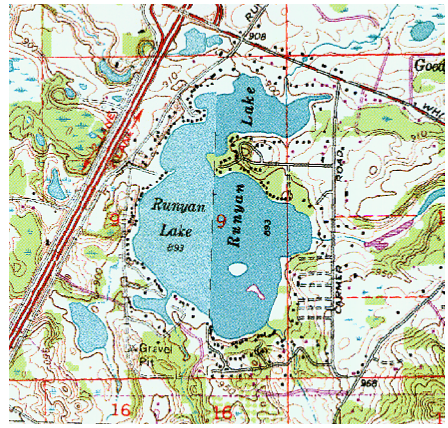

Water Quality Update

Runyan Lake
Water Quality Update and Management Recommendations

Prepared for:
Runyan Lake Association
10456 Runyan Lake Road
Fenton, MI 48430

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

May 2005

Project No: 58400101

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Introduction

PROJECT BACKGROUND

Runyan Lake is located in Sections 9 and 10 of Tyrone Township in Livingston County (T. 4N, R. 6E; Figure 1). In September of 2004, Progressive AE was retained by the Runyan Lake Association to conduct a water quality update and make recommendations for fisheries and aquatic plant management. This report contains a discussion of study findings, recommendations, and conclusions.

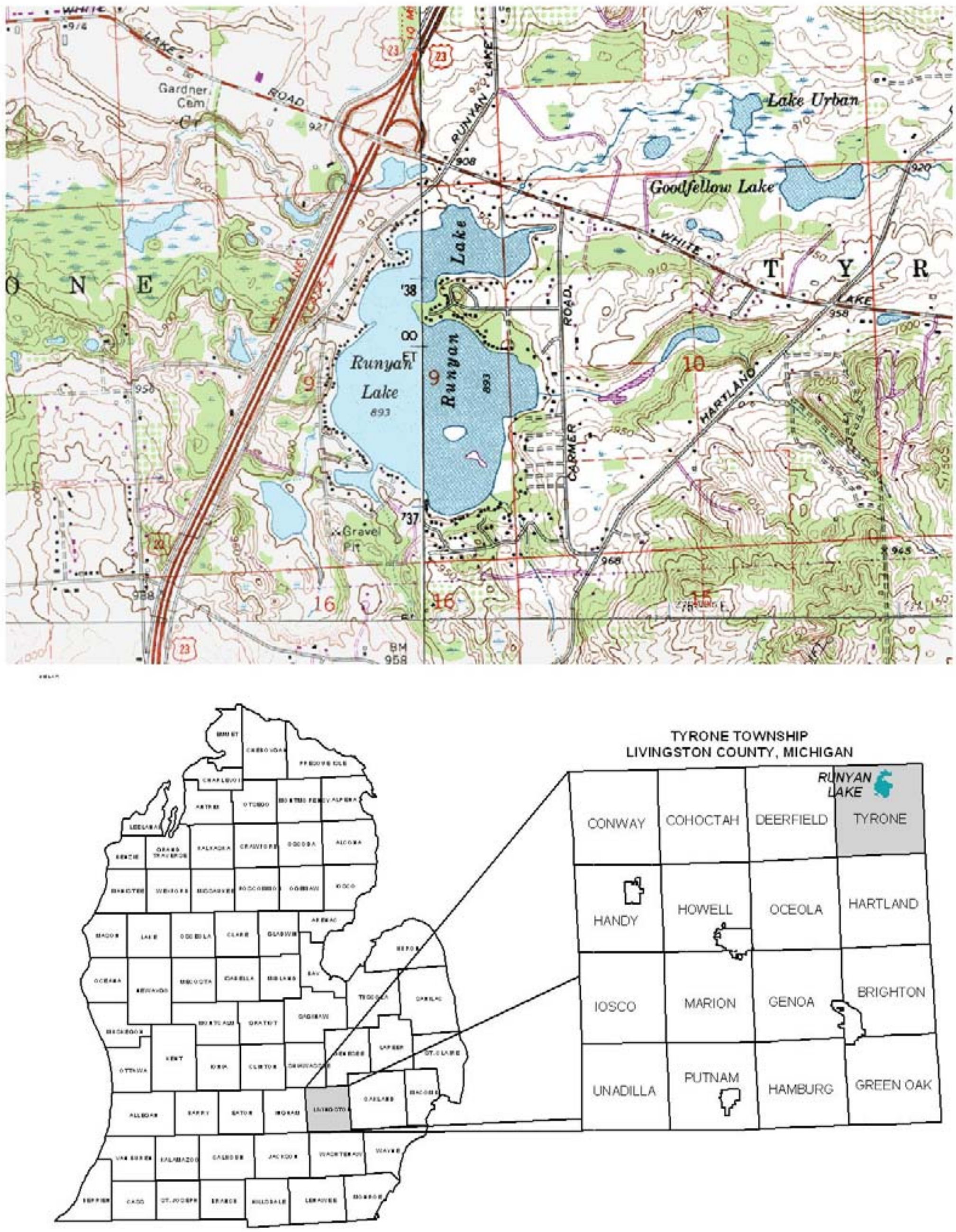


Figure 1. Project location map.

LAKE AND WATERSHED CHARACTERISTICS

A summary of the physical characteristics of Runyan Lake and its watershed is provided in Table 1. Runyan Lake has a surface area of 174 acres, a maximum depth of 55 feet, and a mean or average depth of 32.8 feet. Approximate depth contours in Runyan Lake are shown in Figure 2. Runyan Lake contains about 5,721 acre-feet of water, a volume which would cover an area over 9 square miles to a depth of 1 foot. The lake has a shoreline 2.5 miles long and a shoreline development factor of 1.9. 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 Runyan Lake (i.e., 174 acres), the shoreline of Runyan Lake is 1.9 times longer because of its irregular shape.

TABLE 1
RUNYAN LAKE
PHYSICAL CHARACTERISTICS[1]

Lake Surface Area	174	Acres
Maximum Depth	55	Feet
Mean Depth	32.8	Feet
Lake Volume	5,721	Acre-Feet
Shoreline Length	3.6	Miles
Shoreline Development Factor	1.9	
Lake Elevation	893	Feet
Watershed Area	7,471	Acres
Ratio of Lake Area to Watershed Area	1:43	

Watershed Land Uses	Acres	Percent of Total
Agriculture	1,957	26%
Residential Development	887	12%
Wooded/Undeveloped	3,882	52%
Wetlands	745	10%
Total		**100%**

The land area surrounding a lake that drains to the lake is called its watershed or drainage basin. The Runyan Lake watershed comprises 7,471 acres (Figure 3). The majority of the watershed is wooded/undeveloped, although a large portion of the land area abutting the lake is residential development. It should be noted that the information on land cover presented herein is somewhat dated. It is likely that, in recent years, substantial urbanization has occurred in Runyan Lake's watershed.

Water drains to Runyan Lake from a number of small tributaries, the largest being Denton Creek which enters the lake at the north end. Runyan Lake’s outlet flows westerly to Hoisington, Bennett, and Lobdell lakes before emptying into the Shiawassee River and eventually into Lake Huron via the Saginaw River and Saginaw Bay.

