ONTARIO

Ministry of the
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Report on Water Quality in Loughborough Lake 1972

REPORT on WATER QUALITY

in

LOUGHBOROUGH LAKE

1972

GENERAL TABLE OF CONTENTS

LIST OF FIGURES	ii
PREFACE	iii
SUMMARY	v
PURPOSE OF THE SURVEYS	1
DESIGN OF THE SURVEYS	
Timing	2
Selection of Sample Locations	2
Field Tests	5
Bacteriological Tests	5
Chemical Tests	5
DESCRIPTION OF LOUGHBOROUGH LAKE AREA	
Lake and Soil Characteristics	5
Shoreline Development and Water Usage	6
RESULTS AND DISCUSSION	
Bacteriology	9
Chemistry	13
Aquatic Weeds in Shoreline Areas	18
FUTURE CONSIDERATIONS	19
TABLE I A List of Aquatic Weeds Found in Loughborough Lake	20
INFORMATION OF GENERAL INTEREST TO COTTAGERS	
Microbiology of Water	A-1
Rainfall and Bacteria	A-2
Water Treatment	A-2
Septic Tank Installations	A-4
Dye Testing of Septic Tank Systems	A-5
Boating Regulations	A-6
Ice Oriented Recreational Activities	A-7
Eutrophication or Excessive Fertilisation and Lake Processes	A-7
Control of Aquatic Plants and Algae	A-10
Phosphorus and Detergents	A-10
Ontario's Phosphorus Removal Program	A-11
Control of Biting Insects	A-12

LIST OF FIGURES

Figure 1	Use of Secchi Disc to Determine Water Clarity	4
Figure 2	Soil Types near Loughborough Lake	7
Figure 3	Cottage Development and Contours of Loughborough Lake	8
Figure 4	May Bacteriological Survey	11
Figure 5	July Bacteriological Survey	12
Figure 6	The Mean of Chlorophyll a and Secchi Disc Measurements in Loughborough Lake Relative to a Curve describing the Chlorophyll a - Secchi Disc Relationship in Many Ontario Lakes	15
Figure 7	Dissolved Oxygen and Temperature Profiles at Station 8	16
Figure 8	Dissolved Oxygen and Temperature Profiles at Station 45	17
Figure 9	Major Areas of Shoreline Aquatic Plant Growth	21
Figure 10	Photographs of Some Common Aquatic Plants Found in Loughborough Lake	22
Figure 11	Photographs of Some Common Aquatic Plants Found in Loughborough Lake	25

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 many 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 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 ever 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 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, 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 Loughborough Lake is one of a series dealing with the water quality aspects of the recreational lakes studied in 1972. As well as defining the present status of water quality in the lakes, the data are meant to provide an historical reference for comparison of conditions at any future time.

SUMMARY

Surveys were carried out in Loughborough Lake in 1972 in May, July, and September, to evaluate the present status of the water quality with respect to bacteria, algae and aquatic plant growth. Plant nutrient and dissolved oxygen concentrations in the surface and bottom waters were determined.

The lake is in Frontenac County and lies within two distinct bedrock regions in an area characterized by shallow, well-drained soil, rolling terrain, and frequent marshy areas. The shoreline is generally steeply sloping and has soil cover less than the 1.5 meters (5 feet) required by the Ministry of the Environment for the installation of standard subsurface septic tank systems.

The bacteriological water quality was generally good; however, during the July survey there were indications of more bacteria gaining access to the lake, probably due to runoff washed in by the rainfall two days prior to the survey. The lack of rainfall during the surveys means that the results are essentially representative of dry weather conditions.

Chemical water quality was also good and low numbers of algae were present in the water. Dissolved oxygen concentrations were generally high but by September had decreased in the bottom waters of the Western Basin to minimum concentrations required for supporting sensitive fish such as trout.

Aquatic plants of at least 10 different species were visible in shallow areas near the inlets.

PURPOSE OF THE SURVEY5

The surveys were designed, and tests selected, in order to evaluate the present conditions in the lakes with respect to:

- concentration of bacteria
- plant nutrients and algae
- water quality with depth
- density and species of aquatic plants
- inventory of shoreline development

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. The two problems can result from a common or different source of pollution, but 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 if the water is used for drinking or swimming. This type of pollution can be remedied by preventing wastes from reaching the lake and water quality will return to satisfactory conditions since most disease causing bacteria do not persist in the lake.

Nutrient enrichment, or eutrophication, results from the addition of plant fertilizers which occur naturally and are also present in virtually all forms of raw or treated human wastes. High concentrations of these fertilizers (plant nutrients), mainly nitrogen and phosphorus, support extensive growths of rooted aquatic plants and of microscopic free-floating plants called algae. Eutrophication greatly affects the lake appearance but generally does not pose a health hazard. Problems due to nutrient enrichment are generally long lasting and may become irreversible.

Changes in water temperature, dissolved oxygen and quality with depth are very important characteristics of a lake and were examined in the surveys.

The growth of weeds along the shore was noted during the surveys. Aquatic weed beds provide shelter and food for many kinds of fish. Too much growth is undesirable since it can upset the oxygen balance in the lake and can interfere with recreational uses of the lake.

DESIGN OF THE SURVEYS

Timing

Five day bacteriological, chemical and biological surveys were carried out from May 11 to 15 and from July 5 to 9. The bacteria numbers were so low that only chemical samples were collected over a three day period from September 11 to 13.

A proper estimation of the bacterial population requires several measurements 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 will give reliable bacterial data.

Chemical samples were collected on the first and last days of the surveys at inlet and outlet stations and on the first, third and fifth days at the mid lake stations. Chlorophyll samples were collected each day at the inlet and mid lake stations.

Selection of Sample Locations

Forty nine bacteriological sample sites were established over the whole lake. Chemical samples were collected at 7 inlet stations, 2 outlet stations and at 4 mid-lake stations. In addition to these surface samples, chemical and bacteriological samples were taken from the bottom water at the mid-lake stations. Aquatic plant samples were collected in areas representative of sparse, medium and dense growth.

Field Tests

The temperature and dissolved oxygen values were measured at the deep water stations with an electronic probe lowered into the lake and water clarity was measured with a Secchi disc, (Figure 1). The pH and conductivity of the samples were measured in the field.

Bacteriological Tests

Three groups of bacteria were determined on each sample: total coliforms, fecal coliforms, fecal streptococci. These organisms are used as "indicators" of fecal contamination. 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. The total coliforms, fecal coliforms and fecal streptococci organisms are all indigenous to man and other warm blooded animals and are found in the colon and feces in tremendous numbers. Hence, these indicator organisms in the water denotes the presence of fecal contamination and hence the risk of disease causing organisms.

Standard plate count (SPC) determinations were made on some mid-lake stations in order to determine densities of some natural water bacteria. The SPC media will only support the growth of those organisms that don't require special nutrients, oxygen requirements and/or incubation temperatures.

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 depend on the mineral content.

