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REPORT OF WATER QUALITY IN DEVIL LAKE FRONTENAC COUNTY 1974

Ministry of the Environment

Ontario

The Honourable
George A. Kerr, Q.C.,
Minister

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Deputy Minister

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PREFACE

The Province of Ontario contains many thousands of beautiful small inland lakes which are most attractive for recreational use. Lakes close to urban areas and accessible by road often receive heavy use in terms of cottage development, camp sites, trailer parks and picnic areas.

A heavy influx of people may subject a lake and its surrounding environment to great stress. In some cases, developments are carried out on attractive lakes only to find that when this is complete the lake qualities which were initially so appealing have been damaged. The appearance of the shoreline can be marred by construction, fishing ruined by over-harvesting or by the growth and decay of excessive amounts of algae and weeds. Motor boats introduce noise and petroleum pollution. Inadequate disposal of human wastes can place a great stress on the lake environment.

The accepted custom of having "a place at the lake" continues to apply pressure for more development, giving rise to an even greater expansion of problems.

The Ontario Ministry of the Environment is attempting to bring some of these stress factors under control with a variety of programs. The cottage pollution control program was initiated in 1967 and was expanded in 1970 in order to solve the cottage waste disposal problem in recreational lakes. There are three on-going studies carried out by the Ministry.

1. Evaluation of existing waste disposal systems and enforcement of repairs to those found to be unsatisfactory.
2. Research to improve the knowledge of septic tank operation and effects in shallow soil areas and evaluation of alternative methods of private waste disposal.
3. Evaluation of present water quality in a number of recreational lakes. A totally undeveloped lake near Huntsville was studied in 1972 and 1973 in order to obtain more information about natural water quality conditions within a Precambrian Lake, which would assist in defining any unnatural conditions encountered in the developed lakes surveyed.

This report on Devil Lake is one of a series dealing with the water quality aspects of the recreational lakes studied in 1974. As well as defining present status of water quality in the lakes, the data is meant to provide an historical reference for comparison of conditions at any future time.

SUMMARY

Surveys were carried out during June, August and September of 1974, to evaluate the bacterial, chemical and biological quality of the waters of Devil Lake.

Devil Lake, comprised of eight contiguous basins with a maximum depth of 42 m (138 feet), is located in Frontenac County about 35 miles (56 km) north of Kingston. Most of it's approximately 220 cottages and four resorts are confined to the northern and eastern sections of the 23 miles (36 km) of shoreline.

The June survey showed that the bacteriological water quality of Devil Lake in 1974 was good and with only one exception, was within the Ministry of the Environment Microbiological Criteria for Total Body Contact Recreational Use. The bacterial densities in the mouth of the western inflow (Stn. 15) were high and this was thought to be due to animal activities. Several other scattered locations had densities of coliforms higher than the main group but none approached the Recreational Criteria. The total coliform levels in the bottom waters were much lower than that of the surface waters.

As is usual in lakes of this depth, dissolved oxygen became progressively depleted in the bottom waters, reaching a minimum of 5% of saturation in the deepest waters by late September. This degree of depletion has adverse implications on the continued presence of cold water fish species (lake trout) in Devil Lake.

The mineral quality of the waters was low and stable, with a moderate hardness as is characteristic of lakes on the Precambrian Shield. Phosphorus and iron levels showed an accumulation in the bottom waters from spring to fall, but remained low in the surface waters. Algae levels were indicated to be consistently low by chlorophyll a measurements.

The shallower areas of the lake provided a suitable habitat for a wide variety of common aquatic plants.

PURPOSE OF THE SURVEY

As a result of human activity in the recreational lake environment, some wastes may reach the lake itself and this can lead to either or both of two major types of water quality impairment: microbial contamination, and excessive growths of algae and aquatic plants. While the two problems can result from a common source of pollution, the consequences of each are quite different.

Microbial contamination by raw or inadequately treated sewage does not significantly change the appearance of the water but poses an immediate public health hazard when the water is used for drinking or swimming. This type of pollution can be remedied by preventing wastes from reaching a lake. If this is the only source of pollution, satisfactory water quality will then return since disease causing bacteria do not usually persist in lake water.

Problems due to nutrient enrichment may be long lasting even if further excess nutrients are prevented from entering the lake. Nutrient enrichment, or eutrophication, results from the addition of plant fertilizers which occur naturally and which are also present in virtually all forms of raw or treated human wastes. High concentrations of these fertilizers (plant nutrients), mainly nitrogen and phosphorus, can support excessive growths of rooted aquatic plants and of microscopic free-floating plants called algae.

While aquatic weed beds provide shelter, and both algae and rooted plants provide food for many kinds of fish, excessive growths of either are undesirable since they can upset the oxygen balance in the lake, interfere with recreational uses, and greatly affect the lake's appearance. They do not, however, generally pose a health hazard.

In order to detect either of these conditions, the surveys were designed, and tests selected, to evaluate the current conditions of the lake with respect to:

- lakeshore development
- the distribution and abundance of bacteria
- changes in temperature, dissolved oxygen and water quality with depth
- plant nutrients and suspended algae
- densities and species of aquatic plants

DESIGN OF THE SURVEYS

Sampling Locations and Frequency

A proper estimate of the bacterial population requires several measurements of bacterial densities over a period of time which can then be averaged as a geometric mean. Measurements over 5 consecutive days at each station are regarded as the minimum number which when taken at many lake stations, will give reliable bacteriological results.

Five day bacteriological, chemical and biological surveys were carried out from June 5 to 9. Additional chemical and biological samples were collected from August 12 to 16, and from September 27 to 29.

Samples for bacterial analysis were taken daily one meter below the surface at 34 stations established throughout the lake, as well as from one meter above the bottom at two mid-lake stations (Figure 1).

Chemical samples were taken through the illuminated layer of surface water and from one meter above bottom at each mid-lake station, but at the inlet and outlet stations, were collected one meter below the surface. During the five day spring and summer surveys chemical samples were obtained on the first and fifth day. Through the three day fall survey they were collected each day. Separate samples for chlorophyll analysis were collected daily through the illuminated surface water at the mid-lake and inlet stations.

Aquatic plant samples were obtained from areas representative of sparse, medium and dense growth.

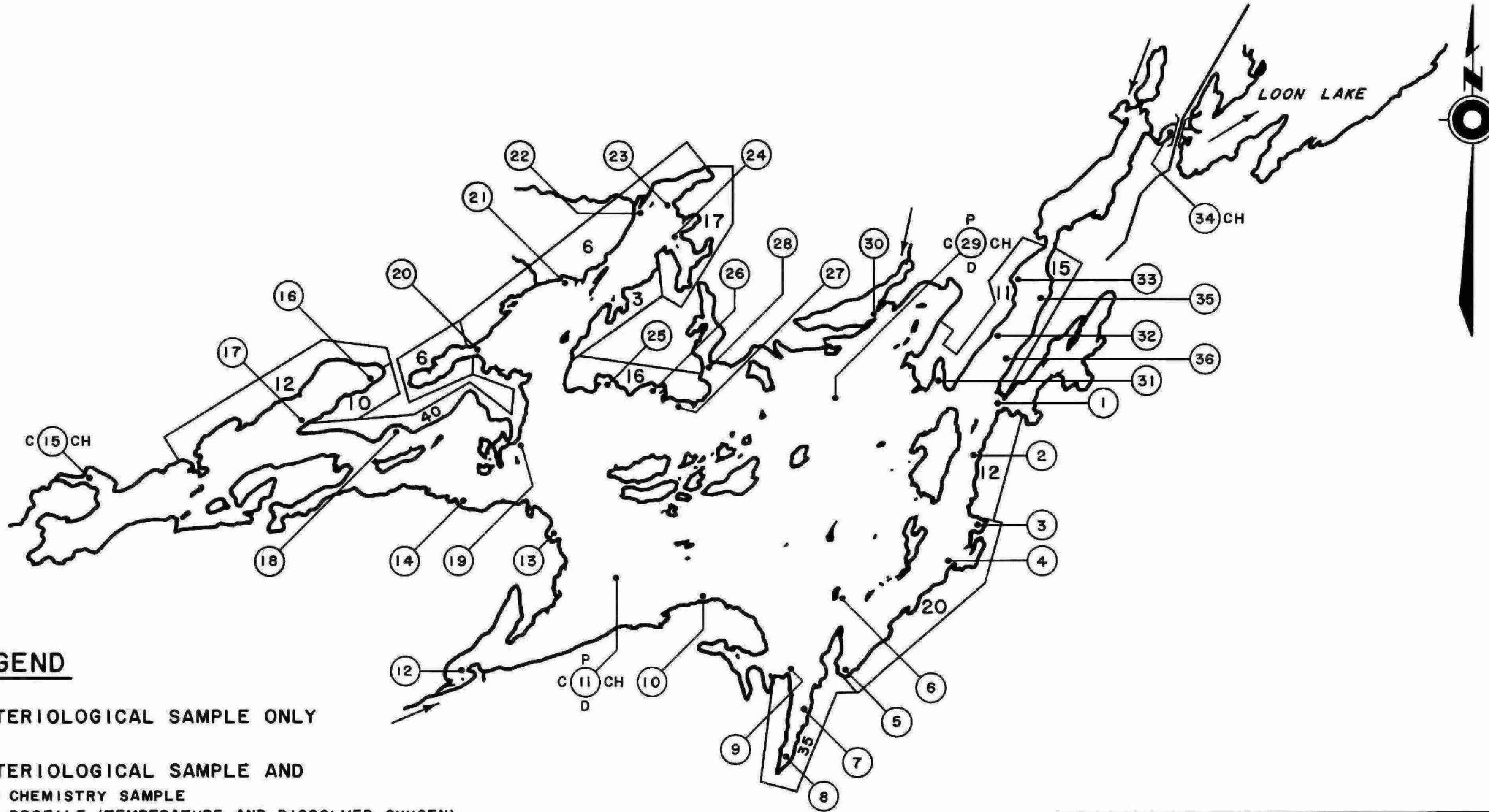
Field Tests

The variations in temperature and dissolved oxygen values with depth were measured at the two deep water stations with an electronic probe lowered into the lake and water clarity was measured with a Secchi Disc, (Figure 2). The pH of the samples was also measured in the field.