[1] Shoreline length, lake elevation, watershed, and lake areas were determined by examining a United States Geological Survey topographic map of the Runyan Lake area (scale: 1" = 2000'). Lake volume and maximum and mean depths were derived from a depth contour map of Runyan Lake (Jude and Ervin 1986). Digital data derived from the Department of Environmental Quality Michigan Resource Information System (MIRIS) was utilized to delineate land use types (MDEQ 1978).

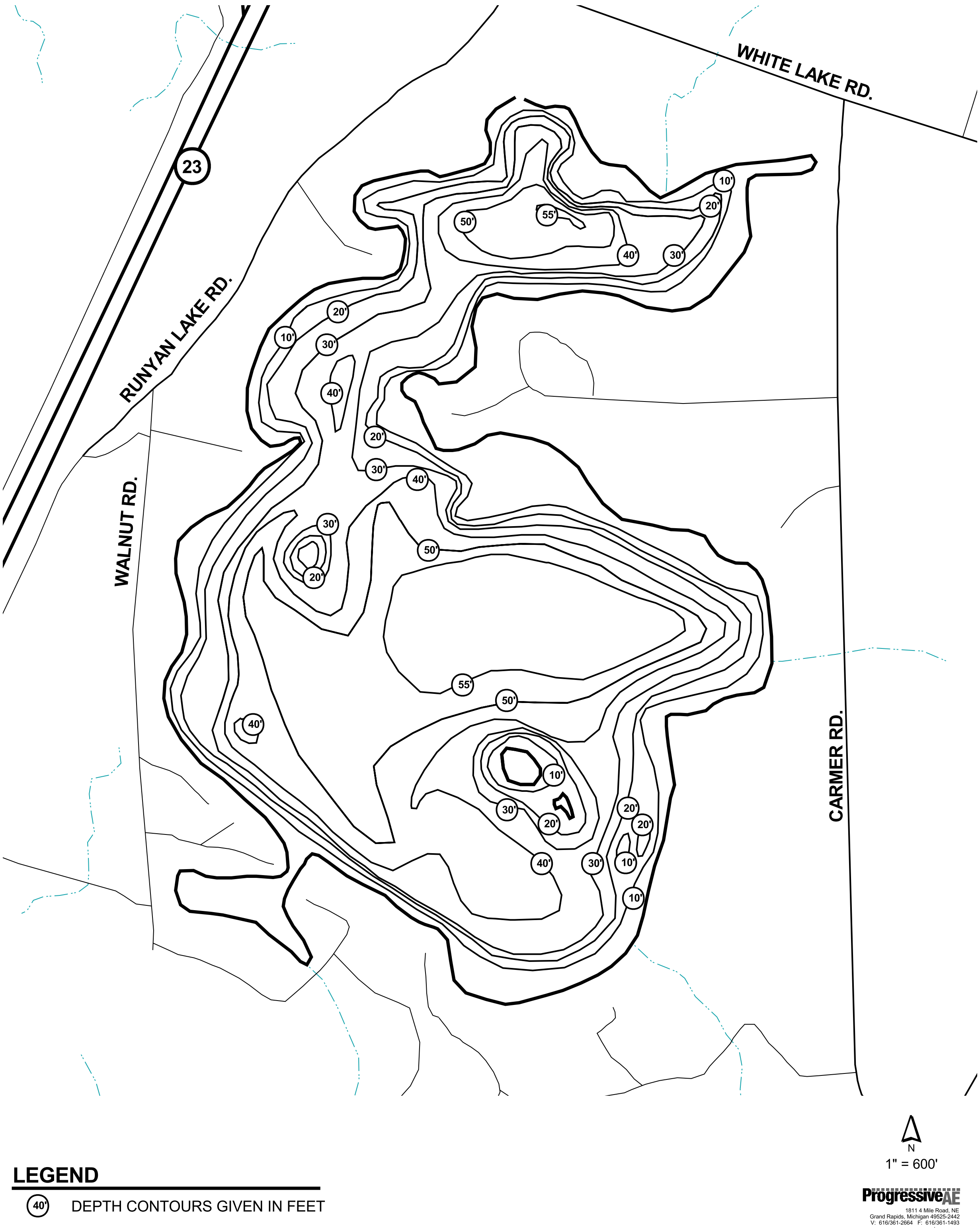


Figure 2. Runyan Lake depth contour map.