Total and soluble phosphorus were measured in the inlet and bottom water

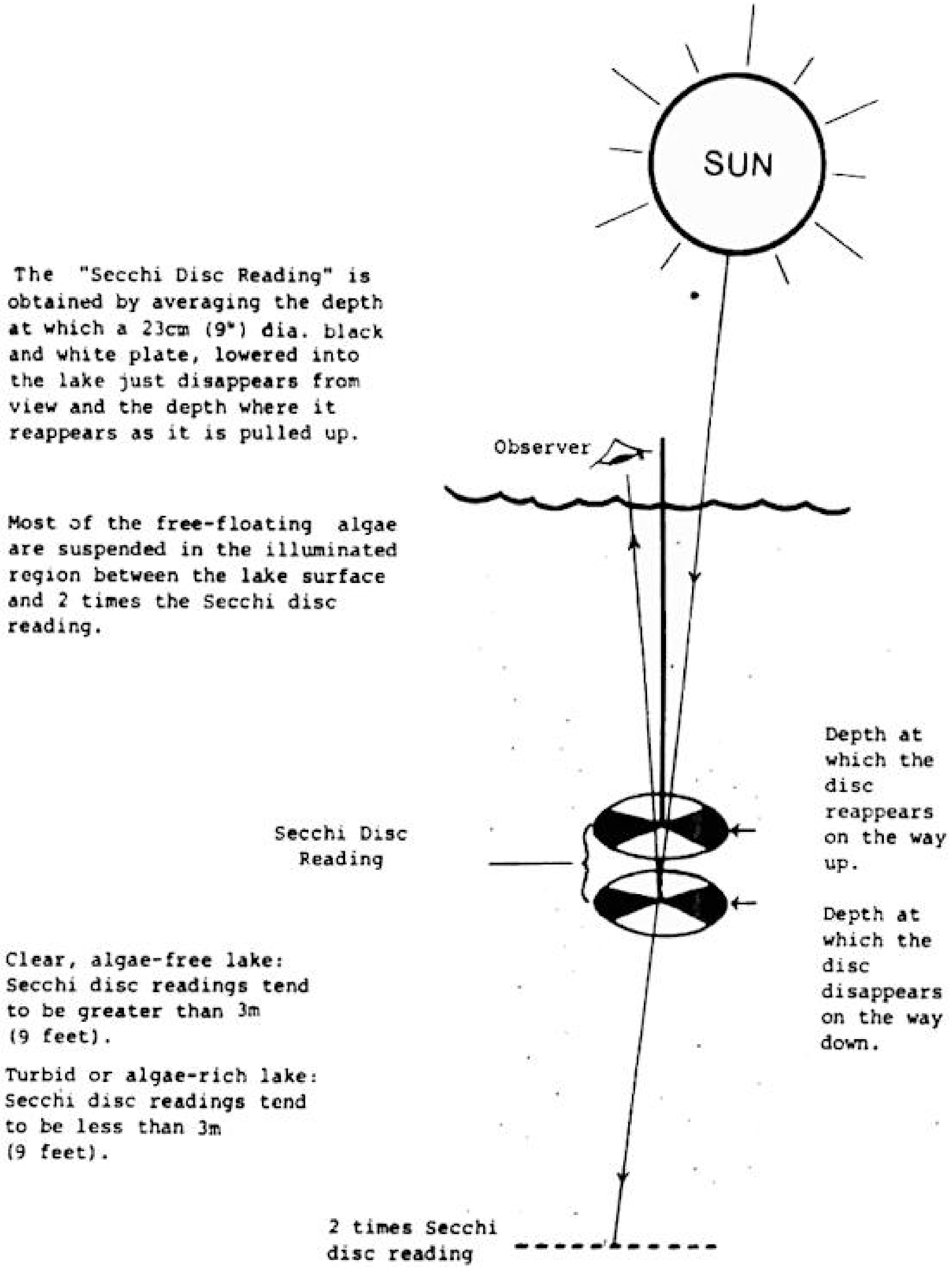

FIGURE 1: Use of Secchi Disc to determine water clarity.

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 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 is regenerated from decaying organic matter in these forms.

Chlorophyll a concentrations are an indication of the amount of algae in the water. The live algae are confined mainly to the lighted surface waters which extend down to a depth of about twice the Secchi disc reading. The chlorophyll samples were collected by raising the sample bottle through the depth of the illuminated zone as it filled. The sample was then representative of the average number of algae through the depth of the surface waters.

DESCRIPTION OF THE LOUGHBOROUGH LAKE AREA

Lake and Soil Characteristics

Loughborough Lake is approximately 16 kilometers (10 miles) north of Kingston in Storrington and Loughborough Townships, Frontenac County. The lake is about 26 kilometers (15 miles) long but only a few hundred meters wide except at Battersea Bay. The water surface area is 18 square kilometers (4,450 acres) contained by 101 kilometers (63 miles) of shoreline. There are two distinct basins which have different characteristics. The east basin has a mean depth of only 2 meters (7 feet) and a maximum depth of 6 meters (20 feet) while the west basin has a mean depth of 15 meters ('7 feet) and a maximum depth of 30 meters (126 feet). The east basin is 11 square kilometers.

The lake lies in a transition zone between two bedrock types. The Southern and Western half of the shoreline of the West Basin is underlain by Black River limestone. The remaining shoreline is mostly harder and less soluble Precambrian igneous and metamorphic bedrock. The topography of the limestone areas is flat to undulating while the Precambrian areas have rocky hills.

The soils of the area (Figure 2) are of a till nature and are generally less than the 1.5 meters (5 feet) in depth required by the Ministry of the Environment for the installation of standard subsurface septic tank systems. A large percentage of the shoreline soil is of the Farmington Series which consists of a shallow, well-drained, calcareous loam with depths from 10 to 50 centimeters (4 to 12 inches). The Rockland and Monteagle sandy loam-rock soil complexes both have numerous rock outcrops with the Monteagle soil complex having a greater ratio of soil to outcrop than the Rockland areas.

The third soil type of significance other than the muck and marsh areas, is the Bondhead sandy loam, shallow phase, which consists of 30 to 60 centimeters (1 to 2 feet) of well-drained, calcareous loam till. The shoreline is generally gradual to steeply sloping with farmland predominating above the bluffs in the western basin. The eastern basin is generally heavily wooded.

Shoreline Development and Water Usage

There are approximately 400 cottages on Loughborough Lake (Figure 3) with 150 grouped at the South-Western end of the lake and another 100 are grouped northwest of the Hamlet of Battersea. High bluffs along the north shore in the western basin of the lake and lack of road access along the eastern basin have restricted development in these areas. The lake is serviced by one marina near Battersea.

Most cottagers use the lake as their source of domestic water supply. Recreational uses of the lake include boating, swimming and angling.

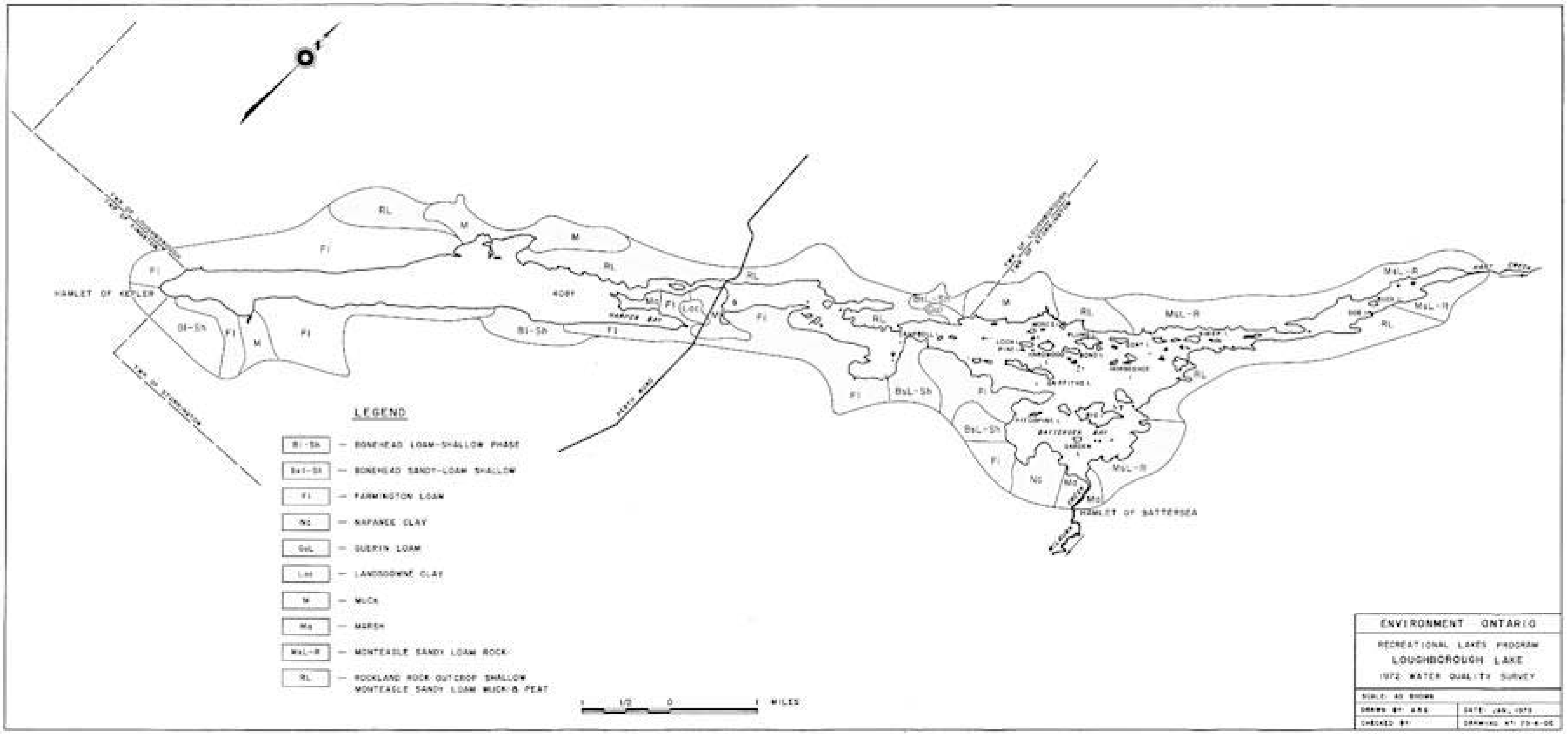

FIGURE 2: Soils Of The Loughborough Lake Area.