Bacteriological Tests

The numbers of bacteria in each of three types of "indicator" organisms were determined on each sample. The three bacterial types, total coliform, fecal coliform and enterococcus (fecal streptococcus) bacteria are all indigenous to man and other warm blooded animals, and are found in the

FIGURE 1 - LOCATIONS OF SAMPLING STATIONS AND MAJOR AREAS OF COTTAGE DEVELOPMENT ON DEVIL LAKE



LEGEND

7 — BACTERIOLOGICAL SAMPLE ONLY

P
C 8 CH — BACTERIOLOGICAL SAMPLE AND
D

C — CHEMISTRY SAMPLE
P — PROFILE (TEMPERATURE AND DISSOLVED OXYGEN)
CH — CHLOROPHYLL SAMPLE
D — DEPTH SAMPLE

27 — 27 COTTAGES

1 .5 0 1 KILOMETRES

0 1/2 1 MILES

MINISTRY OF THE ENVIRONMENT	
RECREATIONAL LAKES PROGRAM DEVIL LAKE 1974 WATER QUALITY SURVEY	
SCALE: AS SHOWN	
DRAWN BY: A.R.S.	DATE: DEC., 1975
CHECKED BY:	DRAWING Nº: 5877

The "Secchi Disc Reading" is obtained by averaging the depth at which a 23cm (9") dia. black and white plate, lowered into the lake just disappears from view and the depth where it reappears as it is pulled up.

Most of the free-floating algae are suspended in the illuminated region between the lake surface and 2 times the Secchi disc reading.

Clear, algae-free lake: Secchi disc readings tend to be greater than 3m (9 feet).

Turbid or algae-rich lake: Secchi disc readings tend to be less than 3m (9 feet).

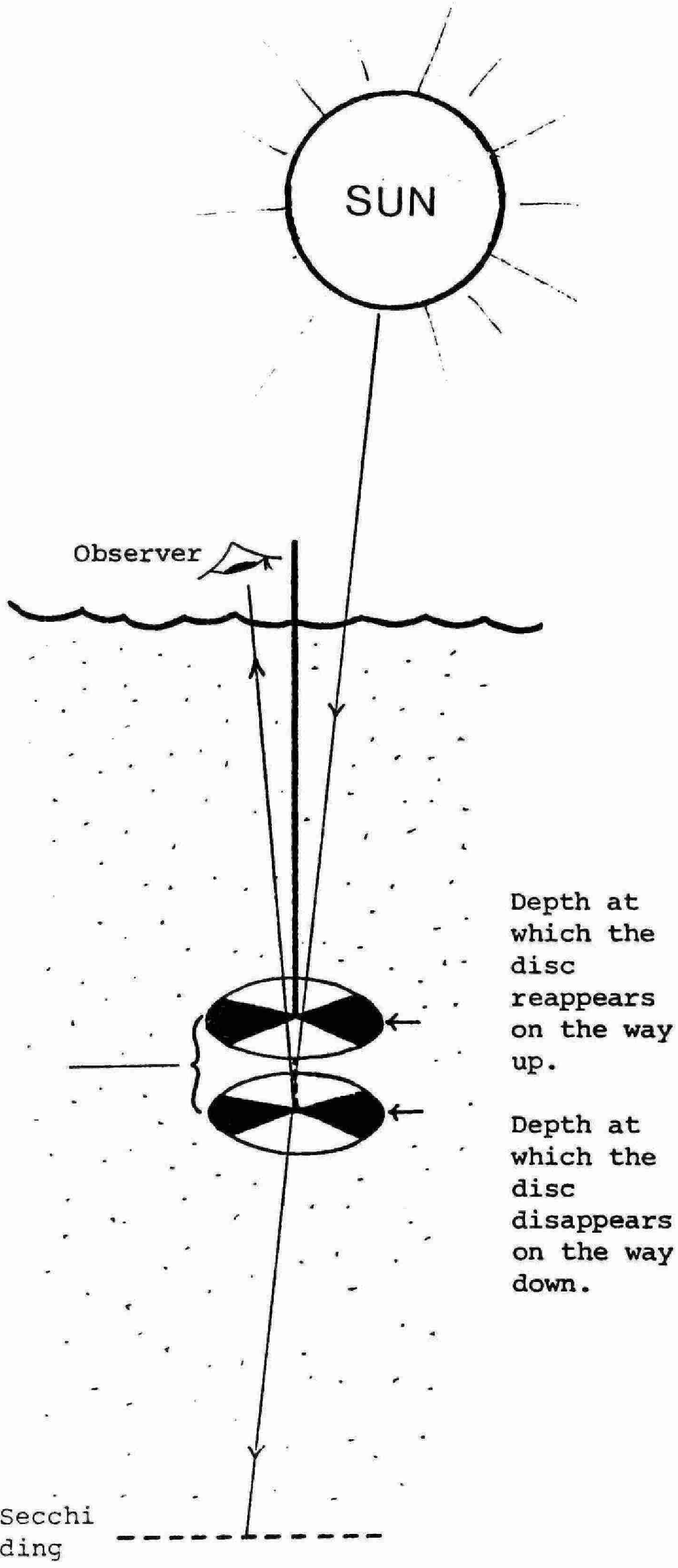


FIGURE 2: USE OF SECCHI DISC TO DETERMINE WATER CLARITY

colon and feces in tremendous numbers. Many diseases common to man can be transmitted by feces, consequently, the probability of occurrence of these diseases is usually highest in areas where the water is contaminated. These indicator organisms in water connote the possible presence of disease causing organisms.

The density (numbers per 100 ml) of the indicator bacteria in water will vary considerably between pairs of samples taken at the same station, or at different stations on a lake, or if taken at different times, and so the assessment of water quality cannot be determined accurately from a single water sample.[1] Therefore, the bacteriological surveys require many samples to be taken at several lake stations over a period of time, and following this the large amount of data so obtained is reduced by calculation to meaningful and easily manipulated statistics.

> These data were then evaluated by statistical techniques in the following manner. The geometric mean, the most appropriate central value, and standard deviation were calculated for the values of each of the three bacterial types at every station, providing concise valid data. Statistically significant variations in the bacterial densities between stations, or groups of stations was determined by a One Way Analyses of Variance and Bartlett's Test of Homogeneity. By these means the data from each station were tested against that of every other station until all stations with similar geometric mean densities were separated into groups (Group A, B ---).

The group results, and those for individual stations, were then displayed on a map of the lake with each group identified by different stippling. Within each stippled area the group geometric mean applied for each type of bacteria, unless otherwise indicated by individual station values. The areas of better or worse bacterial quality were defined by the group geometric mean densities, and so any inputs of bacterial contamination, and the areas they affect, were readily identifiable.

Chemical Tests

Hardness, alkalinity, chloride, iron and conductivity were measured in order to define the mineral composition of the water. The types of plants and animals which thrive, effects of toxic materials and suitability of the lake for various management techniques are affected by the mineral content.

[1]Guidelines and Criteria for Water Quality Management in Ontario - MOE, 1974.

Total and soluble phosphorus were measured in the inlet and bottom water samples while total phosphorus only was measured in the mid-lake and outlet surface samples. Soluble phosphorus concentrations are used mainly to substantiate various interpretations of the total phosphorus concentrations.

The total Kjeldahl nitrogen is (apart from ammonia nitrogen) essentially the amount of nitrogen contained in organic material. It was measured in all of the chemical samples. The soluble forms of nitrogen (Ammonia, Nitrite and Nitrate) were measured in the inlet and bottom water samples. They are particularly important in bottom waters since nitrogen may be regenerated from decaying organic matter in these forms.

