A WATER QUALITY STUDY OF SANDY LAKE MANITOBA

A Project Report
Presented to
The Department of Civil Engineering
The Faculty of Engineering
The University of Manitoba

In Partial Fulfilment
of the Requirements for the Degree
of Bachelor of Science in Civil Engineering

by
Nancy Scott
October 29, 1992

A WATER QUALITY STUDY
OF
SANDY LAKE MANITOBA

A Project Report
Presented to
The Department of Civil Engineering
The Faculty of Engineering
The University of Manitoba

In Partial Fulfilment
of the Requirements for the Degree
of Bachelor of Science in Civil Engineering

by
Nancy Scott
October 29, 1992

ABSTRACT

A study was designed to develop recommendations to reduce the water quality deterioration of Sandy Lake. This involved determining the trophic state of the lake and providing forecasts of Sandy Lake's future. It was believed that if improved environmental regulations were not implemented, the aesthetic appeal of the area would decrease, public health safety may be at risk, property values would drop and the Town of Sandy Lake would experience socioeconomic stress.

Results concluded that Sandy Lake was an accelerating eutrophic lake. Excessive algae growth and noxious lake odors were a common occurrence within this populated area. Phosphorus was found to be the problem nutrient promoting the abundant growth.

Main point sources of the phosphorus input were septic fields, grey water fields and outhouses. Non point sources included agricultural runoff and wind transported sediment.

Recommendations formulated to reduce the high phosphorus overload were as follows:

1. Installation of water and sewer mainlines conecting to the Town services
2. Holding tank requirements
3. Location regulations - outhouses, septic and grey water fields
4. Provision of a Natural Filtration System
5. Use of a lake aeration System

In order to provide measurable recommendations a much more extensive investigation would be required to determine the phosphorus contribution of each source. This would highlight areas of great concern, allowing them to be dealt with immediately to decrease the eutrophication process.

ACKNOWLEDGEMENTS

This study would not have been completed without the guidance and support of many people. Their time and input was appreciated immensely. A special thanks is extended to Prof. Art Sparling for his assistance throughout the summer. I would also like to thank the following people for their help with data collections and analysis.

Mr. Bill Howard

Mr. Al Beck

Mr. Shane Hopkie

TABLE OF CONTENTS

REFERENCES

LIST OF TABLES

LIST OF FIGURES

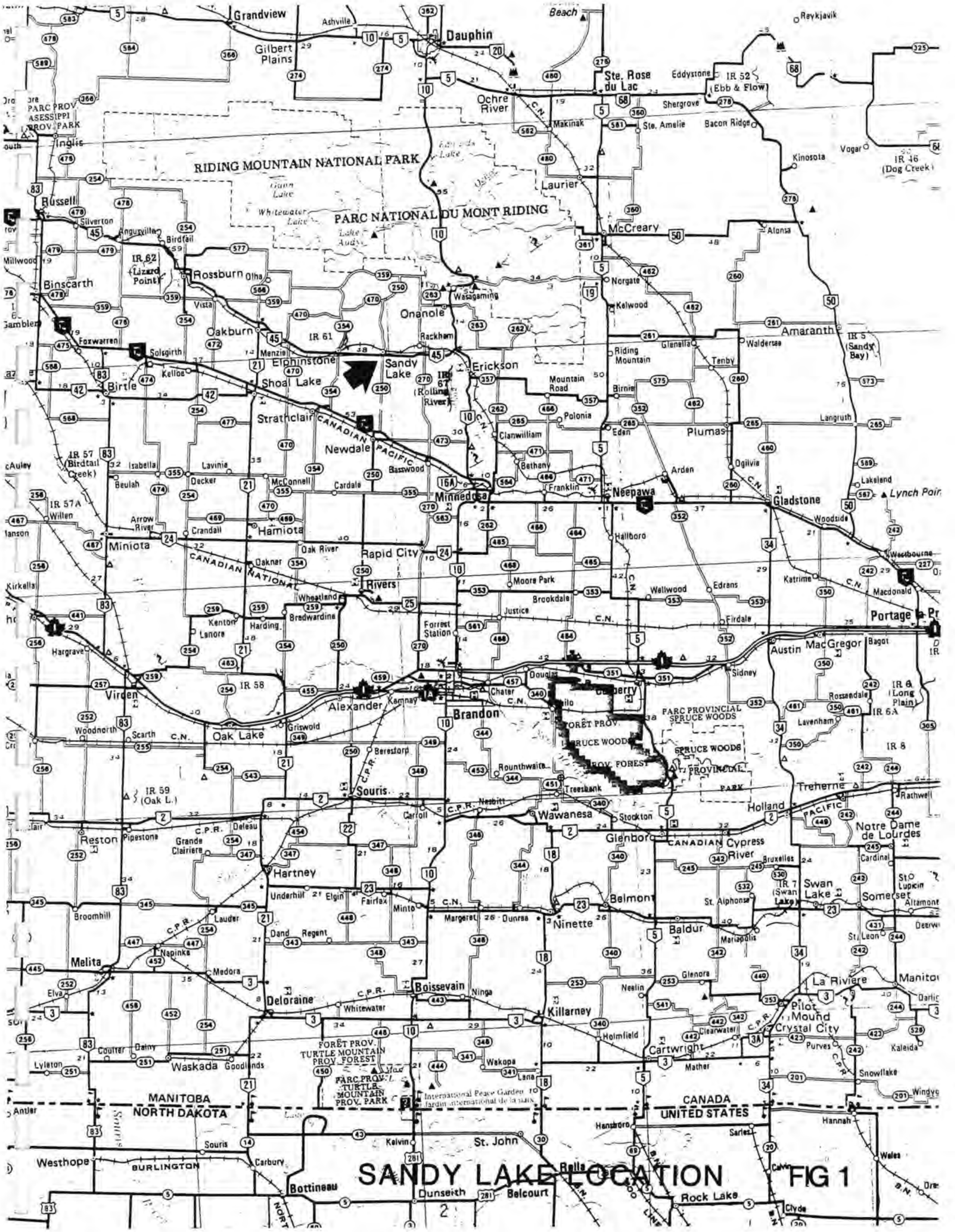
LIST OF ABBREVIATIONS AND SYMBOLS

D.O.	-	dissolved oxygen
CO_2	-	carbon dioxide
H_20	-	water
CH_20	-	carbohydrate (algae)
m	-	meters
km	-	kilometres
ft	-	feet
TSI	-	trophic state index
SD	-	seechi disk
Chl	-	chlorophyll a
n:p	-	nitrogen:phosphorus
CMR	-	calculated mass ratio

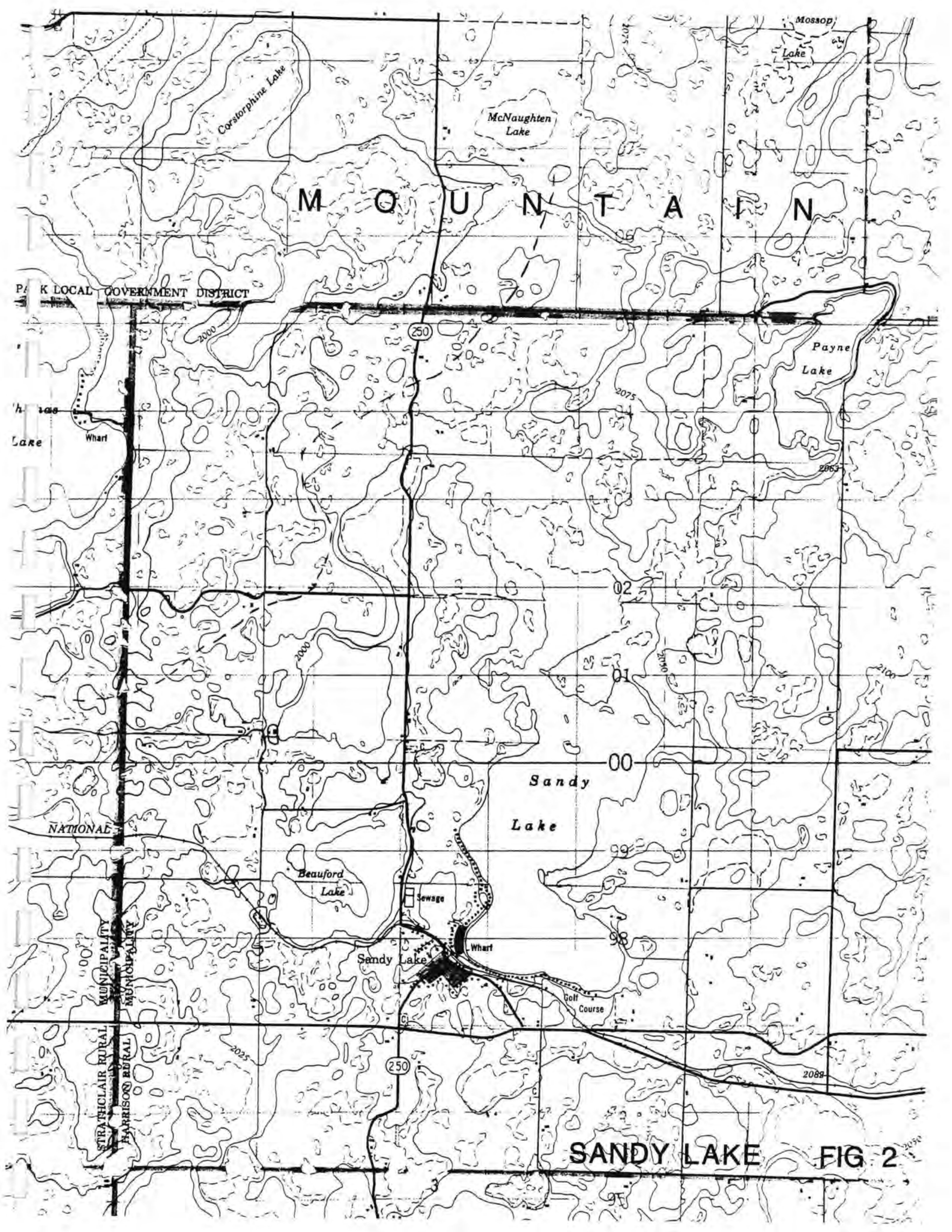
I. INTRODUCTION

Sandy Lake is located in Western Manitoba approximately one hour north of Brandon, near the south boundary of Riding Mountain National Park (Figure 1). The Town of Sandy lake is situated at the south west corner of the lake and has a population of approximately 350 people year round (Figure 2). However the population of Sandy Lake grows dramatically during the summer months (May to September). This scenic area with its rolling topography and shallow warm lakes in close proximity to the Park has proven to be very attractive to cottage goers and recreationers. Swimming, waterskiing, windsurfing and fishing in the summer, hunting in the fall, and icefishing and skidooing in the winter are popular recreational activities. The small farming Town of Sandy Lake is economically dependent on its seasonal residents and tourists.

However, conflicts have arisen due to intensive cottage development and demands that are now occurring in the once unpopulated, agricultural region. Excessive algae growth is prominent throughout the lake which is magnified significantly during drought conditions. Yet, there is an increasing demand from the public to build more cabins and campgrounds. As well, the rights of present land owners concerning usage and development of land has to be respected. Finally and most importantly is the degradation of the environment with water quality the first priority.



SANDY LAKE LOCATION FIG 1



SANDY LAKE FIG 2

II. OBJECTIVES

The intent of the study is to develop recommendations to reduce the water deterioration of Sandy Lake. This involves preventative and corrective management procedures regarding the water quality and lake levels, as well as insight into the repercussions of future development, and landowners property values. The main study tasks that the recommendations are to be based upon include:

1. Identification of the trophic state of the lake examined

2. Future forecast of the state of Sandy Lake based on trends from historic data

Once the above objectives have been defined the sources leading to the deterioration of the lake and its surrounding area will be examined. It is believed that future problems will occur if the improvements are not implemented. Aesthetic appeal will decrease, public health safety may be at risk, property values will decrease and the Town of Sandy Lake will experience socioeconomic stress.

Improvements are to be based on three main criteria; environmental quality, public safety, and aesthetic considerations.

Public safety is the protection of the public from contaminated waters. Location and number of outhouses, grey water fields, and possible leaking septic tanks are of main focus.

Aesthetic considerations assume that the present trophic state of the lake is satisfactory. Excessive algae growth, lower water levels, and increased amounts of toxic gases released from the lake cannot be accepted.

Maintenance of environmental quality is the most critical of the three issues because without some level of satisfactory quality, public safety and accepted aesthetics will not be possible. Lakes located in populated areas experience accelerated eutrophication as a result of excessive nutrient loading. Minimal environmental regulations in the past are believed to be a main cause of Sandy Lakes' current trophic state. This study will be an attempt to determine the problem nutrient and expose it's sources. However, prior to dealing with the objectives it is imperative that standard liminological information relevant to that of Sandy Lake be acknowledged.

A. RATIONALE

Sandy Lake is undergoing accelerated stages of the eutrophication process which occurs when there is a disturbance in a lake community between the relationship of nutrients and the community organization.

"Algae production in fresh water lakes became acute because of increasing pollution. Nutrients added to lakes directly in sewage or indirectly as runoff increases algae concentrations and shifts many lakes from phytoplankton communities dominated by diatoms of green algae to those dominated by blue green algae." (Krebs, pg 82.).

Algal blooms known scientifically as phytoplankton along with zooplankton dominate the ecology of a lake. The ecosystem also includes macrophytes, plants which are rooted around the shoreline or are free floating, bacteria, bottom feeders (detrivors such as worms, beatles etc.), various fish species and insects.

Within the boundaries of the aquatic ecosystem environmental conditions vary, changes in temperature, oxygen and gradations of light influence the life type in specific areas.

B. LIMNOLOGICAL FEATURES

A temperate lake's vertical structure for the summer period is comprised of three layers:

1. Epilimniom - top layer
2. Metalimnium - middle layer
3. Hypolimnium - bottom layer

The photosynthetic level occurs at the top of the hypolimniun and acts as a major divider. Photosynthetic production at depths deeper than this point are net losses for the phytoplankton. Light penetration is so low that it is no longer effective for photosynthesis. This is commonly referred to as the aphotic zone. Above this level the euphotic zone exists and production outweighs respiration losses. The amount of dissolved oxygen (D.O.) in the water is greatest at the surface water where there is an interchange between the water and atmosphere.

In the spring the ice melts and the water begins to warm up until the lake's surface water temperature is 4 degrees Celsius at which the water is most dense (fig 2) and begins to sink.

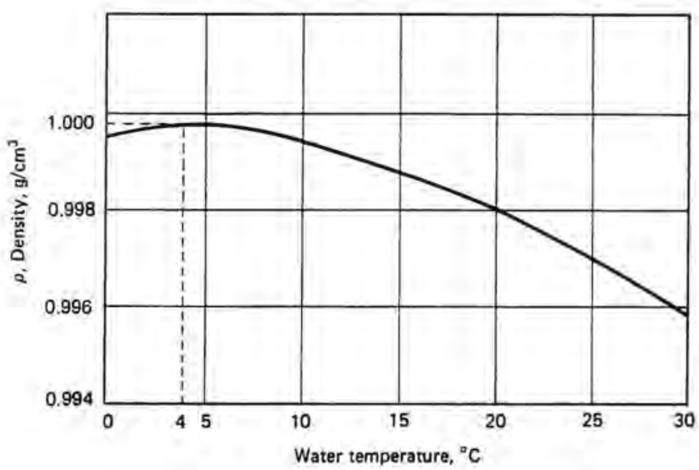


Figure 3: Density vs Temperature Relationship

The colder water underneath rises and then it to is heated until eventually the entire body is of uniform temperature and density. At this point the slightest winds can cause complete circulation of water and "spring overturn" occurs. The spring overturn mixes the nutrients, plankton and oxygen from their original levels allowing oxygen to replenish the lake and the nutrients to return to the top.

As surface water temperatures rise, the density difference opposes mixing, and vertical stratification appears. The surface waters from the eplilimnium keep a fairly constant temperature, the metalimnion zone water temperature decreases constantly with depth (to a point at which a thermocline is reached where temperature decreases at its highest rate, - 1 degree celsius for each meter or depth) . This also results in greater density differences between the layers of water. Below the metalimnion is the deep, cold hypolimnium layer where the temperature gradient again is minimal at approximately four degrees celsius. Winds are unable to overcome the thermal density gradient and circulation of the water is restricted to the epilimnion.

The fall season lowers the surface water temperature until it's higher density causes it to sink to the bottom and warmer water replaces it. Recirculation continues allowing oxygen and nutrients to be recharged throughout the lake.

Once again the epilimnion includes the entire water depth and water temperature is constant. This "Fall Overturn " continues until ice forms. The ice may act, along with conduction from the bottom mud, as a form of solar collector and creates slightly warmer water underneath it. This ends up with a slightly inverted stratification although overall the stability of the water is undisturbed. Finally, the cycle of stratification is repeated in the spring.

Temperature stratification is much more defined in deeper lakes, than in shallow lakes. In the case of Sandy Lake, a shallow lake, it may have temporary stratification of short duration, but it is without a thermocline.

Oxygen stratification parallels that of temperature. During the summer, the primary source of oxygen occurs at contact of the lake surface with the atmosphere.

Oxygen is required by all organisms (except anaerobic bacteria) for respiration. Photosynthetic plankton release oxygen during daylight hours. As a result, dissolved oxygen levels vary significantly in relation to season, time of day and depth.

Limited amounts of algae growth have a positive effect on a lake. With the sunlight's energy algae will consume waste products (inorganic compounds) of hetertrophic bacteria and releases oxygen into the water.

$$CO_2 + 2\ H_2O \text{ ---(sunlight)--- } CH_2O + O_2 + H_2O$$

$$CH_2O = \text{New algae cells}$$

However, without sunlight as a source of energy, algae uses oxygen from the water to catabolize stored food. This reaction increases the oxygen demand of the water.

$$CH_2O + O_2 \text{ ------- } CO_2 + H_2O$$

Moreover, some species of algae have negative effects on water quality because they produce oily substances that cause taste and odors.

Dissolved oxygen decreases with depth, to the point where oxygen depletion is expected in the deeper waters along with the appearance of ferric sulphide, manganese sulphide, and hydrogen sulphide in the summer stagnation period. The nutrient cycle is intensive due to nutrients being freed (because of high water temperatures at deeper depths) from the hypolimnion into the surface waters where the nutrients become available to phytoplankton. The spring and fall overturns allow oxygen to replenish throughout. While with winter, although the cool water temperatures allow maximum oxygen solubility and the bacterial decomposition slows down, oxygen levels can reach serious lows conceivably resulting in partial or total fish kill.

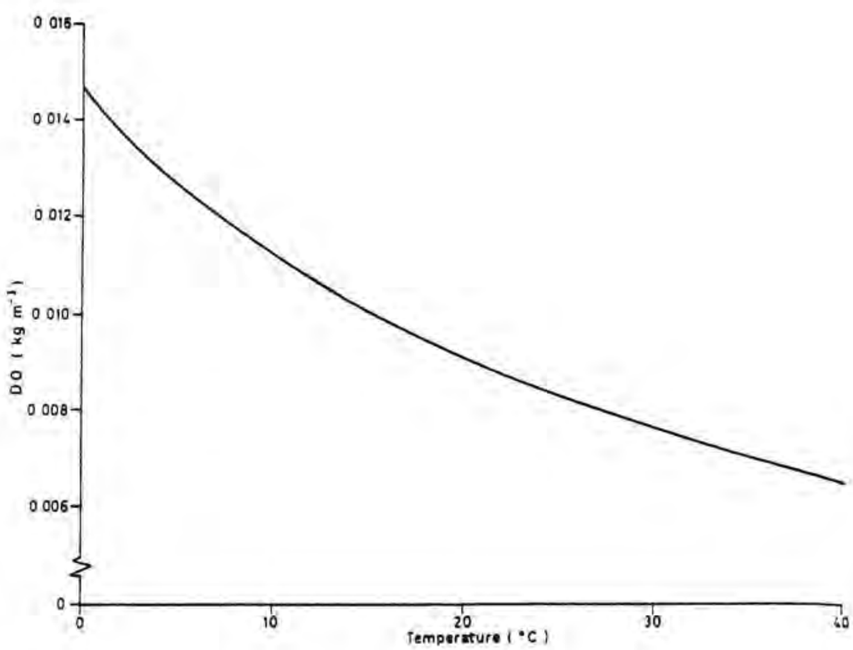


Figure 4: Dissolved Oxygen Levels as a Function of Temperature

The final stratification factor in a water body is light. Sunlight is the energy source of a lake. The penetration of light, which determines the region of photosynthesis, is dependent on the water's turbidity produced by sediments and phytoplankton and it's absorption of light rays, season and time of day. With respect to light, the lake is composed of two basic layers:

1. Trophogenic Zone (Epilimnion approx.) - photosynthesis dominates
2. Tropholytic Zone (Hypolimnion approx.) - decoposition dominates

Compensation Depth is the term defining the boundary between the two zones. At the boundary photosynthesis balances respiration, below this depth light penetration is so low that it is no longer effective (light intensity approx. 1 % of full noon sunlight incident to the surface).

Another major contributor to distribution of temperature, oxygen, nutrients and organisms is the influence of currents and seiches. A seiche is produced mainly by wind's movement and heavy rain showers. Winds cross the lake and pile water on the leeward side, leaving a depression on the windward end. Once the wind stops currents commence flowing back to the windward side. However, momentum is not broken on the shore forcing water to flow back again. An oscillation or rocking motion is established and continues until halted by friction of the lake basin or opposing wind/rain.

The density of water has a role in the mixing of water due to winds. When the warm surface waters of the Epilimniom pile on at the leeward end, the windward side of the lake is replaced with cooler waters of the Metalimnium. Thus an oscillation is established between the lighter water layer of the Epililimnion and the heavier waters of the Metalimnium. This circulation distributes heat and nutrients vertically in the lake, moving plankton, fish and other organisms.

The aquatic ecosystem is made up of different communities throughout various areas of a lake. Photosynthetic activity controls the type of habitat occurring in each area:

1. Littoral Zone - light penetration to the bottom, shallow water, rooted plants (ie. bullrushes, sedges).
2. Limnetic Zone - light penetration reaches compensation depth, plant and animal plankton, fish.
3. Profundal Zone - no effective light, energy source is organic material fallen from the limnetic zone, decomposer organisms prominent.
4. Benthic Zone - region just above bottom of the lake, vast amount of biological activity consisting of anaerobic bacteria.