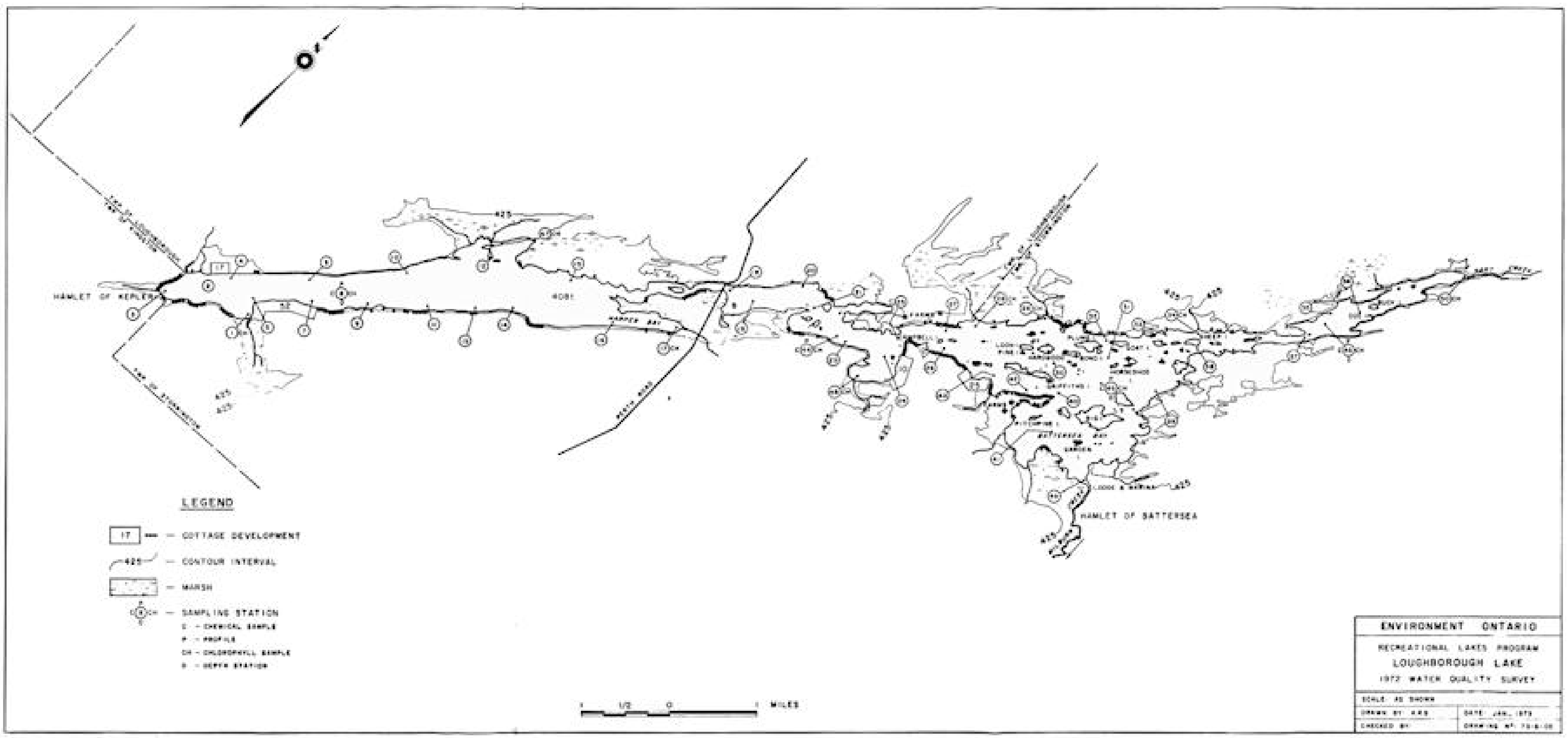

FIGURE 3: Cottage Development Around Loughborough Lake.

The common game fish are lake trout, large and smallmouth bass, pike and numerous coarse fish (1).

There are no direct discharges of wastes into Loughborough Lake from communal or municipal sewage treatment facilities and no pollution from the municipal solid waste disposal sites is apparent.

RESULTS AND DISCUSSION

Bacteriology

The quantities of bacteriological data necessitated statistical methods to summarize the results into a concise presentation without the inconsistency associated with manual interpretation. The methods used are based on the analysis of variance and Barlett's test of homogeneity by which stations on a lake can be grouped into areas with the same bacterial level. Areas or stations with only slight differences in bacterial concentration can be isolated. It was found on previous work that areas, or stations, with significantly higher bacterial numbers generally indicated a pollution input. Details of statistical methods and data are available on request.

Based on the data received from the 1972 spring and summer surveys, Loughborough Lake was exceptionally clean bacteriologically and well within the Ministry of the Environment Criteria which states: "Where ingestion is probable. recreational waters can be considered impaired when the coliform (TC), fecal coliform (FC), and/or enterococcus (FS) geometric mean density exceeds 1000, 100, and/or 20 per 100 ml, respectively" (2).

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(1) Loughborough Lake, Storrington and Loughborough Townships, Lake Survey, 1970, Ontario Department of Lands and Forests, 1970.

(2) Water quality Criteria, Ontario Ministry of the Environment, 1972.

In May, Loughborough Lake had an overall mean of 7 TC/100 ml with four minor exceptions (Figure 4). A mid-lake depth station, 80, and Station 14, both in the western basin had low levels of 1 TC/100 ml, while Stations 28 and 34 within the influence of two creeks had slightly higher levels. In July the TC counts increased slightly over the May survey. The Western Basin, (Group D), had 14 TC/100 ml, while the narrows (Group B) had 104 TC/100 ml and the Western Basin (Group A), had 35 TC/100 ml. Group C, adjacent to the hamlet of Battersea revealed significantly higher TC level of 204 TC/100 ml. However, these higher TC counts cannot be considered indicative of recent fecal pollution since fecal conforms were not encountered in these areas (Figure 5).

The water quality surveys were carried out in dry weather which would definitely reduce the amount of wastes being flushed into the water, and correspondingly, reduce the chances of detecting waste inputs. However, 0.25 inches of precipitation was measured at the Kingston and Hartington meteorological station on July 5. Total coliform levels were generally higher on the first day of the survey (July 5) at several stations. It could be speculated that these higher TC levels encountered on the first day of the survey may have been the residual indication of a large bacterial contamination washed in by the rainfall two days before the survey. However, there were no other indications of a bacterial input from cottaged shoreline.

For both the spring and summer surveys the fecal coliforms and fecal streptococcus counts were exceedingly low. The mean for both parameters during both surveys were 1/100 ml.

The mean Standard Plate Count densities at Stations 8, 44, 45 and 46, during the May survey were 1,140/100 ml, 7,100/100 ml, 1,260/100 ml, and 340/100 ml respectively. In July the SPC levels remained about the same at 1,220, 1,970, 1,360 and 810/100 ml respectively.

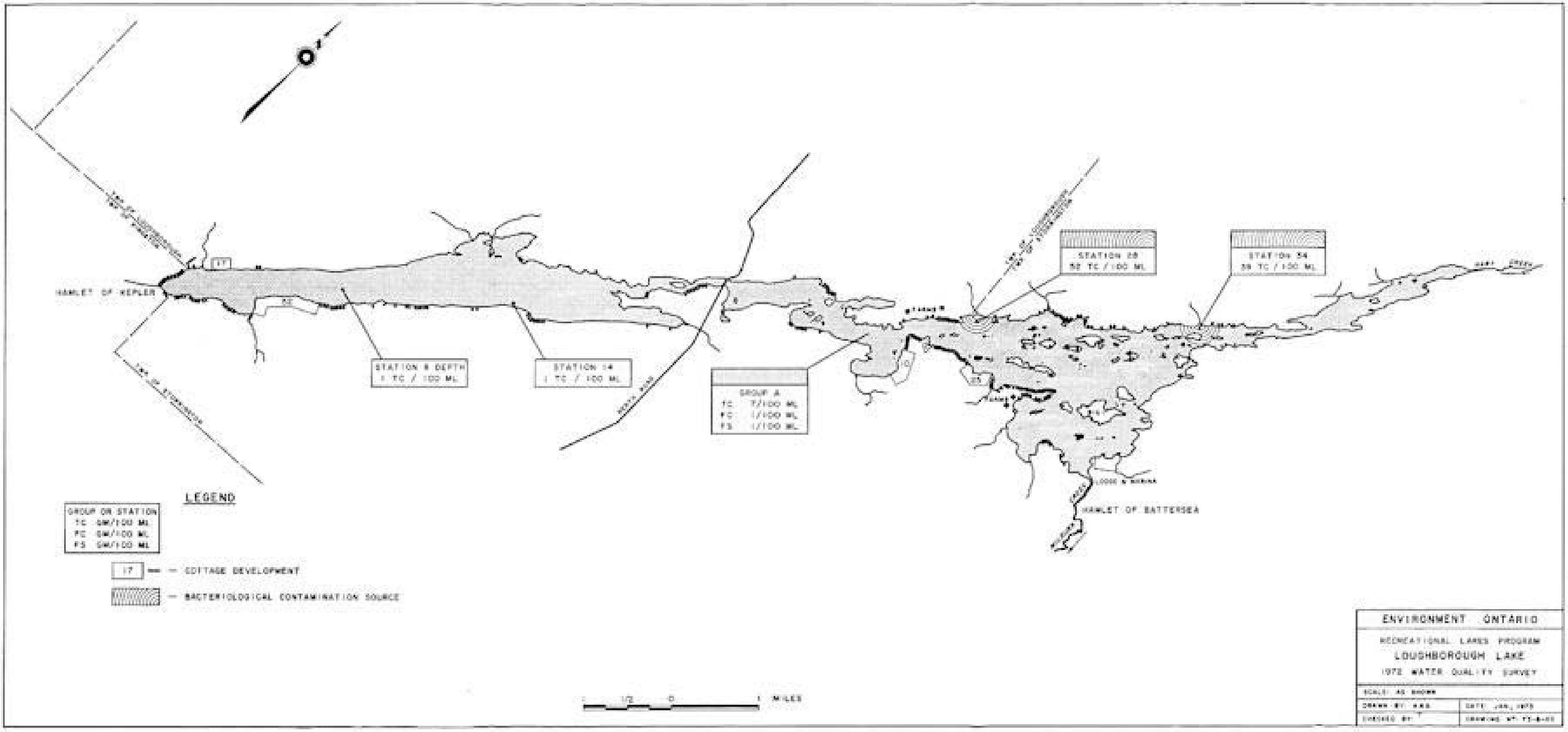

FIGURE 4: Survey A (May 11-15).

