cost of implementing the best management practices needed.
> (i) A summary of the public participation process, including the opportunity for public comment, during watershed management plan development and the partners that were involved in the development of the watershed management plan.
> (j) The estimated periods of time needed to complete each task and the proposed sequence of task completion.
> (k) A description of the process that will be used to evaluate the effectiveness of implementing the plan and achieving its goals.
>
> (3) The department shall accept and review watershed management plans submitted for approval under this rule at any time throughout the year.
> (4) The department reserves 90 days to review and comment on watershed management plans submitted for approval.

In addition, grant recipients are required to match at least 25 percent of the project costs, either with currency or in-kind services. By providing a higher percentage of project costs, above and beyond the required 25 percent, applicants can increase their chance of receiving a grant. Thus, it will be necessary to prepare and receive approval for a watershed management plan for the Spring Lake watershed, and to acquire funds or organize in-kind services to be used as a project cost-share.

Nonpoint source fund rules state that grant funds can be only be used for two purposes: “To implement the physical improvement portion of an approved watershed management plan,” or “to reduce nonpoint source pollution from sources as identified by the department.” “Physical improvements” are defined in the draft rules as “structural or vegetative practices used to control nonpoint source pollution.”

The draft Clean Water Fund rules state that grant funds can be used for the following purposes that may be applicable to Spring Lake:

- Provide state match to establish and implement the conservation reserve enhancement program in Michigan. CMI funds will pay for the establishment cost of the riparian buffer strips, filter strips, field wind breaks, and grass waterway practices. They could also provide a one-time payment for voluntary, permanent easements for the same practices. This program will target agricultural lands within riparian corridors.
- Implement water quality protection or improvement activities in approved watershed management plans that are required under a National Pollutant Discharge Elimination System wastewater discharge permit for stormwater discharges from separate stormwater drainage systems and that are not otherwise required by federal law.
- Implement programs to identify and require the correction of illicit connections to separate storm sewer systems.
- Implement programs to do one or both of the following:
    - Identify failing on-site septic systems, determine the extent of failing on-site systems, and determine the impact of failing on-site systems on designated uses.
    - Implement corrective measures in areas where failing on-site septic systems have been determined to be threatening or impairing designated uses.

It should be emphasized that since the Clean Water Fund rules are in draft form, revisions are possible. Therefore, grant-eligible activities may ultimately differ from those stated above. At this time, it is recommended that a watershed management plan be prepared and than an application be submitted to the Department of Environmental Quality for grant funding. It is proposed that those activities that are not grant eligible be funded with local assessments. The proposed watershed management activities are outlined as follows:

## TABLE 11
## PROPOSED SPRING LAKE WATERSHED MANAGEMENT ACTIVITIES

| **Activity** | **Grant Eligible?** |
|---|---|
| Shorelands Management | |
| Fertilizer controls | Yes - some activities |
| Shoreline buffer strips | Yes |
| Soil testing | Yes |
| Stormwater Management | |
| Street sweeping/vacuuming | Yes |
| Removal illicit stormwater connections | Yes |
| Stormwater ordinance | No |
| Protection of Environmentally Sensitive Land | |
| Wetland protection | Uncertain; ordinances: no |
| Conservation easements | Yes |
| Critical land purchases | Yes |
| Agricultural Land Management | |
| Filter strips | Yes |
| Erosion control | Yes |
| Nutrient management | Uncertain |
| Streambank Stabilization | Yes |

### INFORMATION AND EDUCATION

Much of the pollutant load that enters Spring Lake is from residential lands immediately adjacent to Spring Lake. In order to reduce fertilizer runoff and septic seepage, cooperation from lake residents will be critical to the success of the overall project. In order to obtain residents' cooperation, information regarding proper shorelands management should made available via annual newsletters and meetings. In addition, newsletters should be used to update all lake residents regarding lake water quality, boating safety, impacts of invader species, and project activities.

# Recommended Improvement Plan

Current and historical water quality data indicate Spring Lake is eutrophic: deep-water dissolved oxygen becomes depleted in late summer; levels of the plant nutrient phosphorus are very high; rooted plant and algae growth is excessive; and water clarity is low. Spring Lake is nutrient-enriched and, biologically, is highly productive.