Each of the above zones are closely dependent on one another in nutrient and energy flow.

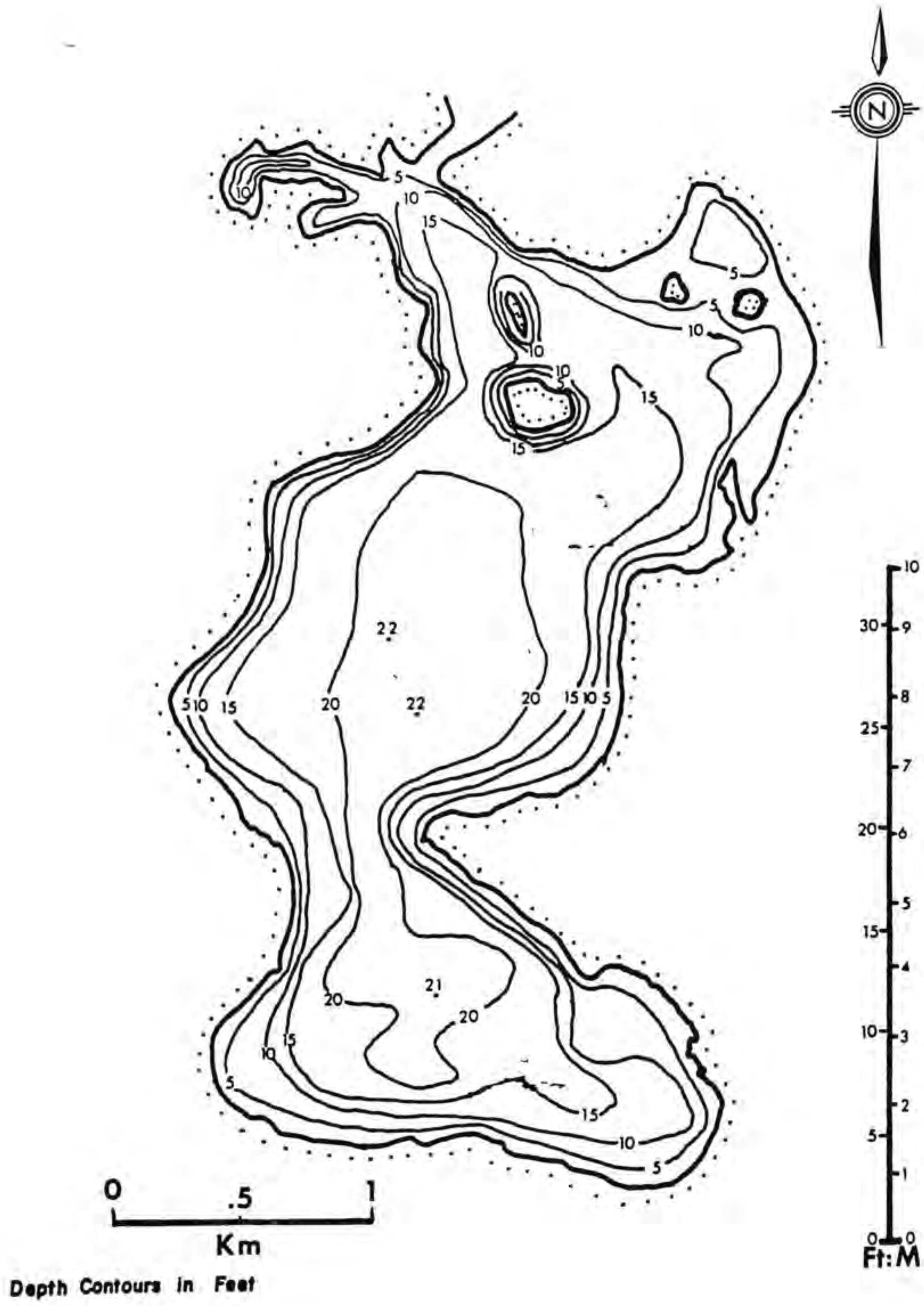
III DATA COLLECTION

Sandy Lake lies within, what was once, the mixed woods section of the Boreal Forest although most of the land has been cleared for farming. Deciduous Trees are found in narrow bands between the north and east shorelines and surrounding grain fields, while in two areas the grain fields border the shore. Tree species include white and black poplars, birch and willows. The soil structure consists of a thin layer of grey type topsoil over top of substrate composed of glacial moraine. The lake's shoreline consists mainly of sand, gravel and boulder beaches with the best sand beach located adjacent to the town. Some of the small bays have shorelines composed mainly of organic muck. The lake bottom is composed mainly of soft grey organic muck at depths exceeding three meters (Sunde, 1957).

Aquatic vegetation is prominent along most of the shoreline. To the point that it is common for cabin owners to rake vegetation from water areas in front of their dwellings. Bullrush beds and sedges extend outwards from shore to depths of one to two meters along most gravel and boulder beaches. In some bays along the west and north shores of the lake there are areas of drowned out trees. These are mainly willows.

It is difficult to detect any streams in or out of the lake. One seasonal inlet stream that was discovered is located at the extreme south end of the lake. The outlet from Sandy Lake occurs at the north end of the lake. This is a short, broad, channel which opens into a series of marshes known as North Sandy. North Sandy has an surface area of 1.400 10^6 m^2 (2 km by .7 km) with the central two thirds of the lake between 2.4 m and 3.4 m deep. This area has not been included in the study.

The surface area of Sandy Lake is 4.840 x 10^6 m^2. It is a long, narrow lake, approximately 3.5 km x 1.5 km. The maximum depth recorded was 6.3 m while the mean depth is 3.23 m, resulting in a lake volume of 1.918 x 10^7 m^2 (Figure 5). The area of the drainage basin is 3.070 x 10^7 m^2. The outflow of water per year was calculated to be 5.283 x 10^5 m^3/yr. Knowing the outflow, a flushing rate was determined occurring once every 36 years (Beck, 1986). There is intensive cabin development along significant stretches of beach frontage. Presently there are close to three hundred cabins situated on the lake. The oldest development, dating back to the 1920's, is at the south end while the newer cabins are located on the west shoreline. At the south end of the lake cottage areas are tightly confined between railway tracks and the lake shore. Two thirds up the west shoreline is the main campground. The campground includes approximately 30 sites. Development of a new Lions campground is in the construction phase at the south end of the lake behind the lake front cottages. At the south east corner of the lake again behind lake front cabins is the Sandy Lake Country Club, which consists of a nine hole golf course and two tennis courts. The mean season length for vactioners is approximately 85 days (Beck, 1986).



SANDY LAKE CONTOURS FIG 5

Data was collected to attempt to describe and quantify the problem that exists at Sandy Lake and it's surrounding environment. Public attitudes and behavioral patterns were also observed in order to better grasp the situation.

The Sandy Lake Cottage Owners Association expressed their concerns regarding the water quality in a 1988 letter addressed to Manitoba Natural Resources. People were wary of swimming in the lake. The cottage owners believed that the lake was deteriorating rapidly due to increasing high amounts of algae, bad lake odors and low lake levels. Prominent complaints were rumours of leaking septic tanks and the minimal environmental restrictions to control waste management.

A Hydrobiological Survey of Sandy Lake, Jan 18,1933 by Dr. A. D. Bajkov was conducted which stated that Sandy Lake was very rich in fish food, abundant amounts of plankton, valuable species of crustaces and minute vegetation. The large aquatic vegetation covering extensive areas of the bottom and the shorelines provide excellent natural spawning places for fish activities. The maximum depth was found to be 20 ft (6.1 m).

A similar study was performed in September of 1957, A Limnological Survey of Sandy Lake by L.A. Sunde, a Manitoba Fisheries Biologist. This survey was much more extensive than that of the 1933 study but similar conclusions were reached.

This study provided Eckumn dredge samples which revealed that the bottom fauna of Sandy Lake was quite abundant in numbers but not in species. It indicated that plankton samples were heavy both in vertical and surface waters and that the number of lower order animals such as rotifers and diatoms, which prey on bacteria and algae, were prominent. The max depth of the lake was 22 ft.

Abundant algae growth, shallow depth, large surface area to volume ratios, warm water temperatures are all characteristics of natural eutrophic lakes. Other factors contributing to excess aquatic plant growth include abundance of sunlight, clarity of water for light penetration and plenty of nutrients which stimulate growth. As photo synthesis production increases, nutrients and organic compounds in the water are regenerated and a cycle of further growth begins. This is most significant in high sunlit areas where phytoplankton becomes concentrated, casting a murky green slime appearance. This in turn, reduces sunlight penetration limiting the depth of growth. Algae, organic debris and sediment sink to the bottom adding to the high bottom organic sediments. All of these factors lead to the conclusion that Sandy Lake is in fact a naturally occurring eutrophic lake.

With the data collected, water levels of the lake were recorded for various years from 1933 to 1992 (Appendix D). It was found that water depth varied from 23 ft to 19 ft. The lower levels were associated with extreme drought conditions.

The existing trophic situation of Sandy was classified through the means of Carlson's Trophic State Index (TSI) using present Seechi Disk transparency and Chlorophyll a results.

Carlson's Index is a numerical scale from 0 to 100. A TSI value of 40 indicating mesotrophic or moderately enriched status and productivity, with 50 units or greater representing an eutrophic, highly enriched and productive status.

The equations used in order to reach a TSI value are as follows:

TSI (SD) = 6 - ln SD/ ln 2

TSI (Chl) = 10 (6 - (2.04-0.68(ln Chl))/ln 2)

The values obtained from these computations were then placed on Carlson's Index (Figure 6).

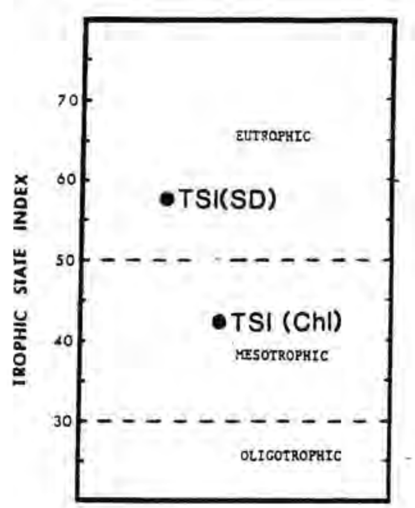


Figure 6: Carlson's Trophic State Index

As well, historical Seechi Disk and Chlorophyll a, data were used in order to gain some additional information on past trends and to project future trends if improvements are not implemented (Table 1).

CARLSON TROPHIC STATE INDEX
1979 - 1986

YEAR	CHLOROPHYLL a(ug/l)	SECCHI DISC(M)	TSI (SD)	TSI (Chl)
1979	7.34	2.4	58.7	50.12
1980	3.1	3.1	58.36	41.67
1981	6.7	3.3	58.27	49.23
1985	2.3	6.2	57.4	38.7
1986	1.6	1.3	59.6	35.18

Table 1: Carlson Trophic State Index Value 1979-1986

Seechi Disc depths (m) and Chlorophyll a concentrations (ug/l) were recorded at different depths, on a weekly basis for the months of July and August (Appendix B). Two sources of data were used: A Report on the Trophic Status of Killarney, Wahtopanah, Rossman and Sandy Lakes, Hughes (1979-81) and Recreation Development Capacity Study in South Riding Mountain Planning District, Beck (1985,86). Both studies included three different stations for tests recorded on a certain date. A mean sample produced from the various locations was used to provide representative samplings.

The Trophic State Index values were plotted for the years 1979,80,81,85,86 (Figure 7).

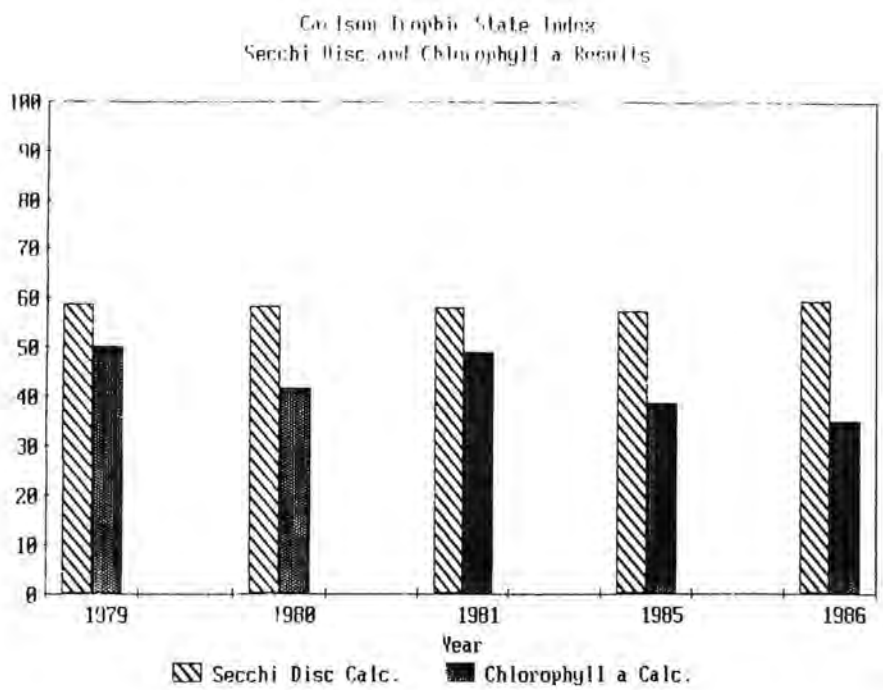


Figure 7: Seechi Disc and Chlorphyll a TSI Values 1979-1986

It was found that the TSI (SD) values were significantly higher than the TSI (Chl) values (approx 25%). However, according to both calculations, the results concluded that Sandy Lake's trophic status is in the high mesotrophic to eutrophic range. Seechi Disc calculations projected the very productive, enriched nutrient water quality.

Because data collection from various sources of different studies was used, discrepancies could have affected the results somewhat. Primary concerns with data include location and depth of sample, and time of year. It is common to have water quality of a lake experience temporary degradation such as extensive algal blooms. This can take place due to seasonal and yearly flucculations. In addition, sunlight penetration, and biological and chemical reactions can also have a major role in vegetation production.

Seechi Disc is used to measure water clarity. In general, the greater the clarity, the less eutrophic the water quality. Seechi Disc depths may have been recorded at lower depths due to high wind or rain action mixing up nutrients within the water columns reducing visibility. The amount of cloud cover at time of depth recording could also affect readings. At increased depth, recordings of the TSI (SD) value would have been slightly lower representing a less eutrophic lake than was observed.

The level of algae in a lake can be reflected by Chlorophyll a concentrations. The determination of biomass (standing crop) uses chlorophyll as an indicator, since it constitutes approximately 1.5% of the dry weight of organic matter of algae. Low algae populations are found at levels near 4 ug/l, while high algae populations exist at concentrations of 8-12ug/l. Even though yearly flocculations will occur, it is evident that longterm increases in Chlorophyll a would be indicative of accelerated enrichment. The low TSI (Chl) values calculated are believed to reflect a less productive lake than what presently exists. From field observations it is evident that Sandy Lake is nutrient enriched beyond the TSI average mean value of 43. Moreover, the probability of the trophic state of the lake improving

Sandy Lake Dissolved Oxygen Levels

Year	Month	Total Ice(cm)	Snow Depth(cm)	Water Depth(m)	Dissolved Oxygen Top	/ Bottom	Remarks
1947	Complete Winterkill						
1956	Perch and most walleye winterkilled - pike survived						
1957	Dec.	30	little	5.8	10.8	6.9	
1958	Feb.	63	drifts	5.8	7.8	2.6	
1959	Mar.	92	28	5.5	9.7	4.6	
1972	Mar.	76	16	4.9	2.5	0.8	
1973	Feb.	46	17	5.5	7.0	2.8	
1974	Feb.	60	35	4.6	6.7	8.1	
1979	Mar.	90	30	4.9	3.5	1.8	
1980	Feb.	77	15	5.5	2.2	2.0	
1982	Feb.	98	8	4.9	9.2	7.4	
1985	Mar.	90	27	3.7	0	0	Winterkill
1986	Dec.	70	8	4.6	7.6	2.2	
1987	Jan.	76	7	4.1	5.0	1.8	
1988	Mar.	86	2	4.6	7.0	4.0	
1989	Jan.	49	15	4.6	5.8	5.6	
1990	Mar.	80	15	4.4	5.1	1.2	
1991	Mar.	75	30	3.8	8.3	1.05	
1992	Mar.	68	20	3.0	5.0	1.6	

Table 2: Yearly Dissolved Oxygen Levels

Various years from present to as far back as 1957 were recorded. Both bottom and top of water D.O. levels were analyzed and it was evident that flocculations from year to year were prominent. One year oxygen levels could be high with the next year complete winter kill occurring as did in 1985. These values were plotted on a graph (Figure 8).

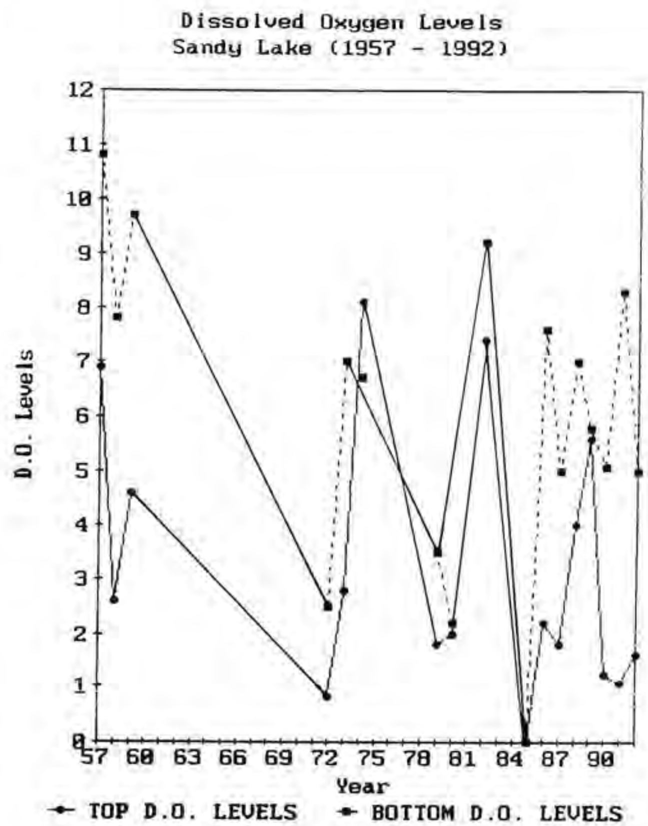


Figure 8: Yearly Dissolved Oxygen Levels

A possible trend that could be extrapolated from the graph would be a decrease in the maximum D.O. content of the water as time progresses. This leads one to believe that with time D.O. levels will be unable to support aerobic productivity resulting in total fish kill and unsafe waters.

D.O. levels were recorded by Fisheries Department Western Region, Province of Manitoba. Data gathering frequency differed from year to year, varying from weekly data to annual recordings (See Appendix). In any case an attempt was made to use consistent data. Variables such as depth of snow, thickness of ice, depth of water, time of year, length of ice cover season and amount of vegetation in area of sample all have a significant effect on the amount of available oxygen in the water. Dissolved Oxygen Level measurements in 1991-92 at monthly intervals illustrate the typical annual decrease in Levels over the winter months (Figure 9).

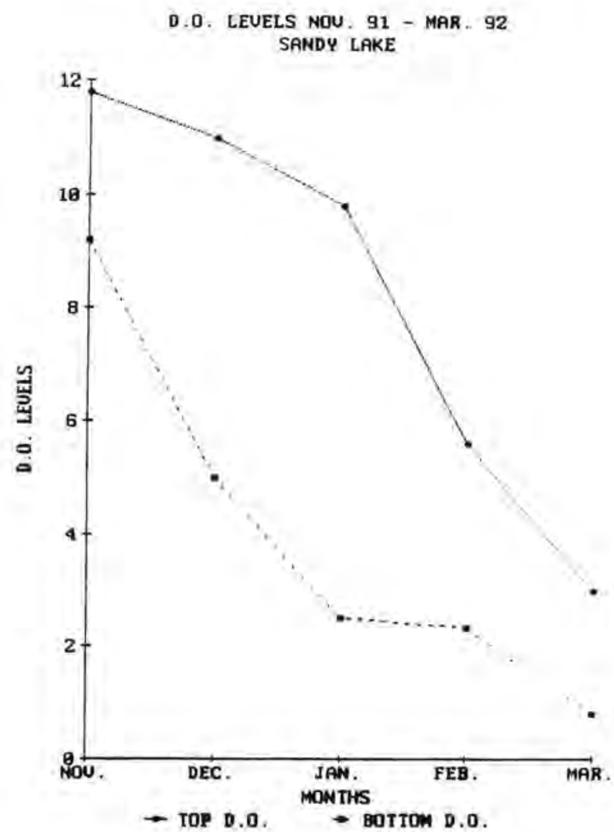


Figure 9: Typical Winter Dissolved Oxygen Levels

Although the D.O. levels helped confirming the eutrophic lake status of Sandy Lake, due to the many uncontrolled variables the D.O. graph was used as a guide and not as a deciding factor in assessing the trophic state.

It is believed that in order to determine the rate of the accelerated enrichment, a consistent sampling program should be implemented for a time period of at least five to ten years. This would highlight years of extreme conditions (little sunlight, high winds, long winters etc.) to be identified as such, and omitted from general trends.

A. PROBLEM NUTRIENTS

Artificial or cultural eutrophication is " the addition to lakes of soluble compounds of nitrogen and phosphorous by human activities" (Middlebrooks, pg 236.), which can drastically shorten the life-span of lakes as is the case of Sandy Lake. Identifying the problem nutrient is necessary, in order to stop the eutrophication process.

A nutrient will be consumed by aquatic vegetation at a rate proportional to the need for that nutrient. Hence, the growth of aquatic vegetation is limited by the nutrient which is available to it in the minimal quantity relative to its needs for growth or reproduction (Rast and Lee, 1978).

A " demand : supply " ratio can be used to determine the limiting nutrient. This means that there could be vast amounts of one nutrient without increased vegetational growth if it is not the nutrient limiting productivity. On the other hand, a small amount of the limiting nutrient can produce excessive amounts of growth. Vegetation requirements are the basis for the demand:supply ratio.