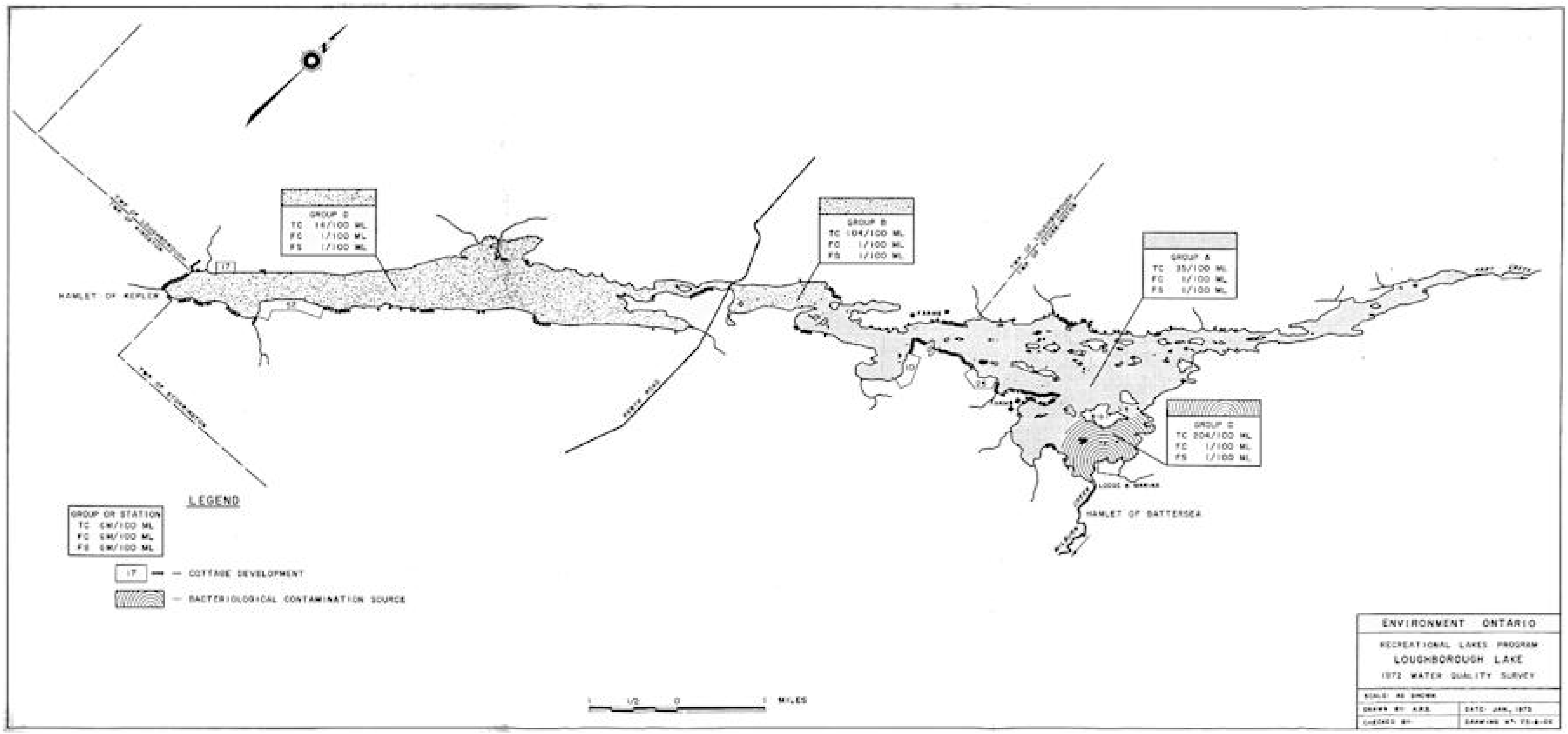

FIGURE 5: Survey B (July 5-9).

Chemistry

The chemical water quality was uniformly good during all three surveys.

The relatively hard water in the Western Basin, as a consequence of runoff from the limestone, is modified towards a somewhat softer character in the Eastern Basin by runoff from the hardrock areas.

Hardness Western Basin 127 to 230 mg/L as $CaCO_3$
Hardness Eastern Basin 90 to 120 mg/L as $CaCO_3$

Hard water is generally regarded as beneficial for fish production and Loughborough Lake does support a productive fishery, although the catchability of some desirable species such as Whitefish and Cisco has decreased (1).

The alkalinity and conductivity results correlate well with variations in hardness, and together with chloride and pH data indicate no unusual mineral water quality characteristics.

Overall ranges:

Alkalinity	-	74 to 216 mg/L as $CaCO_3$
Conductivity	-	183 to 428 µmhos/cm^3
Chloride	-	5 to 8 mg/L as Cl
pH	-	7.1 to 8.4 units

The hardness and alkalinity values decreased over the summer with mid-lake alkalinity averages for the three surveys of 119, 115, and 100 mg/L in the Western Basin and 93, 90 and 76 mg/L in the Eastern Basin respectively.

The nitrogen and phosphorus concentrations were low at the mid-lake stations and the levels near the inlets were within the range expected for natural runoff. There were a few samples from inlet Station 28 with higher concentrations of phosphorus but corresponding high iron values indicate natural conditions rather than a pollution source.

The chemical quality of the bottom waters was good with minimal accumulation of ammonia, iron and phosphorus. Nitrate nitrogen concentrations increased over the summer at Station 8 from 0.16 mg/L in May to 0.26 mg/L in September which is expected for a deep lake containing dissolved oxygen.

The chlorophyll a concentrations were low which would be expected from the low nitrogen and phosphorus values. Suspended algae cause turbidity in the water and therefore reduce the Secchi disc reading. A relationship between chlorophyll a and .Secchi disc was derived by Ministry of the Environment staff and the status of enrichment of Loughborough Lake relative to other well known lakes is shown in Figure 6. The status of enrichment of Loughborough Lake as reflected in water clarity and chlorophyll a concentrations is similar to that of Big Glamor, Balsam and Cameron Lakes, three relatively clear water lakes and is far removed from such highly enriched waters as the Western Basin of Lake Erie, Gravenhurst Bay and the Bay of Quinte.

The temperature data indicated the deep waters at Station 8 were not mixed during the summer and the dissolved oxygen was not all used. Approximately 50% (6 mg/L) of the oxygen remained during the September survey, however, this represents the minimum required for maintenance of sensitive fish species such as trout (2). The dissolved oxygen and temperature values for May and September are shown in Figure 7.

The temperature and dissolved oxygen conditions for Station 45 for all three surveys are shown in Figure 8. The temperature data shows that the water was well-mixed and the dissolved oxygen results possibly reflect effects of plant growth. The beginning of plant growth in may and the release of oxygen by the plants gives rise to the slightly higher dissolved oxygen concentrations near the bottom. In July, the photosynthetically active parts of the plants have grown up closer to the surface and give very high dissolved oxygen there with slightly lower values near the bottom. In September, the same pattern is shown as in July.