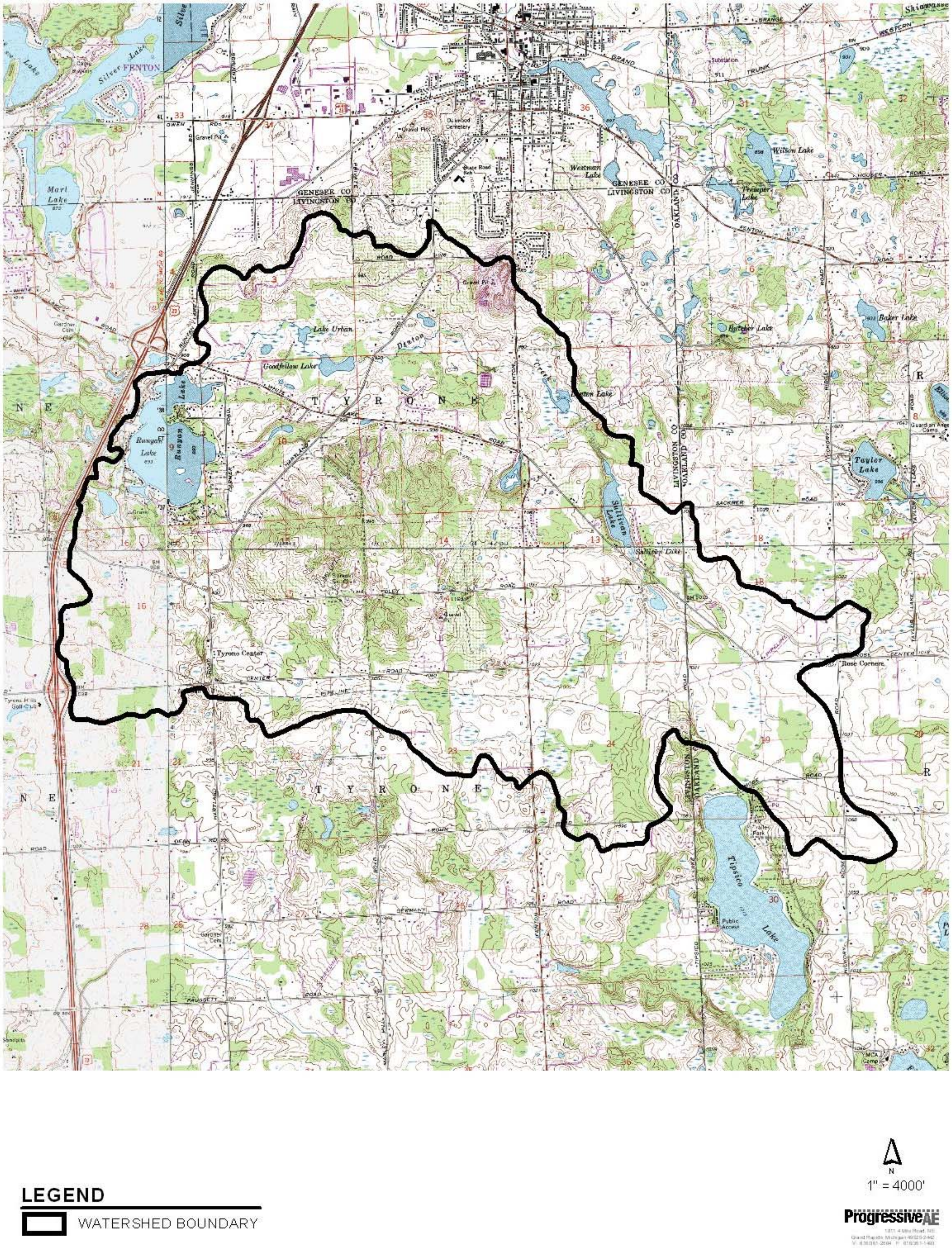


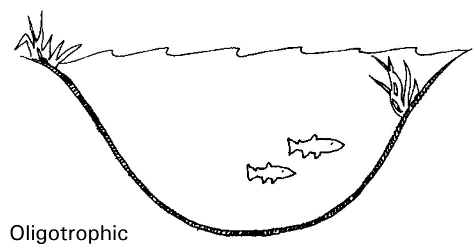
Figure 3. Runyan Lake watershed map.

Lake Water Quality

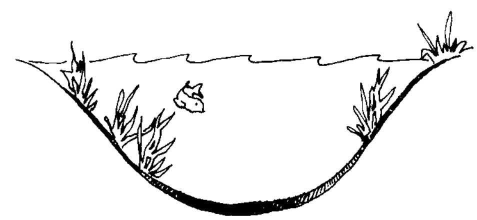
INTRODUCTION

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.

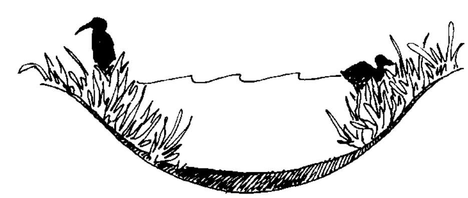
Lakes are commonly classified as **oligotrophic**, **mesotrophic**, or **eutrophic**. Oligotrophic lakes are generally deep and clear with little aquatic plant growth. These lakes maintain sufficient dissolved oxygen in the cool, deep bottom waters during late summer to support cold water fish such as 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.



Oligotrophic



Mesotrophic



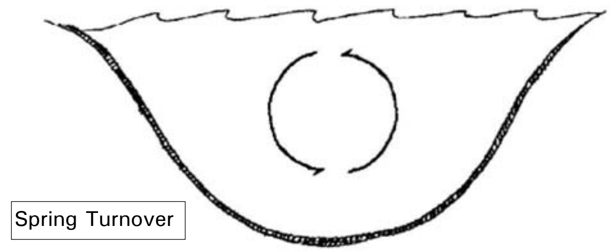
Eutrophic

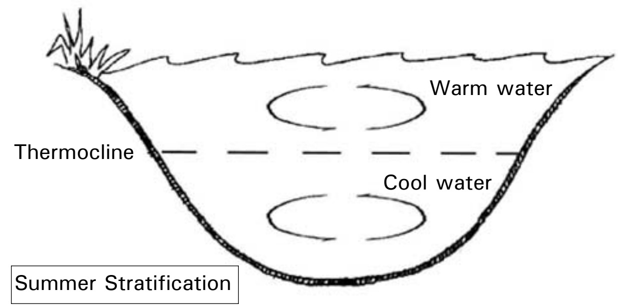
Under natural conditions, most lakes will ultimately evolve to a eutrophic state as they gradually fill with sediment and organic matter transported to the lake from the surrounding watershed. As the lake becomes shallower, the process accelerates. When aquatic plants become abundant, the lake slowly 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.

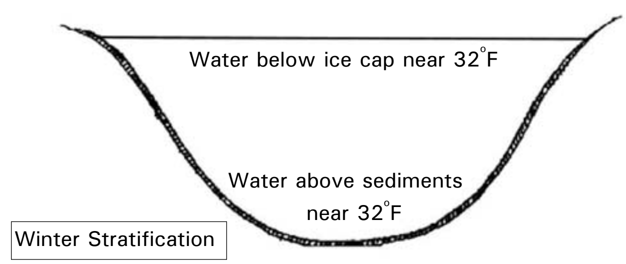
Key parameters used to evaluate the limnological condition of a lake include temperature, dissolved oxygen, total phosphorus, chlorophyll-*a*, and Secchi transparency. A brief description of these water quality measurements is provided as an introduction for the reader. Particular attention should be 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 68°F. Temperature also determines how water mixes in a lake. As the ice cover breaks up on a lake in the spring, the water temperature becomes uniform from the surface to the bottom. This period is referred to as "spring turnover" because water mixes throughout the entire water column. As the surface waters warm, they are underlain by a colder, more dense strata of water. This process is called thermal stratification. Once thermal stratification occurs, there is little mixing of the warm surface waters with the cooler bottom waters. The transition layer that separates these layers is referred to as the "thermocline." The thermocline is characterized as the zone where temperature drops rapidly with depth. As fall approaches, the warm surface waters begin to cool and become more dense. Eventually, the surface temperature drops to a point that allows the lake to undergo complete mixing. This period is referred to as "fall turnover." As the season progresses and ice begins to form on the lake, the lake may stratify again. However, during winter stratification, the surface waters (at or near 32°F) are underlain by slightly warmer water (about 39°F). This is sometimes referred to as "inverse stratification" and occurs because water is most dense at a temperature of about 39°F. As the lake ice melts in the spring, these stratification cycles are repeated. Shallow lakes do not stratify. Lakes that are 15 - 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).

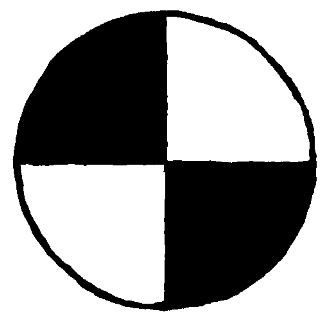
By reducing the amount of phosphorus in a lake, it may be possible to control the amount of aquatic plant growth. In general, lakes with a phosphorus concentration greater than 20 µg/L (micrograms per liter, or parts per billion) are able to support abundant plant growth and are classified as nutrient-enriched 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. 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.



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

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

pH AND ALKALINITY

pH is a measure of the amount of acid or base in the water. The pH scale ranges from 0 (acidic) to 14 (alkaline or basic) with neutrality at 7. The pH of most lakes generally ranges from 6 to 9. Alkalinity is the measure of the pH-buffering capacity of water in that it is the quantitative capacity of water to neutralize an acid.

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 the fall of 2004 and in the spring of 2005 over the two deepest basins of Runyan Lake (Figure 4). Temperature and dissolved oxygen were measured at 10-foot intervals using a YSI Model 550A probe. Samples were collected at the same depth intervals with a Kemmerer bottle and 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 and Prein and Newhof[1], respectively, for analysis. Total alkalinity was titrated at Progressive using Standard Methods Procedure 2320B, and total phosphorus was analyzed at Prein and Newhof using Standard Methods Procedure 4500P-E. In addition to the depth interval samples at the deep basins, Secchi transparency was measured and vertical composite chlorophyll-*a* samples were collected from the surface to a depth of twice the Secchi transparency at each sampling site. Chlorophyll-*a* samples were analyzed by Prein and Newhof using Standard Methods Procedure 10200H. In addition to the in-lake samples, total phosphorus and *E.coli* bacteria samples were collected from each of the flowing tributaries during each sampling period. *E. coli* samples were placed on ice and delivered immediately to the Kent County Health Department[2] for analysis.