Chlorophyll a concentrations are an indication of the amount of suspended algae in the water. The live algae are confined mainly to the illuminated surface waters which extend down to a depth of about twice the Secchi disc reading. The chlorophyll samples were collected by filling the sample bottle as it was lowered and raised from this depth, and were thus representative of the average algal density through this illuminated zone.

DESCRIPTION OF THE DEVIL LAKE AREA

Lake and Soil Characteristics

Devil Lake is located about 35 miles (56 km) north of Kingston in Bedford Township of Frontenac County. Public access to the lake is from County Road #10.

The surface area of Devil Lake is about 74 km^2 (2,620 acres) and is contained by 36 km (23 miles) of shoreline. The mean depth of the lake which is comprised of eight small basins is 14.5 m (47 feet) while the maximum depth is 42 m (138 feet).

The lake lies at an elevation of 430 feet (131 m) above mean sea level and is drained to the north-east by a single outflow to Newboro Lake. The water level is controlled by a small dam located at Bedford Mills and is operated by the Gananoque Light and Power Company. The drainage basin area of Devil Lake is about 40 km^2 (9,700 acres) with the main source of water entering the lake from the west via a small creek.

Lying within the Precambrian Shield, Devil Lake is surrounded by mixed forest developed on the Monteagle sandy loam soil series. The soils are of stony, gravelly or sandy loam texture and are shallow in depth , overlying granite and gneiss rocks of Precambrian age.

Lakeshore Development and Water Usage

Shoreline relief and absence of roads have precluded development in many areas of the lake. Most of the approximately 220 cottages and four resorts are confined to the northern and eastern shores (Figure 1).

Many cottagers use the lake water as their source of domestic water supply (see p.A-2). The lake is also used for such recreational activities as angling, swimming, boating and snowmobiling. Information from the Ontario Ministry of Natural Resources indicates that smallmouth and largemouth bass, northern pike and lake trout are the commonly sought sport fish.

RESULTS & DISCUSSION

Microbiology

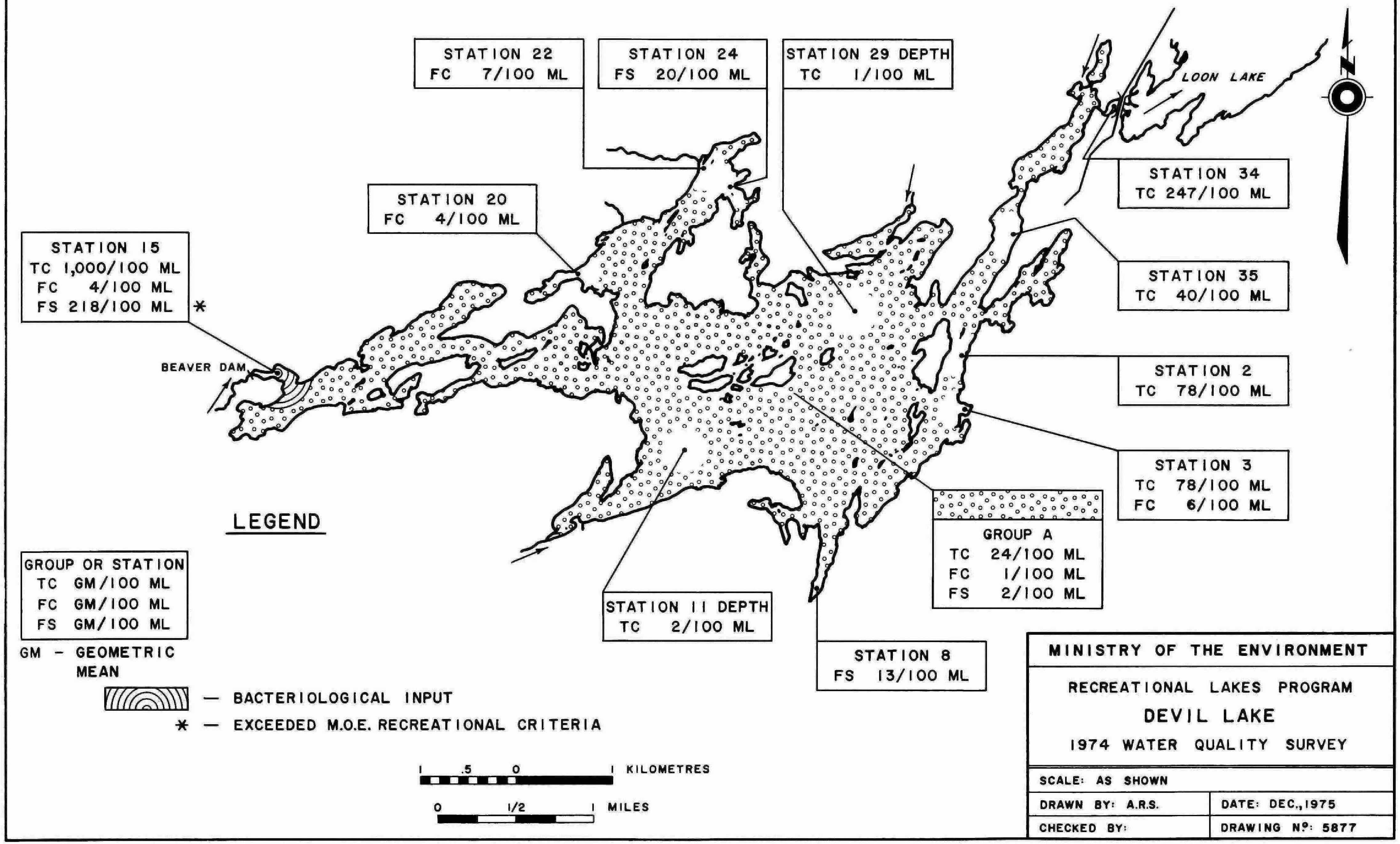
The June survey showed that the bacteriological water quality of Devil Lake in 1974 was good and with only one exception, was within the Ministry of the Environment Microbiological Criteria for Total Body Contact Recreational Use, which states:

> "Where ingestion is probable, recreational waters can be considered impaired when the coliform (TC), fecal coliform (FC) and/or enterococcus (fecal streptococcus, FS) geometric mean density exceeds 1,000, 100, and/or 20 per 100 ml respectively, in a series of at least ten samples per month,....1

In June, the mean bacterial densities for the major homogeneous section of Devil Lake were 24 TC, 1 FC and 2 FS per 100 ml (Group A, Figure 3). The bacterial densities in the mouth of the western inflow (Station 15) equalled the total coliform criteria and exceeded the fecal streptococcus criteria with values of 1,000 TC, 4 FC and 218 FS per 100 ml. These elevated bacterial densities can likely be attributed to animal activity. A beaver dam was found in the inflow. The bacterial densities at both the north-eastern inflow (Station 34) and the north central inflow (Station 22) were also higher than the main group with values of 247 TC and 7 FC per 100 ml, respectively. A bay in the north central region of the lake (Station 24) had levels of fecal streptococcus which equalled the Recreational Criteria (20 FS per 100 ml). The levels of total coliforms in the bottom waters, monitored by Stations 11D and 29D, were much lower than the surface water, with values of 2 TC and 1 TC per 100 ml respectively. The density of fecal streptococcus at a southern bay (Station 8) was appreciably higher than the main group with 13 FS per 100 ml. The relative densities of fecal bacteria at this location indicated an input of animal origin. Total coliform densities in the eastern shore locations (Stns. 2, 3, and 35) were appreciably higher than the main body of water with values of 78 TC and 40 TC per 100 ml respectively. Two small bays in the north (Stn. 20) and east (Stn. 3) had fecal coliform densities of 4 FC and 6 FC per 100 ml respectively, which were slightly higher than most of the lake.

(1) Guidelines and Criteria for Water Quality Management in Ontario MOE - 1974.

FIGURE 3 - DISTRIBUTION OF BACTERIA DURING THE JUNE 5 TO JUNE 9 SURVEY



No problems were encountered in June, although it should be noted that the highest bacterial densities in a lake are usually found in the summer, as water temperature, recreational and wildlife activities increase. Therefore, summer data would have been useful to assess the bacteriological water quality of Devil Lake for recreational use.

Chemistry

Temperature and dissolved oxygen profiles were determined at open water Stations 11 and 29 (Figure 4) during each of the three surveys. Only slight differences between the two sampling locations were observed and for this reason, results from only the deeper location (Station 11) are presented.

On June 7 of the first survey, a thermocline (zone of rapid temperature decline) extended from 2 m beneath the surface to 7 m. Water temperatures ranged from 20°C at the surface to 7.5°C in near bottom waters (Figure 4). Dissolved oxygen remained saturated from the surface to a depth of 10 m; but below this depth, decreased to 50% of saturation at 1 m above bottom (Figure 4).

By the mid-August survey, the thermocline had shifted downward to a zone between 7 and 11 m of depth, surface water temperatures were in the 22-24°C range and bottom water dissolved oxygen saturations had declined to 13% (Figure 4).