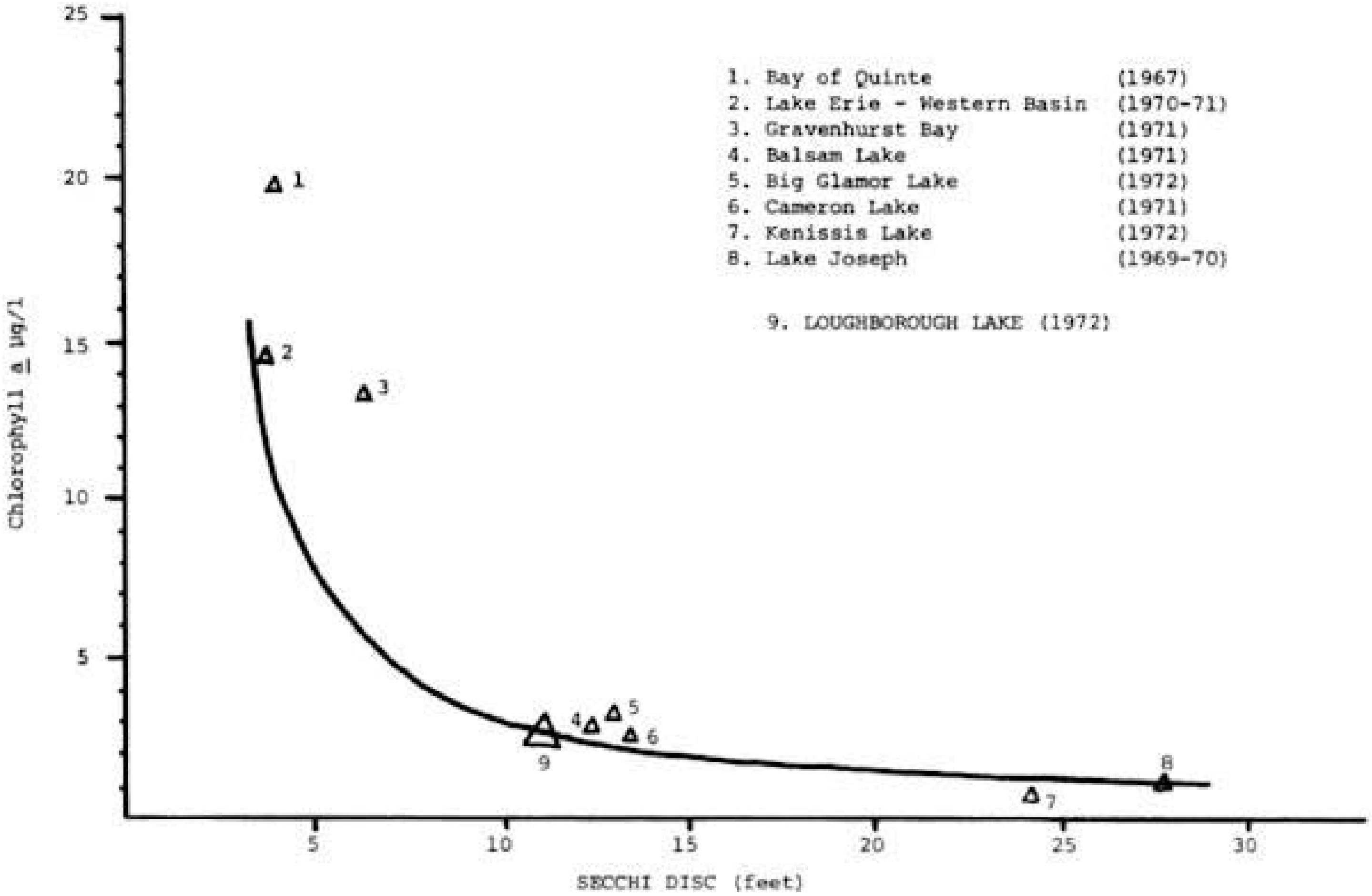

Figure 6: The mean of chlorophyll a and Secchi Disc measurements in Loughborough Lake relative to a curve describing the chlorophyll a - Secchi disc relationship in many Ontario lakes. Eight other well known lakes are included for comparison with Loughborough Lake.

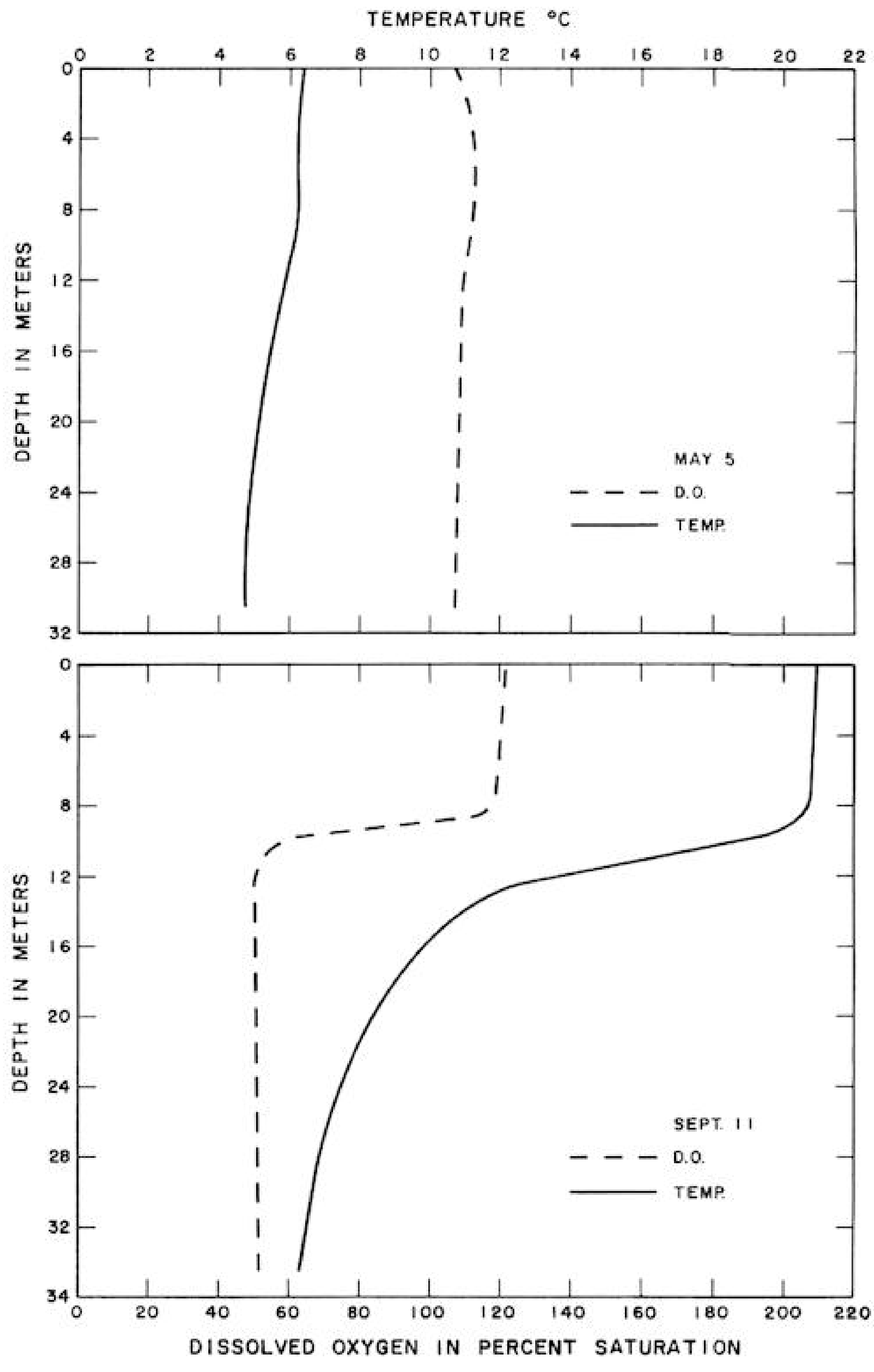

FIGURE 7: Dissolved Oxygen and Temperature Profiles at Station 8.