There are several sources of pollution to Spring Lake, including lake sediments which cause nutrients to be recycled within the lake itself, lawn fertilizers, septic systems, urban stormwater runoff, and runoff from agricultural lands. In order to protect and enhance the quality of Spring Lake over the long term, steps must be taken in conjunction with in-lake improvements to reduce pollution inputs from the watershed to the extent possible.

**Improvement Plan Elements**

The improvement plan for Spring Lake is proposed to include the control of nuisance plants via the select use of herbicides and aquatic plant harvesting, watershed management to reduce the input of pollutants to Spring Lake, information and education, and water quality monitoring. The improvement plan elements are described further as follows:

**Aquatic Plant Control**

C Eurasian Milfoil Control: The major nuisance rooted plant in Spring Lake is Eurasian milfoil, a plant which is not native to Michigan or the United States. Because Eurasian milfoil can spread rapidly by fragmentation, this plant is proposed to be controlled with the select use of herbicides. Herbicide treatments for milfoil control are most effective when conducted early in the growing season (May or early June).

C Mechanical Harvesting: Mechanical harvesting involves cutting and removing vegetation from the lake. Harvesting is proposed to be conducted along developed shoreline areas where nuisance aquatic plant growth (other than Eurasian milfoil) is inhibiting recreational use and enjoyment of the lake. To ensure optimum removal of plant biomass, harvesting is generally conducted in late June or July.

C Algae Control: Nuisance algae growth can be temporarily controlled with copper-based herbicides. The longevity and effectiveness of an algae treatment is dependent on weather, nutrient levels in the lake, and other conditions. Unlike most other aquatic herbicides that tend to rapidly break down, copper does not degrade and can accumulate in lake sediments. In light of these considerations, it is recommended that herbicide treatments for algae control be kept at a minimum. It is proposed that developed shoreline areas where nuisance plant growth is occurring be treated once annually at the peak of the summer growing season (July or August).

C Alum Treatment: Although not recommended at present, consideration should be given to the application of aluminum sulfate (alum) to the bottom waters of Spring Lake to reduce the internal recycling of phosphorus from the lake sediments. The effectiveness of an alum treatment would be enhanced if watershed management practices are implemented prior to the alum treatment.

**Watershed Management**:

The watershed management element of the Spring Lake Improvement Plan is proposed to focus on wetland protection and the reduction of pollution inputs from residential, urban, and agricultural lands in the watershed.

C Shoreland Management: Reduce phosphorus inputs from residential areas near Spring lake by:

! Promoting policies to reduce the use of phosphorus-based lawn fertilizers near the lake.

! Promotion of proper lakeside landscaping and lawncare practices.

! Proper septic system maintenance.

C Wetland Protection: Wetlands in the Spring Lake watershed filter and purify runoff water and provide valuable habitat for fish and wildlife. In order to promote protection of wetlands, it is proposed that:

! Detailed wetland maps be distributed to all governmental units in the watershed.

! The lake board partner with the Natural Areas Conservancy of West Michigan and local governmental units to establish conservation easements over critical lands in the watershed.

C Urban Stormwater Management: In order to minimize the impact of new development, special stormwater regulations for Spring Lake watershed should be adopted that emphasize water quality protection.

C Clean Michigan Initiative Grant Program - Develop a watershed management plan for:

! Agricultural best management practices (stream corridor filter strips, sedimentation basins, etc.).

! Illicit stormwater connections.

! An evaluation of imperviousness as a basis for implementation of periodic street cleaning with state-of-the-art street sweeping equipment.

**Information and Education:** Prepare and disseminate annual publications to all lake residents to provide information on shoreland management practices, lake water quality, boating safety, impacts of invader species, and updates on project activities.

**Water Quality Monitoring**: Expand water quality database to better discern: seasonal thermal stratification, dissolved oxygen, and total phosphorus dynamics; impacts of invader species, and the magnitude and importance of internal phosphorus loading. Additional water quality data is needed to guide future management decisions.