The late September survey found Devil Lake to be still stratified with respect to temperature and dissolved oxygen, but with only a 5% level of dissolved oxygen saturation in the bottom water (Figure 4).

The observed seasonal decline in the bottom water dissolved oxygen is a common occurrence in Ontario Lakes and is commonly caused by the decomposition of organic material which settles to the lake bottom. Some consequences of dissolved oxygen depletion and its implication to the lake as a habitat for fish and other lake processes are discussed on p. A-6.

Devil Lake is a moderately soft water lake as indicated by alkalinity and hardness measurements (see table below). Little difference in several mineral constituents existed among surface and bottom waters and the inflowing stream (mean values summarized below) and no seasonal trends were evident with the exception of iron which showed somewhat higher concentrations in the bottom waters of the lake and an increase from spring to fall.

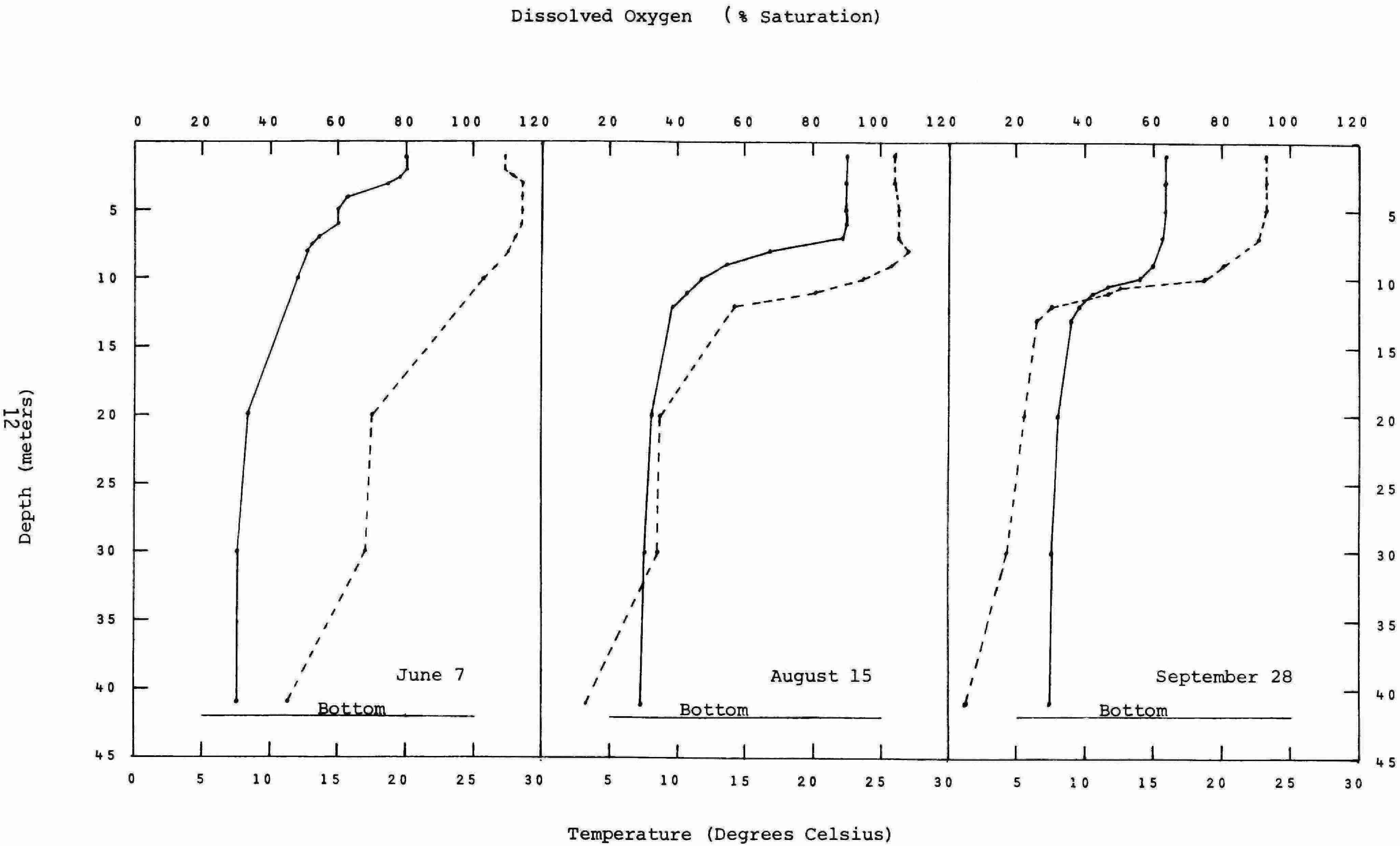


Figure 4 : Temperature (—) and dissolved oxygen (---) profiles at Station 11 of Devil Lake, 1974.

MEAN VALUES ALL INFLOW, LAKE SURFACE AND LAKE BOTTOM SAMPLES		
Alkalinity (mg/l as $CaCO_3$)		73
Hardness (mg/l as $CaCO_3$)		83
Chloride (mg/l)		1.8
Conductivity (μmhos/cm)		175
Total iron (mg/l)	a) surface waters	<0.05
	b) 1 m above bottom	0.10
Sulphate (mg/l)		10
Sodium (mg/l)		2
Potassium (mg/l)		1.4

Total phosphorus concentrations in the inflow did not differ significantly from the survey average of 15 μg/l found for the surface waters of the lake. Phosphorus concentrations were somewhat higher in the bottom waters of the lake where they also showed a marked increase from spring to fall (see table below). The elevated phosphorus concentrations in the bottom waters, although not excessive, may provide a potential for late growth of algae in the lake after the waters have cooled and mixed from surface to bottom. However, mixing of the lake had not occurred by the late September surveys, so the response of the suspended algae to recirculation of supplies of nutrients from the bottom water was not documented.

Averages for each of the three surveys.
at 1 m above lake bottom

	Total P	Soluble reactive P	Total iron	Dissolved Oxygen
		μg/l		% saturation
Spring	20	1	60	50
Summer	35	19	90	13
Fall	59	34	150	5

Nitrate and ammonia-nitrogens in the surface waters and the inflow were almost without exception below the limits of analytical detection (<10 μg N/l) throughout the survey periods. Concentrations of these nutrients were somewhat higher in the bottom waters, but no seasonal trends were evident. Lake concentrations of total Kjeldahl nitrogen averaging 270 μg N/l were lower than amounts in the 300-500 μg/l range found in the inflow.

Chlorophyll a and Water Clarity

Chlorophyll *a* concentrations (an indication of the density of suspended algae) were low during each of the three surveys and averaged 1.7 μg/l overall. The corresponding mean Secchi disc reading (a measure of water clarity) was 5.5 m.

Lakes exhibit their symptoms of enrichment in several ways (see P.A-6 for an explanation of the relationships among nutrient enrichment, lake water clarity and abundance of suspended algae). A curve relating chlorophyll *a* and Secchi disc values was derived by staff of the Ministry of the Environment from data on more than 100 Ontario lakes and illustrates the status of Devil Lake relative to other well-known Ontario lakes (Figure 5). Based on chlorophyll *a* and Secchi disc data collected during the three surveys, Devil Lake is characterized by a low degree of enrichment.

Aquatic Plants in Shoreline Areas

A large number (26 different species) of aquatic plants were identified from collections made in 1974 in Devil Lake (Table). Those found to be most widely distributed and in greatest density (tapegrass, stonewort, water milfoil and several pond weeds) are commonly known as "weedy" types and are abundant in shallow, fertile lakes and ponds of northeastern North America. Most of the aquatic plant growth was found in shallow shoreline areas and in bays near the inflows and outflows of the lake (Figure 6) where bottom materials of suitable texture and fertility have accumulated. Cottagers wishing to control aquatic plant growth in localized areas adjacent to swimming areas and docks should refer to P. A-10.