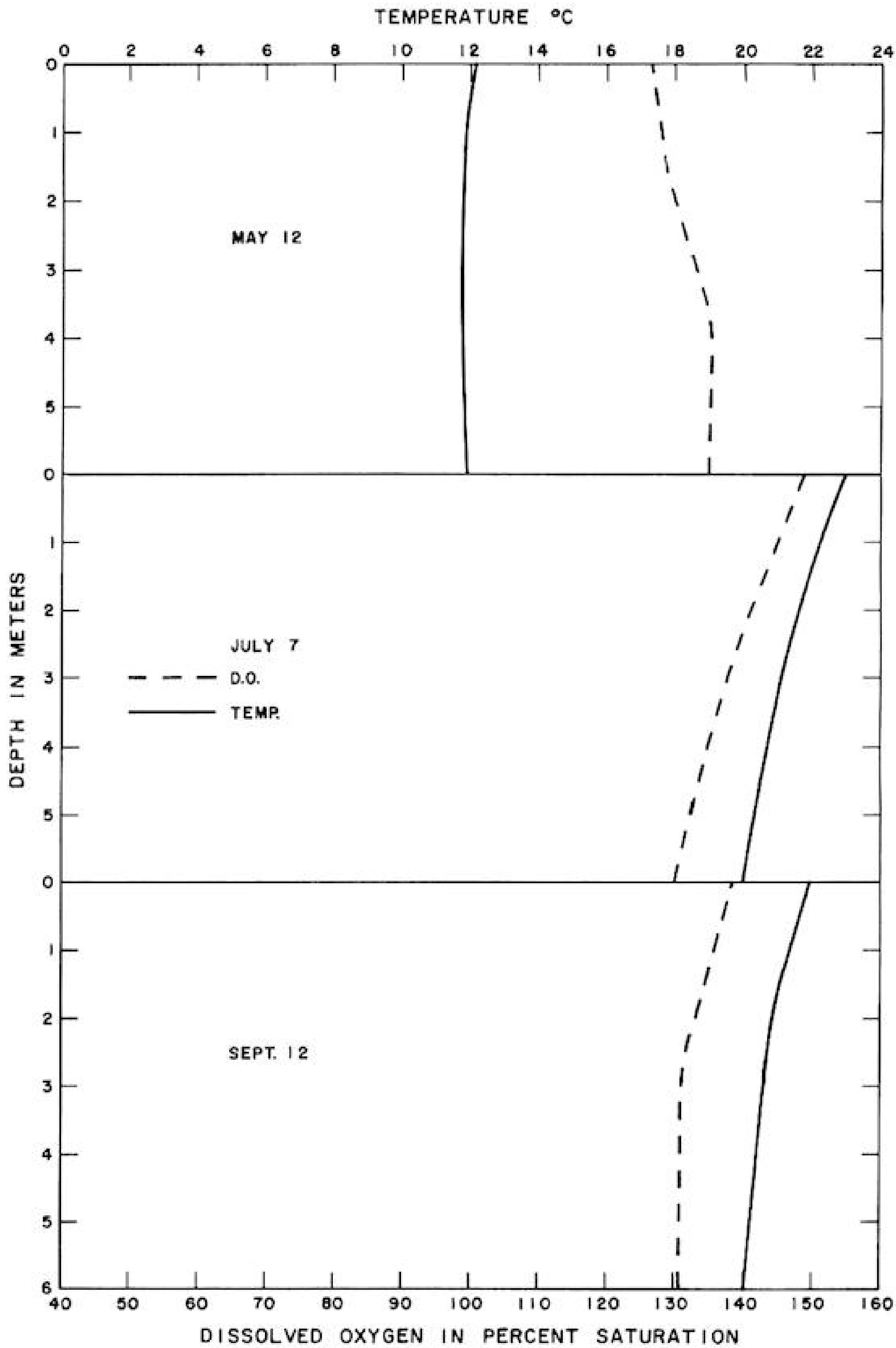

FIGURE 8: Dissolved Oxygen and Temperature Profiles at Station 45.

As the plants grow, they remove carbon dioxide from the water which causes the calcium bicarbonate $Ca(HCO_3)_2$ to decompose and this results in precipitation of insoluble calcium carbonate ($CaCO_3$) onto solid objects and onto the plants themselves. This is why many aquatic plants are white and brittle, they are encrusted with lime. This process is the most likely cause of the observed decrease in water alkalinity over the summer in Loughborough Lake.

When these plants die and decompose in the late fall and winter, the dissolved oxygen under the ice may fall to very low levels in the weed bed areas. For this reason, some samples will be collected under the ice in late winter in order to determine whether or not there is any serious oxygen depletion at that time.

The plants also release nitrogen. phosphorus and carbon dioxide as they decompose and these nutrients accumulate under the ice and support larger numbers of algae when the ice melts and sunlight reaches the water. Winter samples will indicate to what extent nutrients are building up under the ice.

Aquatic Weeds in Shoreline Areas

Aquatic weeds representing fourteen genera, from which ten different species were identified, were found in shoreline areas of Loughborough Lake (Table I). Some of the plants could only be identified to genus because of the lack of fruiting and flowering structures (e.g. milfoil. buttercup, bulrush). Figure 9 outlines the location and extent of the weed beds and lists the weeds found in each area. While this figure shows the distribution of the weeds, the density or dominance of any particular plant type was not determined.

Figures 10 and 11 are photographs of some of the more common weeds found in Loughborough Lake.

It is noteworthy that the major shoreline weed beds on the lake are found in or around the deltas of inflowing streams. Following heavy rainfalls, these streams likely carry a substantial sediment load which fall to the lake bottom at the mouth of the stream. Hence, a suitable substrate for aquatic plants in these shallow areas of Loughborough Lake has built un over the years. Nutrient input from the streams probably helps to maintain the growths of aquatic plants in the delta areas. The remaining weed beds in the lake were generally located in the shallow water along sheltered sections of shoreline, in bays or near protected islands.

FUTURE CONSIDERATIONS

Although the chemical biological and bacteriological conditions were generally quite good in Loughborough Lake, there does not appear to be any room for complacency with regard to recreational use and waste disposal.

The cottage pollution control survey carried out by the Private Waste and Water Management Branch classified 17 disposal systems as direct polluters and 202 as public health nuisances. One hundred and seventy four of the public health nuisances were discharging wastes directly on the ground. The rest had a variety of other objectionable features including systems too close to wells, ponding of tile beds, and inadequate leaching pits. Some cottages had more than one problem.

It is noteworthy that the water quality was good despite the large number of substandard waste disposal systems, The lack of rainfall immediately preceding and during the five day water quality surveys on Loughborough lake may have been responsible for the low numbers of bacteria found in the lake. Previous studies have indicated that during periods of rainfall, large numbers of bacteria may gain access to the lake from faulty waste disposal systems. It is strongly recommended that all people concerned carry out those remedial measures advised by staff of the Private Waste and Water Management Branch as soon as possible.

Table 1: A list of the aquatic weeds found in Loughborough Lake and the number of areas in which each plant type occurred. For convenience, the plants are divided into two categories: (a) submergent - aquatic weeds which live, for the most part, underwater and (b) emergent - aquatic weeds which produce floating or aerial leaves.

Scientific Name (Genus species)	Common Name (s)	Distribution (number of areas)
SUBMERGENT		
Ceratophyllum demersum	coontail	2
Chara spp. *	chara, stonewort	8
Anacharis canadensis	canada waterweed	2
Myriophyllum sp	milfoil	1
Najas flexilis	bushy pondweed	2
Potamogeton alphinus		1
P. amplifolius	big leaf pondweed, bass weed	3
P. richardsonii	richardson's pondweed	2
P. zosteriformis	flat-stemmed pondweed	5
Ranunculus spp	water buttercup	1
Utricularia vulgaris	bladderwort	1
Vallisneria americana	tapegrass, wild celery	4
EMERGENT		
Lemna trisulca	star duckweed	2
Nuphar sp.	yellow waterlily	2
Nymphaca sp.	white waterlily	3
Sagittaria sp.	arrowhead	1
Seirpus sp.	bulrush	7

* *Chara* is technically an alga, but because it grows in long strands it is most often classified as an aquatic weed.