Nitrogen:Phosphorus Atomic Weight Ratios:

Mixed Phytoplankton - 16 : 1

Algae common to Lakes - 24 : 1

(Atomic Weight of N = 14.01, Atomic weight of P = 30.97)

Example Calculations:

Phytoplankton:

16 x 14.01/30.97= 7.24 mg of N : 1 mg of P

Algae:

24 x 14.01/30.97= 10.86 mg of N : 1 mg of P

For N:P mass ratios less than 7.24 : 1 and 10.86 : 1 respectively, nitrogen is the limiting factor. Ratios greater than the above range indicate phosphorus is the limiting nutrient.

An earlier study completed in 1986 on Sandy lake used a Calculated Mass Ratio to determine its sensitivity. The Calculated Mass Ratio was derived by Hutchinson (1957), which claims that ten percent of total phosphorus present in natural water is comprised of soluble orthophosphate. From the data collected in the months of July and August of 1986 a CMR of 22.81 was calculated, much higher than the 7.24 and 10.86

range. Phosphorus was definitely the problem nutrient at Sandy Lake. (Beck, 1986). This is found to be consistent with temperate shallow prairie lakes world wide. (Vollenweider, 1968)

B. PHOSPHORUS SOURCES

It has been determined that even with the addition of minimal amount of phosphorus the ecological balance of Sandy Lake is upset. This limiting nutrient initiates an abnormal growth of aquatic vegetation, algae and phytoplankton, with algae being the most serious (N:P = 24 : 1).

> "Decaying algae use up oxygen which is vital to the survival of fish and other organisms. Gradually, with the depletion of dissolved oxygen, anaerobic micro-organisms which thrive in the absence of dissolved oxygen become predominant, giving rise to the malodorous by-products of decomposition generally associated with gross pollution."(Goulden 1970)

The deep water of the lake is unable to support aerobic life forms which results in limited number of species existing in the lake. However, regardless of the species numbers, individual numbers and biomass still remain high.

Ample magnitudes of algae can clog water intake lines, and destroy the value of a lake for boating, swimming, and other forms of recreation.

In order to improve the environmental quality, public safety and aesthetic considerations of the Lake, it is essential to expose all sources of phosphorus, and identify those which may be controllable. To provide measurable recommendations, extensive detail should be used in determining the amount of phosphorus from various sources. This would allow the recommendations to have a certain value of effectiveness and provide insight into which sources should be dealt with immediately in decreasing the eutrification process. Providing a Phosphorus Budget would require a intensive sampling over a long term period (years) which is beyond the scope of this paper.

Beck's Recreational Development Capacity Study of Six Lakes in the South Riding Mountain Planning District (1986), attempted to produce a Phosphorus Budget with a variety of models and data sources. However similar to Beck's study, the high observed phosphorous levels in the lake could not be explained through the calculated budget. The sources and their parameters are referenced as well as additional sources, in identifying entry of the problem nutrient (Appendix A).

Point Sources:

1. Cabin outhouses and septic fields
2. Cabin grey water fields
3. Leaking Septic/Holding Tanks
4. Campground facilities

Non Point Sources:

5. Runoff from cultivated grain fields (soil erosion)

6. Natural Sources (precipitation, soil transport by wind)
7. Phosphorus released from the bottom sediments during anaerobic activity.

Point sources are direct points of entry into an area and therefore can be easily located. Cabin outhouses, septic fields and grey water fields were believed to be a major contributor to the phosphorus loading. With the confined cabins areas in most lake front developments, outhouses, septic and greywater fields were located either at the sides or fronts of cabins. The very porous sand/gravel soil conditions contributed to the easy movement of the phosphorus into the lake. Purposely leaking holding tanks, due to holes punched in the bottom to reduce pumping charges, are of common knowledge to cottage owners and add another major concern. It is evident from summer time observation that campground facilities are inadequate. Minimal distances between out houses and water, very limited shower availability as well as extremely high numbers of campers result in the use of the lake as a bathing area and overloaded facilities.

On the other hand, nonpoint sources have an infinite number of lake entry locations which are more difficult to detect than those of the point sources.

Fertilizers used in nitrifying the land to improve crop production, have an adverse effect when nitrifying a lake. Phosphates (PO_4) injected into the topsoil can either wash into the lake by means of soil erosion or through dry deposition (wind), thus, resulting in phosphorus sediment settling at the bottom of the lake.

During aerobic conditions phosphorus is taken up by the soil bottom sediments, reducing the amount of available phosphorus. However, during anaerobic conditions the opposite occurs and phosphorus is restored to the water column.

With Sandy Lake's lengthy flushing rate of 36 yrs and unpredictable cycle of aerobic and anaerobic conditions it is believed that the net rate of phosphorus intake to release is minimal and for the most part can be ignored.

Point sources are much easier to control than the nonpoint sources. Moreover, accelerated eutrophication is largely due to the overcrowding of an aquatic environment such as Sandy Lake. This in turn has a tremendous effect on the heavy phosphorus overload. Thus it was believed that the point sources were of main concern and to be used as a basis for improvement recommendations.

IV RECOMMENDATIONS

The following recommendations are proposed to reduce the water deterioration of Sandy Lake:

1. Installation of Water and Sewer Mainlines connecting to the Town services.

   Advantages:

   - Stops point phosphorus sources
   - Accommodates future needs
   - Provides drinkable water
   - Good time to implement

   Disadvantages:

   - Very high costs
   - Capacity upgrades of Town's water and sewer facilities required
   - Hard to implement

2. Holding Tank Requirements and Records

   Advantages:

   - Stops septic field leaching
   - Records/tests insurance

   Disadvantages:

   - High costs
   - Does not solve grey water problem
   - Can lead to intentional perforation

3. Location Regulations - Outhouses, Grey Water Fields, Septic Fields

   Advantages:

   - Low cost
   - Easy to implement

Disadvantages:

- Phosphorus loading not stopped (minimized)
- Bandaid treatment

The installation of water and sewer mainlines would include a set of mainlines running from the south east corner of the lake through to the north west corner where development ceases. The lines would accommodate all development present and future (only private land can still be developed). Cabins and campgrounds would require individual service lines to access the main lines. The use of mainlines would stop phosphorus loading completely.

Presently, water used for drinking is transported by the cabin owners, while water for bathing and cleaning comes from private lake intake lines. During past hot summer months Sandy Lake water has been declared by some as unfit for body contact. This condition is expected to worsen. Therefore, there is a need for clean, drinkable water.

With very few cabins having holding tanks, it is believed that the time for implementing this recommendation should occur prior to more cabin owners installing the high price tanks.

The installation of new lines would require capacity upgrades of the Town's water and sewer facilities thus making this recommendation a very costly one. Of course with high costs, implementation would be a struggle.

High public support is necessary. Shared costs would have to be involved between the property owners and various levels of government.

The second recommendation option would require that each cabin/campground within a certain vicinity of the lake, install holding tanks. The owners would have to produce records of tanks being pumped or pressurized as insurance of proper upkeep. This would stop septic field leaching completely.

Again high costs are involved and most likely this would come from the owner's pocket. Drinking and bathing water conditions have not been addressed, nor have the grey water fields.

The last point source recommendation states that regulations regarding locations of septic and grey water fields should be implemented. This option would be fairly easy to implement at relatively low cost.

Problems would arise due to the confined space that is available in various locations. This would have to be dealt with on an individual basis.

This is a bandaid solution. The phosphorus loading has not been stopped, just reduced. Existing problems would have to be dealt with at a future date.

Although nonpoint sources were believed not to be critical the general recommendations would include:

4. Provision of a natural filtration system band along cultivated shorelines
5. Use of a lake aeration system to improve aerobic conditions

A natural filtration system consisting of alphalpha or similar vegetation would reduce soil erosion. The inclusion of tall coniferous trees along the band would also aid in minimizing phosphorus input, through wind transport.

Use of an aeration system at times of low dissolved oxygen levels has been proven to reduce regeneration of nutrients from lake bottom sediments, while often controlling algae blooms. As well, aeration allows fish and other aerobic species to survive during these crucial times.

V CONCLUSIONS

Findings indicated that Sandy Lake's trophic state was a natural eutrophic lake experiencing accelerated enrichment. High phosphorus overload was the problem nutrient creating the artificial eutrophication.

Future forecasts of the lake suggest that water quality will continue to deteriorate at an increasing rate. However, data collection was insufficient to provide further information.

It is therefore recommended that an intensive (5-10 yr) sampling program be completed on Sandy Lake.

Recommendations for preventative and corrective water quality procedures included:

1. Installation of Water and Sewer Mainlines connecting to the existing Town systems
2. Holding tank requirements and records
3. Location regulations regarding outhouses, grey water fields, septic fields
4. Provision of a natural filtration system band along cultivated shorelines
5. Aeration system to improve lake aerobic conditions

It is proposed that a Phosphorus Budget be established to provide a comparative measure of the individual phosphorous sources to Sandy Lake. This would allow more effective recommendations based on relative advantages (ie. amount of phosphorus reduced) and disadvantages (ie. cost) of mitigation options.

VI BIBLIOGRAPHY

BECK, A.E. "Recreational Development Capacity Study of Twelve Lakes in the South Riding Mountain Planning District", Water Standards and Studies Report No. 87-5, 1985 and No. 88-4, 1986.

CHUTE, Robert "Environmental Insight"; Harper and Row, New York, 1971.

FRANSON, Mary "Standard Methods for the Examination of Water and Wastewater"; Port City Press, Baltimore, 1985.

GOULDEN, P.D. "Detergents, Phosphates, and Water Pollution"; Technical Bulletin No. 22, 1969.

Inland Waters Branch "The Control of Eutrophication"; Technical Bulletin No. 26, 1970.

KREBS, Charles "The Message of Ecology"; Harper and Row, New York, 1988.

MIDDLEBROOKS, E.J. "Modeling The Eutrophication Process"; National Technical Information Service, Utha, 1973.

SUNDE, L.A. A limnological Survey of Sandy Lake, Manitoba Fisheries Sept. 57.

BAJKOW, Dr. A.D. Hydrobiological Survey of Sandy Lake, Dept. of Mines and Natural Resources - Fisheries Branch, Jan 18, 1933.

SELLERS, B. "Engineering Limnology"; Pitman Publishing, Boston, 1984.

SMITH, Robert "Ecology and Field Biology"; Harper and Row, New York, 1980.

BOLLENWEIDER, Richard "Water Management Research"; Organization for Economic Co-Operation and Development, 1968.

HUGHES, C. "a Report on Fine Trophic Status of Killarney, Wahtopanah, Rossman and Sandy Lakes" Water Standards and Studies 32-30, July 1982.

APPENDIX A

PHOSPHORUS DATA

TABLE 6: CALCULATION PROCESS FOR THE SANDY LAKE PHOSPHORUS BUDGET.*

STEP	PARAMETER	QUANTITATION
1.	Gross Drainage Basin (A)	$3.868 \times 10^7 m^2$
2.	Lake Surface Area (Ao)	$4.840 \times 10^6 m^2$*
3.	Surface Area of Other Lakes in A (Ao_1)	$3.140 \times 10^6 m^2$
4.	Drainage Basin ($Ad = A-[Ao+Ao_1]$)	$3.070 \times 10^7 m^2$
5.	Lake Volume (V)	$1.918 \times 10^7 m^3$
6.	Lake Mean Depth (Z = V/Ao)	3.23 m
7.	Net Annual Runoff (r)	0.051 m/yr
8.	Net Annual Evaporation (E_V)	-0.130 m/yr
9.	Outflow $Q = [Ad \cdot r]+E_V \cdot [Ao+Ao_1]$	$5.283 \times 10^5 m^3$/yr
10.	Flushing Rate (p = Q/V)	0.028 times/yr
11.	Areal Water Load (qs = Q/Ao)	0.109 m/yr
12.	Retention Coefficient (R = 13.2/13.2 +qs)	0.992
13.	P Loading Rate for Precipitation (L_{Pr})	41 mg/m^2/yr
14.	P Contribution from Precipitation ($J_{Pr} = L_{Pr} \cdot Ao$)	1.984×10^8 mg/yr
15.	P Export Coefficient (E)	23.3 mg/m^2/yr
16.	P Contribution from Drainage Basin ($J_D = E \cdot Ad$)	7.153×10^8 mg/yr
16(a).	P Contribution from Sediments During Anoxia ($J_S = L_S \cdot Ao \cdot days$)	N/A
17.	Total P from Natural Sources ($J_N = J_{Pr} + J_D + J_S$)	9.137×10^8 mg/yr
18.	P Contribution per Capita Year (S)	8.0×10^5 mg/yr.
19.	Sewage Treatment Retention Coefficient (R_S)	0.63
20.	Total Campground Site Units (U)	5 units
21.	Mean Persons per Unit (P)	1.51 persons/unit
22.	Mean Season Length (SL)	85 days
23.	Campground Capita Years ($N_{CY}' = [U \cdot P \cdot SL]/365$)	1.76 capita years
24.	P Contribution from Campground ($J_A' = S \cdot N_{CY}'[1-R_S]$)	5.204×10^5 mg/yr
25.	Number of Cottages (N_C)	231 units**
26.	Capita Years per Cottage (P_C)	0.63 capita years
27.	Number of Residences (N_D)	4 units***
28.	Capita Years per Residence (P_D)	4.3 capita years
29.	Total Occupant Capita Years ($N_{CY}'' = P_C \cdot N_C + P_D \cdot N_D$)	162.73 capita years
30.	P Contribution from Occupants ($J_A'' = S \cdot N_{CY}''[1-R_S]$)	4.817×10^7 mg/yr
31.	Total P from Artificial Sources ($J_A = J_A' + J_A''$)	4.869×10^7 mg/yr
32.	Total P Supply ($J_T = J_N + J_A$)	9.624×10^8 mg/yr
33.	Predicted Spring Total P Concentration ($P = [J_T(1-R)]/Q$)	0.015 mg/L

* Only the contiguous south basin is considered.

** 5 of the 236 cottages are equipped with holding tanks and are therefore excluded from the calculation. * BELIEVED THAT SOME HOLDING TANKS HAVE HOLES IN THEM

*** Only residences presumed not to be connected to community sewerage are included.

Table 12: VALIDATION OF PHOSPHORUS BUDGETS BY COMPARISON TO OBSERVED 1986-87 FALL & WINTER VALUES.

LAKE	PREDICTED* P (mg/L)	ACCEPTABLE RANGE (mg/L)	MEAN OF FALL & WINTER OBSERVED (mg/L)	MODEL VALIDITY
Otter	0.107	0.131-0.081	0.179	Not valid
Little Jackfish	0.016	0.019-0.013	0.201	Not valid
Sandy	0.015	0.018-0.012	0.030	Not valid
Dummy	0.031	0.037-0.025	0.034	Valid
Stewart	0.030	0.036-0.025	0.028	Valid
Wolf	0.059	0.071-0.047	0.062	Valid

* Per tables 4 to 9, inclusive.

APPENDIX B

SEECHI DISC AND CHLOROPHYLL *a* DATA

Table 5: Mean chlorophyll a (µg/l) and Secchi disc (m) per station and the equivalent trophic state index (Carlson, 1977) for each parameter and station 1979, 1980 and 1981.

Lake	Station	1979 Chlorophyll a (µg/l) Mean ± SD	1979 Chlorophyll a TSI	1979 Secchi Disc (m) Mean ± SD	1979 Secchi Disc TSI	1980 Chlorophyll a (µg/l) Mean ± SD	1980 Chlorophyll a TSI	1980 Secchi Disc (m) Mean ± SD	1980 Secchi Disc TSI	1981 Chlorophyll a (µg/l) Mean ± SD	1981 Chlorophyll a TSI	1981 Secchi Disc (m) Mean ± SD	1981 Secchi Disc TSI
Killarney Lake	WQ460	17.6±20.2	58.7	1.9±0.7	50.7	16.2±9.0	57.8	1.0±0.2	60.7	19.3±10.6	59.6	0.9±0.3	59.6
	WQ461	17.7±18.8	58.8	1.8±0.8	51.5	16.3±7.9	58.0	1.0±0.2	60.0	20.1±10.4	59.9	0.9±0.2	59.9
	WQ462	20.6±22.0	60.2	1.8±0.8	51.5	15.5±6.0	57.4	1.0±0.2	60.0	19.3±11.4	59.7	0.9±0.2	59.7
	Mean	18.6±20.0		1.8±0.8		16.0±7.6		1.0±0.2		19.5±10.6		0.9±0.2	
Lake Wahtopanah (Rivers Reservoir)	WQ481	150.0±22.0[a]	79.8	1.6±1.5	52.9	41.1±49.8	67.0	1.5±1.1	54.3	14.1±18.4	56.5	1.4±0.7	55.0
	WQ482	46.5±53.6	68.2	1.2±0.7	57.9	60.3±76.0	70.8	1.7±1.2	52.5	13.8±19.7[b]	56.3	1.5±0.9	54.0
	WQ483	43.7±50.0	67.6	0.6±0.2	66.4	65.5±86.7	71.6	1.2±0.8	57.1	13.6±20.1	57.3	1.1±0.5	56.1
	Mean	80.3±11.3[a]		1.2±0.8		55.7±71.6		1.5±1.0		13.8±19.0[b]		1.4±0.7	

a) August 1, 1979 Chlorophyll a of 798 µg/l inordinately high and Secchi Disc of 3m also high.
b) No analysis June 24, 1981

Lake	Station	1979 Chlorophyll a (µg/l) Mean ± SD	1979 Chlorophyll a TSI	1979 Secchi Disc (m) Mean ± SD	1979 Secchi Disc TSI	1980 Chlorophyll a (µg/l) Mean ± SD	1980 Chlorophyll a TSI	1980 Secchi Disc (m) Mean ± SD	1980 Secchi Disc TSI	1981 Chlorophyll a (µg/l) Mean ± SD	1981 Chlorophyll a TSI	1981 Secchi Disc (m) Mean ± SD	1981 Secchi Disc TSI
Posman Lake	WQ496	19.1±13.1	59.5	1.6±0.5	53.6	10.6±10.7	53.7	1.9±0.9	50.9	7.5±5.5	50.3	1.5±0.6	54.4
	WQ497	16.1±7.8	57.8	1.5±0.6	53.8	12.6±14.5	55.4	1.9±0.9	50.4	7.9±3.0	50.8	1.4±0.5	54.7
	WQ498	14.5±5.3	56.8	1.5±0.5	53.8	11.8±13.4	54.8	1.9±0.9	50.7	7.6±5.9	50.4	1.4±0.5	54.8
	Mean	16.6±9.3		1.5±0.5		11.7±12.7		1.9±0.9		7.6±6.4		1.4±0.5	
Sandy Lake	WQ502	7.1±4.9	49.8	2.5±1.4	47.0	2.3±1.4[a]	38.9	3.0±0.5	44.0	4.5±2.8[b]	45.3	4.1±0.4	39.6
	WQ503	9.7±10.4	52.9	2.8±1.1	45.2	2.6±1.5[a]	40.0	3.5±0.8	41.9	4.0±2.7	44.1	4.6±0.7	38.0
	WQ504	8.1±5.8	51.1	2.4±0.8	47.2	3.0±1.9[a]	41.4	2.6±0.5	46.4	3.8±2.5	43.8	1.6±0.3	53.0
	Mean	8.3±7.3		2.6±0.9		2.7±1.6		3.0±0.8		4.1±2.6		3.4±1.4	

a) No analysis July 18, 1980
b) No analysis May 28, 1981

Table 4. Mean Chlorophyll a ($\mu g/l$) and mean Secchi disc (m) values for for Sandy Lake during 1979, 1980 and 1981.

Date	Chlorophyll a ($\mu g/l$)[1]	Secchi Disc (m)[1]
June 1, 1979	14.2	1.8
June 8, 1979	5.9	2.4
June 15, 1979	2.0	3.3
June 22, 1979	4.5	4.3
June 29, 1979	2.5	3.8
July 6, 1979	5.2	2.7
July 13, 1979	6.7	2.4
July 20, 1979	3.8	2.6
July 27, 1979	20.0	2.3
August 3, 1979	11.8	2.0
August 10, 1979	21.1	1.6
August 16, 1979	7.3	1.4
August 24, 1979	5.7	2.7
August 27, 1979	5.6	2.7
May 15, 1980	3.3	2.3
May 26, 1980	2.4	2.5
May 29, 1980	3.6	2.8
June 5, 1980	2.1	2.7
June 12, 1980	1.3	3.6
June 19, 1980	1.4	3.6
June 26, 1980	1.4	3.3
July 3, 1980	0.6	3.8
July 10, 1980	1.1	3.4
July 18, 1980	NA[a]	3.4
July 31, 1980	2.1	3.2
August 7, 1980	4.1	3.1
August 14, 1980	3.1	2.3
August 22, 1980	4.2	2.5
August 28, 1980	5.7	2.8
May 14, 1981	2.5	3.9
May 21, 1981	2.6	3.8
May 28, 1981	2.4[b]	3.8
June 4, 1981	1.4	3.9
June 18, 1981	1.7	3.5
June 25, 1981	1.8	3.9
July 2, 1981	2.6	3.3
July 9, 1981	2.1	3.4
July 23, 1981	7.3	3.2
July 30, 1981	6.8	3.4
August 6, 1981	6.0	3.3
August 18, 1981	7.5	2.8
August 27, 1981	7.9	2.7

[1] Each reported value for 1979, 1980 and 1981 is a mean of values from Stations WQ502, WQ503, and WQ504.

[a] No chlorophyll a analysis July 18, 1980.

[b] Station WQ502, chlorophyll a not analyzed, May 28, 1981.