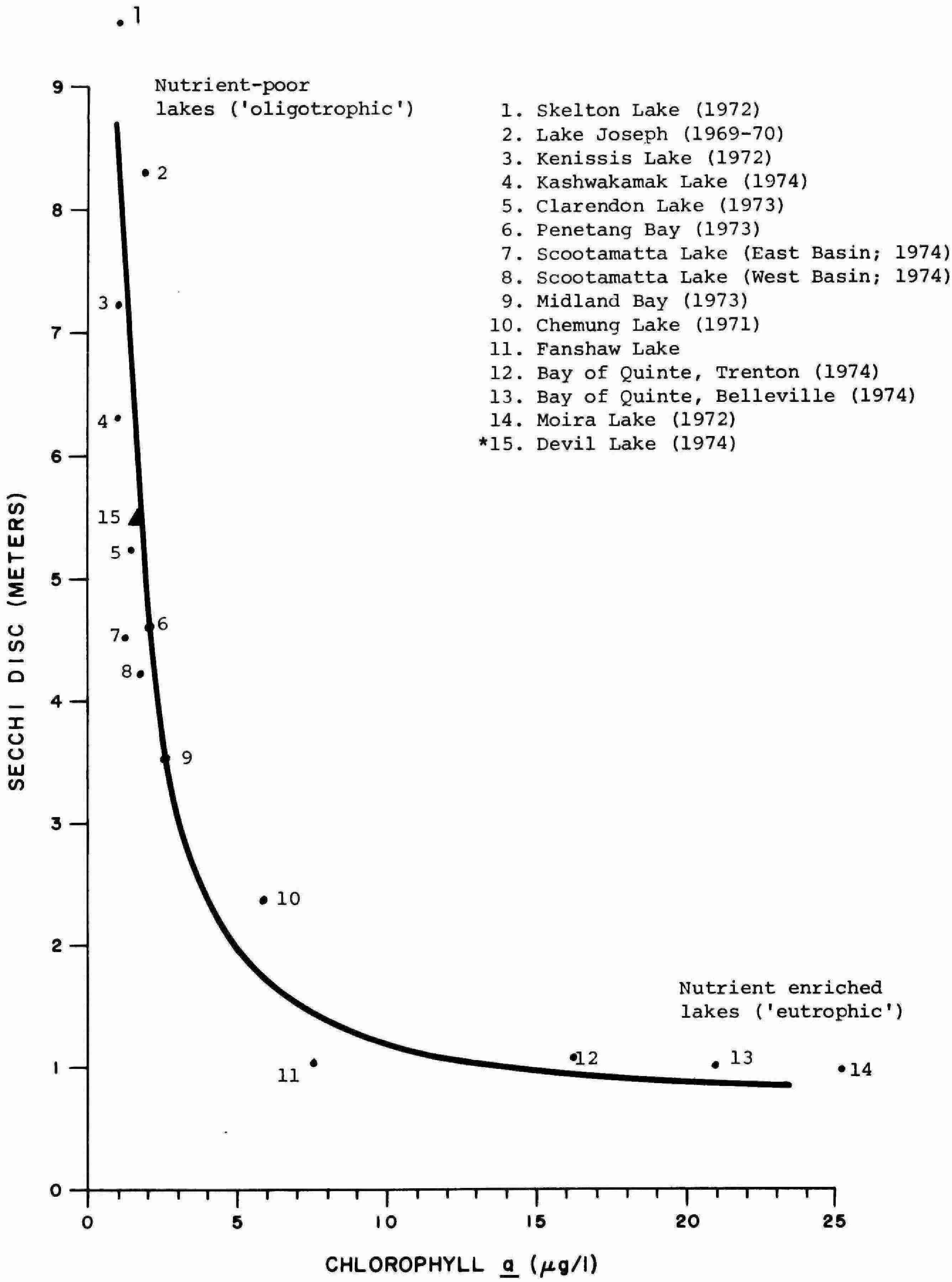


Figure 5: Relationship between chlorophyll a and Secchi disc developed from data on over 100 Ontario Lakes and showing the status of enrichment of Devil Lake relative to several other lakes in the province.

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Table I: A list of the aquatic plants found in Devil Lake during the summer of 1974. The plants are divided into two categories (a) submergent - aquatic plants which live, for the most part under water and (b) emergent - aquatic plants which produce floating or aerial leaves. The number of collecting sites in which species occurred is also given.

Scientific Name (Genus species)	Key to Figure 5	Common Name(s)	Frequency Distribution
Submergent			
Najas flexilis	a	Bushy pondweed	11
Potamogeton Robbinsii	b	Robbins' pondweed	10
Vallisneria americana	c	Wild celery, Tapegrass	10
Bidens Beckii	d	Water marigold	10
P. strictifolius	e	Narrow-leaf pondweed	10
*Chara sp.	f	Stonewort	9
P. Richardsonii	g	Richardson's pondweed	9
P. amplifolius	h	Bass weed, Muskie weed	9
P. zosteriformis	i	Flat-stemmed pondweed	9
P. gramineus	j	Variable pondweed	8
P. natans	k	Floating-leaf pondweed	8
Myriophyllum sp.	l	Water milfoil	8
Anacharis canadensis	m	Canada waterweed, Elodea	7
P. pectinatus	n	Sago pondweed	6
P. crispus	o	Curly-leaf pondweed	4
P. augustifolius	p	Pondweed	3
Ceratiophyllum demursum	q	Coontail	2
Polygonum coccineum	r	Smartweed	2
Sparganium sp.	s	Bur reed	1
Ranunculus sp.	t	Buttercup	1
Fontinalis sp.	u	Water moss	1
Emergent			
Nuphar variegatum	v	Yellow waterlily	12
Nyphaea odorata	w	White waterlily	7
Sagittaria latifolia	x	Common arrowhead	7
Typha latifolia	y	Common cattail	3
Scirpus sp.	z	Bulrush	2

*Chara is an alga

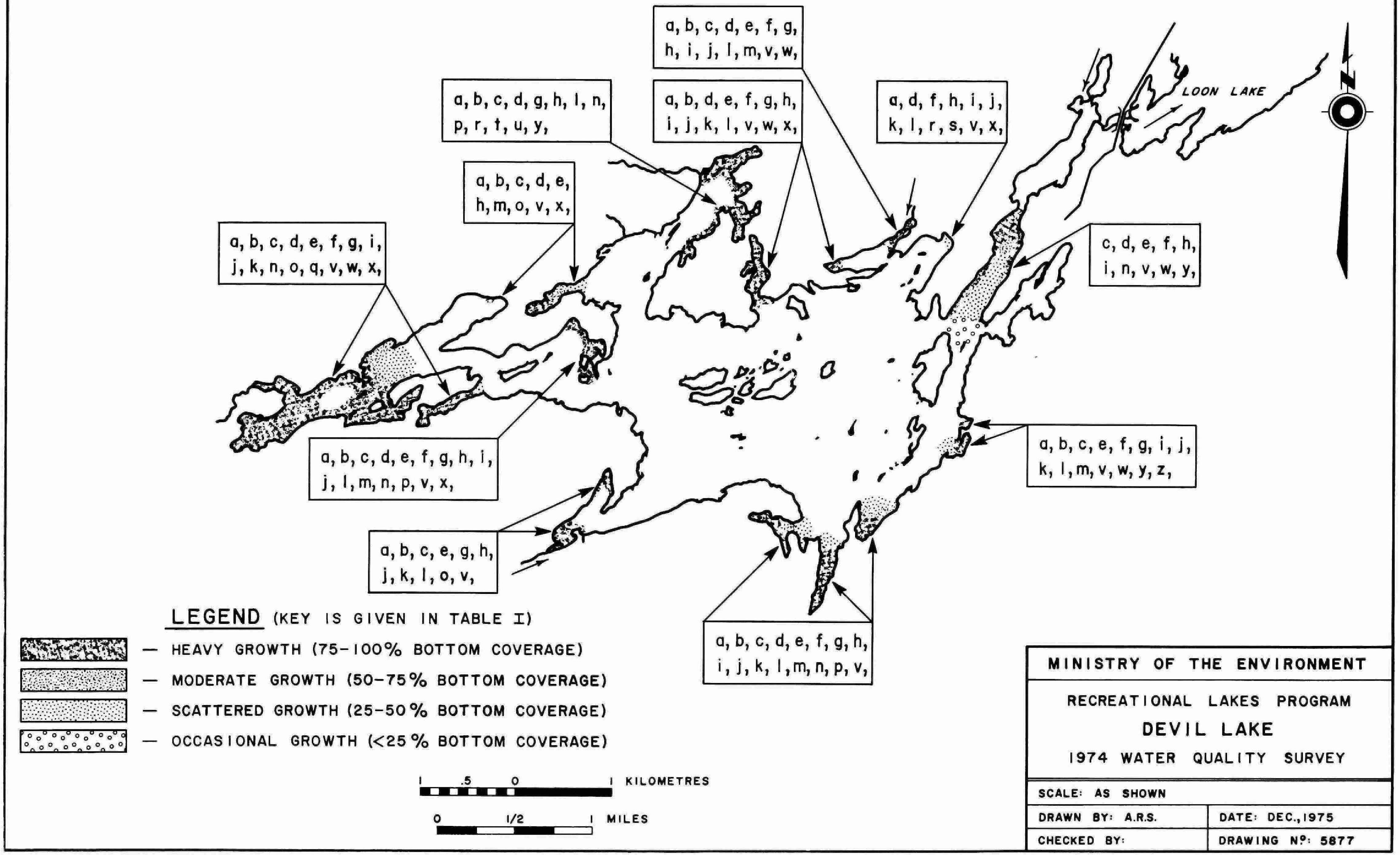


FIGURE 6 – MAJOR AREAS OF SHORELINE AQUATIC PLANT GROWTH IN DEVIL LAKE

INFORMATION OF GENERAL INTEREST TO COTTAGERS

MICROBIOLOGY OF WATER

For the sake of simplicity, the micro-organisms in water can be divided into two groups: the bacteria that thrive in the lake environment and make up the natural bacterial flora; and the disease causing micro-organisms, called pathogens, that have acquired the capacity to infect human tissues.