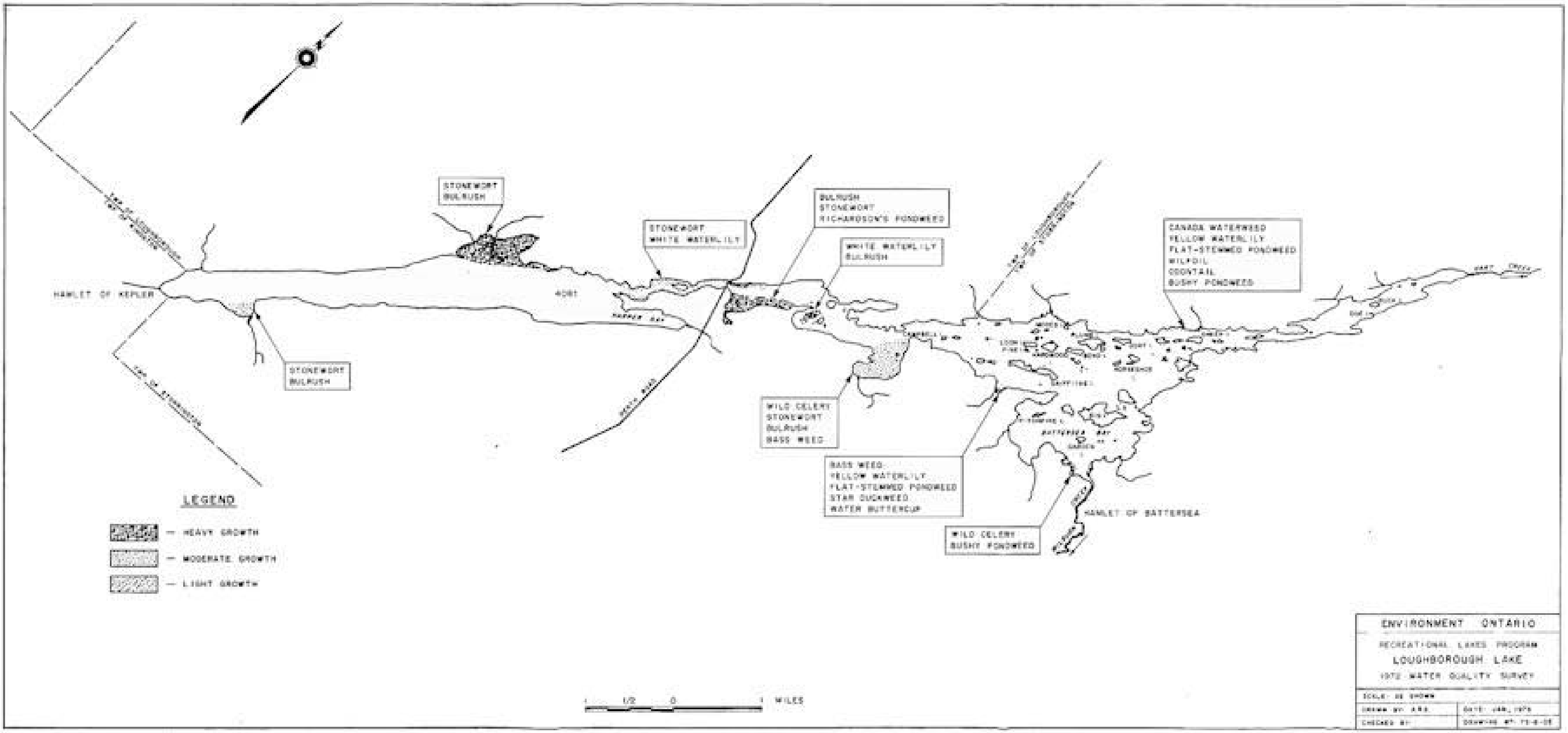

FIGURE 9: Major Areas of Shoreline Aquatic Plant Growth.

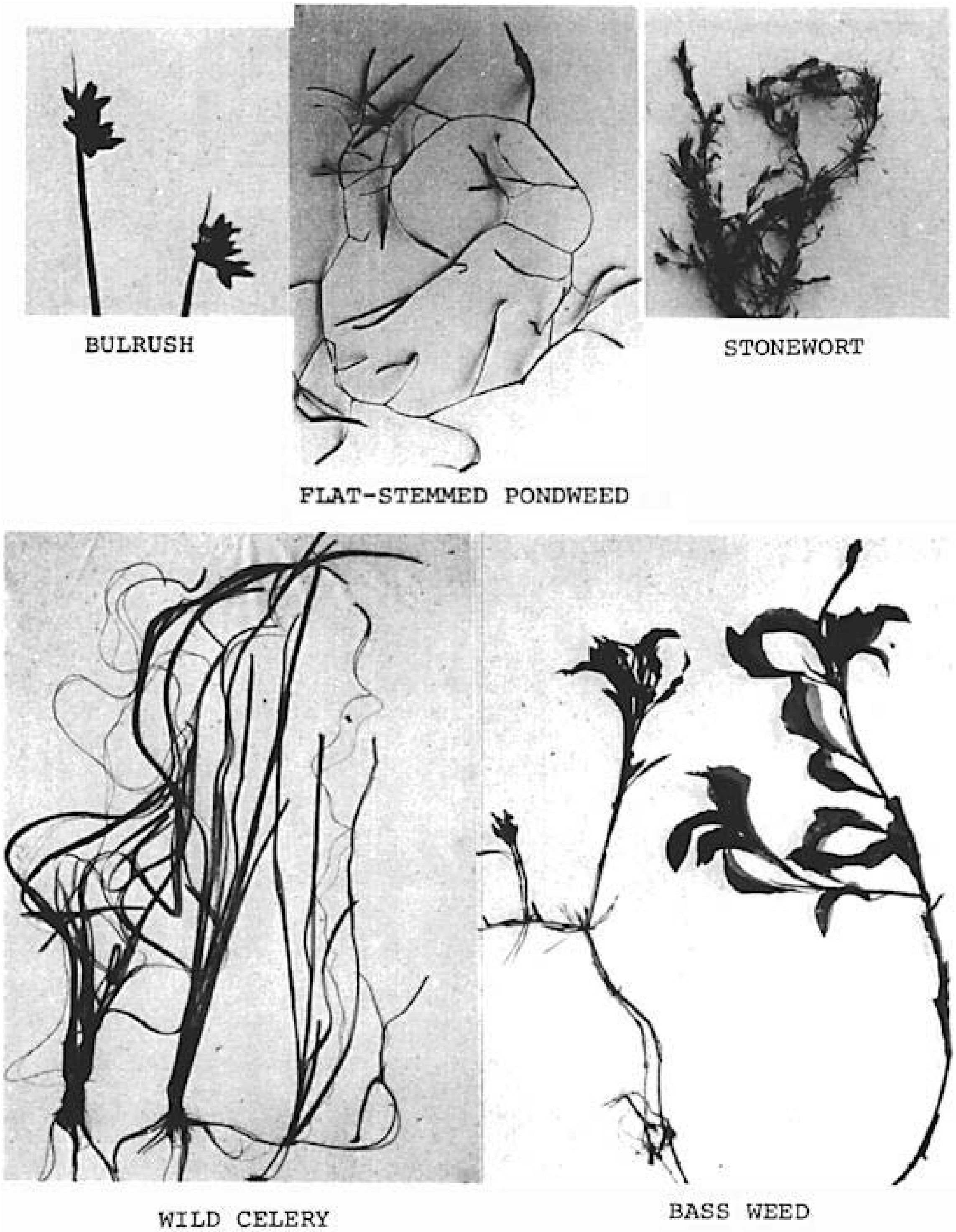

FIGURE 10: Photographs of some common aquatic plants found in Loughborough Lake.

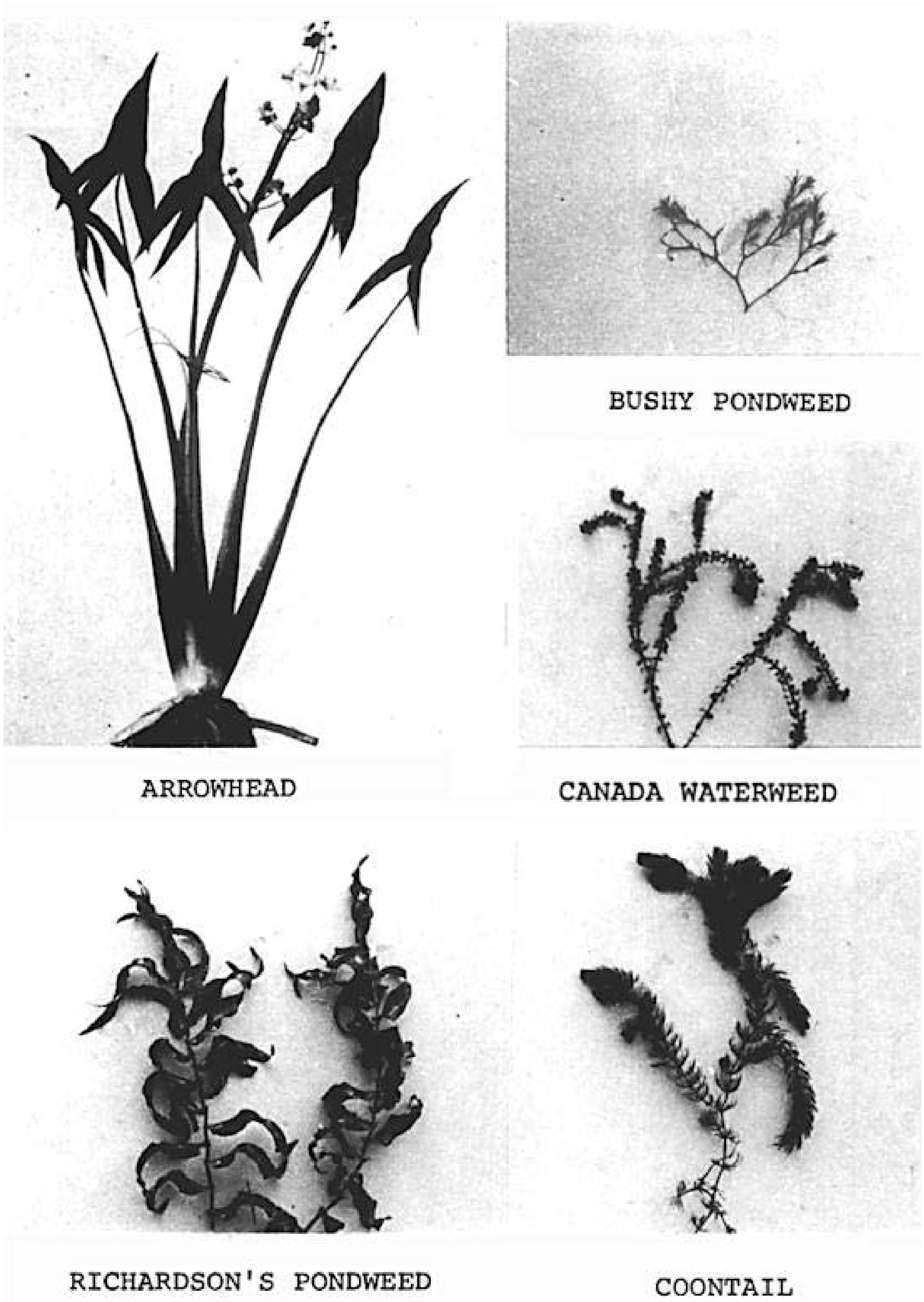

FIGURE 11: Photographs of some common aquatic plants found in Loughborough Lake.