SAMPLING RESULTS AND DISCUSSION

Sampling results indicate that Runyan Lake exhibits some mesotrophic characteristics (i.e., moderate phosphorus concentrations and reduced deep-water dissolved oxygen levels during stratification) as well as oligotrophic characteristics (i.e., excellent transparency and low chlorophyll-*a* levels) (Table 3 and Table 4). When compared to historical data (Progressive AEP 1996), it appears that spring phosphorus levels in the lake have declined slightly (from 16 µg/l in 1995 to 14 µg/l in 2005). A more substantial decline was observed in the mean chlorophyll-*a* levels (from 4.5 µg/l in 1995 to 0.5 µg/l in 2004-2005), while Secchi transparency increased dramatically (from an average of about 9.0 feet in 1995 to an average of 18.5 feet in 2004-2005). It should be noted, however, that this apparent improvement in water quality may be related, in part, to the recent infestation of zebra mussels (*Dreissena polymorpha*) in Runyan Lake. Zebra mussels feed on algae suspended in the water column. Some lakes infested with zebra mussels have experienced increases in transparency and reduced chlorophyll-*a* levels as algae have been removed from the water column. Concurrent with the increase in transparency is an increase in the growth of macrophytes (i.e., large aquatic plants) in the lake. This phenomenon appears to be occurring in Runyan Lake.

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

[2] Kent County Health Department Regional Laboratory, 700 Fuller, NE, Grand Rapids, MI.

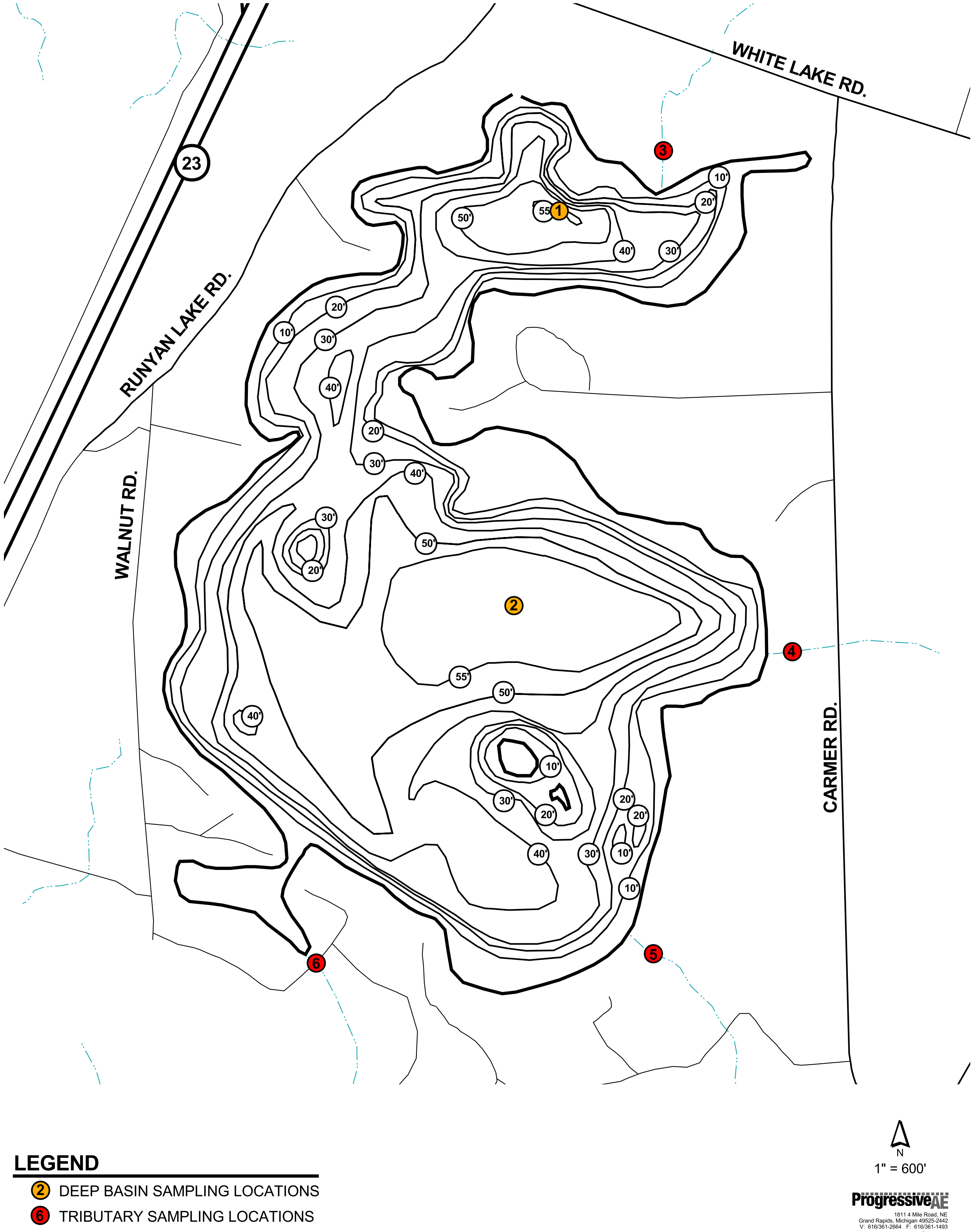


Figure 4. Sampling location map.

TABLE 3
RUNYAN LAKE
DEEP BASIN WATER QUALITY DATA

Sample Location	Sample Depth (feet)	Temperature (°F)	Dissolved Oxygen (mg/L)[1]	Total Phosphorus (µg/L)[2]	pH (S.U.)[3]	Total Alkalinity (mg/L as $CaCO_3$)[4]
			September 23, 2004			
1	1	71.4	8.3	14	9.1	199
1	10	70.5	8.2	16	9.1	200
1	20	69.5	7.6	13	9.2	202
1	30	54.0	2.5	26	8.5	206
1	40	47.0	0.9	119	8.9	209
1	50	44.0	1.3	21	8.8	223
2	1	71.5	8.8	12	9.0	190
2	10	70.5	8.2	56	9.1	193
2	20	69.5	7.8	16	8.9	195
2	30	54.5	8.5	9	8.7	205
2	40	47.5	3.6	13	8.8	206
2	50	45.0	1.1	13	8.4	212
			April 12, 2005			
1	1	49.0	13.9	5	8.0	215
1	10	48.0	13.6	24	8.0	212
1	20	44.0	14.2	22	7.9	220
1	30	42.0	13.5	5	7.8	221
1	40	40.5	13.1	13	7.8	220
1	50	40.0	9.5	5	7.5	240
2	1	48.0	14.4	5	8.0	212
2	10	47.0	13.8	15	8.1	215
2	20	45.0	14.0	5	7.9	217
2	30	42.0	14.0	24	8.1	220
2	40	41.0	13.6	41	8.0	217
2	50	40.5	13.1	5	7.9	218

[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 $CaCO_3$ = micrograms per liter as calcium carbonate.