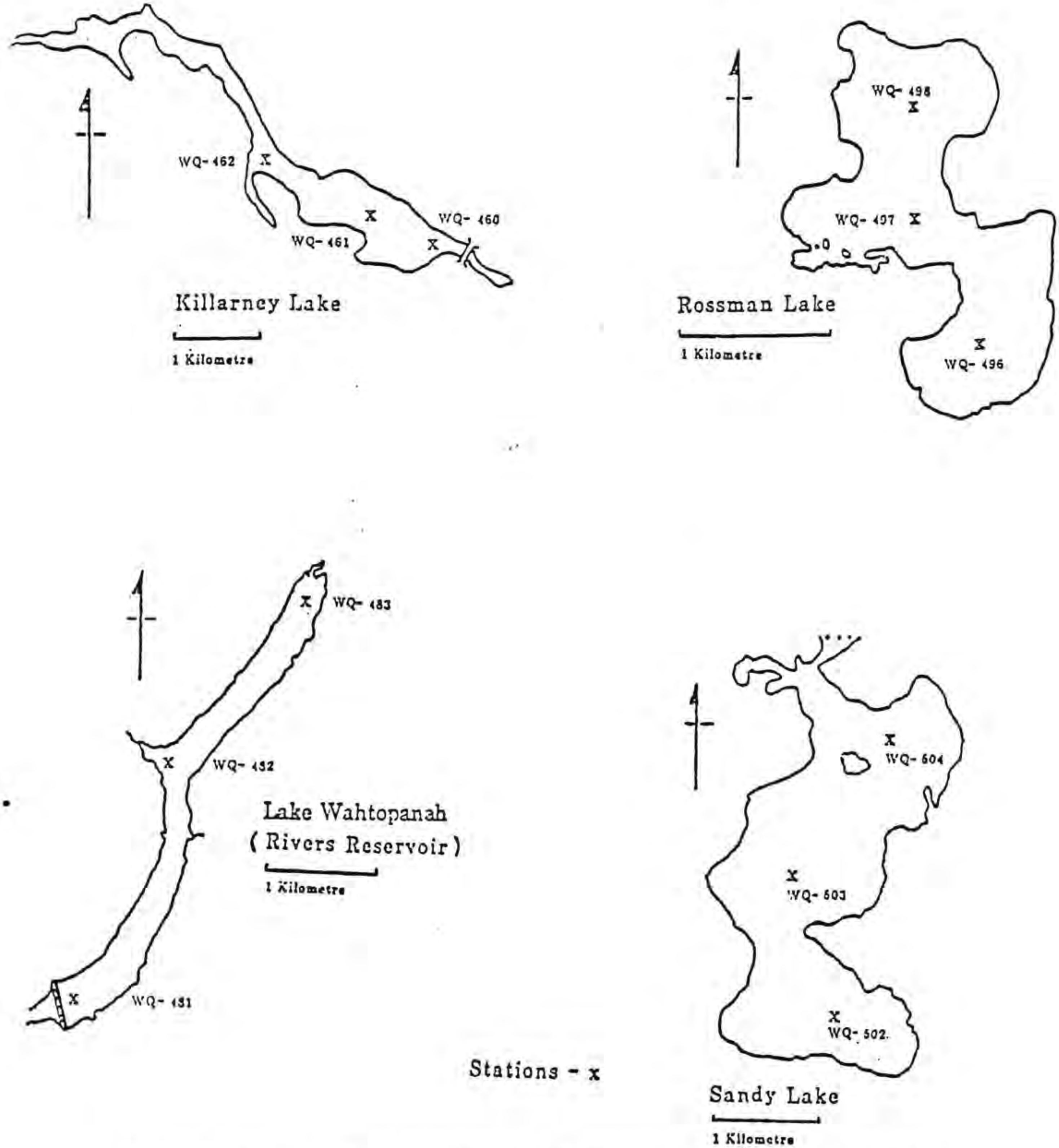


Figure 1: Water quality stations on Killarney, Wahtopanah, Rossman and Sandy Lakes.

HUGHES (1982)

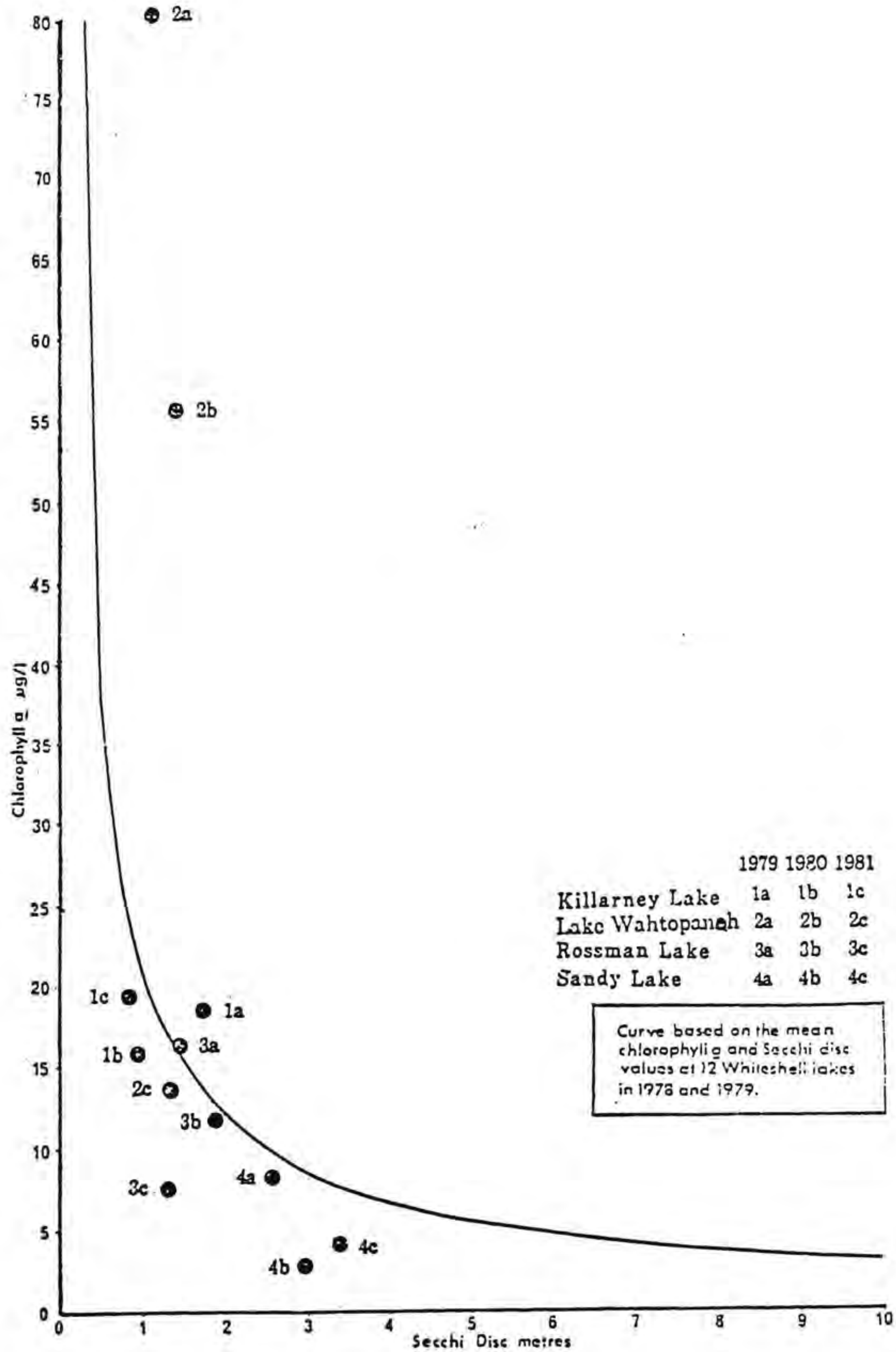


Figure 2: Chlorophyll a and Secchi disc values for Killarney, Wahtopanah Rossman and Sandy Lakes.

STATION WQ0942, SOURCE - SANDY LAKE
SAMPLING LOCATION - N E END LATITUDE 50:33 LONGITUDE 100:10

FROM 85 06 01
TO 86 01 31

DATE	COND US/CM	T.R. MG/L	F.R. MG/L	N.F.R. MG/L	PH PH UNITS	ALKALINITY MG(CACO3)/L	ALKALINITY MG(HCO3)/L	ALKALINITY MG(CO3)/L	ALKALINITY MG(OH)/L
85 07 03	1560.0	1410.	1380.	25.	8.80	326.	334.	31.	0.
85 07 09	1580.0	1300.	1300.	5. L	8.95	324.	307.	43.	0.
85 07 16	1580.0	1340.	1340.	65.	8.85	326.	315.	41.	0.
85 07 23	1570.0	1310.	1310.	5. L	8.90	326.	329.	34.	0.
85 07 30	1620.0	1320.	1320.	5. L	8.85	336.	337.	36.	0.
85 08 07	1530.0	1300.	1300.	5. L	8.90	330.	334.	34.	0.
85 08 14	1540.0	1290.	1290.	5. L	8.85	312.	307.	36.	0.
85 08 20	1520.0	1280.	1280.	5. L	8.75	318.	334.	26.	0.
85 08 27	1540.0	1220.	1220.	5. L	8.80	324.	332.	31.	0.
85 10 24	1530.0	1270.	1270.	5. L	8.70	328.	342.	29.	0.
86 01 15	1810.0	1480.	1480.	5. L	8.75	386.	432.	19.	0.

DATE	CALCIUM MG(CA)/L	MAGNESIUM MG(MG)/L	HARDNESS MG(CACO3)/L	MANGANESE MG(MN)/L	IRON MG(FE)/L	POTASSIUM MG(K)/L	SODIUM MG(NA)/L	DO MG(O2)/L	TURBIDITY NTU
85 07 03	26.	193.	858.	0.03	0.08	41.	31.	9.4	6.00
85 07 09	29.	220.	978.	0.05	0.03	39.	36.	9.1	0.85
85 07 16	26.	192.	854.	0.06	0.04	40.	30.	7.5	0.80
85 07 23	29.	210.	960.	0.08	0.04	39.	35.	7.5	0.85
85 07 30	24.	180.	800.	0.07	0.04	40.	32.	7.8	1.00
85 08 07	26.	208.	921.	0.06	0.04	45.	32.	---	0.70
85 08 14	27.	200.	891.	0.05	0.06	44.	30.	7.4	1.00
85 08 20	29.	216.	962.	0.05	0.03	40.	36.	7.9	0.75
85 08 27	25.	175.	783.	0.05	0.02 L	41.	30.	8.0	1.00
85 10 24	28.	186.	837.	0.03	0.05	43.	31.	10.9	2.00
86 01 15	32.	189.	857.	0.06	0.05	42.	34.	7.2	0.75

DATE	SILICA MG(SIO2)/L	TKN MG(N)/L	NH3 + NH4 MG(N)/L	NO3-NO2 MG(N)/L	P-TOTAL MG(P)/L	CHLORIDE MG(CL)/L	SULPHATE MG(SO4)/L	CHLORO-A UG/L	T.COLI MPN/100 ML
85 07 03	5.9	1.90	0.02	0.01 L	0.020	12.	590.	~~1.3~~	23
85 07 09	6.2	1.90	0.02	0.01 L	0.020	12.	560.	~~2.3~~	0
85 07 16	6.9	1.90	0.02	0.03	0.025	14.	600.	3.5	0
85 07 23	7.5	2.00	0.02	0.01 L	0.030	13.	590.	6.1	0
85 07 30	8.8	2.10	0.03	0.01 L	0.030	13.	590.	~~8.7~~	4
85 08 07	9.2	2.00	0.07	0.01 L	0.060	13.	600.	6.1	4
85 08 14	10.0	1.90	0.08	0.01 L	0.035	12.	640.	7.0	23
85 08 20	11.0	1.90	0.08	0.02	0.035	13.	606.	7.0	23
85 08 27	10.0	2.00	0.04	0.01	0.025	13.	592.	~~2.9~~	3
85 10 24	11.0	2.10	0.13	0.05	0.040	13.	586.	---	---
86 01 15	14.0	2.60	0.32	0.10	0.020	15.	700.	---	---

DATE	F.COLI MPN/100 ML	SECCHI DISC METRES
85 07 03	0	-4.50
85 07 09	0	4.00
85 07 16	0	2.50
85 07 23	0	1.90
85 07 30	4	1.80
85 08 07	0	1.80
85 08 14	0	2.60
85 08 20	9	1.80
85 08 27	3	1.20
85 10 24	---	1.80
86 01 15	---	---

STATION WQ0943, SOURCE - SANDY LAKE
SAMPLING LOCATION - MIDDLE LATITUDE 50:33 LONGITUDE 100:10

FROM 85 06 01
TO 86 01 31

DATE	COND US/CM	T.R. MG/L	F.R. MG/L	N.F.R. MG/L	PH PH UNITS	ALKALINITY MG(CACO3)/L	ALKALINITY MG(HCO3)/L	ALKALINITY MG(CO3)/L	ALKALINITY MG(OH)/L
85 07 03	1560.0	1320.	1320.	5. L	8.85	318.	325.	31.	0.
85 07 09	1500.0	1360.	1360.	5. L	8.85	328.	322.	38.	0.
85 07 16	1580.0	1370.	1370.	5. L	9.00	326.	310.	43.	0.
85 07 23	1570.0	1310.	1310.	5. L	8.90	336.	332.	33.	0.
85 07 30	1620.0	1340.	1340.	5. L	8.95	330.	325.	38.	0.
85 08 07	1520.0	1300.	1300.	5. L	8.91	330.	320.	41.	0.
85 08 14	1530.0	1290.	1290.	5. L	8.75	322.	315.	35.	0.
85 08 20	1510.0	1280.	1280.	5. L	8.10	320.	332.	29.	0.
85 08 27	1540.0	1240.	1240.	5. L	8.70	320.	332.	29.	0.
85 10 24	1530.0	1260.	1260.	5. L	8.75	326.	334.	31.	0.
86 01 15	1770.0	1500.	1500.	5. L	8.45	384.	454.	7.	0.

DATE	CALCIUM MG(CA)/L	MAGNESIUM MG(MG)/L	HARDNESS MG(CACO3)/L	MANGANESE MG(MN)/L	IRON MG(FE)/L	POTASSIUM MG(K)/L	SODIUM MG(NA)/L	DO MG(O2)/L	TURBIDITY NTU
85 07 03	25.	195.	865.	0.03	0.04	40.	31.	9.3	1.00
85 07 09	27.	210.	932.	0.03	0.03	40.	34.	9.8	0.65
85 07 16	26.	190.	847.	0.06	0.04	40.	31.	8.1	0.70
85 07 23	27.	200.	890.	0.06	0.04	39.	32.	7.6	1.00
85 07 30	25.	190.	844.	0.02 L	0.02	34.	34.	7.8	0.60
85 08 07	26.	207.	916.	0.05	0.03	44.	32.	7.6	0.55
85 08 14	27.	205.	910.	0.04	0.04	47.	30.	9.6	0.50
85 08 20	28.	213.	947.	0.05	0.03	40.	35.	7.8	0.70
85 08 27	26.	178.	797.	0.05	0.02 L	40.	32.	8.0	1.00
85 10 24	27.	180.	808.	0.02	0.04	43.	31.	10.9	1.00
86 01 15	31.	188.	852.	0.06	0.05	43.	34.	6.2	0.65

DATE	SILICA MG(SIO2)/L	TKN MG(N)/L	NH3 + NH4 MG(N)/L	NO3-NO2 MG(N)/L	P-TOTAL MG(P)/L	CHLORIDE MG(CL)/L	SULPHATE MG(SO4)/L	CHLORO-A UG/L	T.COLI MPN/100 ML
85 07 03	6.4	1.90	0.01	0.01 L	0.020	12.	600.	1.5	9
85 07 09	5.8	1.00	0.01	0.01 L	0.020	12.	554.	45.5	4
85 07 16	6.0	1.80	0.01	0.01 L	0.025	14.	600.	11.4	0
85 07 23	6.8	1.90	0.03	0.01 L	0.030	13.	556.	12.2	0
85 07 30	8.2	2.00	0.02	0.01 L	0.025	13.	623.	7.0	0
85 08 07	8.5	2.00	0.03	0.01	0.025	13.	615.	2.6	0
85 08 14	9.7	1.90	0.08	0.01 L	0.035	12.	640.	11.4	4
85 08 20	9.8	2.00	0.11	0.02	0.040	13.	566.	7.9	7
85 08 27	10.0	2.00	0.04	0.01	0.020	13.	600.	10.5	0
85 10 24	12.0	2.10	0.14	0.06	0.025	13.	526.	---	[illegible]
86 01 15	14.0	2.60	0.32	0.11	0.015	15.	693.	---	---

DATE	F.COLI MPN/100 ML	SECCHI DISC METRES
85 07 03	0	5.00
85 07 09	0	3.10
85 07 16	0	2.20
85 07 23	0	2.00
85 07 30	0	3.00
85 08 07	0	2.50
85 08 14	4	2.70
85 08 20	0	1.80
85 08 27	0	1.60
85 10 24	---	3.00
86 01 15	---	---

Appendix IV(e-ii)

STATION WQ0944, SOURCE - SANDY LAKE
SAMPLING LOCATION - S E END LATITUDE 50:32 LONGITUDE 100:10

FROM 85 06 01
TO 86 01 31

DATE	COND US/CM	T.R. MG/L	F.R. MG/L	N.F.R. MG/L	PH PH UNITS	ALKALINITY MG(CACO3)/L	ALKALINITY MG(HCO3)/L	ALKALINITY MG(CO3)/L	ALKALINITY MG(OH)/L
85 07 03	1560.0	1360.	1360.	5. L	8.80	326.	334.	31.	0.
85 07 09	1580.0	1330.	1330.	5. L	8.90	328.	317.	41.	0.
85 07 16	1580.0	1360.	1360.	5. L	8.95	326.	315.	41.	0.
85 07 23	1620.0	1330.	1330.	5. L	8.90	332.	322.	41.	0.
85 07 30	1620.0	1320.	1320.	5. L	8.85	336.	342.	34.	0.
85 08 07	1510.0	1300.	1300.	5. L	8.80	326.	315.	41.	0.
85 08 14	1530.0	1290.	1290.	5. L	8.90	310.	305.	35.	0.
85 08 20	1510.0	1260.	1260.	5. L	8.75	318.	325.	31.	0.
85 08 27	1540.0	1240.	1240.	5. L	8.80	326.	339.	29.	0.
85 10 24	1540.0	1280.	1280.	5. L	8.65	330.	329.	36.	0.
86 01 15	1820.0	1540.	1540.	5. L	8.35	390.	476.	5.	0.

DATE	CALCIUM MG(CA)/L	MAGNESIUM MG(MG)/L	HARDNESS MG(CACO3)/L	MANGANESE MG(MN)/L	IRON MG(FE)/L	POTASSIUM MG(K)/L	SODIUM MG(NA)/L	DO MG(O2)/L	TURBIDITY NTU
85 07 03	25.	194.	861.	0.03	0.04	41.	31.	9.5	1.00
85 07 09	28.	215.	956.	0.04	0.03	39.	36.	8.7	0.55
85 07 16	26.	190.	847.	0.05	0.04	39.	31.	7.7	0.95
85 07 23	27.	200.	890.	0.06	0.04	39.	33.	7.7	1.00
85 07 30	25.	190.	844.	0.05	0.03	40.	35.	8.0	0.90
85 08 07	25.	202.	894.	0.04	0.03	43.	31.	7.7	0.85
85 08 14	27.	200.	891.	0.07	0.07	43.	30.	7.5	1.00
85 08 20	29.	211.	938.	0.04	0.03	41.	35.	8.0	0.65
85 08 27	25.	174.	778.	0.04	0.02 L	40.	31.	8.1	0.85
85 10 24	28.	182.	819.	0.02	0.04	43.	31.	11.0	1.00
86 01 15	32.	191.	862.	0.06	0.05	44.	33.	6.3	0.70

DATE	SILICA MG(SIO2)/L	TKN MG(N)/L	NH3 + NH4 MG(N)/L	NO3-NO2 MG(N)/L	P-TOTAL MG(P)/L	CHLORIDE MG(CL)/L	SULPHATE MG(SO4)/L	CHLORO-A UG/L	T.COLI MPN/100 ML
85 07 03	6.1	1.90	0.01	0.01 L	0.050	12.	610.	1.3	7
85 07 09	5.8	1.90	0.01	0.01 L	0.020	12.	596.	3.5	0
85 07 16	6.1	1.90	0.02	0.01 L	0.025	14.	600.	4.4	0
85 07 23	6.8	1.90	0.03	0.01 L	0.025	13.	596.	5.3	0
85 07 30	8.2	2.00	0.02	0.01 L	0.025	13.	620.	3.5	0
85 08 07	8.1	1.90	0.03	0.01 L	0.025	13.	600.	16.6	0
85 08 14	9.3	1.90	0.06	0.01 L	0.035	12.	650.	5.3	9
85 08 20	9.7	1.90	0.06	0.01 L	0.035	13.	585.	5.3	0
85 08 27	9.8	2.00	0.02	0.01 L	0.025	13.	570.	8.7	0
85 10 24	12.0	2.00	0.12	0.08	0.025	13.	590.	---	---
86 01 15	14.0	2.60	0.33	0.10	0.020	15.	700.	---	---

DATE	F.COLI MPN/100 ML	SECCHI DISC METRES
85 07 03	4	4.40
85 07 09	0	3.50
85 07 16	0	2.20
85 07 23	0	2.00
85 07 30	0	2.00
85 08 07	0	3.00
85 08 14	9	1.06
85 08 20	0	1.00
85 08 27	0	1.00
85 10 24	---	3.00
86 01 15	---	---

Appendix IV(e-iii)

STATION WR0943, SOURCE - SANDY LAKE
SAMPLING LOCATION - MIDDLE LATITUDE 50:33 LONGITUDE 100:10

FROM 86 06 01
TO 87 01 30

DATE	COND US/CM	T.R. MG/L	F.R. MG/L	N.F.R. MG/L	PH PH UNITS	ALKALINITY MG(CACO3)/L	ALKALINITY MG(HCO3)/L	ALKALINITY MG(CO3)/L	ALKALINITY MG(OH)/L
86 07 07	1420.0	1200.	1200.	7.	8.60	312.	349.	16.	0.
86 07 15	1430.0	1200.	1200.	5.	8.65	322.	354.	19.	0.
86 07 22	1440.0	1300.	1300.	6.	8.70	318.	349.	19.	0.
86 07 29	1420.0	1200.	1200.	7.	8.70	306.	329.	22.	0.
86 08 12	1410.0	1200.	1200.	6.	8.70	320.	351.	19.	0.
86 10 15	1480.0	1200.	1200.	5. L	8.45	328.	386.	7.	0.
87 01 12	1690.0	1400.	1400.	5. L	8.10	380.	464.	0.	0.