INFORMATION OF GENERAL INTEREST TO COTTAGERS

MICROBIOLOGY OF WATER

For the sake of simplicity, the microorganisms 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 microorganisms, 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 do not change the appearance of the water but pose 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 waterborne infections such as typhoid fever, polio or hepatitis but he may catch lesser infections of gastroenteritis (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, subclinical infections usually associated with several water born viruses. These virus 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 1 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 he 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 amount 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.

The standard plate count (SPC) populations given in the text supply an indication of the number of these bacteria in the lake.

RAINFALL AND BACTERIA

The "Rainfall Effect" referred to in the text, relates to a phenomena 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. Tn 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 he 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.
Boll the water for a minimum of five minutes to destroy the disease causing organisms.

(b) Chlorination Using a Household Bleach containing 4 to 5¼% Available Chlorine.
Eight drops of a household bleach solution should be mixed with one gallon of water and allowed to stand for 1.5 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% 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	55 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 that you obtain permission in writing to install a septic tank system. Permission can be obtained from the local Medical Officer of Health or in some instances from the Regional Engineer of the Ministry of the Environment. Any other pertinent information such as sizes, types and location of septic tanks and tile fields can also be obtained from the same authority.

i) General Guidelines.

A septic tank should not be closer than:

- 50 feet to any well, lake, stream or pond.
- 5 feet to any building.
- 10 feet to any property boundary.

The tile field should not he 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.
- 10 feet to a property boundary.
- 50 feet to any lake, stream or pond.

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 he at least 5 feet of soil between the bottom of the weeping tile trenches and the top of the ground water table or bedrock.

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 only 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 REGULATION

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 equipment of a type approved by the Ministry of the Environment. Equipment which will be approved by the Ministry of the Environment includes: 1) retention devices with or without circulation which retain all toilet wastes for disposal ashore, and 2) incinerating devices which reduce all sewage to ash.

To be approved, equipment shall:

1) be non-portable,
2) be constructed of structurally sound material,
3) have adequate capacity for expected use,
4) be properly installed,
5) in the case of storage devices, 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 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 regards to 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 - Fuel hoses must be in good condition and all connections tight.
4 - If the bilge is cleaned prior to the boating season the waste material must not be dumped into the water.

5- Fuel tanks must not be overfilled and that space must be left for expansion if the fuel warms up.

6 - Vent pipes should not be obstructed and fuel needs to be dispensed at a correct rate to prevent "blow-back".

7 - Empty oil cans must be deposited in a leak-proof receptacle.

ICE-ORIENTED RECREATIONAL ACTIVITIES

The Ministry of the Environment is presently preparing regulations to control pollution from ice-oriented recreational activities. In past years, there has been indiscriminate dumping of garbage and sewage on the ice. The bottoms of fish huts have been left on the ice and become a navigational hazard to boaters in the spring. Broken glass has been left on the ice only to become injurious to swimmers. With the anticipated introduction of the regulations, many of these abuses will become illegal.

EUTROPHICATION OR EXCESSIVE FERTILIZATION AND LAKE PROCESSES

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.

Aquatic plants and algae are important in maintaining 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 provide 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 will abound with life which unfortunately is not considered aesthetically pleasing. This change to poor water quality becomes apparent after a period of years in which extra nutrients are added to the lake and a 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 a 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 don't 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 can aggravate the condition and in some cases can 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 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. 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.

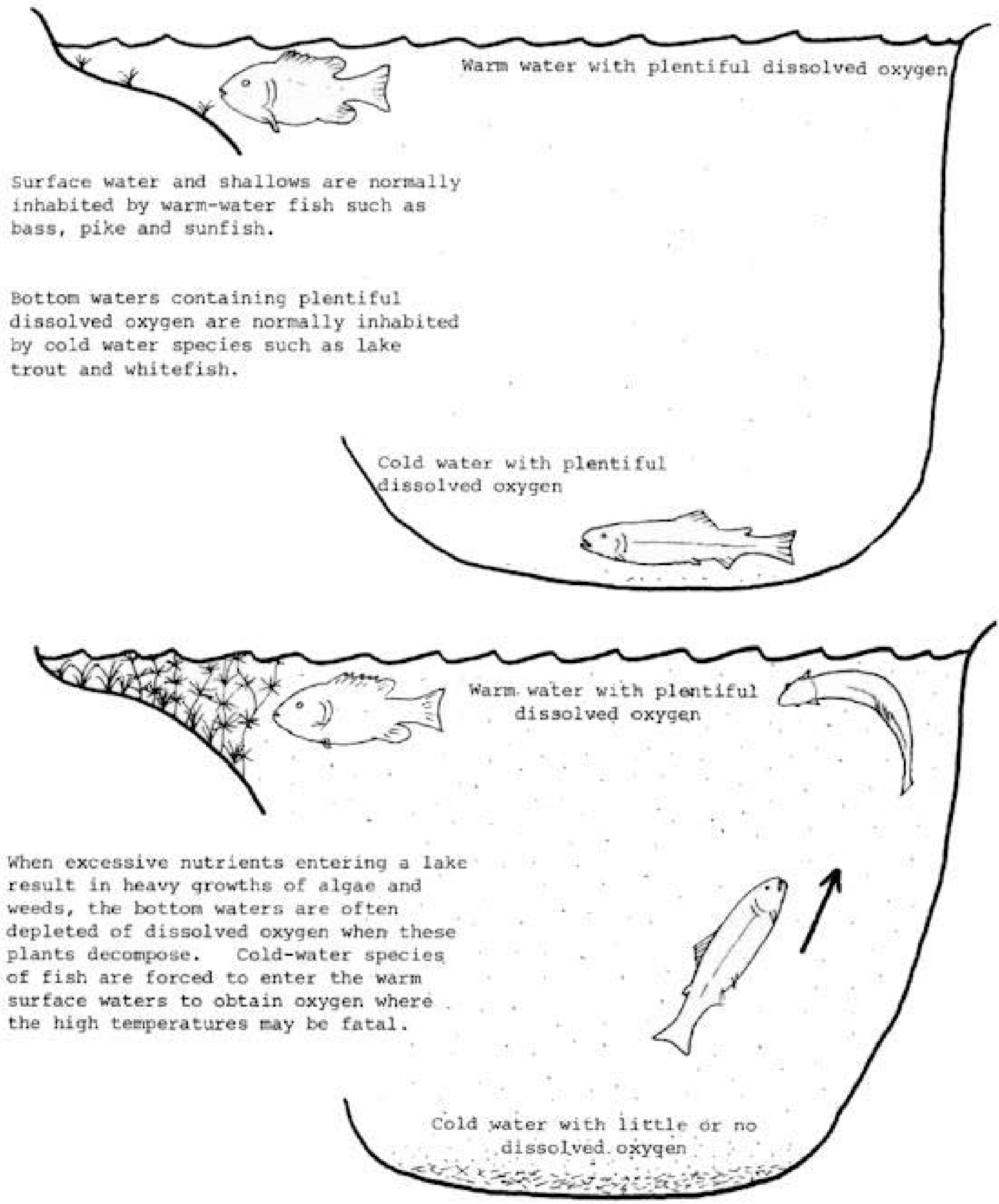

FIGURE A-1: Decomposition Of Plant Matter At The Lake Bottom Can Lead To Death Of Deep-water Fish Species.

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 life and should be reasonable in cost. At the present time there is no one chemical which will adequately control all species of algae and 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 Biology Section, Water Quality Branch, Ministry of the Environment, Box 215, Rexdale, Ontario.

PHOSPHORUS AND DETERGENTS

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

in past years approximately 50 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% to 20% on August 1, 1970 and to 5% on January 1, 1973.

It should be recognized that automatic dishwashing compounds were not subject to the recently approved government regulations and that surprisingly high number of automatic dishwashers are present in resort areas (a 1969 questionnaire indicated that about 501 of the cottages In the Muskoka Lakes have automatic dishwashers). Cottagers utilizing such conveniences may be contributing significant amounts of phosphorus to recreational lakes. 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.

ONTARIO'S PHOSPHORUS REMOVAL PROGRAM

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 per cent of the population serviced with sewers. The program 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. The program 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 eutrophication.

Phosphorus removal facilities must be operational at wastewater treatment plants by December 31, 1973 in the most critically affected areas of the Province, including all of 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 program will involve 156 plants of which 85 are in the Lake Erie basin and another 30 in the Lake Huron drainage basin. 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 57 plants ranging in size from 0.5 to 180 mgd serving an additional 3,100,000 persons. Treatment facilities utilizing the Lower Great Lakes must meet effluent guidelines of less than 1.0 milligrams 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 per cent 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 programmes 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 Biology Section, Water Quality Branch of the Ministry of the Environment, Box 215, Rexdale, Ontario.