TABLE 4
RUNYAN LAKE
SURFACE WATER QUALITY DATA

Date	Sample Location	Secchi Transparency (feet)	Chlorophyll-*a* (μg/L)[1]
September 23, 2004	1	21.0	0
September 23, 2004	2	19.5	0
April 12, 2005	1	16.5	1
April 12, 2005	2	17.0	1

Although deep water dissolved oxygen levels were low in Runyan Lake during the September 2004 sampling period, there appears to be sufficient oxygen in the cool, deep waters of the lake to sustain a cold water fish species (i.e., lake herring) (Jude and Ervin 1996). The fact that a cold water fish species can survive in Runyan Lake attests to the high quality of the lake.

Runyan Lake's pH and alkalinity values are indicative of a typical southern Michigan hardwater lake. Lakes, like Runyan Lake, that have high alkalinity (over 100 mg/L as $CaCO_3$) are able to sustain large inputs of acid with little change in pH. The ability of the lake to maintain a stable pH is crucial to the survival of its aquatic inhabitants. The high alkalinity in Runyan Lake may also contribute to the good water quality observed in the lake. During spring and summer months when plants in the lake are actively growing, calcium carbonate will precipitate from the water column. It can often be seen encrusted on submersed aquatic plants and appears as a white coating. In some cases, calcium carbonate will bind with phosphorus and remove it from the water column making it unavailable to stimulate algae growth. This phenomenon appears to be occurring in Runyan Lake where marl deposits are present throughout much of the shallow-water portions of the lake.

In addition to the samples collected from the lake proper, samples were collected from Denton Creek and several smaller tributary streams that discharge to Runyan Lake (Table 5). Total phosphorus levels were generally low in Denton Creek (Site 3) and somewhat higher in the smaller tributaries (Sites 4, 5, and 6). However, the flow rate from these smaller tributaries is low and these streams do not appear to be a substantial source of phosphorus loading to Runyan Lake. Bacteria levels measured in all of the tributaries were well below the State of Michigan public health standard for safe swimming.

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

TABLE 5
RUNYAN LAKE
TRIBUTARY SAMPLING DATA

Date	Site No.	Total Phosphorus (µg/L)[1]	*E. Coli* Bacteria/100 mL)[2]
September 23, 2004	3	16	88
September 23, 2004	4	45	26
September 23, 2004	5	46	91
September 23, 2004	6	31	34
April 12, 2005	3	6	24
April 12, 2005	4	54	83
April 12, 2005	5	30	11
April 12, 2005	6	8	14

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

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. An extensive aquatic plant survey of Runyan Lake was conducted on September 23, 2004. The survey was conducted in accordance with procedures developed by the Department of Environmental Quality in which the lake is divided into numerous assessment sites and a determination is made of the type and relative abundance of plants in each assessment site. The Standard Aquatic Vegetation Summary Sheet from the survey is included in Appendix A. Plant types observed during the survey are listed in Table 6. Diagrams of many of the plants listed are included in Figure 5.

TABLE 6
RUNYAN LAKE AQUATIC PLANTS

Common Name	Scientific Name	Group	Occurrence
Whorled watermilfoil	*Myriophyllum verticillatum*	Submersed	Common
Muskgrass	*Chara* sp.	Submersed	Common
Illinois pondweed	*Potamogeton illinoensis*	Submersed	Common
Southern naiad	*Najas guadalupensis*	Submersed	Common
Bulrush	*Scirpus* sp.	Emergent	Common
White water lily	*Nymphea odorata*	Floating-leaved	Sparse
Large-leaf pondweed	*Potamogeton amplifolius*	Submersed	Sparse
Cattail	*Typha* sp.	Emergent	Sparse
Pickerelweed	*Pontederia cordata*	Emergent	Sparse
Bladderwort	*Utricularia vulgaris*	Submersed	Sparse
Curly-leaf pondweed	*Potamogeton crispus*	Submersed	Sparse
Wild celery	*Vallisneria americana*	Submersed	Sparse
Whitestem pondweed	*Potamogeton praelongus*	Submersed	Found
Thinleaf pondweed	*Potamogeton* sp.	Submersed	Found
Yellow water lily	*Nuphar* sp.	Floating-leaved	Found
Water stargrass	*Heteranthera dubia*	Submersed	Found
Coontail	*Ceratophyllum demersum*	Submersed	Found
Submerged bulrush	*Scirpus subterminalis*	Submersed	Found
Eurasian watermilfoil	*Myriophyllum spicatum*	Submersed	Found
Canadian waterweed	*Elodea canadensis*	Submersed	Found