The "pathogens" are generally introduced to the aquatic environment by raw or inadequately treated sewage, although a few are found naturally in the soil. The presence of these bacteria does not change the appearance of the water but poses an immediate public health hazard if the water is used for drinking or swimming. The health hazard does not necessarily mean that the water user will contract serious waterborn infections such as typhoid fever, polio or hepatitis, but he may catch less serious infections of gastro-enteritis (sometimes called stomach flu), dysentery or diarrhea. Included in these minor afflictions are eye, ear and throat infections that swimmers encounter every year and the more insidious but seldom diagnosed, sub-clinical infections usually associated with several waterborn viruses. These viral infections leave a person not feeling well enough to enjoy holidaying although not bedridden. This type of microbial pollution can be remedied by preventing wastes from reaching the lake and water quality will return to satisfactory conditions within a relatively short time (approximately one year) since disease causing bacteria usually do not thrive in an aquatic environment.

The rest of the bacteria live and thrive within the lake environment. These organisms are the instruments of biodegradation. Any organic matter in the lake will be used as food by these organisms and will give rise, in turn to subsequent increases in their numbers. Natural organic matter as well as that from sewage, kitchen wastes, oil and gasoline are readily attacked by these lake bacteria. Unfortunately, biodegradation of the organic wastes by organisms uses correspondingly large amounts of the dissolved oxygen. If the organic matter content of the lake gets high enough, these bacteria will deplete the dissolved oxygen supply in the bottom waters and threaten the survival of many deep-water fish species.

RAINFALL AND BACTERIA

The "Rainfall Effect" referred to in the text, relates to a phenomenon that has been documented in previous surveys of the Recreational Lakes. Heavy precipitation has been shown to flush the land area around the lake and the subsequent runoff will carry available contaminants including sewage organisms as well as natural soil bacteria with it into the water.

Total coliforms, fecal coliforms and fecal streptococci, as well as other bacteria and viruses which inhabit human waste disposal systems, can be washed into the lake. In Precambrian areas where there is inadequate soil cover and in fractured limestone areas where fissures in the rocks provide access to the lake, this phenomenon is particularly evident.

Melting snow provides the same transportation function for bacteria, especially in an agricultural area where manure spreading is carried out in the winter on top of the snow.

Previous data from sampling points situated 50 to 100 feet from shore indicate that contamination from shore generally shows up within 12 to 48 hours after a heavy rainfall.

WATER TREATMENT

Lake and river water is open to contamination by man, animals and birds (all of which can be carriers of disease); consequently, NO SURFACE WATER MAY BE CONSIDERED SAFE FOR HUMAN CONSUMPTION without prior treatment, including disinfection. Disinfection is especially critical if coliforms have been shown to be present.

Disinfection can be achieved by:

(a) Boiling

Boil the water for a minimum of five minutes to destroy the disease causing organisms.

(b) Chlorination using a household bleach containing 4 to 5¼ percent available chlorine.

Eight drops of a household bleach solution should be mixed with one gallon of water and allowed to stand for 15 minutes before drinking.

(c) Continuous Chlorination

For continuous water disinfection, a small domestic hypochlorinator (sometimes coupled with activated charcoal filters) can be obtained from a local plumber or water equipment supplier.

(d) Well Water Treatment

Well water can be disinfected using a household bleach (assuming strength at 5 percent available chlorine) if the depth of water and diameter of the well are known.

CHLORINE BLEACH
Per 10 ft. Depth of Water

Diameter of Well Casing in Inches	One to Ten Coliforms	More Than Ten Coliforms
4	0.5 oz.	1 oz.
6	1 oz.	2 oz.
8	2 oz.	4 oz.
12	4 oz.	8 oz.
16	7 oz.	14 oz.
20	11 oz.	22 oz.
24	16 oz.	31 oz.
30	25 oz.	49 oz.
36	35 oz.	70 oz.

Allow about six hours of contact time before using the water.

Another bacteriological sample should be taken after one week of use.

Water Sources (spring, lake, well, etc.) should be inspected for possible contamination routes (surface soil, runoff following rain and seepage from domestic waste disposal sites). Attempts at disinfecting the water alone without removing the source of contamination will not supply bacteriologically safe water on a continuing basis.

There are several types of low cost filters (ceramic, paper, carbon, diatomaceous earth sometimes impregnated with silver, etc.) that can be easily installed on taps or in water lines. These may be useful to remove particles, if water is periodically turbid, and are usually very successful. Filters, however, do not disinfect water but may reduce bacterial numbers. For safety, chlorination of filtered water is recommended.

SEPTIC TANK INSTALLATIONS

In Ontario, provincial law requires under Part 7 of the Environment Protection Act that before you extend, alter, enlarge or establish any building where a sewage system will be used, a Certificate of Approval must be obtained from the Ministry of the Environment or its representatives. The local municipality or Health Unit may be delegated the authority to issue the Certificate of Approval. Any other pertinent information such as size, types and location of septic tanks and tile fields can also be obtained from the same authority.

(1) General Guidelines

A septic tank should not be closer than:

-50 feet to any well, lake, stream, pond, spring, river or reservoir

-5 feet to any building
-10 feet to any property boundary

The tile field should not be closer than:

-100 feet to the nearest dug well
-50 feet to a drilled well which has a casing to 25 feet below ground
-25 feet to a building with a basement that has a floor below the level of the tile in the tile bed
-10 feet to any other building
-10 feet to a property boundary
-50 feet to any lake, stream, pond, spring, river or reservoir

The ideal location for a tile field is in a well-drained, sandy loam soil remote from any wells or other drinking water sources. For the tile field to work satisfactorily, there should be at least 3 feet of soil between the bottom of the weeping tile trenches and the top of the groundwater table or bedrock.

Recognizing that private sewage systems are relatively inefficient where shallow and inappropriate soil conditions are present (e.g. Precambrian areas) the Ministry of the Environment is conducting research into alternate methods of private sewage disposal in unsewered areas; into the improvement of existing equipment and methods of design and operation for these systems; and into the development of better surveillance methods such as by the use of chemical, biological and radioactive tracers to detect the movement of pollutants through the soil mantle.

DYE TESTING OF SEPTIC TANK SYSTEMS

There is considerable interest among cottage owners to dye test their sewage systems; however, several problems are associated with dye testing. Dye would not be visible to the eye from a system that has a fairly direct connection to the lake. Thus, if a cottager dye-tested his system and no dye was visible in the lake, he would assume that his system is satisfactory, which might not be the case. A low concentration of dye is not visible and therefore expensive equipment such as a fluorometer is required. Only qualified people with adequate equipment are capable of assessing a sewage system by using dye. In any case, it is likely that some of the water from a septic tank will eventually reach the lake. The important question is whether all contaminants including nutrients have been removed before it reaches the lake. To answer this question special knowledge of the system, soil depth and composition, underground geology of the region and the shape and flow of the shifting water table are required. Therefore, we recommend that this type of study should be performed only by qualified professionals.

BOATING AND MARINA REGULATIONS

In order to help protect the lakes and rivers of Ontario from pollution, it is required by law that sewage (including garbage) from all pleasure craft, including houseboats, must be retained in suitable equipment. Equipment which is considered suitable by the Ministry of the Environment includes (1) retention devices with or without re-circulation which retain all toilet wastes for disposal ashore, and (2) incinerating devices which reduce all sewage to ash.

Equipment for storage of toilet wastes shall:

1. be non-portable
2. be constructed of structurally sound material
3. have adequate capacity for expected use
4. be properly installed, and
5. be equipped with the necessary pipes and fittings conveniently located for pump-out by shore-based facilities (although not specified, a pump-out deck fitting with 1½-inch diameter National Pipe Thread is commonly used).

An Ontario regulation requires that marinas and yacht clubs provide or arrange pump-out service for the customers and members who have toilet-equipped boats. In addition, all marinas and yacht clubs must provide litter containers that can be conveniently used by occupants of pleasure boats.

The following "Tips" may be of assistance to you in boating:

1. Motors should be in good mechanical condition and properly tuned.
2. When a tank for outboard motor testing is used, the contents should not be emptied into the water.
3. If the bilge is cleaned, the waste material must not be dumped into the water.
4. Fuel tanks must not be overfilled and space must be left for expansion if the fuel warms up.
5. Vent pipes should not be obstructed and fuel needs to be dispensed at a correct rate to prevent "blow-back".
6. Empty oil cans must be deposited in a leak-proof receptable, and,
7. Slow down and save fuel.