The Spring Lake Improvement Plan is proposed to be implemented over a four-year period beginning in the year 2000 and continuing through 2003. Once the watershed management elements of the plan have been substantially implemented, consideration should be given to the application of aluminum sulfate (alum) to the bottom waters of Spring Lake to mitigate internal phosphorus recycling in the lake.

# Project Implementation and Financing

Improvements for Spring Lake are being implemented in accordance with Part 309 (Inland Lake Improvements) of the Natural Resources and Environmental Protection Act (P.A. 451 of 1994). The budget for the Spring Lake Improvement Plan is presented in Table 11.

Pursuant to provisions of the Act, public hearings were held and a special assessment district has been established from which revenue is being generated to finance the improvements.

The Special Assessment District for Spring Lake includes all properties which border the lake and back lots which have deeded or dedicated lake access. Under this plan, developed lakefront properties are being assessed one unit of benefit and developed back lots with deeded or dedicated lake access are being assessed 1/2 unit of benefit. Undeveloped lakefront parcels are being assessed 1/2 unit of benefit, and undeveloped back lots are being assessed 1/4 unit of benefit. In addition, contiguous lots in common ownership are being assessed as one parcel provided only one house exists on the parcel. Businesses are being assessed, based on the number of boat slips installed on Spring Lake. Finally, it is proposed that Muskegon and Ottawa Counties each pay 5 percent of the total project cost.

The $150,250 annual cost of the project is being assessed for a four-year period (2000 to 2003). A breakdown of costs based on this approach is presented in Table 12.

### TABLE 12
### SPRING LAKE IMPROVEMENT PLAN PROPOSED BUDGET 2000 THROUGH 2003

| **Improvement** | **Annual Cost** |
|---|---|
| Aquatic Plant Control[1] | $78,000 |
| Eurasian milfoil: 100 acres @ $300/acre | |
| Harvesting: 100 acres @ $300/acre | |
| Algae control: 200 acres @ $50/acre | |
| Administration and Inspections @ $8,000/year | |
| Grant Application and Watershed Management Plan[2] | $6,250 |
| Watershed Management | $25,000 |
| Shorelands | |
| Wetlands | |
| Urban | |
| Agriculture | |
| Information and Education | $5,000 |
| Water Quality Monitoring | $16,000 |
| Project Administration[3] | $5,000 |
| Contingencies[4] | $15,000 |
| Total Annual Cost | $150,250 |

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[1] The acreages shown for plant control are for budgeting purposes only. The actual amount of herbicides used or harvesting conducted in any given year will depend on the type and distribution of aquatic vegetation.

[2] This purpose of this project element is to pursue a grant under the recently approved Clean Michigan Initiative (CMI) environmental bond to supplement local funds. The watershed management elements of the Spring Lake project may be eligible for up to $300,000 in CMI grant funds.

[3] Project administration will include all costs incurred by the Spring Lake - Lake Board including postage, copies, mailings, notices, and legal.

[4] Part 309 of the Natural Resources and Environmental Protection Act, Act 451 of 1994, states that a lake board may add not less than 10% or more than 15% of the total project cost for contingent expenses.

## TABLE 13
## SPRING LAKE
## COST BREAKDOWN

| Parcel Type | Units of Benefit | Annual Assessment[1] |
|---|---|---|
| Developed Lakefront Parcels | 1 | $144 |
| Undeveloped Lakefront Parcels | 1/2 | $72 |
| Developed Backlot Parcels | 1/2 | $72 |
| Undeveloped Backlot Parcels | 1/4 | $36 |
| Business: Backlot (no slips) | 1 | $144 |
| Businesses: <50 slips | 4 | $576 |
| Businesses: 50 - 100 slips | 8 | $1,152 |
| Businesses: 101 - 150 slips | 12 | $1,728 |
| Businesses: >150 slips | 16 | $2,304 |
| Muskegon County Contribution | 5% | $7,500 |
| Ottawa County Contribution | 5% | $7,500 |

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[1] Includes the cost of the feasibility study.

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