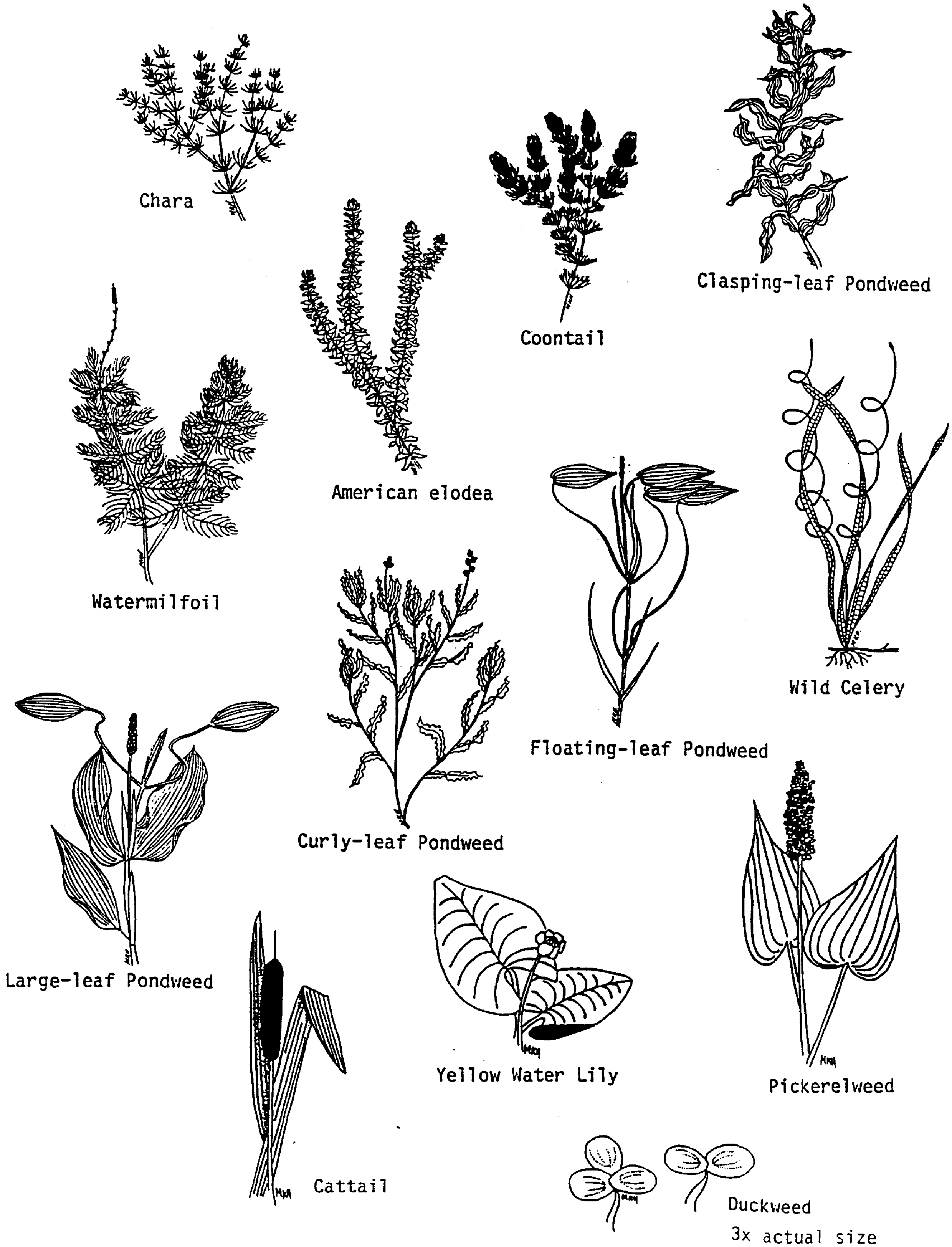


Figure 5. Common aquatic plants.

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 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 (Figure 6). 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 6). 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 treating the lake with a species-selective systemic herbicide. 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 of 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.

Runyan Lake contains a healthy and diverse population of aquatic plants. During the September 2004 survey, 15 submersed plant species were observed in the lake. The most common submersed species were whorled milfoil, muskgrass, Illinois pondweed, and southern naiad. Fortunately, Eurasian milfoil was only found in one small area immediately south of the access site off of Robin Drive at the southwest end of the lake. Although whorled milfoil is common in Runyan Lake, it is a native variety of milfoil that does not have the nuisance growth characteristics of Eurasian milfoil. As previously noted, the recent infestation of zebra mussels in Runyan Lake appears to have increased the amount of light penetration into the water column, which may allow rooted plants to grow at deeper depths in the lake than previously observed. In some lakes infested with zebra mussels, scientists have observed a shift in algae types from beneficial green algae to undesirable blue-green algae.

Currently, nuisance aquatic plant growth occurs only in small, localized areas of the lake (approximately 15 to 20 acres total). Mechanical harvesting, manual removal (raking or pulling the plants out), or the small scale use of herbicides in these areas may be necessary to alleviate nuisance conditions. However, the large scale use of broad spectrum contact herbicides should be avoided in order to preserve fishery habitat and to maintain Runyan Lake's natural ability to fend off invasive exotic species such as Eurasian milfoil and curly-leaf pondweed (*Potamogeton crispus*). Areas found to be infested with Eurasian milfoil should be treated with a selective systemic herbicide, such as 2,4-D or Renovate (triclopyr).

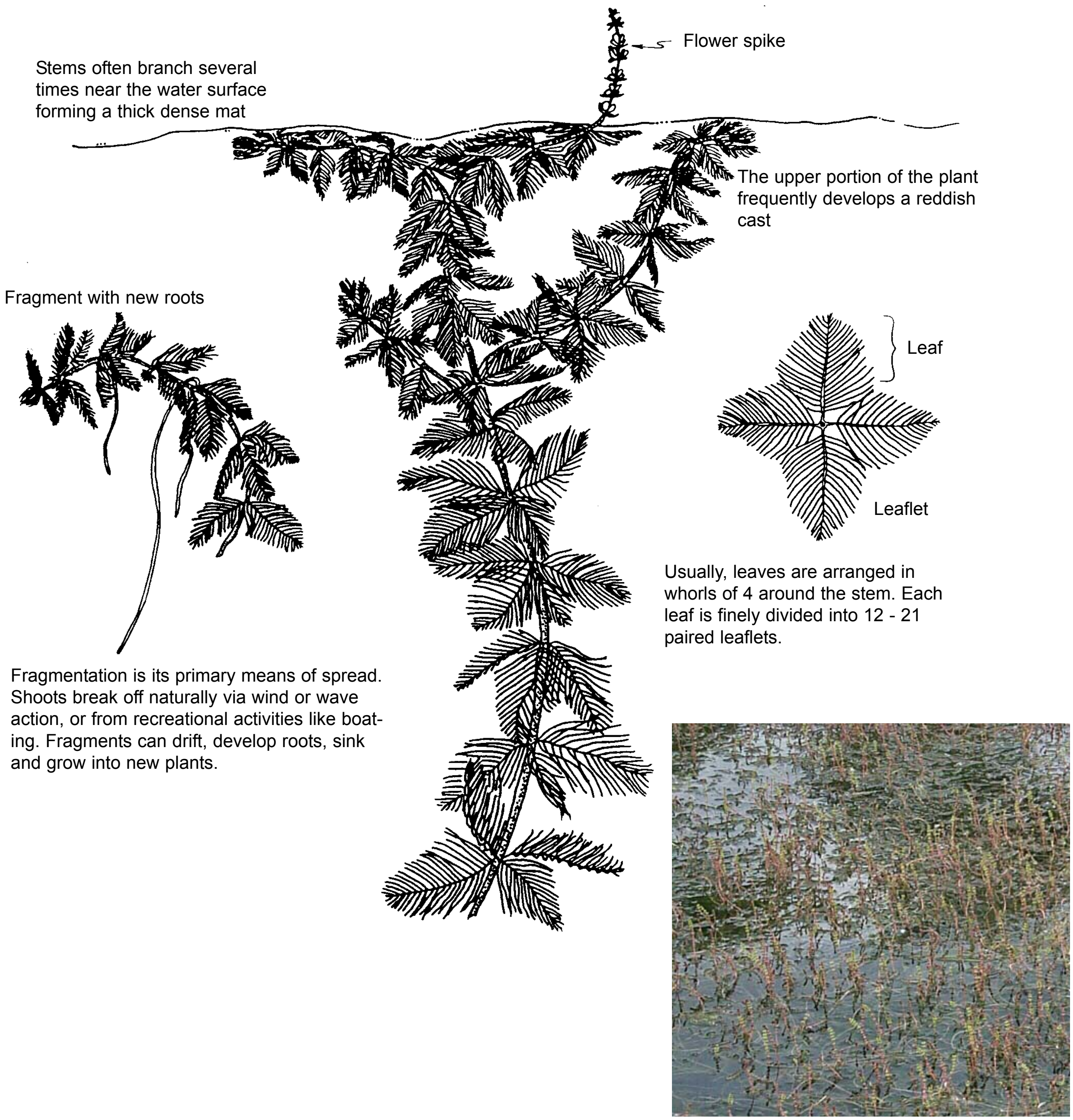


Figure 6. Eurasian milfoil. Inset, below right: Eurasian milfoil canopy.

Runyan Lake's Fishery

Runyan Lake supports a diverse warm water fishery including northern pike, largemouth bass, yellow perch, pan fish (bluegills, crappie, sunfish, etc.), and various minnow species (Jude and Ervin 1996). A cold water species, the lake herring (*salmonidae* sp.) is also found in Runyan Lake (Jude and Ervin 1981; 1996). Runyan Lake is a private access lake; therefore, no Department of Natural Resources data exists on the lake. Based on the historical fisheries studies that have been conducted on Runyan Lake, the fishery is very diverse and growth is generally good, although several species grow at a rate slightly below state averages (Jude and Ervin 1996).