DATE	CALCIUM MG(CA)/L	MAGNESIUM MG(MG)/L	HARDNESS MG(CACO3)/L	MANGANESE MG(MN)/L	IRON MG(FE)/L	POTASSIUM MG(K)/L	SODIUM MG(NA)/L	DO MG(O2)/L	TURBIDITY NTU
86 07 07	31.	154.	710.	0.05	0.03	37.	25.	7.0	1.50
86 07 15	32.	158.	730.	0.06	0.05	31.	25.	8.4	2.00
86 07 22	31.	164.	753.	0.06	0.03	41.	26.	8.0	1.00
86 07 29	32.	161.	742.	0.07	0.04	42.	27.	6.6	1.00
86 08 12	35.	167.	773.	0.08	0.05	42.	28.	7.3	1.00
86 10 15	35.	156.	729.	0.02 L	0.03	37.	28.	8.9	1.40
87 01 12	43.	178.	841.	0.16	0.08	43.	33.	6.1	0.73

DATE	SILICA MG(SIO2)/L	TKN MG(N)/L	NH3 + NH4 MG(N)/L	NO3-NO2 MG(N)/L	P-TOTAL MG(P)/L	CHLORIDE MG(CL)/L	CHLORO-A UG/L	SECCHI DISC METRES	SAMPLE DEPTH METRES
86 07 07	7.9	1.80	0.02	0.01 L	0.040	11.	2.6	1.25	4.00
86 07 15	8.5	1.90	0.02	0.01 L	0.035	11.	2.1	1.00	0.60
86 07 22	9.1	1.90	0.01	0.01 L	0.040	12.	2.8	1.20	2.40
86 07 29	10.0	2.00	0.02	0.01 L	0.015	12.	1.0 L	1.30	5.40
86 08 12	12.0	1.90	0.06	0.02	0.035	12.	2.1	1.00	0.60
86 10 15	13.2	1.70	0.01	0.12	0.035	11.	---	---	3.60
87 01 12	15.4	2.25	0.30	0.10	0.035	14.	---	---	4.90

STATION NQ0966, SOURCE - SANDY LAKE
SAMPLING LOCATION - SOUTH NARROWS LATITUDE 50:33 LONGITUDE 100:10

FROM 86 06 01
TO 87 01 30

DATE	COND US/CM	T.R. MG/L	F.R. MG/L	N.F.R. MG/L	PH PH UNITS	ALKALINITY MG(CACO3)/L	ALKALINITY MG(HCO3)/L	ALKALINITY MG(CO3)/L	ALKALINITY MG(OH)/L
86 07 07	1430.0	1200.	1200.	9.	8.60	312.	346.	17.	0.
86 07 15	1430.0	1200.	1200.	6.	8.65	322.	354.	19.	0.
86 07 22	1450.0	1300.	1300.	6.	8.65	316.	342.	22.	0.
86 07 29	1430.0	1200.	1200.	5.	8.70	314.	334.	24.	0.
86 08 06	1430.0	1200.	1200.	5. L	8.75	312.	322.	29.	0.
86 08 12	1430.0	1200.	1200.	6.	8.70	320.	346.	22.	0.
86 10 15	1480.0	1200.	1200.	5. L	8.40	324.	386.	5.	0.
87 01 12	1710.0	1400.	1400.	5. L	8.15	374.	456.	0.	0.

DATE	CALCIUM MG(CA)/L	MAGNESIUM MG(MG)/L	HARDNESS MG(CACO3)/L	MANGANESE MG(MN)/L	IRON MG(FE)/L	POTASSIUM MG(K)/L	SODIUM MG(NA)/L	DO MG(O2)/L	TURBIDITY NTU
86 07 07	31.	154.	711.	0.06	0.04	35.	25.	7.5	1.50
86 07 15	31.	156.	721.	0.06	0.05	30.	25.	8.1	2.00
86 07 22	32.	166.	763.	0.07	0.03	41.	26.	7.6	1.50
86 07 29	32.	161.	743.	0.07	0.04	42.	26.	7.9	2.00
86 08 06	32.	161.	742.	0.05	0.04	41.	27.	8.4	1.00
86 08 12	34.	170.	786.	0.08	0.06	42.	26.	6.5	0.70
86 10 15	35.	156.	728.	0.02 L	0.03	38.	28.	9.8	0.60
87 01 12	43.	179.	845.	0.08	0.05	44.	33.	6.9	1.11

DATE	SILICA MG(SIO2)/L	TKN MG(N)/L	NH3 + NH4 MG(N)/L	NO3-NO2 MG(N)/L	P-TOTAL MG(P)/L	CHLORIDE MG(CL)/L	CHLORO-A UG/L	SECCHI DISC METRES	SAMPLE DEPTH METRES
86 07 07	8.1	1.90	0.02	0.01	0.040	11.	1.0 L	1.25	3.00
86 07 15	8.6	2.00	0.01	0.01 L	0.035	11.	1.0 L	1.20	2.40
86 07 22	9.2	1.90	0.01	0.01 L	0.040	12.	2.8	1.40	0.00
86 07 29	10.0	1.90	0.02	0.01 L	0.010 L	12.	1.4	1.20	1.00
86 08 06	11.0	1.90	0.02	0.01 L	0.030	11.	1.4	1.60	2.40
86 08 12	12.0	1.90	0.04	0.01	0.035	12.	2.0	1.50	4.00
86 10 15	12.8	1.80	0.01	0.12	0.030	11.	---	-	1.20
87 01 12	14.0	2.15	0.19	0.14	0.025	14.	---	---	3.50

Appendix III (c-iv)

APPENDIX C

DISSOLVED OXYGEN DATA

1990 - 1991 WINTER DISSOLVED OXYGEN TESTS

			ICE		SNOW			OXYGEN			
WATERBODY (Lat. Long.)	Stn. (#)	Date (Y,M,D)	Total Thick. (cm)	Opaque Thick. (cm)	Depth (cm)	Cover (%)	Water Depth (m)	Top D.O. (ppm)	Bottom D.O. (ppm)	Test Method	Ma (#
Rock Lake 49°13'x99°15'	1	90 12 11	27	0	14	100	2.0	13.50	N\D	YSI	3
	1	91 01 15	58	0	18	100	2.5	10.30	10.00	YSI	
	2		50	0	15	100	3.0	11.50	11.10		
	3		55	0	12	100	3.0	12.50	8.00		
	4		57	0	12	100	3.0	14.00	8.00		
	1	91 02 20	70	0	12	100	2.6	6.60	10.00	YSI	
	2		68	0	10	100	3.1	9.80	9.00		
	3		67	0	12	100	3.5	9.80	11.50		
	4		70	0	10	95	3.1	11.20	10.50		
	1	91 03 14	75	10	9	100	3.0	8.80	11.40	YSI	
	2		66	3	9	100	3.15	9.20	8.70		
Rossman Lake 50°44'x100°42'	1	91 03 11	65	0	40	100	5.25	6.40	0.50	YSI	3
	2		70	0	30	100	5.50	8.30	0.45		
"Rupa" Lake 50°39'x100°22'	unable to test due to access problems										
Russell Reservoir 50°48'x101°19'	1	91 01 10	60	1	12	100	3.0	6.40	6.30	YSI	3
	2		51	1	10	100	4.3	7.00	6.60		
	1	91 02 19	93	10	11	100	3.2	5.30	5.20	YSI	
	2		60	2	16	100	4.5	6.00	5.40		
Sandy Lake 50°33'x100°09'	1	90 12 12	34	0	12	100	4.5	15.00	12.00	YSI	3
	2		32	0	12	100	3.5	14.50	14.00		
	3		32	0	12	100	4.2	14.00	9.50		
	6		32	0	10	100	1.7	3.10	2.30		
	1	91 01 10	60	0	10	100	4.5	13.20	10.00	YSI	
	2		55	0	10	100	1.7	13.10	N\D		
	3		50	0	12	100	4.5	11.50	3.80		
	4		62	0	10	100	4.2	12.00	5.50		
	6		52	0	10	100	1.5	0.20	N\D		
	1	91 01 22	65	0	15	100	4.5	11.20	7.20	YSI	
	2		61	0	12	100	3.5	10.00	N\D		
	3		65	0	15	100	4.5	11.00	5.00		
	4		65	0	12	100	4.0	10.20	4.40		

1990 - 1991 WINTER DISSOLVED OXYGEN TESTS

			ICE		SNOW			OXYGEN			
WATERBODY (Lat. Long.)	Stn. (#)	Date (Y,M,D)	Total Thick. (cm)	Opaque Thick. (cm)	Depth (cm)	Cover (%)	Water Depth (m)	Top D.O. (ppm)	Bottom D.O. (ppm)	Test Method	M (
Sandy Lake (continued)	1	91 02 06	69	0	12	100	4.0	10.00	6.40	YSI	
	2		67	0	10	100	3.5	8.40	3.95		
	3		70	0	10	100	4.5	9.50	3.65		
	4		78	0	10	100	4.0	6.50	0.75		
	5		69	0	10	100	2.0	9.30	1.90		
	6		50	0	20	100	1.5	0.60	N\D		
	1	91 02 19	70	0	18	100	4.0	10.10	7.70	YSI	
	2		73	0	16	100	1.5	8.00	N\D		
	3		80	0	15	100	4.0	9.10	8.50		
	4		77	0	15	100	3.7	8.50	6.00		
	1	91 03 08	76	3	26	100	4.25	9.10	2.10	YSI	
	2		78	3	30	100	3.5	7.10	3.55		
	3		75	0	29	100	4.25	8.30	1.05		
	4		85	0	26	100	4.0	8.00	0.60		
Seech Lake 50°40'x100°28'	1	91 01 22	60	0	50	100	11.0	10.60	3.75	YSI	
	1	91 03 12	75	0	32	100	11.0	10.30	0.70	YSI	
Shoal Lake 50°24'x100°36'	1	90 12 12	open water		N\D	N\D	N\D	N\D	N\D	YSI	
	2		37	0	11	100	2.0	17.80	9.20		
	3		36	0	10	100	2.25	18.20	9.20		
	4		40	0	10	100	2.5	19.20	3.55		
	5		38	0	10	100	2.5	16.40	8.80		
	6		37	0	11	100	2.5	15.80	11.00		
	7		35	5	20	100	4.0	14.00	4.75		
	8		38	0	10	100	4.0	13.80	3.45		
	9		34	0	15	100	3.5	13.20	5.60		
	Lisle Metrix probe			N\D	N\D	N\D	N\D	11.90	N\D	N\D	
	1	91 01 11	62	5	10	100	2.0	7.60	6.80	YSI	
	2		60	0	10	100	2.0	5.40	4.65		
	3		65	3	10	100	2.25	5.00	0.75		
	4		68	2	13	100	2.5	4.15	0.85		
	5		60	5	18	100	2.5	4.20	1.75		
	6		60	2	15	100	2.5	4.00	4.20		
	7		55	2	12	100	4.0	3.00	0.90		
	8		60	0	15	100	4.0	2.45	0.65		
	9		58	0	20	100	3.5	2.65	0.65		
	Lisle Metrix probe			N\D	N\D	N\D	N\D	7.20	N\D	N\D	

INTER- DEPARTMENTAL MEMORANDUM

FROM G. A. Edwards

Resource Technician

PROVINCE OF MANITOBA

DATE MARCH 20, 1972

TO Mr. W. N. Howard

Fisheries Biologist

SUBJECT Winter Oxygen Test Results for 1972 - Western Region

				Depth (Inches)		(Feet)	(P.P.M.) Dissolved	
District	Lake	Date	Stn.	Ice	Snow	Water	Top	Bottom
NEEPAWA	Beaver Dam	Mar 2	I	30	8	6.5	.4	-
			II	27	8	4.5	0	-
	Irwin	Mar 3	I	42	4	13.5	1.2	2.2
			II	35	4	11.0	.4	1.9
	Minnedosa	Mar 3	I	35	8	17.5	3.4	1.6
	Park	Mar 3	I	38	3	6.5	2.6	-
	Pacey	Mar 2	I	23	12	15.5	.2	.1
			II	22	12	12.5	.3	.4
	Sandy	Mar 6	I	30	6	13.6	2.4	1.2
			II	30	6	16.0	2.5	.8
	Shoal	Mar 7	I	36	6	7.0	3.0	3.0
			II	33	6	9.0	2.4	3.3
	Silver Beach	Mar 13	I	27	13	13.5	5.8	1.2
			II	27	13	13.0	6.2	1.4
	Tokaryk	Mar 6	I	30	9	13.0	2.45	2.1
			II	31	9	7.0	2.9	2.1
BRANDON	Sewell	Mar 8	I	39	5	4.75	0	-
			II	38	5	5.5	0	-
	Jackson	Mar 8	I	29	6	18.0	.1	0
	Kenton Res.	" 8	I	36	3	24.0	2.2	.2
	Prescot Dam	Mar 7	I	37	3	11.0	.1	0
KILLARNEY	Balmur	Mar 9	I	33	7	5.0	0	-
	(Sec 15&16 T. 3, R.14W)		II	38	7	5.5	0	-
	Bone	Mar 9	I	44	3	4.5	0	-
			II	44	3	4.5	0	-

1980

Lakes Tested for Dissolved Oxygen - Winter 1979-1980

South Side of Riding Mountain

Lake	Date/80	Stn.	Ice (inches)	Snow (inches)	% Snow Cover	Depth Ft.	D.O. Top	D.O. Mid	D.O. Bottom
Antoniw's Pond	Mar. 5	1	28	10	100	10	0.1		0
		2	27	15		7	0		0
Arrow	Mar. 4	1	27	12		15	0.8		0
		2	27	12		8	0.6		0
Crawford (or Prest All)	Mar. 6	1	27	8		29	5.0		1.3
Chorney (#41) = Czorny - Hard.	Mar. 3	1	27	7		14	3.5		0
		2	28	8		10	3.3		0
Dummy (Blue)	Mar. 14	1	30	10		35	2.0		0.4
		2	31	10		38	2.1		0.4
Firby's (SE 10-16-19)	Feb. 27	1	29	3		20	1.0		0
		2	30	4		12	1.0		0
#58 (on W.M.A.)	Mar. 4	1	28	12		13	0.2		0
Groschak = Groszak	Mar. 3	1	28	10		38	1.7		0
		2	28	12		15	1.8		0
Horseshoe	Mar. 3	1	28	10		35	1.4		0
		2	28	10		28	1.6		0
Imrie	Mar. 6	1	27	12		19	3.0	1.6	0
		2	27	14		15	2.8		0
Little Jackfish	Mar. 14	1	32	10		8	4		
		2	32	8		18	4		2.0
		3	33	12		8	0.6		
Nora	Mar. 6	1	30	3		21	0.5		0.2
		2	31	5		18	0.6		0.2
Olha	Mar. 5	1	28	12		15	1.0		0.6
		2	28	10		7	0 Strong H_2S smell		0
Rossman	Mar. 5	1	27	10	100	16	4		0.6
		2	28	12		17	4.5		0.8
Russell Res.	Mar. 5	1	26	10		9	2.6		0.6
Sandy	Feb. 27	1	31	6		18	2.2		2.0
Sandy L Pond (400)	Feb. 27	1	29	3		9	0.1		
Seech	Mar. 3	1	27	10		37	1.2		2.6
Silver Beach	Mar. 5	1	26	10		15	3.0		0.6
Stewart = Stuart	Mar. 3	1	28	6		14	2.5		1.0
Thomas	Mar. 14	1	30	10		22	5.0		4.0
Tokaryk	Mar. 5	1	28	10		9	4.5		1.6

Neepawa District

Lake	Date/80	Stn.	Ice (inches)	Snow (inches)	% Snow Cover	Depth Ft.	D.O. Top	D.O. Mid	D.O. Bottom
#Eighteen	Feb. 26	1	28	4		22	2		0
		2	27	6		18	1.8		0

1979 D. O. Test Summary - South of Riding Mountains

District	Lake	Date	Station	Depth Feet	Total Ice	Opaque Ice	Av. Snow Depth	Top D.O.	Bottom D.O.	Remarks
Killarney	Pelican Lake	21 03 79	1	13	38"	0	12"	0.1	0.1	
			2	7	36"	0	12"	0.3		
			3	14	38"	0	11"	0.1	0.1	
			4	10	39"	8"	12"	0.1	0.1	
			5	11	41"	0	12"	0.1	0.1	
			6	12	40"	0	11"	0.1	0.1	
			7	10	40"	0	10"	0.1	0.1	
Neepawa	Kerr	22 03 79	1	9.8	35.4"		11"	2.0	0	
			2	13.1	33.9"		14.2"	1.2	0.8	
	Irwin	22 03 79	1	12.5	37"		8.7"	1.0	0.6	
			3	15.3	44.5"		11.8"	1.0	0.4	
			6	7.4	41.7"		6.3"			Centre 3.2 ppm.
			7	6.6	39.4"		9.8"			Centre 4.4
	Patterson	14 03 79	1	18.5	38.2"		7.9"	0	0	
		14 03 79	2	7.6	30.71		12.2"	0		
	Gertrude	15 03 79	1	16.4	32.7"		8.66"	1.0	0.2	
			2	28.9	30.7"		13.8"	1.6	0	
	Tokar[illegible]k	14 03 79	1	23	31.9"		11.8"	0	1.4	
			2	19.7	36.2"		8.7"	2.0	0.2	
	Olha	14 03 79	1	14.8	30.3"		10.6"	0	2.6	
			2	13.1	36.2"		13.0"	0	0	
	Minnedosa Res.	14 03 79	1	11	38"		9"	2.1	1.4	
	Sandy	"	1	16	36"		12"	3.5	1.8	
	F.W.I. #311	"	1		36"		8"	0.0	0.0	H_2S
	Fourteen	"	1		36"		10"	0.0	0.0	H_2S Water brown in colour
	Eighteen	15 03 79	1	20	30"	1"	12"	3.4	1.8	
	C.L.I. #11									Surrounded by private land, not tested
	Seech	16 03 79	1	40	35"		9"	7.0	3.0	
	Horseshoe		1	37	35"		12"	1.0	0.0	18' O_2 -2.2 ppm.
	Chappell		1		35"		10"	0.0	0.0	H_2S
	Corstorphine		1		33"	1"	12"	0.0	0.0	H_2S
	C.L.I. #25		1	17	35"		8"	0.4	0.0	

aterbody	Station (#)	DATE (Y M D)	Total ice thick. (cm)	Opaque ice thick. (cm)	Snow depth (cm)	Snow cover (%)	Water depth (m)	Top D.O. (ppm)	Bottom D.O. (ppm)	Map (#)
	3		46	5	24	100	3.5	11.6	1.95	
	4		45	2	30	100	3.25	15.2	2.85	
	5		44	0	19	100	3.0	15.6	2.55	
	1	92 01 07	58	15	12	100	3.0	11.1	2.3	
	2		50	10	20	100	3.5	10.5	1.8	
	3		50	5	17	100	3.5	10.1	3.0	
	4		52	2	14	100	3.25	13.1	5.0	
	5		52	0	13	100	3.0	13.5	3.4	
	1	92 02 12	61	0	20	100	3.2	5.0	3.0	
	2		60	0	25	100	3.5	3.7	1.7	
	3		58	7	20	100	3.5	4.1	ND	
	4		62	15	18	100	3.4	9.2	8.0	
	1	92 02 25	69	23	30	100	3.0	3.2	1.0	
	2		65	ND	21	100	3.5	1.1	0.2	
	3		ND	ND	ND	100	3.5	3.4	1.3	
	4		ND	ND	ND	100	3.4	6.9	0.7	
"Rupa" Lake	1	92 03 05	52	30	12	100	2.0	0.45	ND	44
Sandy Lake	1	91 11 27	40	7	5	100	4.2	13.0	14.1	45
	2		37	4	4	100	3.1	12.2	12.1	
	3		35	3	4	100	4.0	11.8	9.2	
	4		32	3	3	100	4.0	11.1	9.1	
	1	91 12 18	50	12	19	100	4.2	12.4	13.5	
	2		48	4	20	100	3.1	12.2	9.2	
	3		47	3	22	100	4.0	12.0	5.0	
	4		48	3	17	100	4.0	10.0	1.0	
	1	92 01 06	58	12	19	100	4.2	11.0	10.2	
	2		58	4	20	100	3.1	9.6	8.1	
	3		60	3	20	100	4.0	9.3	1.1	
	4		60	3	18	100	4.0	9.5	1.2	
	1	92 01 20	60	20	22	100	4.2	10.9	7.0	
	2		57	7	26	100	3.1	8.5	ND	
	3		57	8	27	100	4.0	9.8	0.7	
	4		60	10	17	100	3.75	9.4	ND	
	1	92 02 18	67	7	27	100	4.5	8.2	2.6	
	2		62	12	25	100	3.2	5.6	4.1	
	3		62	5	17	100	4.5	5.6	2.3	
	4		68	9	16	100	3.8	4.7	0.7	
	1	92 03 05	70	ND	20	100	4.2	6.1	4.5	
	2		68	ND	22	100	3.5	4.2	2.3	
	3		68	ND	20	100	4.2	5.0	1.6	
	4		70	ND	20	100	4.0	3.0	0.8	