EUTROPHICATION OR EXCESSIVE FERTILIZATION AND LAKE PROCESSES

In recent years, cottagers have become aware of the problems associated with nutrient enrichment of recreational lakes and have learned to recognize many of the symptoms characterizing nutrient enriched (eutrophic) lakes. It is important to realize that small to moderate amounts of aquatic plants and algae are necessary to maintain a balanced aquatic environment. They provide food and a suitable environment for the growth of aquatic invertebrate organisms which serve as food for fish. Shade from large aquatic plants helps to keep the lower water cool, which is essential to certain species of fish and also provides protection for young game and forage fish. Numerous aquatic plants are utilized for food and/or protection by many species of waterfowl. However, too much growth creates an imbalance in the natural plant and animal community particularly with respect to oxygen conditions, and some desirable forms of life such as sport fish are eliminated and unsightly algae scums can form. The lake will not be "dead" but rather abound with life which unfortunately is not considered aesthetically pleasing. This change to poor water quality becomes apparent after a period of years during which extra nutrients are added to the lake and return to the natural state may also take a number of years after the nutrient inputs are stopped.

Changes in water quality with depth are a very important characteristic of the lake. Water temperatures are uniform throughout the lake in the early spring and winds generally keep the entire volume well mixed. Shallow lakes may remain well mixed all summer so that water quality will be the same throughout. On the other hand, in deep lakes, the surface waters warm up during late spring and early summer and float on the cooler more dense water below. The difference in density offers a resistance to mixing by wind action and many lakes do not become fully mixed again until the surface waters cool down in the fall. The bottom water receives no oxygen from the atmosphere during this unmixed period and the dissolved oxygen supply may be all used up by bacteria as they decompose organic matter. Cold water fish, such as trout, will have to move to the warm surface waters to get oxygen and because of the high water temperatures they will not thrive, so that the species will probably die out (see Figure next page).

Low oxygen conditions in the bottom waters are not necessarily an indication of pollution but excessive aquatic plant and algae growth and subsequent decomposition in the bottom waters can aggravate the condition and in some cases result in zero oxygen levels in lakes which had previously held some oxygen in the bottom waters all summer. Although plant nutrients normally accumulate in the bottom waters of the lakes, they do so to a much greater extent if there is no oxygen present. These nutrients become available for algae in the surface waters when the lake mixes in the fall and dense algae growths can result.

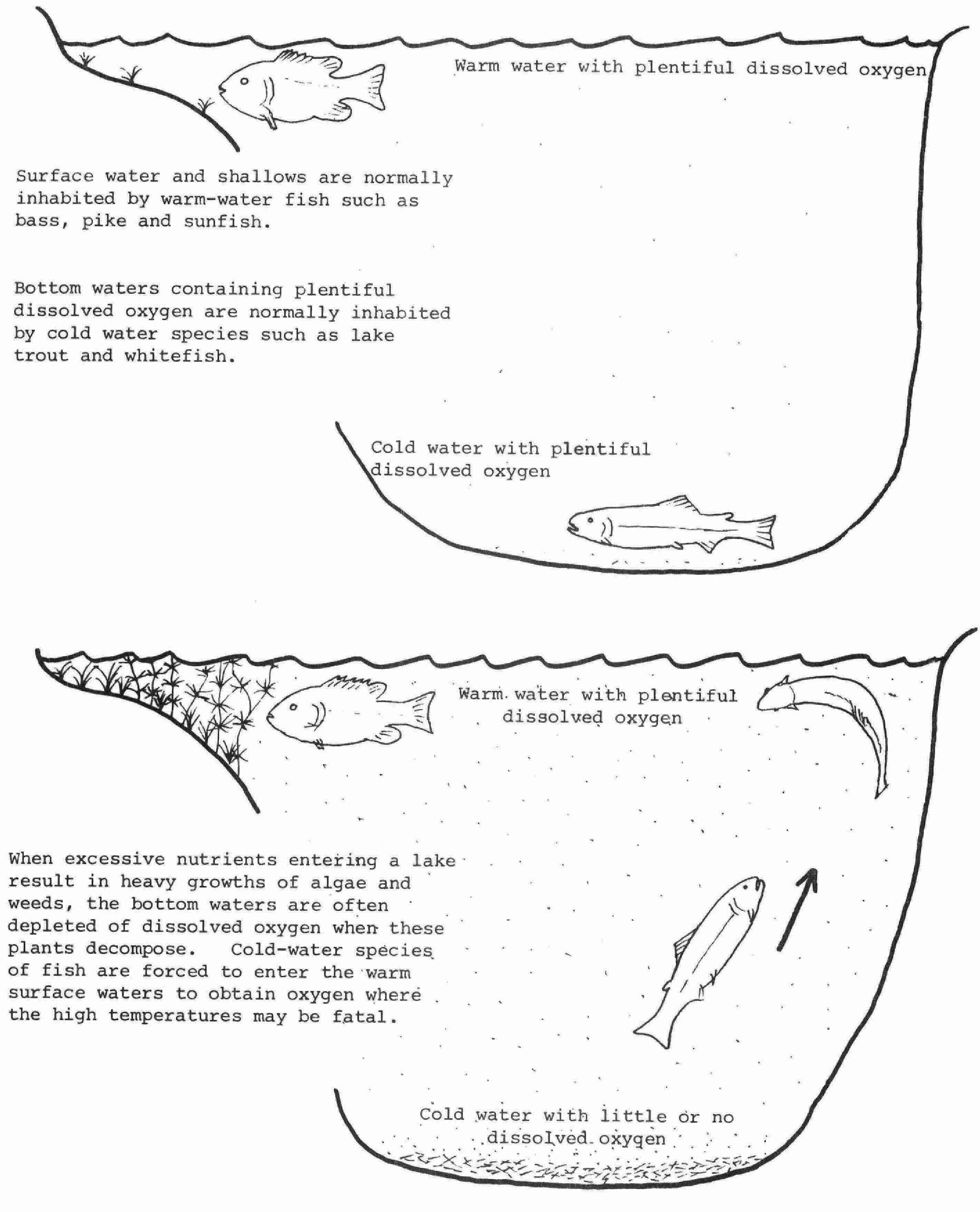


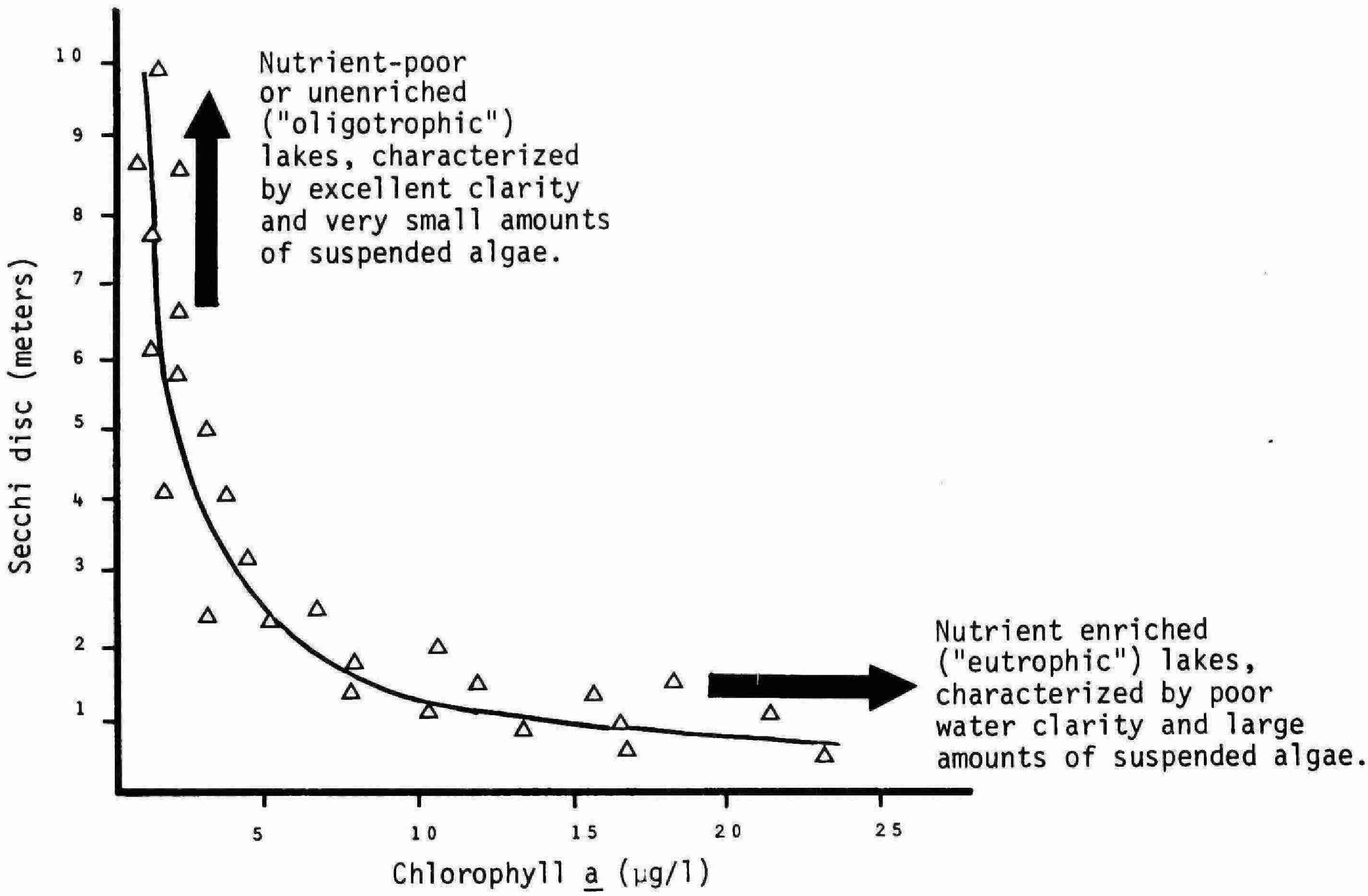
FIGURE A-1: DECOMPOSITION OF PLANT MATTER AT THE LAKE BOTTOM CAN LEAD TO DEATH OF DEEP-WATER FISH SPECIES.