Jude and Ervin (1981; 1996) have indicated that Runyan Lake, due to its low nutrient levels (and thus low productivity), may be at or near its biological carrying capacity (i.e., the theoretical maximum amount of fish that the lake can support). Thus, stocking may not greatly improve the lake's fishery. Jude and Ervin (1996) noted that northern pike are an important top predator in the lake that may be over-fished. They recommended that further study of the lake's northern pike fishery be conducted to determine if successful spawning is occurring and to evaluate the need for possibly stocking this species.

The recent introduction of zebra mussels into Runyan Lake may alter the food chain dynamics which, in turn, could impact the fishery. As zebra mussels consume planktonic algae and compete with zooplankton for food, plankton-consuming fish species (such as herring and juvenile perch) and various predator species may be impacted as well. The change in algal composition (from edible green algae to inedible blue-green algae) often associated with zebra mussel infestations usually affects the forage fish first and eventually the predator fish. Additional study will be required to determine to what extent the introduction of zebra mussels in Runyan Lake may be impacting the fishery.

Watershed Management

Effective management of the Runyan Lake watershed to reduce pollution inputs is critical to improving and protecting lake water quality over the long-term. Of primary concern is phosphorus, since phosphorus is the nutrient that most often stimulates excessive growth of aquatic plants and algae, leading to a variety of problems known collectively as eutrophication. Given the fact that Runyan Lake has a relatively long water residence time (i.e., it takes several years for the volume of water in the lake to be flushed by incoming waters), the lake is very sensitive to pollution inputs. Once a pollutant such as phosphorus is introduced into the lake, it will take several years for the pollutant to be flushed out and perhaps many more years for the lake to show signs of recovery. Watershed management, by its nature, is an ongoing process which requires continued vigilance and effort.

A review of historical aerial photographs of the Runyan Lake area (Figures 7 thru 9) reveals that development around the lake increased dramatically between 1940 and 1980. In 1940, Runyan Lake had only about 75 homes around the lake, and the Fenton Highway (west of the lake) was still under construction. By 1955, the lake perimeter contained approximately 120 homes, and in 1957, US-23 was constructed immediately west of the lake. The construction of US-23 greatly increased the accessibility of Runyan Lake and thus made it more attractive for residential development. The excavation of the cove at the southwest end of the lake and the canal at the northeast corner of the lake occurred between 1955 and 1963. By 1980, approximately 180 homes bordered the lake and, at present, approximately 230 homes abut the lake. As natural groundcover and wetlands in the area were replaced by rooftops, roads, and other impervious surfaces, water runoff to the lake increased as the quality likely decreased. Clearly, development in the area has had a direct impact on the quality of Runyan Lake, especially in the near-shore areas.

The construction of a sewer system around Runyan Lake in the 1980's was an important first step in curbing nutrient inputs to the lake. However, given the density of development immediately adjacent to the lake, runoff from developed shorelands appears to be the major controllable source of phosphorus loading to Runyan Lake. The amount of phosphorus transported to the lake in residential runoff could be substantially reduced if vegetative buffer strips (i.e., greenbelts) are established around the lake perimeter and the use of lawn fertilizers containing phosphorus is curtailed by area residents.

Sediment and nutrient inputs resulting from future development and construction activities in the Runyan Lake watershed are another potential source of pollution to the lake. Given the proximity of the City of Fenton and the rate of urbanization regionally, it is anticipated that substantial increases in residential construction in the watershed will occur in the future. Without proper planning and development controls, an increase in urbanization within the watershed has the potential to adversely impact the water quality of Runyan Lake. Part 91 (Soil Erosion and Sedimentation) of the Natural Resources and Environmental Protection Act, PA 451 of 1994, requires a permit from the local soil erosion enforcement agency for construction activities which disturb one acre or more or are within 500 feet of a lake or stream. The local enforcing agency for Livingston County is the Livingston County Drain Commissioner. Although this act is intended to provide regulatory protection against soil erosion and sedimentation, it is important for area residents to monitor area development for potential violations of the act.

Stormwater emanating from future development sites in the watershed is another major cause of concern. Often, as part of the subdivision review process, the drain commissioner will critique stormwater

Figure 7. Runyan Lake area, 1940.

Figure 8. Runyan Lake area, 1955.

Figure 9. Runyan Lake area, 1980.

management proposals to ensure proper facilities are in place to protect receiving waters and properties. As new developments are proposed within the watershed, lake residents should inquire specifically about the stormwater management measures that will be employed to protect the quality of Runyan Lake.

Another means of curbing nutrient and sediment loading to the lake would be for lake residents to request the establishment of riparian corridors or conservation easements along Denton Creek and other significant tributaries as development proposals are submitted. These areas would remain in an undeveloped state and act as buffers which would decrease the amount of pollutants entering Runyan Lake and its tributaries.

Wetlands within the Runyan Lake watershed are an essential component of the lake system. They provide valuable fish and wildlife habitat, and act to purify and filter pollutants from incoming waters. Pursuant to provisions of Part 303 (Wetland Protection) of the Natural Resources and Environmental Protection Act PA 451 of 1994, regulations exist that restrict the development and destruction of wetlands. However, lake residents should monitor development in the Runyan Lake watershed to help ensure excessive encroachment of area wetlands and the loss of valuable wetland functions does not occur.

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 Runyan Lake must rely largely on the efforts of lake residents. In order to achieve the greatest level of effectiveness, a program should be established to promote the dissemination of information on watershed management practices and concepts. The program should address sources of pollution from existing development as well as potential sources of pollution from future development. The program is proposed to include:

- The publication of a lake protection guidebook for mailing to all lake residents. The guidebook would focus on watershed management issues and would contain the following:
  - Information regarding proper lakeside lawn care and landscaping practices.
  - Information on wetland locations, functions, values, and regulations.
  - Information on Runyan Lake’s water quality.
  - Guidance on how to limit future introductions of invader species such as Zebra mussels and Eurasian milfoil.
- Active involvement by representatives of Runyan Lake in local land use planning and zoning. As development proposals are submitted to the Township for review, issues such as retention of vegetative ground cover along stream corridors, stormwater management, and soil erosion control should be examined and discussed.
- Monitoring of development within the watershed to ensure compliance with environmental protection statutes.

Study Findings and Management Implications

Based on the information collected and reviewed during the period of study, a summary of study findings and management recommendations for Runyan Lake are presented below.

Water Quality: Sampling performed as part of the study indicates that the water quality of Runyan Lake is good. The lake exhibits relatively low phosphorus and chlorophyll-*a* levels, and excellent transparency. During the period of summer thermal stratification, dissolved oxygen levels in the deep waters of the lake are sufficient to support a cold water fish species--the lake herring. When compared to data collected from the lake in 1995, the lake shows improvement in some water quality parameters. However, this apparent improvement in water quality may be related, in part, to the recent introduction of zebra mussels in Runyan Lake.