1973

DISTRICT	LAKE	DATE	STN.	DEPTH Inches ICE CLEAR	WHITE	SNOW	Feet WATER	% SNOW COVER	P.P.M. DISSOLVED O_2 TOP	BOTTOM
	Patterson	Feb 26	I	26	-	10	7.5	100	0	-
			II	26	-	3	9.0	-	1.6	-
	Sandy	Feb 26	I	18	-	7	18.5	100	7.0	2.8
			II	18	-	7	22.5	-	5.6	.2
	Shoal	Feb 26	I	40	-	4	7.5	100	3.4	-
			II	37	1	4	9.0	-	2.4	-
	Tokaruk	Feb 26	I	28	-	8	13.5	100	6.6	6.0
			II	28	-	8	10.0	-	9.8	9.4
	Park	Feb 27	I	38	1	1	6.5	100	4.2	-
	Irwin	Feb 27	I	39	½	1	12.0	50	11.6	-
	South Pacey	" 27	I	30	-	6	15.0	100	4.2	1.0
SWAN R.	Black Beaver	Mar 2	I	19	1	6	17.5	100	.2	0
			II	20	-	10	7.5	-	2.2	-
			III	22	-	10	7.0	-	.5	-
KILLARNEY	Overend	Feb 19	I	32	3	5	6.5	100	5.2	-
	Bone	Feb 19	I	37	½	3	5.0	80	18.4	-
			II	37	½	3	4.5	80	13.8	-
	Grass	Feb 19	I	38	1	5	4.0	100	o	-
	Pelican	Feb 20	I	35	-	2	7.5	50	9.6	10.2
			II	35	-	2	18.0	-	12.6	9.6
			III	32	-	3	10.0	-	6.8	10.2
			IV	39	-	3	8.0	-	15.4	15.0
			V	33	-	3	12.0	-	9.0	-
	Rock	Feb 20	I	32	-	3	6.5	100	21.8	-
			II	36	1	4	9.5	100	5.8	4.6
	Lorne	Feb 20	I	36	-	2	6.0	30	0	-
	Pilot Mnd. Res.	Feb 21	I	35	-	1	14.5	30	22.8	1.4
	Crystal City Res.	Feb 21	I	28	-	1	7.5	40	18.8	-
	Swan Lake	Feb 21	I	33	-	3	4.5	90	6.0	-
			II	33	-	3	4.5	-	4.8	-

KEY
DISS. - Dissolved
B. - Bottom
OXY. - Oxygen

DISSOLVED OXYGEN TESTS - WESTERN REGION - 1974

DISTRICT	LAKE	DATE	STATION	MAP. REF	DEPTH	TOTAL ICE (in)	OPAQUE ICE (in)	AVE. SNOW DEPTH(in)	TOP DISS. OXY.(PPM)	B. DISS. OXY(PPM)	REMARKS
[illegible]an River	Woody R	03/01/74	1			27		8	8.0	10.6	
		18/01/74	1			24		8	9.8	11.8	
		25/01/74	1			25		8	9.4	8.8	
		02/02/74	1			28		10	9.6	9.0	
		07/02/74	1			36		10	7.4	9.0	
		22/02/74	1			26		9	7.6	7.3	
		28/02/74	1						8.2	8.6	
		10/03/74	1						10.1	8.6	
	Indian Birch R.	03/01/74	1			27		6	1.8	2.0	
		18/01/74	1			24		8	1.2	1.0	
		25/01/74	1			26		8	0.2	0.4	
		02/02/74	1			36		10	0.2	0.4	
		07/02/74	1			30		10	0.0	0.0	
	Swan Lake	02/01/74	1			30		6	8.4		
		18/01/74	1			22		5	10.8		
		25/01/74	1			24		5	8.4		
		02/02/74	1			24'		12	7.6		
		07/02/74	1			27		12	8.1		
		22/02/74	1			30		10	7.9		
		28/02/74	1						6.2		
		10/03/74	1						9.6		
	Swan R.	11/01/74	1			16		14		8.0	
		18/01/74	1			14		15	6.0	6.2	
		25/01/74	1			30		5	5.2	5.0	
		02/02/74	1			30		10	2.4	3.0	
		07/02/74	1			36		10	4.0	4.0	
		13/02/74	1			27		10	3.8	3.8	
			2			24		12	4.2	3.6	
			3			20		16	3.4	4.0	
		22/02/74	1			25		14	2.7	2.6	
			2			16		14	2.9	2.6	
			3			24		10	2.8	3.0	
			4			24		10	3.0	4.2	
		10/03/74	1						5.0	4.8	
			2						4.8	4.8	
	Line	11/03/74	1	2A	7	24	8	12	5.4		No Slush
			2		7	24	1	18	0.2		No Slush
	Black Beaver	07/03/74	1	1A	7	18	5	24	4.6		
			2		7	18	7	24	2.8		
			3		8	20	7	24	1.8		
			4		9	20	6	24	1.4		*Layered
			5		8	20	*	14	1.0		
	Gas L(#4)	10/03/74	1			23		13	2.6	1.0	2"Slush
	Nick Lake (#3)	10/03/74	1			23		10	4.8	3.2	10"Slush
	Shanty L West of Wellman	18/03/74	1			30	7	14	1.1	.6	
	Swan Lake	10/02/74	1						9.6		
G'View	Shanty L	11/03/74	1		4	18	Slush	12	0.0		H_2S
	near		2		5½	18	3	12	0.0		H_2S
	Baldy Mtn		3		3	18	Slush	12	0.0		H_2S
Roblin	E&WGoose	04/03/74	1	1C	21	30	1	12	0.5W		
			2		9	31	1	12	0.1E		
	Lost	12/03/74	1		3½	20	Slush	12	0.0		H_2S
			2		2	20	Slush	12	0.0		H_2S
	Mitchell	04/03/74	1	2D	18	24	7	12	1.2		Springs
	Beautiful	04/03/74	1	1B	9	32	0	12	0.2		
	Chubb	04/03/74	1	2C	21	18	10	10	0.4		10"Slush
	Mossberry	12/03/74	1	2B	16	24	2	10	5.6		4" Slush
	Trapper	12/03/74	1		4	20	Layered	12	0.0		H_2S
			2		4	20	Layered	12	0.0		H_2S
	Persse	07/03/74	1		[illegible]	24	Layered	14	0.0		H_2S
			2			[illegible]	0	20	0.[illegible]	0.2	
Neepawa	Sandy	13/02/74	1	13D	[illegible]	20		14	6.[illegible]	[illegible].1	
			2		[illegible]	18		14	7.[illegible]	6.4	

Shoal Lake District

Lake	Date	Stn.	Ice Inches	Snow Inches	% Snow Cover	Water Depth Ft.	D.O. Top	D.O. Middle	D.O. Bottom
Arrow	Mar. 8	1	40	3-6	95	13.5	7.2		1.6
Blue	Mar. 12	1	38	0-8	98	40.0	9.0		0.0
Imrie	Mar. 17	1	41	4-8	100	10.0	6.8		6.0
Groschak	Mar. 12	1	31	4-6	100	38	7.8		0.0
Horod	Mar. 12	1	36	4-8	100	12	8.4		1.0
Horseshoe	Mar. 8	1	34	2-8	100	30	6.2		0.0
Kies	Feb. 23	1					Strong H_2S smell		
	Mar. 12	1	38	0-12	99	10	0.0		0.0
Little Jackfish	Feb. 23	1	38	1-8	90	19	10.4		8.6
Olha	Mar. 8	1	37	2-8	100	14	8.0		1.4
Patterson	Mar. 8	1	41	2-10	98	11	4.8		1.4
Rezak	Mar. 22	1	36	3	100	25	3.0	2.6	0.0
Rossman	Mar. 8	1	42	0-6	95	6	8.4		
Rozdeba	Feb. 23	1	35	1-3	90	17	7.4		6.4
Sandy	Feb. 23	1	39	0-3	75	16	9.2		7.4
Sandy L.Pond	Feb. 23	1	32	1-4	100	9	2.8		
Shoal	Mar. 2	1	41	0-4	75	6	14.6		
Silver Beach	Mar. 8	1	37	6-8	100	11.5	3.8		0.8
		2	36	8-12	100	5.75	6.6		
Stewart	Mar. 12	1	46	0-6	95	10	10.0		8.2
Tokaryk	Mar. 8	1	40	0-7	90	15	6.8		2.6
Wolf	Mar. 12	1	41	0-5	70	10	12.2		11.0
		2	40	0-6	75	6	5.8		
Lake 14	Feb. 23	1	36	1-8	100	11	8.0		
Lake 156	Feb. 23						Strong H_2S smell		
Lake 311(Gull)	Feb. 23	1	36	1-6	100	7	6.2		
Lake 522	Feb. 23	1	34	2	40	7	1.6		
				Neepawa District					
Gertrude	Mar. 16	1	40	4	100	18	6.6		2.0
Irwin	Mar. 10	1	40	1	70	17	4.2		0.8
Kerr	Mar. 16	1	42	3	80	6	7.0		
		2	42	3	80	19	5.0		3.4
Minnedosa	Mar. 10	1	42	1	99	10	3.6		2.0
Otter	Dec. 31 /81	1					14		
	Jan. 25		Minnows jamming,		some	dead and dying		O_2 = 0.0	
Pine Creek	Feb. 24	1	Open Water				9.2		
Squirrel Cr.	Feb. 24	1	32	Nil		3	5.6		
		2	36	No Water					
		3	42	Nil		6	2.6		
Topolinski	Mar. 18	1	40	3	90	6	3.4		
		2	40	3	90	11	5.8		1.2
Lake [illegible]	Mar. 16	1	48	4	85	15	4.6		0.4
		2	48	4	85	9	5.2		

erbody ame)	Stn. (#)	Date (Y,M,D)	Ice: Total Thick. (cm)	Ice: Opaque Thick. (cm)	Snow: Depth (cm)	Snow: Cover (%)	Water: Depth (m)	Water: Top D.O. (ppm)	Water: Middle D.O. (ppm)	Water: Bottom D.O. (ppm)	Map (#)
lican Lake	2	87 01 26	73	13	3	95	3.25	15.0		14.2	48
	3		75	10	3	80	3.0	1.2		5.2	
	4		80	18	2	85	3.7	4.6		4.0	
	5		80	10	2	80	4.0	5.4		7.2	
	6		84	15	2	70	3.0	5.0		4.6	
	1	87 02 18	78	7	5	100	2.75	2.0		2.2	49
	2		72	10	5	100	3.25	1.8		3.0	
	3		73	8	2	100	3.75	0.2		1.4	
	4		77	17	7	100	3.50	0.8		0.8	
	5		79	0	4	100	3.5	0.4		0.6	
	6		80	14	14	100	3.0	0.4		0.6	
	7		80	0	10	100	2.5	1.4		2.2	
	8		77	0	4	100	2.5	1.8		1.2	
*	chemicals gave lower than actual measurements										
	1							0		0	
	2							6.8		9.0	
	3							1.6		5.8	
	4							4.2		3.8	
	5							3.8		4.6	
	6							4.0		3.8	
	9	87 02 19					3.0	1.6		2.2	
	10						2.2		10.6		
	11						2.75		13.6		
	12						2.25		11.6		
*	new chemicals gave better results										
ansom Pond	1	87 03 10	70	0	0	0	2.25	6.4	-	3.6	50
ock Lake	1	87 01 19	70	9	9	100	2.5	8.0	-	7.4	51
	2		70	5	3	100	3.25	8.2	-	8.6	
	3		75	12	5	100	2.75	11.2	-	9.4	
	1	87 02 18	73	3	15	100	2.8	2.2	-	1.2	
	2		65	0	16	100	2.75	1.8	-	2.6	
	3		70	0	10	100	2.5	1.2	-	1.2	
	4		54	3	15	100	2.0	-	1.6	100 yd out from #5	
	5		Avery's	Spring					9.0		
	6		Caver's	Spring					1.8	(off shore)	
	3	87 03 09	72	15	12	100	2.0	-	2.4	-	
	4								9.0		
Sandy Lake	1	86 12 17	58	4	7	100	2.7	8.4		8.2	52
	2		70	40	8	100	4.9	7.6		2.2	
	3		62	34	9	100	5.2	10.2		8.0	
	4		52	35	10	100	1.8		10.6		
	5		55	30	8	100	4.9	9.6		8.0	
	6		51	7	7	100	3.4	11.4		10.0	
	1	87 01 18	70	0	8	100	3.5	5.0		3.0	
	2		76	0	7	100	4.5	5.0		1.8	
	3		75	0	0	100	5.25	6.2		2.2	
	4		70	0	0	100	4.0	5.6		4.2	
	5		70	0	5	100	4.5	7.2		4.6	
	6		65	0	10	100	3.0	8.2		8.0	
	1	87 02 16	77	28	13	100	4.0	5.2		4.8	
	2		80	20	10	100	5.0	5.4		3.8	
	3		80	40	15	100	5.2	6.4		3.6	
	4		70	35	17	100	3.0	6.4		6.4	
	5		65	30	15	100	5.2	6.6		4.4	
	6		65	10	17	100	3.5	6.4		7.0	

Waterbody (Name)	Stn. (#)	Date (Y,M,D)	Ice Total Thick. (cm)	Ice Opaque Thick. (cm)	Snow Depth (cm)	Snow Cover (%)	Water Depth (m)	Water Top D.O. (ppm)	Water Middle D.O. (ppm)	Water Bottom D.O. (ppm)	Map (#)
Sandy Lake	1	87 03 03	80	35	30	100	4.0	4.6	-	4.6	52
	3		78	30	30	100	4.2	6.4	-	4.2	
	6		80	5	29	100	3.5	6.2	-	6.4	
Sharpe Lake	1	86 12 18	58	15	2	100	2.75	-	2.8	-	53
	2		56	13	3	90	1.25	-	0.4	-	
	3		55	15	2	90	1.25	1.2	-	0.8	
	4		60	12	5	100	2.0	1.2	-	0.8	
	5		52	6	4	100	2.25	0.8	-	1.2	
	6		58	17	4	100	1.5	4.0	-	4.0	
	1	87 01 13						0.4	-	0.0	
	2							0.2	-	0.0	
	3							2.2	-	0.0	
	4							1.8	-	0.0	
	5							3.0	-	2.0	
	6							3.0	-	2.0	
Shoal Lake	1	86 12 15	53	0	5	99	2.2	14.4	-	19.2	54
	2		53	0	2	99	2.9	9.4	-	12.8	
	3		51	4	5	90	4.1	8.0	-	7.4	
	4		51	4	2	85	4.6	6.2	-	6.0	
	1	87 01 16	74	0	3	98	2.1	10.4	-	9.6	
	2		66	0	5	98	3.4	14.4	-	9.2	
	3		64	6	5	100	4.0	8.6	-	2.4	
	4		69	0	8	95	4.6	5.0	-	0.0	
	1	87 02 16	84	0	10	100	2.1	5.2	-	3.8	
	2		86	0	10	100	2.7	4.6	-	3.0	
	3		86	0	15	100	4.6	2.0	-	2.0	
	4		79	1	8	100	4.6	0.8	-	0.0	
	1	87 03 11	81	0	15	100	2.1	0.8	-	0.8	
	2		81	0	15	100	2.7	0.6	-	0.8	
	3		81	0	15	100	4.6	0.0	-	0.0	
	4		81	0	15	100	4.6	0.0	-	0.0	
	1	87 03 12	81	0	15	100	2.1	0.8	-	0.4	
Silver Beach	1	87 03 19	81	0	15	100	3.4	2.8	-	2.8	55
South Thomas	1	87 03 10	91	5	15	100	3.7	4.8	-	5.2	56
St. Dalmas	1	87 03 10	91	2	15	100	4.9	3.6	-	4.2	57
Stephenfield Res.	1	87 03 06	87	22	10	100	3.5	2.6	-	2.0	58
	2		80	0	10	100	3.0	3.0	-	2.6	
	3		87	22	13	100	2.0	3.6	-	3.0	
Stormon Lake	1	87 03 28						0.2	-	0.0	59
	2							0.2	-	0.0	
	3							0.2	-	0.0	
Stuart Lake	1	87 03 04	75	35	32	100	3.5	5.4	-	4.6	60
Tokaryk Lake	1	87 03 09	81	5	15	100	3.0	7.2	-	5.4	61
Wahtopanah	1	87 03 06	86	0	18	100	10.0	5.4	-	3.2	62

1989 - 1990 Winter Dissolved Oxygen Tests

Waterbody (Lat. Long.)	Stn. (#)	Date (Y,M,D)	Ice: Total Thick. (cm)	Ice: Opaque Thick. (cm)	Snow: Depth (cm)	Snow: Cover (%)	Water: Depth (m)	Water: Top D.O. (ppm)	Water: Bottom D.O. (ppm)	Test Method	Map (#)
Pelican Lake 49°20'x99°32' (continued)	4	90 02 14	88	0	2	50	3.2	4.1	3.6	YSI	36
	5		85	0	2	50	3.2	3.6	2.0	YSI	
	6		85	0	2	60	2.0	2.6	2.4	YSI	
	7		88	0	2	50	2.0	1.9	11.5	YSI	
	1	90 02 23	90	0	10	100	1.7	6.6	---	YSI	
	2		90	0	8	100	3.0	8.7	9.5	YSI	
	3		90	0	10	100	3.0	6.9	7.7	YSI	
Raven Lake 50°21'x100°38'	1	90 03 19	85	4	15	100	1.8	0.7	---	YSI	37
Rock Lake 49°13'x99°15'	1	90 01 10	67	0	2	90	2.5	9.9	6.5	YSI	38
	2		67	0	4	90	3.0	8.7	8.7	YSI	
	4		67	0	2	90	2.75	7.4	6.6	YSI	
	1	90 02 23	90	0	10	100	2.6	8.0	9.2	YSI	
	2		90	0	10	100	3.0	8.5	9.2	YSI	
	3		90	0	10	100	3.0	7.3	7.3	YSI	
	4		90	0	12	100	3.1	7.5	7.5	YSI	
Rossman Lake 50°44'x100°42'	1	90 02 25	60	8	30	100	4.0	3.4	1.8	300ml	39
	1	90 03 07	75	15	10	100	4.5	2.3	0.6	YSI	
Russell Reservoir 50°48'x101°19'	1	90 03 07	87	2	12	100	4.0	8.8	8.4	YSI	40
Sandy Lake 50°33'x100°09'	1	89 12 06	25	7	3	75	3.0	6.4	6.8	300ml	41
	2		25	1	5	60	4.5	7.8	6.2	300ml	
	1	89 12 15	42	9	4	100	3.0	5.6	7.8	300ml	
	1		42	9	4	100	3.0	11.0	11.0	YSI	
	2		36	8	8	100	1.7	9.2	---	300ml	
	2		36	8	8	100	1.7	11.0	11.0	YSI	
	3		45	4	9	100	1.0	11.5	---	YSI	
	4		40	7	10	100	4.7	11.5	8.0	YSI	
	5		41	2	8	100	4.5	6.4	6.2	300ml	
	5		41	2	8	100	4.5	9.5	6.5	YSI	
	6		41	2	5	100	4.2	10.0	9.0	YSI	
	7		41	2	6	100	5.0	10.0	8.5	YSI	
	8		48	0	3	75	4.2	10.0	9.0	YSI	
	8		48	0	3	75	4.2	6.8	6.0	300ml	
	9		41	1	11	100	4.0	11.0	10.0	YSI	
	10		45	1	9	100	4.5	11.0	10.0	YSI	
	1	90 01 05	57	10	12	100	3.0	9.5	6.5	YSI	
	2		63	6	17	100	1.7	9.5	---	YSI	
	2		63	6	17	100	1.7	8.6	---	300ml	
	3		66	0	16	100	1.0	9.0	---	YSI	
	4		53	6	12	100	4.7	9.7	5.9	YSI	
	4		53	6	12	100	4.7	8.2	6.8	300ml	
	5		62	6	13	100	4.5	9.2	5.6	YSI	
	7		54	3	12	100	5.0	8.6	5.5	YSI	
	1	90 01 18	68	0	9	100	3.0	9.1	5.2	YSI	
	2		63	0	12	100	1.5	9.1	---	YSI	
	2		63	0	12	100	1.5	8.0	---	300ml	
	3		72	0	18	100	1.0	8.2	---	YSI	

1987 - 1988 Winter Dissolved Oxygen Tests

Waterbody (Name)	Stn. (#)	Date (Y,M,D)	Ice		Snow		Water				Map (#)
			Total Thick. (cm)	Opaque Thick. (cm)	Depth (cm)	Cover (%)	Depth (m)	Top D.O. (ppm)	Middle D.O. (ppm)	Bottom D.O. (ppm)	
ak Lake 9°30' x 99°42'	Cherry Point 1	88 01 29	68	0	1	100	2.0	13.0	-	12.6	37
	1	88 01 10	56	Bill Henderson readings				-	15.4	-	
	2							-	17.2		
	3	88 10 16	61	-	-	-	2.2	-	10.2	-	
	1	88 01 30	66	-	-	-	2.2	-	12.2	-	
	2		66	-	-	-	1.8	-	13.6	-	
	1	88 02 06	76	-	-	-	2.0	-	11.8	-	
	2		79	-	-	-	1.8	-	12.4	-	
	3		-	-	-	-	2.3	-	8.6	-	
	1	88 02 13	79	-	-	-	2.1	-	13.2	-	
	2		84	-	-	-	1.8	-	15.0	-	
	3		91					-	8.7	-	
	1	88 02 20	81	-	-	-	2.1	-	10.0	-	
	2		85	-	-	-	1.8	-	11.6	-	
	3		86	-	-	-	2.3	-	7.6	-	
	1	88 02 27	83	-	-	-	2.1	-	9.8	-	
	2		83	-	-	-	1.8		12.4	-	
	3		86	-	-	-	2.3	-	10.8	-	
	1	88 03 05	75	-	-	-	2.1	-	11.8	-	
	2		79	-	-	-	1.8	-	13.2	-	
	3		75	-	-	-	2.3	-	9.0	-	
	3	88 03 19	74	-	-	-	2.3	-	13.2	-	
Iha Lake 0°32' x 100°34'	1	88 03 04	71	0	13	95	4.5	5.8	-	0.0	38
Otter Lake 50°30' x 90°50'	1	88 01 18	57	0	5	100	.75	2.0	-	-	39
	2		Springs					5.0	-	-	
Pelican Lake 49°20' x 99°32'	1	88 03 01	85	-	0	0	3.5	9.2	-	6.0	40
	2		80	0	0	0	3.5	8.0	-	3.4	
	3		80	0	0	0	3.0	8.2	-	9.0	
Robin Pond	1	88 01 20	91	0	10	100	2.0	2.8	-	2.6	
Rock Lake 49°13' x 99°15'	1	88 03 01	75	0	0	0	3.0	10.0	-	9.4	41
	2		75	0	0	0	3.5	9.4	-	10.0	
	3		78	0	0	0	3.0	6.8	-	8.4	
Rolling River Indian Reserve Lakes											
Eagles Lake 50°29' x 100°00'	1	88 01 26	59	0	13	100	6.0	5.0	-	2.5	42
	2		59	0	13	100	5.0	4.0	-	2.0	
Jackfish Lake 50°31' x 100°04'	1	88 01 26	60	-	14	100	4.0	7.0	-	5.0	43
	2		-	-	-	-	4.0	7.0	-	5.0	
Perch Lake 50°27' x 100°00'	1	88 01 26	56	-	13	100	5.5	7.0	-	9.0	
Sandy Lake 50°33' x 100°09'	1	88 01 25	51	0	15	100	5.0	9.5	-	9.0	45
	1	88 03 04	85	0	2	100	5.0	7.0	-	4.0	