Consequently, lakes which have no oxygen in the bottom water during the summer are more prone to having algae problems and are more vulnerable to nutrient inputs than lakes which retain some oxygen.

Like humans, aquatic plants and algae require a balanced "diet" for growth. Other special requirements including those for light and temperature are specific for certain algae and plants. Chemical elements such as nitrogen, phosphorus, carbon, and several others are required and must be in forms which are available for uptake by plants and algae. Growth of algae can be limited by a scarcity of any single "critical" nutrient. Nitrogen and phosphorus are usually considered "critical" nutrients because they are most often in scarce supply in natural waters, particularly in lakes in the Precambrian area of the province. Phosphorus, especially is necessary for the processes of photosynthesis and cell division. Nitrogen and phosphorus are generally required in the nitrate-N (or ammonia-N) and phosphate forms and are present in natural land runoff and precipitation. Human and livestock wastes are a very significant source of these and other nutrients for lakes in urban and agricultural areas. It is extremely important that cottage waste disposal systems function so that seepage of nutrients to the lake does not occur since the changes in water quality brought about by excessive inputs of nutrients to lakes are usually evidenced by excessive growths of algae and aquatic plants.

The large amounts of suspended algae which materialize from excessive inputs of nutrients, result in turbid water of poor clarity or transparency. On the other hand, lakes with only small, natural inputs of nutrients and correspondingly low nutrient concentrations (characteristically large and deep lakes) most often support very small amounts of suspended algae and consequently, are clear-water lakes. An indication of the degree of enrichment of lakes can therefore be gained by measuring the density of suspended algae (as indicated by the chlorophyll a concentration - the green pigment in most plants and algae) and water clarity (measured with a Secchi disc). In this regard, staff of the Ministry of the Environment have been collecting chlorophyll a and water clarity data from several lakes in Ontario and have developed a graphical relationship between these parameters which is being used by cottagers to further their understanding of the processes and consequences of nutrient enrichment of Precambrian lakes. The figure on the next page illustrates the above-mentioned relationship.

In the absence of excessive coloured matter (eg. drainage from marshlands), lakes which are very low in nutrients are generally characterized by small amounts of suspended algae (i.e. chlorophyll a) and are clear-water lakes with high Secchi disc values. Such lakes, with chlorophyll a and Secchi disc values lying in the upper left-hand area of the graph are unenriched or nutrient poor ("oligotrophic") in status and do not suffer from the problems associated with excessive inputs of nutrients. In contrast, lakes with high chlorophyll a concentrations and poor clarity are positioned in the lower right-hand area of the graph and are enriched ("eutrophic"). These lakes usually exhibit symptoms of excessive nutrient enrichment including water turbidity owing to large amounts of suspended algae which may float to the surface and accumulate in sheltered areas around docks and bays.



Measurements of suspended algal density (chlorophyll a) and water clarity are especially valuable if carried out over several years. Year to year positional changes on the graph can then be assessed to determine whether or not changes in lake water quality are materializing so that remedial measures can be implemented before conditions become critical.

CONTROL OF AQUATIC PLANTS AND ALGAE

Usually aquatic weed growths are heaviest in shallow shoreline areas where adequate light and nutrient conditions prevail.

Extensive aquatic plant and algal growths sometimes interfere with boating and swimming and ultimately diminish shoreline property values.

Control of aquatic plants may be achieved by either chemical or mechanical means. Chemical methods of control are currently the most practical, considering the ease with which they are applied. However, the herbicides and algicides currently available generally provide control for only a single season. It is important to ensure that an algicide or herbicide which kills the plants causing the nuisance, does not affect fish or other aquatic plants. Chemical control in the province is regulated by the Ministry of the Environment and a permit must be granted prior to any operation. Simple raking and chain dragging operations to control submergent species have been successfully employed in a number of situations; however, the plants soon re-establish themselves. Removal of weeds by underwater mowing techniques is certainly the most attractive method of control and is currently being evaluated in Chemung Lake near Peterborough. Guidelines and summaries of control methods, and applications for permits are available from the Pesticides Control Section, Pollution Control Branch, Ministry of the Environment, 135 St. Clair Avenue West, Toronto, Ontario M4V 1P5.

PHOSPHORUS AND DETERGENTS

Scientists have recognized that phosphorus is the key nutrient in stimulating algal growth in lakes and streams.

In past years, approximately 50 percent of the phosphorus contributed by municipal sewage was added by detergents. Federal regulations reduced the phosphate content (as P_2O_5) in laundry detergents from approximately 50 percent to 20 percent on August 1, 1970 and to 5 percent on January 1, 1973.

It should be recognized that automatic dishwashing compounds were not subject to the government regulations and that surprisingly high numbers of automatic dishwashers are present in resort areas (a questionnaire indicated that about 30 percent of the cottages in the Muskoka lakes have automatic dishwashers). Cottagers utilizing such conveniences may be contributing significant amounts of phosphorus to recreational lakes because automatic dishwashing compounds are characteristically high in phosphorus. Indeed, in most of Ontario's vacation land, the source of domestic water is soft enough to allow the exclusive use of liquid dishwashing compounds, soap and soap-flakes which are, in general, relatively low in phosphorus.

ONTARIO'S PHOSPHORUS REMOVAL PROGRAMME

By 1975, the Government of Ontario expects to have controls in operation at more than 200 municipal wastewater treatment plants across the province serving some 4.7 million persons. This represents about 90 percent of the population serviced by sewers. The programme is in response to the International Joint Commission recommendations as embodied in the Great Lakes Water Quality Agreement and studies carried out by the Ministry of the Environment on inland recreational waters which showed phosphorus to be a major factor influencing eutrophication. Specifically, the programme makes provision for nutrient control in the Upper and Lower Great Lakes, the Ottawa River system and in prime recreational waters where the need is demonstrated or where emphasis is placed upon prevention of localized, accelerated eutrophication.

Phosphorus removal facilities became operational at wastewater treatment plants on December 31, 1973, in the most critically affected areas of the province, including all the plants in the Lake Erie drainage basin and the inland recreational areas. The operational date for plants discharging to waters deemed to be in less critical condition, which includes plants larger than one million gallons per day (1 mgd) discharging to Lake Ontario and to the Ottawa River system, is December 31, 1975. The 1973 phase of the programme involved 113 plants, of which 48 are in prime recreational areas. An additional 53 new plants, each with phosphorus removal, are now under development, 23 of which are located in recreational areas. The capacities of these plants range from 0.04 to 24.0 mgd, serving an estimated population of 1,600,000 persons.

The 1975 phase will bring into operation another 54 plants ranging in size from 0.3 to 180 mgd serving an additional 3,100,00 persons. Treatment facilities utilizing the Lower Great Lakes must meet effluent guidelines of less than 1.0 milligram per litre of total phosphorus in their final effluent. Facilities utilizing the Upper Great Lakes, the Ottawa River Basin and certain areas of Georgian Bay where needs have been demonstrated must remove at least 80 percent of the phosphorus reaching their sewage treatment plants.

CONTROL OF BITING INSECTS

Mosquitoes and blackflies often interfere with the enjoyment of recreational facilities at the lake-side vacation property. Pesticidal spraying or fogging in the vicinity of cottages produces extremely temporary benefits and usually do not justify the hazard involved in contaminating the nearby water. Eradication of biting fly populations is not possible under any circumstances and significant control is rarely achieved in the absence of large-scale abatement programs involving substantial funds and trained personnel. Limited use of approved larvicides in small areas of swamp or in rain pools close to residences on private property may be undertaken by individual landowners, but permits are necessary wherever treated waters may contaminate adjacent streams or lakes. The use of repellents and light traps is encouraged as are attempts to reduce mosquito larval habitat by improving land drainage. Applications for permits to apply insecticides as well as technical advice can be obtained from the Ministry of the Environment, Pesticides Control Service, 3rd Floor, 1 St. Clair Avenue West, Toronto, Ontario.