Zebra Mussels: The recent infestation of zebra mussels in Runyan Lake has the potential to impact the lake in a number of ways. Although some of the short term impacts may be perceived by some as positive (e.g., increased transparency), the long-term impacts of the infestation will likely be negative. Potential impacts include: Shifts in the composition of algae in the lake from desirable green species to undesirable blue-green algae; increased transparency as zebra mussels feed on algae in the water column; increased plant growth as a result of the increased transparency; and disruption of the food chain as inedible blue-green algae gain dominance in the lake. This change in food chain dynamics could eventually impact the fishery. Additional study will be required to discern the long-term impact of zebra mussels in Runyan Lake.

Aquatic Plants: Runyan Lake maintains a healthy diversity of native aquatic plant species. Most of the plant species observed in the lake are considered to be beneficial in that they provide critical habitat and cover for fish and other aquatic organisms, help to sustain dissolved oxygen levels in the lake, and stabilize shoreline and bottom sediments. Currently, non-native nuisance species such as Eurasian milfoil are not prevalent in the lake. Plant management efforts should focus on the control of exotic, nuisance species that are present in the lake, with minimal control of native plant species. Plant control should only be conducted in isolated portions of the lake where plant growth is interfering with recreational lake uses (perhaps 15 to 20 acres of the lake).

Fisheries: Previous study indicates that Runyan Lake maintains a diverse warm water fishery as well as a cold water fish species not commonly found in southern Michigan lakes. While some fish species are growing slightly below state averages, this appears to be the result of the low nutrient levels in Runyan Lake that naturally limit fish production. Thus, simply stocking the lake will not significantly enhance the lake's fishery. Northern pike have been identified as an important predator fish in Runyan Lake that may be over-fished. In the most recent fishery evaluation of the lake (Jude and Ervin 1996), it was recommended that further study of the lake's northern pike fishery be conducted to determine if successful pike spawning is occurring and to evaluate the need for possibly stocking this species in the future.

Watershed Management: Effective management of Runyan Lake over the long term will necessitate that pollution inputs from the watershed be curtailed to the extent practical. Of primary concern is phosphorus, since it is the nutrient that most often stimulates excessive growth of aquatic plants and algae, leading to a variety of problems known collectively as eutrophication. Given the fact that Runyan Lake has a relatively long water residence time (i.e., it takes several years for the volume of water in the lake to be flushed by incoming waters), the lake is very sensitive to pollution inputs. Once a pollutant such as phosphorus is introduced into the lake, it will take several years for the pollutant to be flushed out and perhaps many more years for the lake to show signs of recovery. Watershed management, by its nature, is an ongoing process which requires continued vigilance and effort.

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- Monitoring of development within the watershed to ensure compliance with environmental protection statutes.

Appendix A
Standard Aquatic Vegetation Summary Sheet

Standard Aquatic Vegetation Summary Sheet

Lake Name: Runyan Lake **Livingston County**
Survey Date: 23-Sep-04 **# AVAS** 49
Surveyors: Jennifer Jermalowicz-Jones, Hausler

ProgressiveAE

Code #	Plant Name	Occurrence per Density Category a	b	c	d	Relative Density Calculations (a x 1)	(b x 10)	(c x 40)	(d x 80)	Relative Density for Entire Littoral Zone Sum	%	Code #	Plant Name
1	E. Milfoil		1			0	10	0	0	10	0.2	1	E. Milfoil
2	Curlyleaf pndwd	1	6			1	60	0	0	61	1.2	2	Curlyleaf pndwd
3	Chara		1	46		0	10	1840	0	1850	37.8	3	Chara
4	Thinleaf pndwd	1	4			1	40	0	0	41	0.8	4	Thinleaf pndwd
5	Flatstem pndwd					0	0	0	0	0	0.0	5	Flatstem pndwd
						0	0	0	0	0	0.0		
6	Robbins pndwd					0	0	0	0	0	0.0	6	Robbins pndwd
7	Variable pndwd					0	0	0	0	0	0.0	7	Variable pndwd
8	Whitestem pndwd			1		0	0	40	0	40	0.8	8	Whitestem pndwd
9	Richardsons pndwd					0	0	0	0	0	0.0	9	Richardsons pndwd
10	Illinois pndwd		29	16		0	290	640	0	930	19.0	10	Illinois pndwd
						0	0	0	0	0	0.0		
11	Largeleaf pndwd		6	3		0	60	120	0	180	3.7	11	Largeleaf pndwd
12	American pndwd					0	0	0	0	0	0.0	12	American pndwd
13	Floating leaf pndwd					0	0	0	0	0	0.0	13	Floating leaf pndwd
14	Water stargrass	1	3			1	30	0	0	31	0.6	14	Water stargrass
15	Wild celery		1	1		0	10	40	0	50	1.0	15	Wild celery
						0	0	0	0	0	0.0		
16	Sagittaria					0	0	0	0	0	0.0	16	Sagittaria
17	Northern milfoil					0	0	0	0	0	0.0	17	Northern milfoil
18	M. verticillatum		4	35	11	0	40	1400	880	2320	47.3	18	M. verticillatum
19	M. heterophyllum					0	0	0	0	0	0.0	19	M. heterophyllum
20	Coontail		2			0	20	0	0	20	0.4	20	Coontail
						0	0	0	0	0	0.0		
21	Elodea		1			0	10	0	0	10	0.2	21	Elodea
22	Utricularia vulgaris		9	1		0	90	40	0	130	2.7	22	Utricularia vulgaris
23	Bladderwort-mini					0	0	0	0	0	0.0	23	Bladderwort-mini
24	Buttercup					0	0	0	0	0	0.0	24	Buttercup
25	Southern naiad		10	6		0	100	240	0	340	6.9	25	Southern naiad
						0	0	0	0	0	0.0		
26	Brittle naiad					0	0	0	0	0	0.0	26	Brittle naiad
27	Scirpus subterminalis		2			0	20	0	0	20	0.4	27	Scirpus subterminalis
28						0	0	0	0	0	0.0	28	
29						0	0	0	0	0	0.0	29	
30	Nymphea		8	4		0	80	160	0	240	4.9	30	Nymphea
						0	0	0	0	0	0.0		
31	Nuphar		3			0	30	0	0	30	0.6	31	Nuphar
32	Brasenia					0	0	0	0	0	0.0	32	Brasenia
33	Lemna minor					0	0	0	0	0	0.0	33	Lemna minor
34	Spirodella					0	0	0	0	0	0.0	34	Spirodella
35	Watermeal					0	0	0	0	0	0.0	35	Watermeal
						0	0	0	0	0	0.0		
36	Arrowhead					0	0	0	0	0	0.0	36	Arrowhead
37	Pickerelweed		5	2		0	50	80	0	130	2.7	37	Pickerelweed
38	Arrow arum					0	0	0	0	0	0.0	38	Arrow arum
39	Cattail	1	8	2		1	80	80	0	161	3.3	39	Cattail
40	Bulrush		10	4		0	100	160	0	260	5.3	40	Bulrush
						0	0	0	0	0	0.0		
41	Iris					0	0	0	0	0	0.0	41	Iris
42	Swamp loosestrife					0	0	0	0	0	0.0	42	Swamp loosestrife
43	Purple loosestrife					0	0	0	0	0	0.0	43	Purple loosestrife
44						0	0	0	0	0	0.0	44	
45						0	0	0	0	0	0.0	45	
										Total	139.9		

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