Winter Dissolved Oxygen Tests 19 85

Shoal Lake District

Lake	Date	Stn.	Ice Inches	Snow Inches	% Snow Cover	Water Depth Ft.	D.O. Top	D.O. Middle	D.O. Bottom	Remarks
Arrow	Feb. 14	1	26	13	100	14	3.4		3.0	
		2	27	11	100	19	4.2		3.4	
	Mar. 6	2	29	12	100	17.5	2.6		0.4	
	Mar. 20	1	28	12	100	12	2.8		0.8	
		2	28	12	100	14	2.2		1.0	
Beauford	Mar. 15	1	35	7	100	5 m	3.4		3.2	
Crawford	Mar. 20	1	34	7	100	24	4.2	12 3.8	0.0	
Czornyj	Mar. 14	1	29	9	100	4.5m	3.6		3m 1.2	
		2	32	10	100	5 m	4.0		3.0	
Dummy (Blue)	Mar. 14	1	29	5	100	14 m	5.2		7m 1.2	
Fourteen	Mar. 19	1	30	8	100	12	2.0		1.6	
		2	31	8	100	12	1.2		0.8	
Groszok	Mar. 14	1	29	9	100	13 m	3.2	5m 0.6	7m 0.2 H_2S at 10 m	
Gull	Mar. 19	1	32	7	100	11	2.0		1.0	
Hoopers	Mar. 22	1					0		0	
Horseshoe	Mar. 14	1	30	8	100	10 m	3.0		5m 2.6	
		2	30	8	100		3.0			
Imrie	Mar. 14	1	30	9	100	4.5m	3.2	2.5m2.4	0.0	
Little Jackfish	Mar. 19	1	30	8	100	24	4.2		1.6	
Olha	Mar. 6	1	28	12	100	13	0	Smells	0	
Shoal Lake	Mar. 8	1	40	7	100	9	1.2		0.4	
		2	40	8	100	7	2.1		0.4	
Silver Beach	Mar. 6	1	25	18	100	17	2.0		0.4	
South Thomas	Mar. 11	1	29	14	100	15	5.8		4.6	
Stuart	Mar. 11	1	29	14	100		2.6		0.8	
Thomas	Mar. 10	1	36	4	100	7	7.4		7.4	
Tokaryk	Mar. 6	1	35	6	100	20	7.2	Smells	0	
675	Mar. 14	1	30	10	100	Strong H_2S smell				
255	Mar. 7	1	32	12	100	Strong H_2S smell				
Sandy	Feb. 14	1	30	11	100	18	3.2		0	
		2	26	16	100	13	1.2		0	
	Mar. 7	1	30	10	100	4 m	0		0	
		2	30	13	100	4.5m	0.7		0	
		3	30	12	100		0	Slight H_2S smell		
		4	30	12	100		0	"	"	
		5	32	8	100		0	"	"	
		6	31	10	100		0.2			
		7	31	8	100		1.0			
	Mar. 10	1	32	11	0		0.1			
		2	32	12			0.6	Perch still alive		
		3	36	7	100		0.2			
		4	35	8			0			
		5	36	7			0.4			

Lake	Date (Y,M,D)	Stn. (#)	Ice Thick. (cm)	Snow Depth (cm)	Snow Cover (%)	Water Depth (m)	D.O. Top (ppm)	D.O. Bottom (ppm)	Map (#)
Pipestone Creek	86 01 31	5	SAME AS ABOVE				8.4	-	43A
	86 03 26	1					2.2	-	
		2					4.6	-	
		3					4.8	-	
		4					3.8	-	
		5					8.2	-	
Rock	86 01 09	1	52	4.0	100	2.5	7.6	7.8	44
		2	65	2.0	100	3.0	6.0	7.2	
		3	62	4.0	100	2.5	11.0	9.8	
	86 02 11	1	80	6.0	100	2.5	5.6	5.6	
		2	72	9.0	100	3.0	6.2	4.2	
		3	72	8.0	100	2.5	6.2	6.0	
		Avery's Spring	Open Water				13.0	-	
		South end of Spring	(Unable to find)				(13.4 - 86 03 01)		
Sandy	86 01 03	1	57	9	100	3.0	8.6	2.4	45
		2	55	10	100	4.5	9.0	3.6	
		3	45	14	100	4.0	8.8	0.0	
	86 01 29	1	62	12	100	3.0	6.0	5.0	
		2	75	10	100	5.0	7.6	7.6	
		3	60	15	100	6.0	7.0	7.4	
	86 03 06	1	70	23	100	3.0	2.0	0.0	
		2	62	27	100	5.0	4.4	0.2	
		3	70	27	100	5.0	3.8	3.2	
Shoal	86 03 18	1	86	23	100	2.3	0.0	-	46
		2	76	30	100	2.1	0.0	-	
	86 03 24	1A	81	8	95	3.9	0.0	0.0	
		2A	79	8	95	4.3	0.0	0.0	
Silver Beach	86 03 19	1	76	30	100	3.9	5.6	0.8	47
675	86 03 06	1	-	-	-	1.5	0.0	-	48
South Thomas	86 03 20	1	77	20	100	6.25	7.0	2.2	49
Stuart	86 03 20	1	80	25	100	5.0	5.2	2.8	50
St. Dalmas	86 03 11	1	75	25	100	7.25	6.0	1.0	51
Stephenfield Res.	86 02 28	1	83	3	100	6.5	4.2	0.8	52
		2	75	7	100	2.5	5.6	3.6	
		3	77	5	100	1.75	3.8	2.8	
	86 03 12	1	8.6	5.0	95	6.5	0.6	0.2	
		2	8.8	2.5	75	2.5	2.6	-	
		3	9.1	5.2	100	3.5	1.0	0.3	
340	86 01 30	1	48	15	100	2.0	5.2	4.8	53
		2	68	5	100	4.0	5.0	4.4	
		3	60	5	100	4.0	5.4	3.2	
	86 03 11	1	80	20	100	4.0	3.0	1.4	
312	86 01 03	1	50	15	100	1.5	0.0	0.0	54
Thomas	86 03 20	1	73	18	100	7.5	7.0	2.0	55
Tokaryk	86 03 19	1	74	20	100	3.4	3.0	2.2	56
Wahtopanah	86 03 03	1	84	10	100	11.5	7.0	5.6	57
		2	84	10	100	2.5	6.6	7.2	
		3	84	20	100	2.0	7.6	7.0	

1988 - 1989 Winter Dissolved Oxygen Tests

Waterbody (Name)	Stn. (#)	Date (Y,M,D)	Ice Total Thick. (cm)	Ice Opaque Thick. (cm)	Snow Depth (cm)	Snow Cover (%)	Water Depth (m)	Water Top D.O. (ppm)	Water Middle D.O. (ppm)	Water Bottom D.O. (ppm)	Map (#)
Sandy Lake (cont'd)	1	89 01 04	43	0	18	100	2.5	7.0	-	6.6	
	2		42	0	17	100	5.0	7.0	-	4.4	
	3		44	0	17	100	5.0	6.8	-	6.0	
	1	89 01 13	40	0	12	100	4.0	6.0	-	5.2	33
	2		47	0	12	100	4.7	5.6	-	-	
	3		50	0	14	100	3.0	6.6	-	-	
	4		53	0	8	100	4.5	7.0	-	6.0	
	5		43	2	14	100	3.2	6.4	-	-	
	6		51	0	8	100	3.0	5.8	-	-	
	7		50	0	8	100	4.0	6.4	-	4.4	
	8		50	4	15	100	4.5	6.2	-	-	
	9		50	0	8	100	4.7	6.2	-	-	
	10		47	0	8	100	5.0	6.8	-	6.0	
	11		43	0	8	100	4.5	5.4	-	-	
	12		45	2.0	10	100	2.2	6.6	-	-	
	13		52	1.0	7	100	4.0	5.8	-	6.0	
	14		53	3.0	9	100	3.0	6.2	-	-	
	15		46	0	7	100	4.5	5.8	-	-	
	13	89 01 17	-	-	-	-	-	1.2	-	-	
	10		-	-	-	-	-	1.6	-	-	
	11		-	-	-	-	-	1.2	-	-	
	5	89 01 20	49	0	15	100	4.7	5.8	-	5.6	
	10		47	0	Cleared		4.7	5.8	-	4.4	
	13		48	0	Cleared		5.1	5.8	-	3.4	
	5	89 02 13	Uncleared strip				5.0	2.0	-	2.0	
	10		Cleared strip				5.0	2.4	-	2.4	
	13		Cleared strip				5.2	1.8	-	1.6	
	15		Uncleared strip				4.3	2.4	-	2.0	
	11	89 02 16	-	-	-	-	-	3.8	-	-	
	15		-	-	-	-	-	1.6	-	-	
	2	89 02 17	-	-	-	-	-	4.2	-	-	
	3		-	-	-	-	-	4.0	-	-	
	8		-	-	-	-	-	3.4	-	-	
	9		-	-	-	-	-	4.2	-	-	
	11	89 02 23	-	-	-	-	-	2.0	-	2.0	
	10	89 03 01	-	-	-	-	-	4.0	-	-	
	11		-	-	-	-	-	4.2	-	-	
	15		-	-	-	-	-	4.0	-	-	
	10	89 03 08	-	-	-	-	5.0	3.8	-	4.2	
	11		-	-	-	-	5.0	4.0	-	4.0	
Shoal Lake 50°24'x100°36'	1	88 12 20	36	1	8	100	16	1.6	-	1.6	34
	2		25	0	13	100	32	4.2	-	3.0	
	3		36	1	8	100	32	5.2	-	4.0	
	1	89 01 04	43	0	18	100	1.7	1.0	-	-	
	1	89 01 17	46	0	13	100	2	0.4	-	0.1	
	2		46	5	15	100	1.5	1.4	-	0.0	
	1	89 03 22	76	1	15	99	22.4	0.0	-	0.0	
Silver Beach 50°51'x101°00'	1	89 01 27	48	1	23	100	4.5	8.2	-	3.0	35

1988 - 1989 Winter Dissolved Oxygen Tests

Waterbody (Name)	Stn. (#)	Date (Y,M,D)	Ice: Total Thick. (cm)	Ice: Opaque Thick. (cm)	Snow: Depth (cm)	Snow: Cover (%)	Water: Depth (m)	Water: Top D.O. (ppm)	Water: Middle D.O. (ppm)	Water: Bottom D.O. (ppm)	Map (#)
Max Lake (cont'd)	D		56	0	6	100	1.0	3.0	-	(75 yd.	out)
	E		50	0	17	100	1.0	2.8	-	(100 "	out)
	5		47	Slush	9	100	1.0	3.2	-	-	-
	F		50	5	15	100	1.0	2.6	-	(25 yd.	out)
(3)	G		53	5	10	100	1.0	4.0	-	(50 yd.	out)
	H		52	5	20	100	1.0	4.0	-	(100 "	out)
	I		52	5	11	100	1.0	4.0	-	(150 "	out)
	G	89 02 10	-	-	-	-	-	1.2	-	0.2	
	A		-	-	-	-	-	1.0	-	0.0	
Minnedosa Lake 50°16'x99°50'	1	89 02 23	78	0	6	100	3.5	0.6	-	0.8	25
	2		80	0	7	100	3.0	0.8		0.8	
	1	89 03 13	-	-	-	-	3.0	2.2	-	0.8	
Minnewasta Lake 49°11'x98°08'	1	89 03 02	70	5	20	100	7.5	7.2	-	6.4	26
	2		68	6	22	100	3.0	8.2	-	8.4	
	3		NO WATER								
Moroz Lake 50°39'x100°24'	1	89 03 09	76	1	18	100	10.0	3.2	-	0.0	27
North Thomas Lake 50°35'x100°15'	1	89 03 13	71	1	20	100	6.5	8.6	-	6.8	28
Raven Lake 50°21'x100°38'	1	88 12 20	30	0	15	100	2.7	4.8	-	3.6	29
	1	89 03 22	76	1	15	100	2.7	0.0	-	0.0	
Rock Lake 49°13'x99°15'	1	89 01 03	50	8	15	100	2.0	8.8	-	0.6	30
	2		52	4	11	100	3.0	4.8	-	4.0	
	3	Avery's	50	0	25	100	2.5	7.8	-	7.2	
	4		39	5	15	100	1.0	-	7.2	-	
	5	Refuge	-	-	-	-	-	10.8	-	-	
	2	89 01 19	60	8	25	100	3.0	4.2	-	4.0	
	3		57	10	38	100	2.5	2.2	-	2.0	
	1	89 02 07	-	-	-	-	-	2.6	-	-	
	3		-	-	-	-	-	1.8	-	-	
	4		-	-	-	-	-	3.0	-	-	
	4	89 02 20	-	-	-	-	-	9.6	-	-	
	5		-	-	-	-	-	0.4	-	-	
	1	89 03 02	69	10	29	100	2.0	0.4	-	0.2	
	2		70	3	25	100	3.0	1.0	-	0.8	
	3		60	10	37	100	2.5	0.4	-	0.6	
	4		50	30	10	100	1.0	0.6	-	-	
Rossendale Baker Hutterite Colony Pond	1	89 03 03	70	5	10	100	2.0	0.4	-	0.0	
Rossman Lake 50°44'x100°42'	1	89 01 27	56	2	18	100	5.5	7.2	-	2.8	31
Sandy Lake 50°33'x100°09'	1	88 12 19	36	0	8	100	2.5	-	-	9.0	32
	2		46	0	8	100	4.0	-	-	6.0	
	3		46	0	8	100	5.0	-	-	6.0	

Year	Date	Station	Ice"	Snow"	Water'	Top	Middle	Bottom	Remarks
1947	Complete winterkill.								
1956	Perch and most walleye winterkilled - pike survived.								
1957	Dec. 19	1 2	12-14 12-14	little little	19 4	10.8	10.0 12.0	6.9	
1958	Jan. 14	1 2	22-23 22-23	drifts drifts	19 6	9.0	8.0 9.0	6.0	Survival
	Feb. 18	1 2	26 26	8-10 8-10	19 6	7.8	6.5 8.0	2.6	
1959	Feb. 10	1 2	24-28 24-28	6-14 6-14	18 11	8.0	7.4 8.3	5.3	Survival
	Mar. 12	1 2	38 38	6-18 6-18	18 10	9.7	9.2 8.1	4.6	
1972	Mar. 6	1 2	30 30	6 6	18.6 16	2.4 2.5		1.2 .8	
1973	Feb. 26	1 2	18 18	7 7	18.5 22.5	7.0 5.6		2.8 .2	
1974	Feb. 13	1 2	24 30	14 14	15 11	6.7 6.4		8.1 7.3	
1979	Mar. 14	1	36	12	16	3.5		1.8	
1980	Feb. 27	1	31	6	18	2.2		2.0	

From 1947 to 1980:

1. Status unknown - 1948, 1955, 1957. [old timers claim 1955 was a winterkill year]
2. Likely Survival in 1949, 50, 51, 52, 53, 54, 58, 59, 60, 61, 62, 63, 64 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80. 81, 82, 83, 84, 86, 87,
3. Some summerkill, 1949, 1955, 1963, 1977.
4. winterkill - 55, 85, 89 - Tmtrily - walleye ok.

Clearing lake ice to save oxygen-starved fish

by Darryl Kalichak

Low water levels and opaque ice are motivating residents to help preserve the fish population at Sandy Lake.

Recently a private maintainer has cleared 140 acres of snow off the ice at Sandy Lake, to make it easier for the sun to penetrate to the water plant growth. This will in turn create higher oxygen levels in the lake, and help preserve the fish population.

"The oxygen level has been holding its own," explained Sandy Lake Game & Fish President, Clifford Lungal. "But in the last week and a half, the level has been dropping quite quickly."

At a meeting Wednesday, the Game & Fish Association decided that a pump will be installed into the lake to aerate the existing situation. This aeration pump will increase oxygen levels in the lake, and will be placed as close as possible to the cleared area.

"Hopefully with the sun penetrating and the pump" says Lungal, "that the whole lake will be saved."

Although the Department of Fisheries offers no guarantees, at least saving 50% of the fish population will be of some help. If the pump doesn't work, the population will be threatened, which will eventually affect the summer fishing season.

The oxygen levels at the lake are, on the average, 2 1/2 parts - 3 parts per million on the whole. Lungal mentioned that this will keep the fish alive but if the levels stay at this point or decrease, they won't be alive for long.

Normal oxygen levels on Sandy Lake should range between 8 - 10%.

"It's almost the critical time," said Lungal. "Once the levels reach 1 1/2 - 2%, that's the time to really panic."

The Fisheries Department have donated a pump, free of charge, and will build baffles at no cost as well, to help the Association out. The aeration pump, which is currently at Moose Jaw, Saskatchewan, would've cost $1100 to $3000 per month to rent.

Up to this point, a little over $3000 has been spent on the project. Donations have been coming in to help the cause from the R.M. of Harrison, Portage la Prairie, and Minnedosa Game & Fish Association, already.

Lungal says that he hopes to have the aeration pump running by Saturday. Local residents are currently picking up the pump at Moose Jaw.

A private snowplower from Virden was approached and was used to clear the snow. A local tractor was also used to help break up the "hard" snow for the maintainer.

The Association approached local contractors to do the snow-clearing, but because of lack of insurance, maintainers in the area declined to go out onto the lake.

Members of the Game & Fish Association have been taking tests on all lakes during the winter to determine oxygen levels. Tests on all lakes in that area, with the exception of Sandy Lake, showed fairly decent oxygen levels. The low water levels in the lake, and the heat from the summer months, are reasons Lungal thinks that oxygen levels at Sandy Lake were low to begin with.

Sunlight shining through clear ice can stimulate oxygen production by the algae in the water, but Sandy Lake has a covering of opaque ice this year. Lungal explained that snowfall during freeze-up and even thaw conditions will create a white, opaque ice which sunlight cannot penetrate.

The pumping will create "an island of oxygen-rich water". Fish will pick up on the moving water and higher oxygen levels.

Baffles will cut down on the snow-drifting into the area.

"Once the sun gets right through the ice, and with at least one month of pumping," explained Lungal, "Things should be okay."

Lungal figures the cost of running the aeration pump will be about $100 per day, after fuel and oil expenses.

Sandy Lake oxygen levels safe

by Darryl Kalichak

Oxygen levels that deteriorated during the winter months on Sandy Lake have "arisen from the dead".

Levels on the lake are at 6.0 and even as high as 7.5 on the oxygen scale, quite acceptable for fish populations to survive.

"We're in good shape now," said Sandy Lake Game & Fish Assoc. President Clifford Lungal. "Now we let nature take its course and wait for the ice to melt."

Lungal mentioned that they won't be able to determine how much "winter-kill" there actually was until the ice has melted and a net is dropped to formulate some sort of final reading.

Even though Sandy lake is safe at the present, the winter of 1989-90 may feature the same problem.

"If we have another good drought," explained Lungal, "we could face the same problem. We'll figure out what to do when and if that time comes."

So fishermen can now breathe a sigh of relief that pickeral will be flourishing once again at the lake.

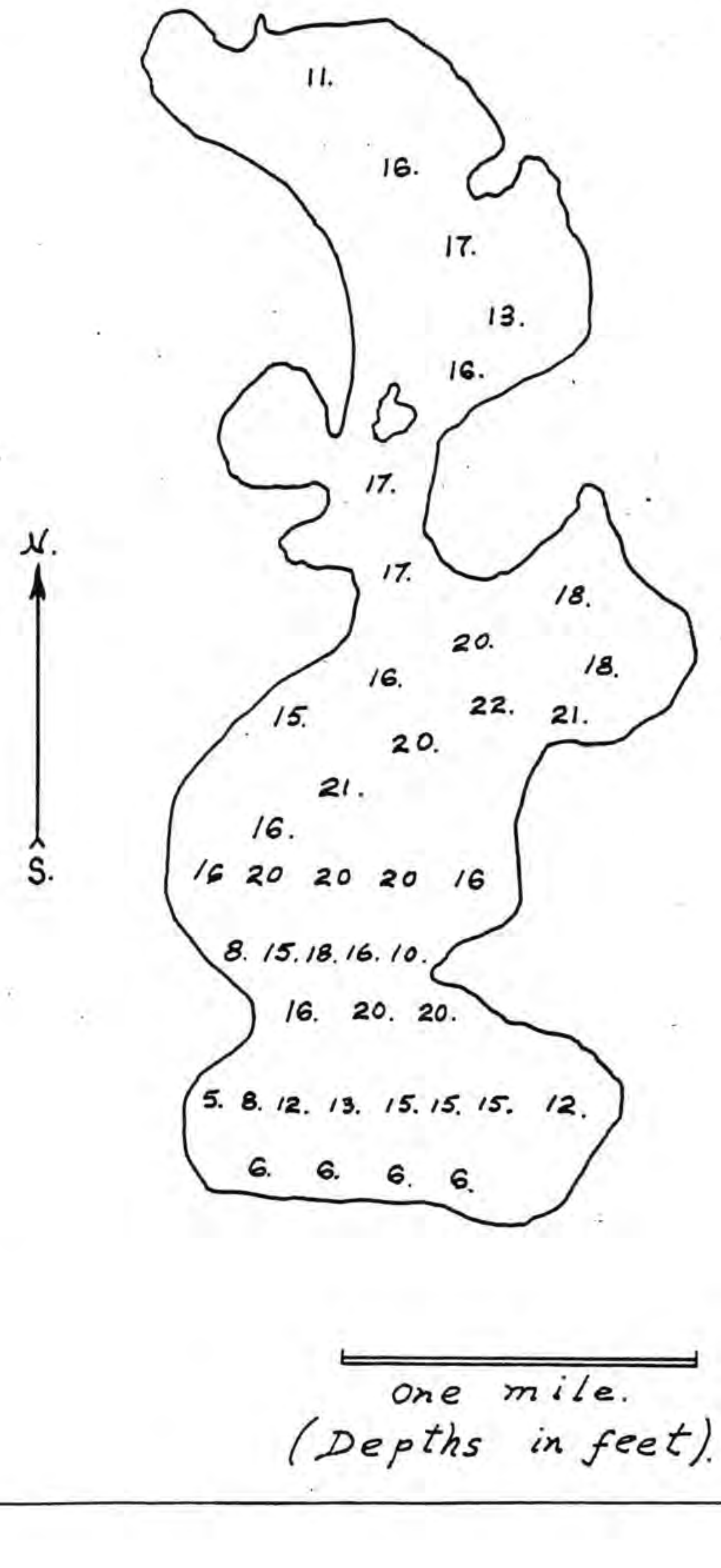
The Sandy Lake Game & Fish Assoc. spend approximately $4,000 this past winter to battle the decreasing water levels. Some of the expenses were aided by donations, including an aeration pump from Moose Jaw, Sask. The pump, which was not used, could've cost up to $50 per day for operation. An aeration pump would've cost up to $2,000, but the Dept. of Fisheries kindly donated the pump.

The only major expenses incurred was when the Association asked a private Virden maintainer to clear a portion of the lake in February, and a tractor to clear a path for the snowplow as well. This was done to help the sun penetrate through opaque ice to increase the deteriorating oxygen levels, as low as 4.0 at times.

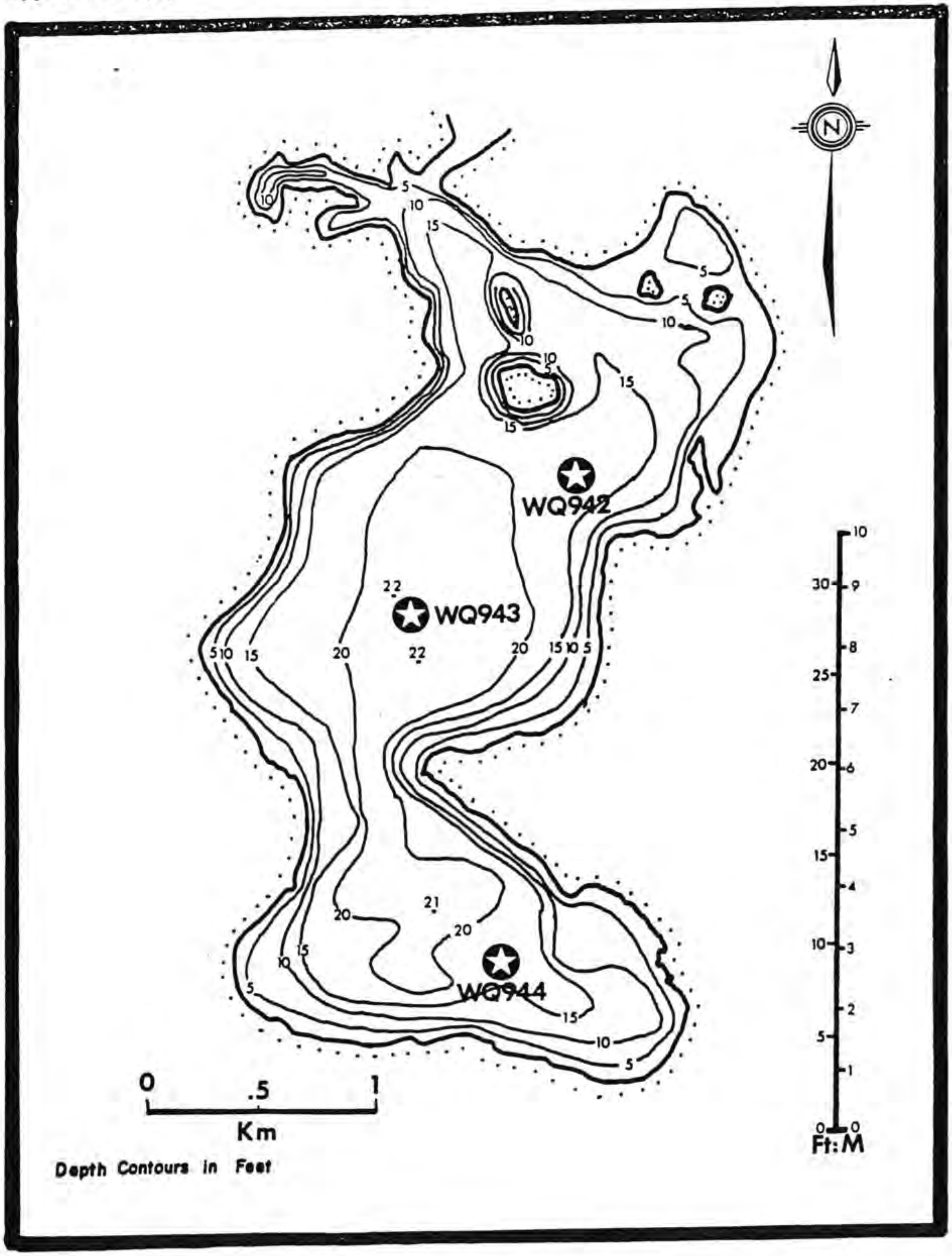
APPENDIX D

LAKE DEPTH DATA

Sandy Lake.- 1933



Appendix I(c)



Sandy Lake contours (ft.) and sampling stations.

SANDY LAKE

Lat. 50°33′ Long. 100°09′ • N.T.S. Sheet 62K/9

Scale in Kilometers · Depth Contours in Meters.

0 .2 .4 .6 .8 1Km

COMMON FISH SPECIES
Perch, Pike, Walleye.

WARNING • This map is intended as an aid to angling only and should not be used for navigation purposes. Shoals and reefs between points of sounding will not be shown.

APPENDIX E

LIMNOLOGICAL DATA

A LIMNOLOGICAL SURVEY OF SANDY LAKE - L.A. SUNDE Sept/1957

TABLE V — IDENTIFICATION AND NUMBER OF BOTTOM ORGANISMS AT EACH STATION: SANDY LAKE

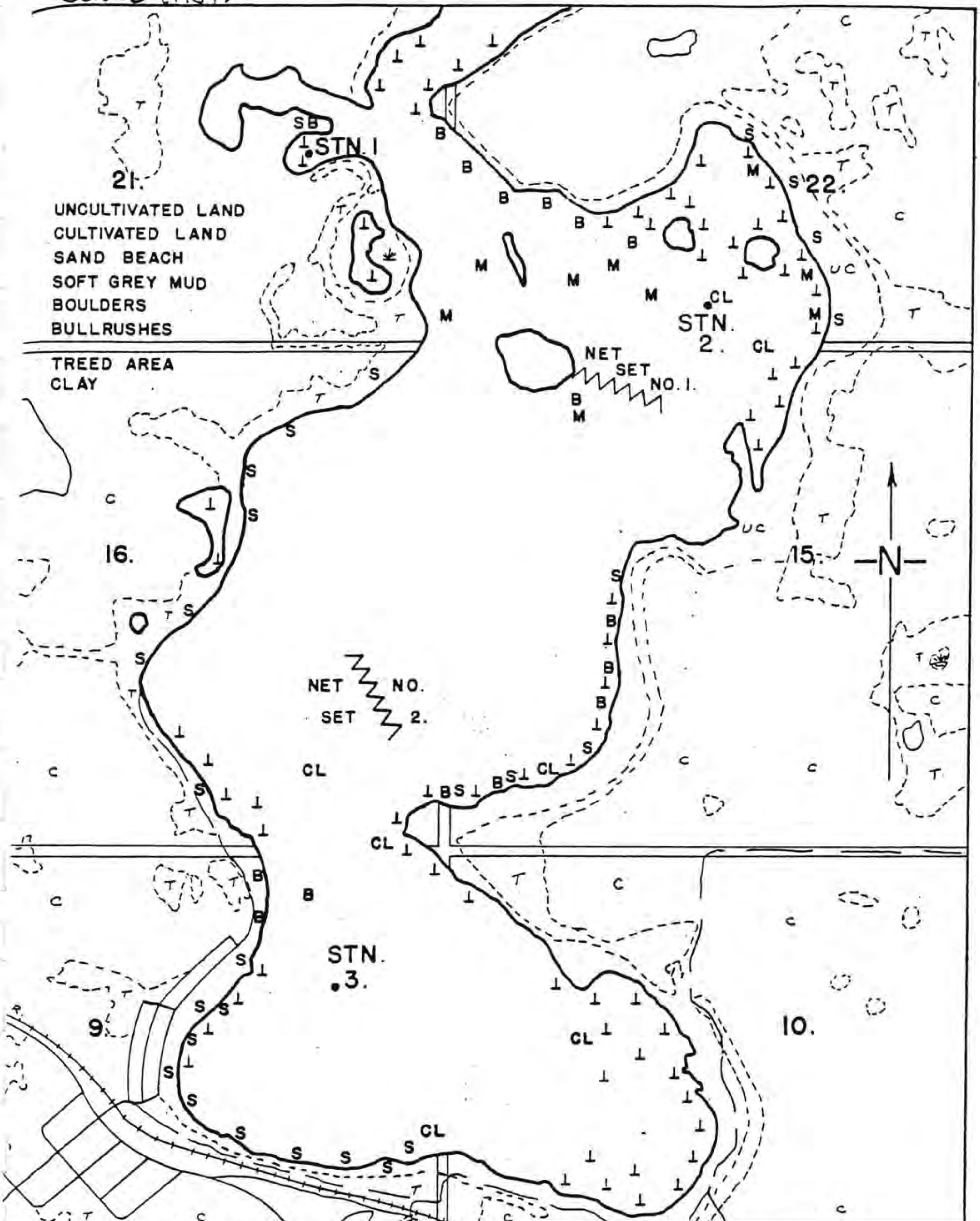
Organism	Stn. 1	Stn. 2	Stn. 3	Stn. 4 *
Depth of water	11 ft.	10 ft.	22 ft.	10'
Insects				
Diptera				
Chironomidae				
Chironomus	17	16	21	85
Cryptochironomus	4	5	6	2
Culicidae				
Corethra	1	2	5	
Ceratopogonidae			1	
Mollusca				
Pelecypoda				
Sphaeriidae	Several		Several	
Pisidium		Many		Several
Gastropoda	Several			
Helisoma		Many		Several
Lymnaea		Few		
Physella		Few		

* Station 4 was located on the first lake to the north of Sandy Lake.

TABLE VI — IDENTIFICATION AND ABUNDANCE OF ORGANISMS IN SANDY LAKE PLANKTON SAMPLES

Organism	Station 2	Station 3
Depth of Water	10 ft.	22 ft.
Crustacea		
Eucyclops	Several	Few
Diaptomus	Many	Several
Diaphanosoma	Few	Few
Nauplius larvae	Few	Few
Rotifera		
Keratella	Many	Many
Brachionus	Many	Several
Filinia	Many	Several
Diatoms		
Asterionella	Many	Many
Fragilaria	Several	Many
Cyclotella	Few	
Epithemia	Few	
Dinoflagellates		
Ceratium	Several	Several

SUNDE (1957)



SANDY LAKE

SCALE – 1" – 1320'.

1957

SUNDE (1957)

TABLE I. PHYSICAL AND CHEMICAL CONDITIONS OF THE WATER OF SANDY LAKE, SEPTEMBER 13, 1957

SEPT 13/1957

Station Number		2	3
Time of Test		2:45 P.M.	3:30 P.M.
Depth of Water		10 ft.	22 ft.
→ Turbidity (Secchi disk)		6 ft.	6 ft.
Temperature:	Air	62°	62°
	Surface	58°	58°
	Bottom	58°	58°
→ pH	Surface	8.2	8.2
	Bottom	8.2	8.2
→ Oxygen (PPM)	Surface	9.0	9.0
	Bottom	9.2	8.9
% Saturation	Surface	87%	87%
	Bottom	89%	86%
Type of Bottom		Soft Grey Muck	Soft Grey Muck (flocculent)

It was fairly cloudy at the time of the tests. Only occasionally did the sun shine. The wind was from the north-west at 15 to 20 m.p.h.

APPENDIX F

COTTAGE OWNER'S ASSOCIATION

[they] lose their lake, the [loss] will naturally
[be] the cottage owners. Cottage owners are
[al]so concerned about their property values
[dr]opping with the deteriation of the lake.
Your attention to these matters would be
much appreciated and I would appreciate
[a] reply to this letter.
We have tried going through Clean
[En]vironment at Dauphin, to no avail.

Yours truly
(Mrs) W. McLeod.
Secty Treas.
Sandy Lake Cottage
Owners Association.

Minister of Mines and Natural Resources.
Mr Penner.

General Delivery
Sandy Lake - MB.
R0J1X0

Dear Sir.

I have been requested by the Sandy Lake Cottage Owners Association to write you concerning our Lake. We feel the lake is deteriorating rapidly. There is a lot of Algae and a very bad odor coming from the lake. People are weary of swimming in it. There have been rumours of holding tanks with holes punched in them, allowing refuse to drain into the lake. The lake is getting very low and there are two pumps running continually, pumping water to the golf course. We feel this is helping to lower the water level.

We also feel the lake is not being policed properly by the game warden?, Fisherman are taking out fish smaller than the size limit allows and we suspect over the limited amount. We also wonder if there should not be a limit on the size of motors used on this lake.

We would very much appreciate a water check done on our lake to determine what is causing the problems, and what, if anything can be done about it.

The Village of Sandy Lake depends heavily on the trade of the Cottage Owners anitoba

Memorandum

Date: August 24, 1988

To: Mr. D. Doyle,
A.D.M.
Box 50, Rm. 800, 1495 St. James St.,
Winnipeg, Manitoba

From: E. R. Elke
Regional Manager
Western Regions
Box 10, 27 2nd Ave. SW,
Dauphin, Manitoba

Telephone:

Subject: **SANDY LAKE - COTTAGE OWNERS ASSOC. COMPLAINTS**

Further to Winstone's August 16th, 1988 memo and Pat's phone call of yesterday I reviewed contents of letter with Crown Lands and Environmental Protection Branch specialists at Dauphin.

Status report for your information:

1) Environmental Control Branch
   - Study on water quality and waste management done 5 years ago.
   - Branch met with Cottagers Assoc. in July regarding concerns covered by this study.
   - Association unable to identify supposed leaking septic tanks.
   - Ongoing consultation between Branch and Association re; waste management.
     Contact person: B. Chrisp- Dauphin, Man.

2) Study on "Cottages Development on Public Road Allowance" done in 1985 - copy attached.

3) Regional Land Use Committee recommendations attached.

4) Complaint of inadequate fisheries enforcement will be addressed by Regional Services Branch.

Sufficient studies have certainly been done. It is time for action by the R.M. of Harrison.

RESOURCES
AUG 26 1988
BRANDON, MAN.

E. R. Elke
Regional Manager.

ERE/bls

c.c. W. Howard
B. Chrisp
L. Misanchuk
P. Perchuk - Please have staff investigate and take appropriate action on fisheries matters.

w# BB

Manitoba

Minister of
Natural Resources

Room 118
Legislative Building
Winnipeg, Manitoba, CANADA
R3C 0V8

October 21, 1988

Mrs. D. McLeod,
Secretary-Treasurer,
Sandy Lake Cottage Owners
Association,
General Delivery,
Sandy Lake, Manitoba.
ROV 1XO

Dear Mrs. McLeod:

I acknowledge your letter of August 2nd, 1988 concerning both water quality and resource management at Sandy Lake. There is intensive cottage development along significant stretches of the beach frontage and there appears to be less than adequate environmental facilities at some locations. The development is primarily on private land and the situation is compounded on part of the lake by the cottage areas being tightly confined between the railway tracks and the lakeshore.

I agree with your Cottage Owners Association that the Village of Sandy Lake (and the Rural Municipality of Harrison) have a direct interest in the continuing water quality of the lake and the attractiveness of the lake and associated beaches. Problems of algae growth have been compounded this year by the extreme drought conditions. You also identified potential problems relating to fish harvesting practices and to the size of motors allowed on power boats and to water being pumped from the lake.

This is a complex problem that should be reviewed in detail with the Municipality of Harrison and local Environmental authorities. I have contacted our Natural Resource Land Manager at Dauphin, Mr. Lorne Misanchuk, and asked him to talk directly with local Environmental staff and to forward recommendations. There is little doubt that any meaningful program to clean up the lake will, of necessity, involve direct costs to the cottagers themselves.

Yours truly,

ORIGINAL SIGNED BY
HONOURABLE JACK PENNER

Jack Penner,
Minister.

cc R.M. of Harrison

RWW/sp

bc Dale Stewart
R. Goulden
L. Misanchuk ✓
B. J. Chrisp ATTN; P. Skobel
R. Winstone

toba

Memorandum

Date August 16, 1988

To Derek Doyle
Assistant Deputy Minister

From R. W. Winstone,
Director,
Lands Branch.

Subject SANDY LAKE - MRS. D. MCLEOD'S LETTER OF AUGUST 2ND ON BEHALF OF THE COTTAGE OWNERS ASSOCIATION

Telephone

Our File Sandy L. Gen.

Lorne Misanchuk is quite familiar with this situation at Sandy Lake. In my opinion there is a very serious pollution problem on this lake and it should be addressed by Environment and Natural Resource staff at Dauphin. Lands Branch have been aware of some of the major environmental problems at Sandy Lake for sometime and they are difficult to deal with as any real solution is likely to be expensive for both the cottage owners, the town and the municipality. I am unsure of the implications to the Province but it is largely a water quality and waste management problem that is compounded by intensive shoreline development without adequate sewage facilities, at least in some of the older development areas.

I recommend that someone such as Ray Elke, who has the Departmental profile to ensure follow up, be asked to organize a detailed report and develop recommendations for the lake. It would be advantageous if you could visit this site when you are in Lorne's area.

R. W. Winstone

RWW/sp

cc L. Misanchuk
R. Elke

WESTERN REGION
AUG 18 1988
RECEIVED

APPENDIX G

AERATION DATA

Aeration Fact Sheet

1. Aeration prevents fishkills. Since 1979, no winterkill has occurred on any waters that are totally aerated.

2. Total lake aeration expands the habitat area available to fish. Dead zones in a lake are eliminated allowing fish to spread out. This reduces competition/predation and improves fish growth, survival and angling success.

3. Aeration improves water quality. Toxic gases are vented to the atmosphere. Some harmful elements are precipitated to the bottom of the lake. Algae problems are usually reduced. High levels of algae can cause fish summerkill and foul taste in water. Aeration can eliminate most water quality complaints from the public.

4. Aeration can reduce water treatment costs, e.g. Stormon Lake. In 1988, no copper sulphate was added to this lake (a $1,000.00 saving) while the use of alum and potassium permanganate was cut in half. Annual hydro costs for the aeration of Stormon Lake (1987/88) amounted to about $900.00. A new brown trout fishery was created.

5. Aeration improves fish growth because the extent and diversity of organisms in the food chain are usually improved.

6. New fisheries can be created in areas provincially recognized as having a fish supply/angler demand imbalance, e.g. Bower Lake in the Turtle Mountain.

   Prior to 1985, Bower Lake had no sport fishery. It was stocked with rainbow trout and by 1987, 91 master angler trout were reported.

7. Sport angling creates economic benefits to the Province and local area, e.g. Bower Lake. Based on census results from two other southern lakes (William and Oak) the worth of the Bower Lake fishery was estimated, i.e.

Bower Lake angler days/year	2,800
Value added worth - $16.05/angler day based on 1988 Oak Lake results) x 2,800 =	$44,900/yr.
Tax payer costs/year	
- capital cost of projects spread over 20 years $\frac{9,000}{20}$ =	$450
- operating (hydro, oil, etc.) =	$1,450
- stocking (4000 trout/year) =	$1,400
Total cost/year	$3,300

Benefit cost $= \frac{\$44,900}{\$3,300} = 13.6$

(sport fishermen contributed $~~113,60~~ 13.60 to the provincial economy for every $1.00 invested. This does not include a similar amount (consumer surplus) that anglers would pay to enjoy this sport. The consumer surplus is a measure of the satisfaction enjoyed by anglers above and beyond their actual cost).

8. The Manitoba Habitat Heritage Corporation is not paying annually into the long term operation/maintenance of aeration projects. The M.H.H.C. Contribution is a one time capital grant. The long term operation/maintenance costs are borne by others, e.g. Towns, Municipalities, social groups (e.g. Lions Club) or other Government agencies (e.g. Parks Branch).

9. The capital costs of all aeration projects to date have been cost shared with other agencies. The proponent normally pays at least 30% of the costs. In one project (aeration of Goudney Reservoir) the Town of Pilot Mound and Manitoba Water Services Board paid 55% of the capital costs.

10. There are only a few town water supplies in southwest Manitoba that have not been aerated to date, e.g. Stephenfield, Irwin and Jackson Lake. Others may never require aeration, e.g. Minnewasta (Morden).

11. There are many waterbodies that are not town water supplies that could be aerated, e.g. next year, there may be as many as three requests for aeration, e.g. Russell Lake, Lake 317, and Robert Lake. Again, these would be cost shared projects with no long term commitments by M.H.H.C.

12. A long term demand for aeration projects can be expected. Although waterbodies are being aerated, people are becoming more informed on the potential of this rehabilitative practice and will likely continue to come forth with future projects. It is impossible to say when demand for this activity will subside.

13. There is a demand for emergency aeration equipment to aerate lakes that winterkill at irregular intervals. In Minnesota, baffle aeration (somewhat similar to what is done at Oak Lake) is the accepted procedure. Lakes such as Stephenfield, Irwin, George, Pelican, Rock, Oak, Max and Sandy are examples of lakes that winterkill periodically and are too large to aerate in their entirety.

    This system would involve the purchase of portable baffles, hoses, submersible pumps and a generator set. A permanently located system could be considered for the north end of Pelican Lake. Alternatives, at some locations, would be partial lake aeration systems similar to that presently being installed at Shoal Lake.

14. Aeration should be considered as a valid fisheries habitat improvement technique. Water quality is improved so that fish can be produced from a previously hostile environment. This procedure can be compared to various wildlife techniques designed to improve wildlife carrying capacity of relatively barren land.

15. Existing aeration

Total lake aeration - 9 waters - Boissevain will make 10 when completed.

Partial lake aeration
(a) Adam Lake - Shoal Lake will make 2 when completed.
(Adam Lake system should be moved.)
(b) Snow clearing - conducted periodically at Oak Lake.
(c) Fish refuge channel - Rock Lake - further channels could be developed at Rock and Swan Lakes.

July /88